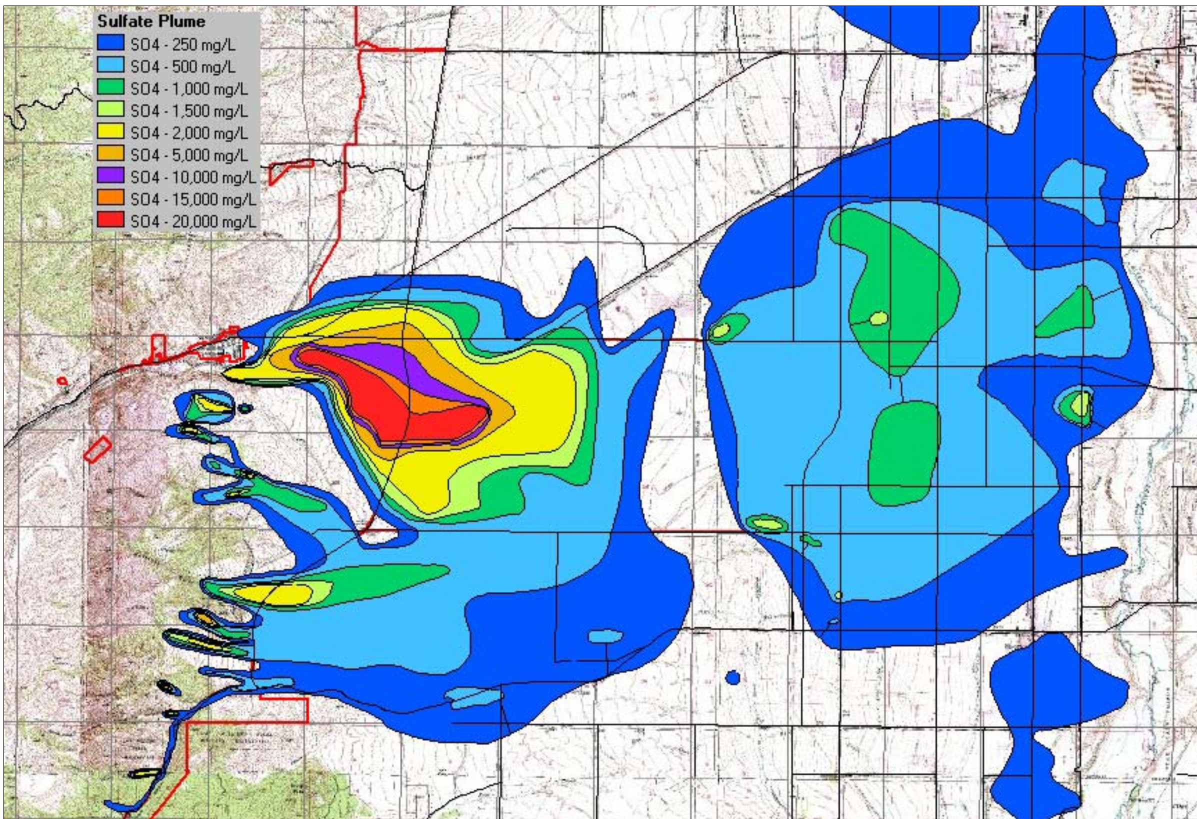
KENNECOTT UTAH COPPER CORPORATION

FINAL DESIGN FOR REMEDIAL ACTION AT SOUTH FACILITIES GROUNDWATER



Prepared by:

Kennecott
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1.0 INTRODUCTION

1.1 Purpose of Final Design

Kennecott Utah Copper Corporation (KUCC) has prepared a Final Remedial Design to address groundwater contamination at KUCC's South Facilities in accordance with the U.S. Environmental Protection Agency's Record of Decision dated December 13, 2000. In addition, many elements of the Final Design and Remedial Action address KUCC's obligations under the Natural Resource Damage (NRD) settlement with the State of Utah from 1995. The Final Remedial Design addresses the size, scope and character of the Remedial Action. Specifically, the Final Design Report:

- describes the problems to be addressed;
- identifies the technical requirements to complete a successful remedial action;
- establishes performance-based criteria for the components of the remedy, emphasizing the period during which the Bingham Canyon mine continues to operate;
- reports the results of design investigations and support activities needed to finalize engineering plans;
- presents the engineering plans and specifications that will implement the performance criteria;
- documents monitoring programs that will be implemented during and following remedial actions;
- provides schedules for implementing the remedial action;
- presents a Preliminary Design-level presentation of alternatives for post-mining water management of the remediation water described in this report.

The *Final Design*, prepared as the engineering-design document for the project, includes the following elements:

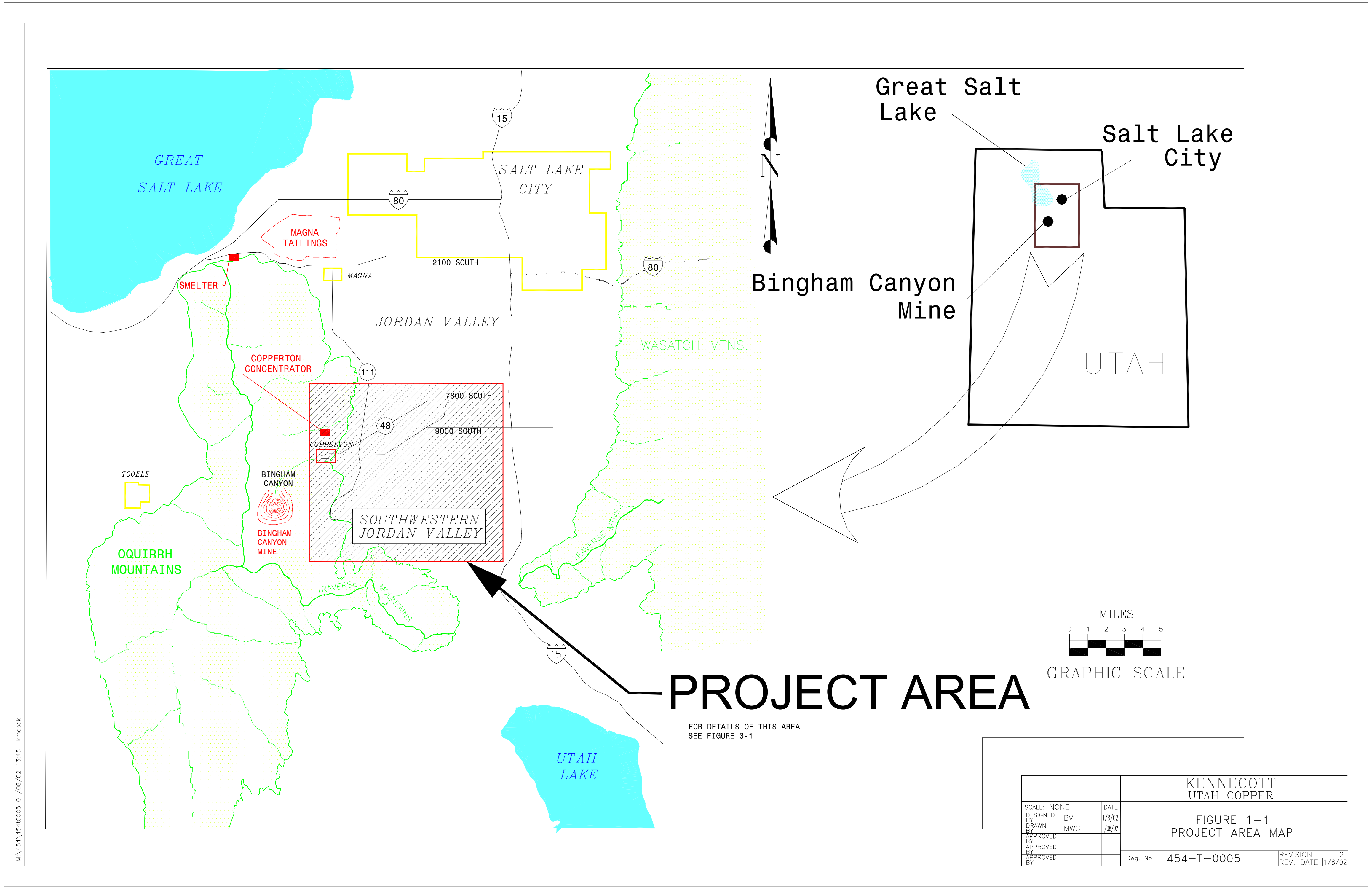
- performance and, as appropriate, design criteria;
- project delivery strategy;
- results of treatability studies and additional field sampling;
- plans, drawings and sketches;
- description of required performance objectives and/or specifications;
- the construction schedule for Remedial Action.

1.2 Site Background and Summary of Site Conditions and Risks

1.2.1 Study Area

The southwest Jordan Valley (SWJV) extends from the KUCC waste rock disposal areas on the eastern edge of the Oquirrh Mountains to the Jordan River. The foothills of the Traverse Mountains bound it on the south; the northern boundary is at approximately 7800 South Street. Figure 1-1 shows the project area.

Figure 1-1 Project Area Map



1.2.2 Site Description

The Bingham Canyon mine is located on the western edge of the SWJV in the Oquirrh Mountains. The open-pit mine covers 1,900 acres and is over one-half mile deep. More than five billion tons of rock have been removed from the pit, resulting in the production of more than 15 million tons of copper and other metals. Waste rock from the mine is placed along the east, west and north sides of the pit, where it receives meteoric precipitation that results in some natural leaching. Prior to 2000, the waste rock was artificially leached with recycled acidic water. The active leaching circuit was phased out beginning in 1999 and finally discontinued on September 29, 2000.

1.2.3 Summary of Site Characteristics and Risks

This section summarizes the regional and site-specific geography, geology and hydrogeology as interpreted from previous site characterization studies. The site description and technical background of the problems are provided in very great detail in the Remedial Investigation (KUC, 1998a) and Feasibility Study (KUC, 1998b) and in the Remedial Design Work Plan (KUC, 2001a). For the Final Design the background material will be significantly abbreviated so that the design elements themselves can be succinctly presented. The following material is adapted, much of it verbatim, from the EPA/UDEQ document "Southwestern Jordan Valley Groundwater Plumes Proposed Plan", issued in August 2000 in conjunction with public comment period on the proposed groundwater cleanup plan or the Record of Decision for the same project. Readers requiring more detail should consult the earlier technical documents that specifically describe the RI/FS programs. Appendix B to this report updates the status and results of groundwater flow and transport modeling since the RI/FS. Appendix C presents the results of the geochemical studies conducted during the Remedial Design phase. Since the completion of the RI/FS, a baseline water level and chemistry report has been completed that documents the nature and extent of groundwater contamination in 2001 and 2002. This report, attached as Appendix D, will be used as the baseline to evaluate the success of the remediation program.

There has been mining in the Oquirrh Mountains since the 1870s. Historical mining processes, including past operations of KUCC, resulted in groundwater contamination. Natural meteoric infiltration and pumped mine-waters reacted with sulfide-bearing waste rock to generate effluents that were high in total dissolved solids, including sulfate. In portions of the system, the waters were acidic and leached metals. In addition to generalized seepage, the Large Bingham Reservoir, the Old Evaporation Ponds, and other collection systems, built to contain such waters, leaked over many years. In the lower part of the valley, non-KUCC mining sources, such as irrigation canals and the ARCO tailings impoundment may also have contributed to elevated concentrations of some constituents.

Intermittent and ephemeral surface waters and groundwater flow from the Oquirrh Mountains toward the Jordan River. The flow of mine-impacted effluents in the ground-water flow system produced plumes of contaminated groundwater within the aquifer in the Southwestern Jordan Valley. The Remedial Investigation (KUC, 1998a) showed that there are about 171,000 acre-feet of groundwater that exceed appropriate water-quality criteria. The U.S. Environmental Protection Agency (EPA) and the Utah Department of Environmental Quality (DEQ) have determined that the ground-water plumes containing sulfate concentrations greater than 1500 mg/L sulfate or acid constitute a risk to human health and the environment that requires remedial actions.

The nature and extent of contamination of the groundwater depend upon location:

- In Zone A, immediately down-gradient of the Bingham Reservoir and the waste-rock piles, the groundwater system includes an acidic plume, surrounded by a partially to fully neutralized zone of high-sulfate waters. Within the high-sulfate acidic plume, there are a variety of heavy metals in solution at concentrations that exceed drinking-water standards, in some places by a factor of one hundred or more.

- In Zone B, located at and down-gradient from the old KUCC Evaporation Ponds, the ground-water contaminant of concern is sulfate, which is present in Zone B at concentrations that average less than 1,500 mg/L but above the State Drinking-Water Primary Standard of 500 mg/L.

Of major concern is the proximity of mining-affected groundwaters, especially Zone A, to municipal well fields of West Jordan and Riverton. Further off-site migration of contaminated groundwaters must be controlled in order to protect these public water-supply systems.

EPA, acting on data developed by KUCC in the Remedial Investigation, defined Remedial Action Objectives for corrective actions with respect to CERCLA in Zone A:

1. Minimize or remove the potential for human risk (by means of ingestion) by limiting exposure to groundwater containing chemicals of concern exceeding risk based concentrations or drinking water Maximum Contaminant Levels;
2. Minimize or remove the potential for environmental risk (by means of flow of groundwater to the Jordan River) to receptors of concern;
3. Contain the acid plume and keep it from expanding;
4. Remediate the aquifer over the long term.

Potential response actions were described and evaluated in the Feasibility Study (KUC, 1998b), which proposed a preferred remedy, discussed in Section 1.3 below.

In addition to the CERCLA response for Zone A that is the principal focus of this Remedial Design, KUCC is coordinating its Zone A activities with remedial actions in Zone B that are intended to resolve Natural Resource Damage Claim issues in the Zone B plume. Both agencies (EPA and UDEQ) and also KUCC understand that the cleanup of the two zones is linked by the historical nexus of origins of the plumes and by the hydrogeology of the groundwater flow systems. The principal objective of the Natural Resource Damage Claim – to "restore, replace or acquire the equivalent" of the damaged ground-water resource - is addressed in a separate settlement between the State of Utah, acting through its Natural Resource Trustee, and Kennecott. Portions of that settlement that overlap the scope of the CERCLA remedial action include:

1. Completing the CERCLA actions;
2. Extracting contaminated groundwater from the acid plume at a minimum rolling average of 400 acre-feet per year to remove contaminant mass and contain the plume;

3. Completing identified source controls in order to comply with KUCC's ground-water discharge permit;
4. Creating a trust fund to be used to "restore, replace or acquire the equivalent" of the lost groundwater to the benefit of the public in the affected area.
5. Producing 3500 acre-ft per year of drinking water from the Zone A sulfate plume that will be delivered to the affected communities.

1.3 Description of Selected CERCLA Remedy

To ensure compatibility, this section is taken verbatim from the U.S. Environmental Protection Agency's Record of Decision (EPA, 2000).

"The selected remedy involves treatment and containment of contaminated groundwater plumes. The principal threats, which caused the groundwater contamination, have been addressed in previous actions or are contained under provisions of a Utah Groundwater Protection Permit.

The selected remedy contains the following elements:

- Continuation of source control measures as administered through the State of Utah Groundwater Protection Program.

- Prevent human exposure to unacceptably high concentrations of hazardous substances and/or pollutants or contaminants by limiting access to the contaminated groundwater. Institutional controls include purchases of land, purchases of water rights, limiting drilling of new wells and increased pumping of nearby old wells as approved (on request) and administered through the State of Utah State Engineer (Division of Water Rights).

- Prevent human exposure to unacceptably high concentrations of hazardous substances and/or pollutants or contaminants through point-of-use management which includes providing in-house treatment units to residents with impacted wells, replacement of their water by hooking the properties up to municipal drinking and/or secondary supplies, and/or modifying their wells to reach uncontaminated waters.

- Contain the acid plume in Zone A by installation of barrier wells at the leading edge of the contamination (1500 ppm sulfate or less), pump and treat the waters to provide a hydraulic barrier to further plume movement while providing treated water for municipal use. The treatment technology for the barrier well waters is reverse osmosis.

- Withdraw the heavily contaminated waters from the core of the acid plume in Zone A and treat these contaminated waters using pretreatment with nanofiltration or equivalent technology, followed by treatment with reverse osmosis to provide drinking quality water for municipal use.[1]

- Monitor the plume to follow the progress of natural attenuation for the portions of the Zone A plume which contain sulfate in excess of the state primary drinking water standard for sulfate (500 ppm sulfate).

[1] The RD elects to not implement nanofiltration technology as part of the treatment program. Rather, the acid groundwater will be neutralized in the tailings line (equivalent technology) and supplemented with lime if necessary. The reverse osmosis treatment system will be used to treat sulfate-contaminated water to produce drinking water.

- Disposal of treatment concentrates in existing pipeline used to slurry tailings to a tailings impoundment prior to mine closure.

- Development of a post-mine closure plan to handle treatment residuals for use when the mine and mill are no longer operating.

1.4 Overview of Implementation

1.4.1 Technical Approach

The selected remedy described in Section 1.3 will be organized into three functional units; 1) containment and extraction of contaminated groundwater, 2) treatment of sulfate contaminated water in the Zone A Reverse Osmosis (RO) facility to produce municipal quality water, and 3) neutralization of acidic groundwater in the tailings line using the naturally occurring neutralization potential of the tails (supplemental lime will be added to the tails if necessary). The purpose, scope and objectives for each of these functional units are detailed in Section 3.0.

1.4.2 Updated Failure Modes and Effects Analysis (FMEA)

As with most CERCLA actions, the RI/FS phase did not produce all the data needed for the Remedial Design. To determine the sorts of information needs that are most critical to successful performance of the selected remedy, KUCC consulted its design team to identify gaps in support information and underlying data. In addition, KUCC elected to use a style of engineering risk assessment called "Failure Modes and Effects Analysis" (FMEA). FMEA is a qualitative evaluation that uses experienced specialists to describe an engineered system in terms of its critical components. Using this description of the system and its components, the specialists then systematically identify (a) ways in which adverse effects could arise; (b) the severity of the consequence(s) of those effects; and (c) how the project could mitigate the adverse effects.

The FMEA process allows the project team to concentrate on the information needed to control risk in the components and the overall system. It provides a traceable rationale for the identification of data needs, and therefore for the studies and projects needed to resolve the remaining uncertainties. Preliminary FMEA evaluations were presented in the Remedial Design Work Plan (KUC, 2001). Current status of the FMEA for this project is summarized in Table 1-1, and the results of this evaluation were used to establish the Final Design described in Section 3.0 below. The FMEA process will continue through the rest of the Remedial Action based on monitoring data, and may be used, in conjunction with the monitoring to guide additional actions.

Table 1-1. Summary of Failure Modes and Effects Analysis

FAILURE MODE	ADVERSE EFFECT	RANK OF CONSEQUENCE	POSSIBLE MITIGATION
Groundwater Collection and Containment System			
Well Casing Fails Above Plume	Acidic or high-SO_4 water flows to vadose zone and re-infiltrates Extraction rate compromised	Low to Moderate, depending on amount of flow lost	1. Plug and redrill well 2. Sleeve well
Extraction rate does not contain plume	Plume is not contained; water quality degrades downgradient	High to Extreme	1. Reconfigure pumping 2. Increase extraction rates 3. Install and pump additional wells 4. Add injection wells to improve containment
Extraction rate creates overdraft on aquifer	Rate of water-level decline exceeds State Engineer's guidelines	Moderate (e.g., adjust pumping rates) to Severe (e.g., adverse impacts to water rights or ground subsidence)	1. Monitor water levels against predictions and adjust pumping as necessary; 2. Respond to direction from State Engineer 3. Add injection wells to improve containment
Delivery pipeline fails (acid plume water)	Contaminated water spills to surface Extraction rate compromised	Low to Moderate, depending on volume and period of interruption	1. Place pipelines above ground for inspection 2. Monitor flow rates and shut down flow automatically if rate falls out of acceptable range 3. Double-wall (or otherwise contain) pipelines 4. Leak detection in double-wall, with failsafe 5. Storage during repairs or shut down pumping
Delivery pipeline fails (sulfate plume water)	Contaminated water spills to surface Delivery rate to water treatment (RO units) is compromised	Low to Moderate, depending on volume and period of interruption	1. Place pipelines above ground for inspection 2. Monitor flow rates and shut down flow automatically if rate falls out of acceptable range 4. Storage during repairs or shut down pumping 5. Shut down treatment facility until pipeline is repaired

FAILURE MODE	ADVERSE EFFECT	RANK OF CONSEQUENCE	POSSIBLE MITIGATION
Water Treatment (RO) and Hydraulic Delivery Systems			
Larger volumes than anticipated require treatment and distribution	Capacity must be increased Rate of aquifer clean-up compromised	Moderate to High, depending on scale of modification to schedule	1. Add additional treatment and/or delivery capacity 2. Add additional distribution capacity
Quality of extracted water degrades beyond requirements of RO feed water	Increased feed pressure Lower permeate recovery and quality	Low (technical) to Moderate (cost)	1. Blend with low-TDS water 2. Use nanofiltration or other pretreatment
Concentrate pipeline fails	Contaminated water spills to surface Delivery rate to Copperton tailings line compromised	Low	1. Place pipelines above ground for inspection 2. Monitor flow rates and shut down flow automatically if rate falls out of acceptable range 3. Provide temporary storage (e.g., Desilting Basin) while pipeline is repaired 4. Shut down treatment facilities until pipeline is repaired
Permeate pipeline fails	Clean water delivery interrupted Regulatory impact for drinking water supplies	Low to Moderate	1. Restore flow 2. Provide alternative fresh water through purchase or alternative source

FAILURE MODE	ADVERSE EFFECT	RANK OF CONSEQUENCE	POSSIBLE MITIGATION
Management of Acidic Flows & RO Concentrates in KUCC Tailings Circuit			
Mechanical failure of tailings pipeline	Contaminated water and solids spill to surface Groundwater extraction and treatment rates compromised; Copper production curtailed	Low to High, depending on volume and period of interruption	1. Inspect and maintain 2. Monitor flow rates and shut down flow automatically if rate falls out of acceptable range [Very difficult technically] 3. Store concentrates (e.g., in Desilting Basin) until tailings flow restored 4. Shut down treatment facilities until pipeline is repaired
Pipeline scale affects performance	Scale adversely affects pipeline performance or maintenance schedule	Low (technical) to Moderate (cost)	Control scale by chemical management or physical removal
Design-basis lime (CaO) amendment does not adequately control chemistry in tails	Chemistry of decant pool exceeds discharge criteria Chemistry of return flow exceeds processing criteria	High	1. Increase CaO dosage 2. Control discharge of WDPS, if a short-term problem 3. Treat decant pool, if a short-term problem 4. Adjust chemistry of process-water, if a short-term problem 5. Blend with gray water (or other waters) 6. Long-term mitigation through lime treatment / high-density sludge system
Metals and metalloids not irreversibly removed in tailings solids	Adverse water-quality impacts to discharge	Low (if reversibility is low) to High	1. Control pH of pipeline system to a value that produces stable solids 2. Amend tailing (e.g., with limestone) to control pH in tailing.

FAILURE MODE	ADVERSE EFFECT	RANK OF CONSEQUENCE	POSSIBLE MITIGATION
Management of Acidic Flows and RO Concentrates in KUCC Tailings Circuit (continued.)			
Tailings acidified	Adverse water quality impacts to groundwater and surface water discharge Adverse impacts to surface reclamation Regulatory & permitting impacts	Moderate (if acidity, metals fluxes are low) to High	1. Add sufficient CaO (or other alkaline amendment) in tailing line to provide excess Net Neutralization Potential in tailing 2. Amend tailing in-situ (e.g., with limestone) to provide additional alkalinity in oxidation zone 3. Re-vegetate with resistant species and soil amendments to control phytotoxicity
Water quality not suitable for discharge to GSL at end of mining	Alternative for water and chemical management required	Moderate (if flow volumes and chemistry are moderate) to High	1. Evaporation with "RCRA" containment for solids 2. "Land application", if concentrations do not exceed regulatory limits

2.0 PROJECT ORGANIZATION AND RESPONSIBILITIES

The overall organization of the project team for the Remedial Action and the project's relationship to EPA and UDEQ oversight is shown in Figure 2-1. The specific responsibilities of each individual or group are discussed below.

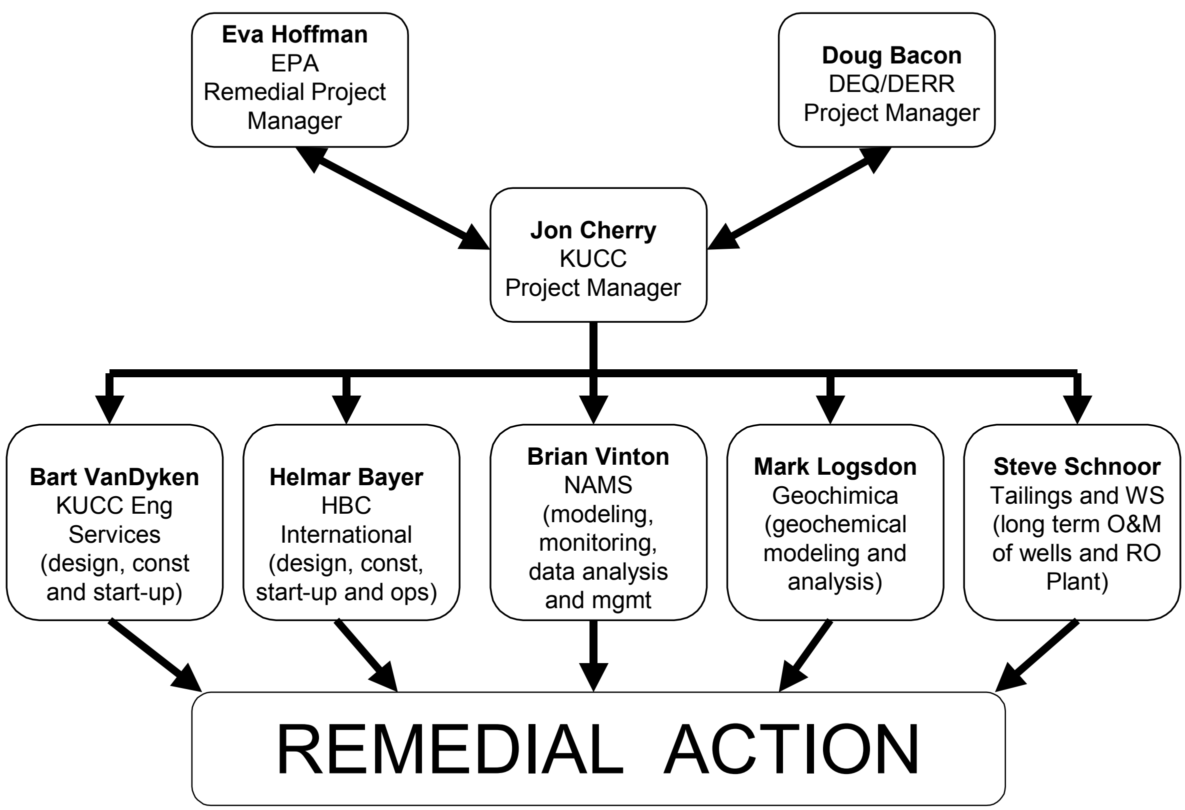
2.1 KUCC Personnel

Mr. Jon Cherry, P.E., is the KUCC Project Manager and main point of contact for communications to and from KUCC. Mr. Cherry is designated as the Design Professional for this program. Mr. Cherry will be responsible for day-to-day communication with the EPA and UDEQ oversight as well as with contractors and consultants hired for specific tasks. His general responsibilities include implementation of a remedial action that will meet the performance criteria specified in the December 13, 2000 Record of Decision (ROD). As project manager, Mr. Cherry will define and clarify the scope of work and objectives for each major activity, and ensure the technical, budget, permitting and schedule requirements are met. Mr. Cherry is a registered professional engineer with over eleven years of RCRA, CERCLA, SARA, and environmental permitting and compliance experience.

Mr. Bart Van Dyken is the KUCC Director of Engineering Services and will oversee the design, construction and start-up of the extraction and treatment facilities. He will be responsible for coordinating the necessary resources to accomplish the design and construction of the various elements and to complete the remedial action phase on schedule. Mr. Van Dyken and his staff will be responsible for the design, documentation, procurement, accounting and construction management of: 1) containment/extraction wells, 2) delivery of the extracted water to the membrane filtration treatment plant(s) and 3) delivery of the treated waters and concentrate streams to water suppliers and the tailings line, respectively. Mr. Van Dyken has over 25 years of engineering experience in large-scale production and environmental remediation projects.

REMEDIAL ACTION ORGANIZATION PLAN

Figure 2-1



Mr. Steve Schnoor, KUCC Tailings and Water Services, will be responsible for the long-term operation and maintenance of the extraction wells, pumps and Zone A Reverse Osmosis Plant. Mr. Schnoor and his staff of operators will be responsible for operating and maintaining the extraction wells and pumps such that the acid and sulfate plumes are contained as required and that the requisite amount of extracted water is delivered to the Zone RO Plant to produce the required volume of drinking water. Mr. Schnoor's team will also be responsible for operating the Zone A RO Plant at the necessary operating configuration to produce 3500 acre-feet per year of drinking water.

2.2 Consultants/Contractors

Mr. Helmar Bayer is the President of HBC International, Inc. and has contracted to KUCC for the past 10 years for treatability testing and design of the membrane treatment plant(s). Mr. Bayer will continue in this capacity, working directly with KUCC Engineering Services, to design, construct and start-up the treatment facilities. Mr. Bayer holds an M.S. in food and fermentation technology and has over ten years experience in wastewater treatment design.

Mr. Mark Logsdon is principal geochemist and President of Geochimica, Inc. and has contracted to KUCC to perform specific geochemical investigations related to the remedial design as well as provide other technical oversight throughout the remedial design process. Mr. Logsdon holds a M.S. in geology with specialization in geochemistry, has published numerous articles on specific geochemical issues and is a recognized expert in his field, with more than 25 years experience in mining-related geochemical studies. Mr. Logsdon will be consulted on an as needed basis to review long term geochemical monitoring in the aquifer and tailings impoundment.

Mr. Brian Vinton is President of North American Mine Services (NAMS). Mr. Vinton and his staff of engineers and technicians have contracted to KUCC over the past ten years for source removal/control projects and the RIFS. Mr. Vinton holds a B.S. in earth science and has over 20 years of experience in the exploration, mining and environmental remediation fields. NAMS is contracted to KUCC as part of the remedial design project to provide technical review, GIS support, groundwater modeling, groundwater monitoring, groundwater data management and source control evaluation.

2.3 Government Oversight: EPA/UDEQ

Dr. Eva Hoffman is the Remedial Project Manager (RPM) from EPA Region VIII for the remedial action. Dr. Hoffman has been the EPA lead project manager for this project during the source removal/control projects and RIFS and will be responsible for coordination of all oversight for the project from EPA's perspective. She also will be responsible for contracting technical support and review from the U.S. Army Corps of Engineers and United State Geological Survey (USGS) to support her oversight role. Dr. Hoffman's responsibilities include ensuring that the remedial action will meet the performance criteria established in the ROD, that the public's interests are protected and that all federal administrative requirements are met.

Mr. Doug Bacon is the lead Project Manager from the State of Utah Department of Environmental Quality (UDEQ) for the remedial action phase of this project. Mr. Bacon was the lead project manager for UDEQ during the FS and ROD. Mr. Bacon will be responsible for coordination of all oversight for the project from UDEQ's perspective and ensuring that all State administrative requirements are met.

2.4 Technical Review Committee (TRC)

The TRC was formed during the initial stages of the RI and has continued through the FS, Remedial Design (RD) and into the remedial action (RA). The committee is comprised of representatives from KUCC, various federal, state and local government agencies, as well as, representatives from local municipalities and local residents. The TRC is co-chaired by the KUCC, EPA and UDEQ project managers. There are two purposes of the TRC. First, the TRC provides a forum in which the technical details and progress of the remedial action can be communicated in a transparent process that allows open dialog between the interested parties. The second purpose of the TRC is to provide technical review in their respective areas of expertise to ensure that basic assumptions are credible and that critical details are not overlooked. Table 2-1 is the current listing of TRC members, their affiliation, phone number and email address.

Table 2-1. South Facilities Technical Review Committee

	NAME	AFFILIATION	PHONE NUMBER	EMAIL
1	Eva Hoffman	EPA	303-312-6764	Hoffman.eva@epamail.epa.gov
2	Helen Dawson	EPA	303-312-7841	Dawson.helen@epamail.epa.gov
3	Joy Emory	FOGSL	801-532-2771	joyemory@hotmail.com
4	Michelle Baguley	HRRR	801-254-4921	Mbaglady@hotmail.com
5	Richard Bay	JVWCD	801-565-8903	RichardB@jvwcd.org
6	Mark Atencio	JVWCD	801-565-8903	MarkA@jvwcd.org
7	Alan Packard	JVWCD	801-565-8903	alanp@jvwcd.org
8	Ryan Evans	KUCC	801-569-6961	Krevans@Kennecott.com
9	Paula Doughty	KUCC	801-569-7120	Doughtyp@Kennecott.com
10	Jon Cherry	KUCC	801-252-3126	Cherryj@Kennecott.com
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(REVISED December 18, 2002)

3.0 FINAL DESIGN

3.1 Purpose, Scope and Objectives of the Final Design

The purpose of the Remedial Design (RD) is to develop and document the technical requirements of the Remedial Action that will be executed by KUCC to resolve the CERCLA issues associated with contamination of groundwater from mining activities. Where appropriate, this design also addresses KUCC's obligations related to the previously mentioned NRD settlement. The general nature of the selected remedy and an overview of the conceptual design for that remedy have been presented in Sections 1.3 and 1.4, above.

The scope of the Final Design includes plans for three "functional units" of the conceptual plan during the period in which the Bingham Canyon mine continues to operate:

- Groundwater containment and extraction system (including monitoring);
- Water treatment (RO) and hydraulic delivery system for treated water and concentrate;
- Management of acid plume water and Zone A RO concentrates in KUCC tailings circuit.

In addition, Appendix A to this Final Design Report describes KUCC's approach to post-mining water management. This appendix has been prepared at the level of a Preliminary Design. The plan for post-mining water management will be updated formally as part of the 5-Year Reviews during Remedial Action. Through the update process, there will be a final engineering design for all aspects of post-mining conditions prior to the actual end of mining act Bingham Canyon, which is expected to be some time between 2013 and 2030, depending on long-term mine planning.

The Final Design addresses processes and designs that will be used by KUCC to meet the terms of the ROD both during operational stages of the mine and after the end of mining. The level of detail for the operational phase is much greater than for the end-of-mining phase, as we expect that much will be learned during the period of expected operation that can be applied in the context of closure but which cannot be anticipated in detail at this time.

This Final Design Report provides the general plans and specifications for a performance-based Remedial Action that would be detailed and executed by KUCC or the selected contractor(s). Objectives of the Final Design include:

- Identify performance and, as appropriate, design criteria for each "functional unit" of the conceptual design;
- Present the results of supplemental testing, sampling and analytical programs executed during the Remedial Design process to address data needs that were identified after the RI/FS;
- Document the performance-based designs in plans and specifications.

The Final Design Report is organized in terms of the three "functional units" discussed below.

3.2 Groundwater Containment and Extraction

Zone A groundwater will be extracted from acid and sulfate contaminant plumes (Figure 3-1). The acid plume contains low pH/high TDS water that will be extracted and routed to the tailings line via the Wastewater Disposal Pump Station (neutralization of the acid water is discussed in Section 3.4). Sulfate water from Zone A will be routed to the RO Plant. The Zone B sulfate groundwater extraction and treatment plan will be implemented by others through various agreements with the State of Utah and local water purveyor(s).

Extraction rates from the Zone A sulfate plume wells will be adjusted to accommodate the feed water requirements at the RO Plant and to produce the required 3500 acre-feet per year of drinking water while containing the sulfate plume at 1500 mg/L on KUCC property. If additional wells are needed to contain the sulfate plume on KUCC property, the average extraction rate would still be in the 2500 to 3500 gpm range with production of 3500 acre feet of drinking water per year. Table 3-1 lists the planned extraction rates and volume for the sulfate and acid extraction wells. Placement of these wells is shown below in Figure 3-2.

3.2.1 Acid Plume Containment and Extraction

Water from the acid wells will be routed to the tailings line via the Wastewater Disposal Pump Station (WDPS). The current acid well, ECG1146, was installed in 1995 along with a pipeline delivery system to the Membrane Filtration Plant (Figure 3-2 and 3-5). A second acid well will be installed approximately ¼ mile east of Highway 111 and adjacent to and south of the Trans Jordan Landfill in late 2002 or early 2003. Additional acid wells will be installed in the future to contain the acid plume. They will be located where the maximum acid-water extraction is likely based on then-current groundwater monitoring and modeling results. The current (December, 2002) extraction rate for ECG1146 is 900 gpm. Routing of flows after extraction is described in Section 3.2.1.2 below.

Optimal containment of the acid plume over the life of the project will be achieved by evaluating the monitoring data described in Section 3.2.3. KUCC will use its calibrated groundwater flow model as a planning tool for ongoing optimization of plume containment and groundwater extraction. The model will be calibrated periodically using data from ongoing monitoring. Extraction rates and well-field geometry will be set according to monitoring results to contain the acid plume, to extract Zone A sulfate waters for treatment to drinking-water standards, to contain the 1500 mg/L sulfate plume on Kennecott property and to balance the hydraulic response of the aquifer (drawdown) with the need to protect the ability of the aquifer to transmit the acid water to the wells.

Figure 3-1 Zone A and Zone B Groundwater Plumes

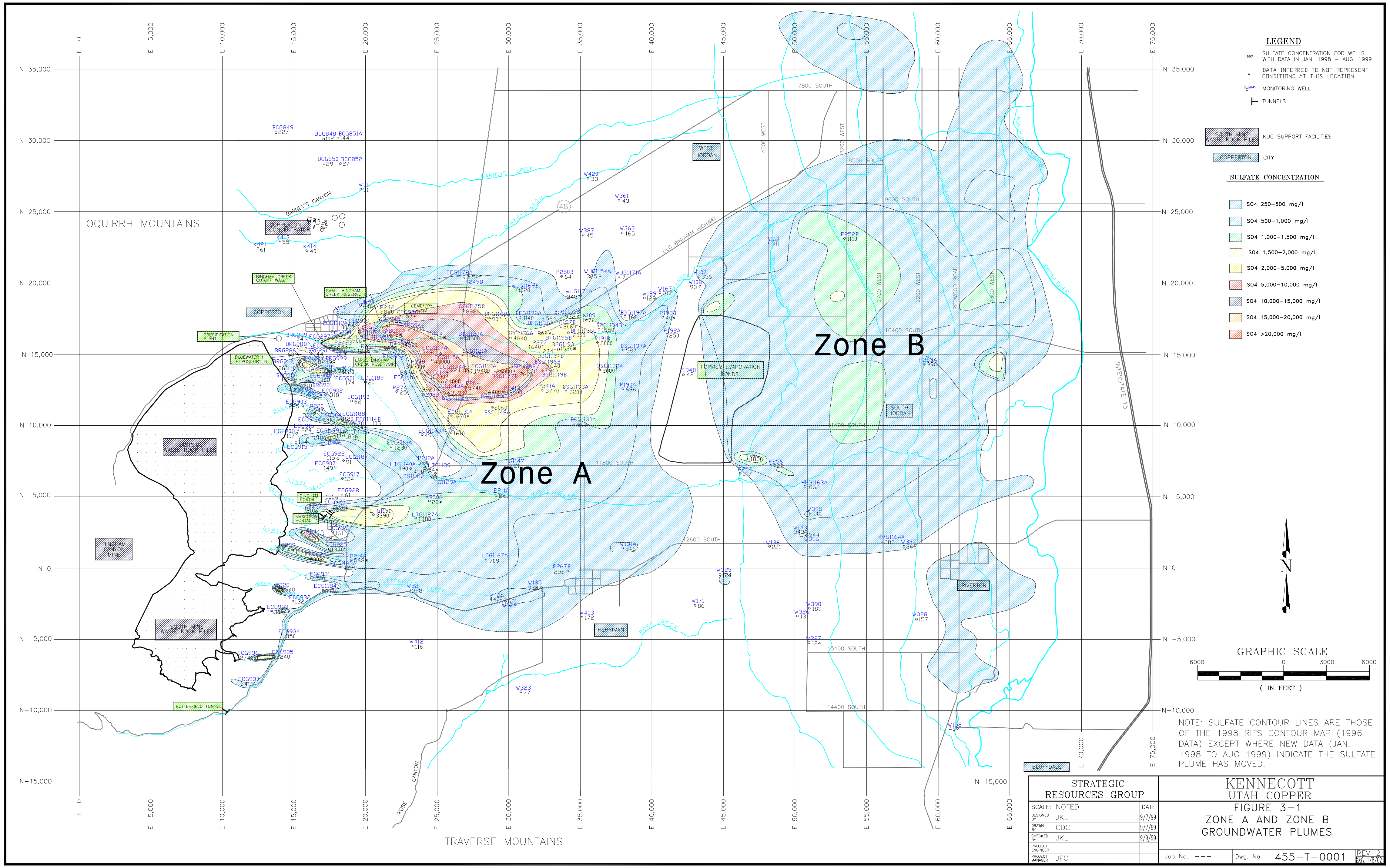


Table 3-1. Extraction Rates for Proposed Remedial Strategy

Well	Model Layer*	Pumping Rate (gpm)	Pumping Rate (as: ac-ft/yr)	Estimated Years[ψ]
Acid Well (ECG1146)	4	750-1500	*(1200-2400)*	0-5
New Acid Well #1	4	Varied[†]	*(Varied[†])*	0-30
New Acid Well #2	4	Varied[††]	*(Varied[††])*	6-50
New Acid Well #3	4 (50%), 5 (50%)	Varied [†††]	*(Varied [†††])*	16-50
BFG1200 (K109)	4, 5, 6	~1100	*(~1750)*	0-50
B2G1193 (K60)	4, 5	~1100	*(~1750)*	0-50
LTG1147	3 (50%), 4 (50%)	~1000	*(~1600)*	0-50

* Layer 3 is approximately 0 – 150 feet below the groundwater table
Layer 4 is approximately 150 – 300 feet below the groundwater table
Layer 5 is approximately 300 – 450 feet below the groundwater table
Layer 6 is approximately 450 – 650 feet below the groundwater table

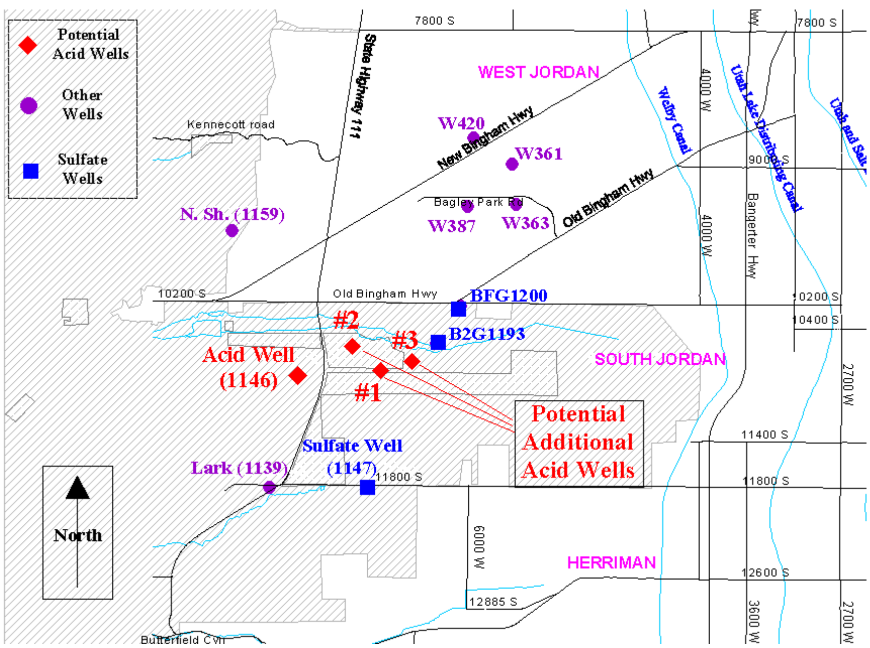
ψ Actual pumping will be evaluated based on water quality and efficiency at this location

† Varied Pumping as necessary: Years 0-15, ~1000 gpm (*1600afy*); Years 16-50, ~500 gpm (*800 afy*)

†† Varied Pumping as necessary: Years 6-15, ~1000 gpm (*1600 afy*); Years 16-50, ~500-750 gpm (*800-1200 afy*)

††† Varied Pumping as necessary: Years 16-30, ~750 gpm (*1200 afy*); Years 31-50, ~500-750 gpm (*800-1200 afy*)

Figure 3-2 Extraction Well Locations



3.2.1.1 Acid Extraction Well Construction

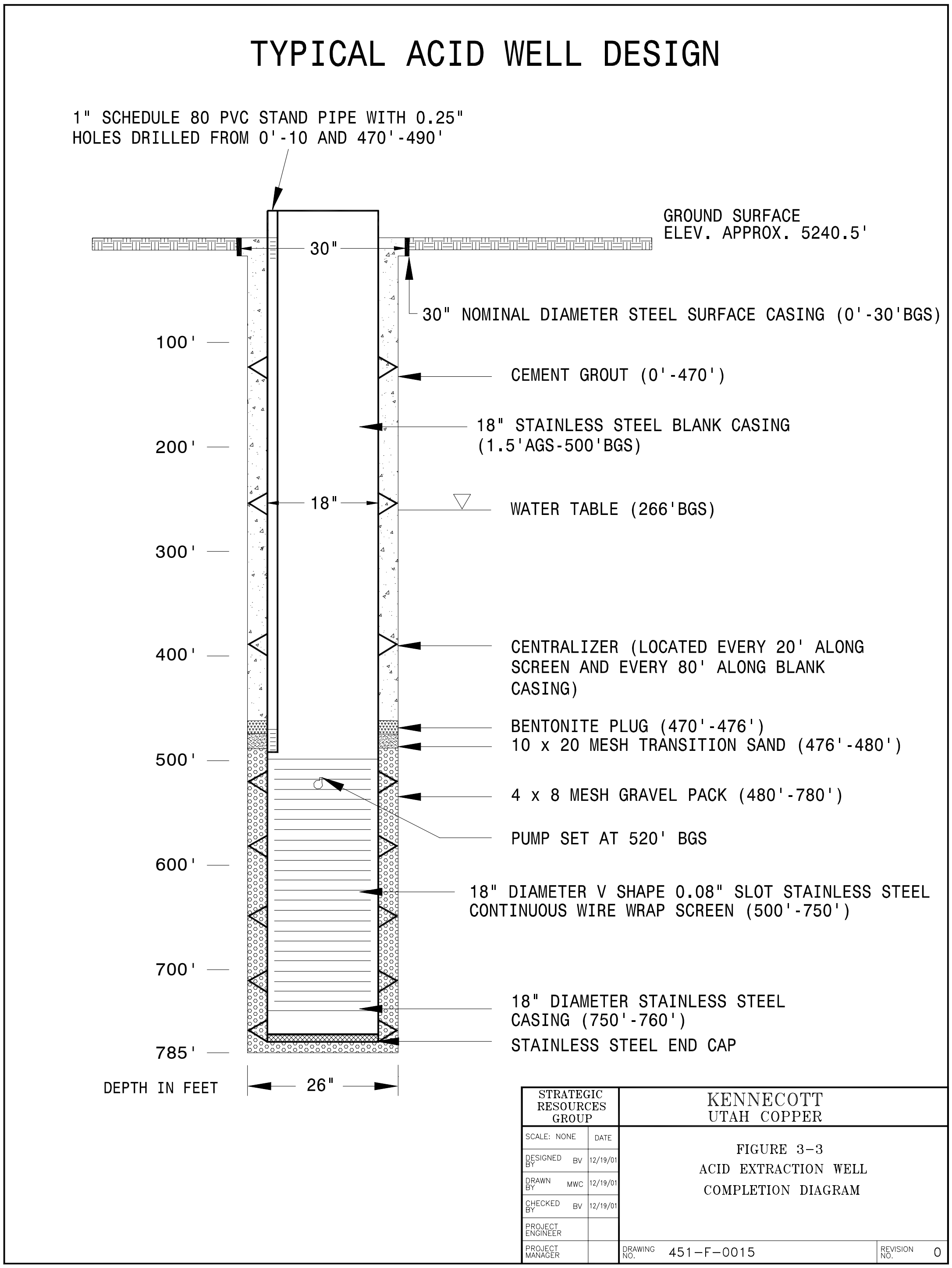
In addition to acid well ECG1146, other acid wells will be drilled and installed in the same manner (Kennecott RI 1998). Typical acid-well design will include an eighteen-inch nominal diameter stainless steel casing and screen (Figure 3-3). A submersible stainless steel pump will be installed at depth within the casing. The well, pump, and appurtenances in contact with low pH water will be stainless steel and designed to withstand the water pumping pressure for each specific well. Screen intervals for all additional wells will include all portions of the aquifer identified during monitoring as containing low pH water (<3.5 pH s.u.).

3.2.1.2 Acid Plume Piping

All of the acid-well water will be piped through a 12-inch to 14-inch HDPE pipe encased in a 16-inch to 18-inch secondary HDPE containment pipe. The current pipeline was designed as such and includes approximately 7500 feet of line from ECG1146 to the Eastside Collection Reservoir (Figures 3-2 and 3-5). The second acid well line will include approximately 4700 feet of line from the planned well site to ECG1146. This line will be sized to facilitate the possibility of maximum volume extraction in the eastern extent of the acid plume. The pipe will be designed to withstand the additional pressure due to its lower elevation location. Each of the respective acid wells will be designed with monitoring devices to ensure proper pump operation, flow metering and depth to water. These devices also will be programmed to shut down the well if any one parameter is not within the tolerance allowed. The secondary containment pipe also will be monitored at each of the down gradient well locations. If any flow is detected in the secondary pipe at any of the acid well sites by the continuous-reading conductance probes, the conductance signal will be conveyed to the electrical circuit at each of the wells, and each well will be programmed to shut down until the problem is identified and repaired.

The current pipeline will be re-routed to the cement-lined canal and/or the Precipitation Plant (P-Plant). Flow in the cement-lined canal will report to the WDPS that delivers water to the beginning of the tailings line. If the WDPS station needs repair and down time is scheduled, the flow from the acid wells will either be shut down until repairs are complete or be diverted to the Bingham Reservoir. Flow to the P-Plant will either be pumped to HDPE-lined evaporation ponds on the Eastside Waste Rock dumps during the summer months or routed to the WDPS or the Bingham Reservoir. The second acid well pipeline will be tied into the pipeline adjacent well ECG1146. Any additional pipelines from future acid wells will also be tied to the pipeline from well ECG1146. The existing pipeline from ECG1146 to the lower cement-lined canal has the capacity to carry up to 3000 gpm.

Figure 3-3 Typical Acid Extraction Well Design



3.2.2 Sulfate plume Containment and Extraction (Zone A)

Water from the sulfate wells in Zone A will be routed to the RO Plants as described in Section 3.3. The wells include LTG1147 (sulfate well), B2G1193 (K60) and BFG1200 (K109). Each of the three wells has existing conveyance lines which will be re-routed directly to the RO Plant. The flow from each well will be regulated by two objectives: (a) to contain the 1500 mg/L sulfate plume on KUCC property and (b) to provide a composite flow that will satisfy the water-quality and quantity requirements of the RO Plant. The current well-field configuration meets these requirements, based on the operations data for pilot-testing the RO Plant over time since 1996. If monitoring and its evaluation through groundwater-flow modeling reveal that additional wells are needed to contain the Zone A sulfate plume, KUCC will develop and submit for approval plans and specifications that are similar to those for the existing well sites. The plan would include supporting monitoring data, drawdown modeling results, and water-quality predictions.

As part of Zone A sulfate containment, KUCC is also evaluating injecting water into a portion of the principal aquifer in the BFG1200/West Jordan Well Field area. Injection would provide additional hydraulic containment for the sulfate plume and also would recharge the overdraft of the principal aquifer that has developed from over-extraction during the last decade or more. Development of a feasibility plan for injection will be evaluated and recommendations completed in 2003.

3.2.2.1 Preliminary Evaluation Report

A Preliminary Evaluation Report (PER) on the feasibility and appropriateness of a particular groundwater source for use as a drinking water source is required under Utah Administrative Codes R309-600, R655-4 and R309-204. A PER and the engineering specifications were submitted and approved by the Division of Drinking Water prior to completion of well BFG1200. Wells B2G1193 and LTG1147 were completed without a PER before details of the Remedial Design were worked out; however, both wells have been discussed with the State, and the State has asked that the information required in the PER be included in the Drinking Water Source Protection Plan (DWSP) for all of the sulfate wells. Any additional sulfate-extraction wells will follow the procedures as defined in the State regulations. All drilling and well construction materials will be in compliance with existing State regulations.

3.2.2.2 Drinking Water Source Protection (DWSP) Plans

All Zone A sulfate wells that are or will be routed to the RO Plant are required by the State to have approved DWSP plans. As agreed with the State, one plan will be completed that will include all three existing sulfate wells. This plan will be completed in 2003.

3.2.2.3 Sulfate Well Construction

Sulfate Well LTG1147 was installed in 1995 (Kennecott RI, 1998) and has been in operation through 2002. B2G1193 was installed in 1997, and BFG1200 was installed in 2000. The typical sulfate-well design includes an eighteen-inch nominal diameter stainless steel screen and a steel casing (Figure 3-4). Each well has a submersible pump, and the combined flow will meet the required volume of 3500 acre feet per year. These wells were originally constructed to supply make-up water to the Copperton concentrator.

3.2.2.4 Sulfate Plume Piping and Routing

Pipelines from current sulfate containment wells currently exist and convey water from the extraction location to the Copperton concentrator. When the Zone A RO Plant construction is complete, these pipelines will be diverted to the plant. Pipeline design and routing can be viewed in Figure 3-5. Each of the lines from the well sites are designed to convey maximum flow from each well. Pipelines are installed per manufacture's instructions.

3.2.3 Groundwater Monitoring

3.2.3.1 Introduction

As part of the Remedial Design/Remedial Action on the CERCLA groundwater plume in the Southwest Jordan Valley, KUCC will monitor the groundwater in and around the contaminant plume. In 2001, a Baseline Groundwater Chemistry and Water Level Study (Appendix D) was conducted to create a representation of the shape and size of the Zone A contaminated groundwater plume at the start of remediation and to document the status of water level changes at the time in the valley. The frequency and intensity of long-term monitoring as discussed in this section is based on the results of that Baseline study and previous Remedial Investigation results.

Future monitoring data will be compared to the baseline representation to evaluate the effectiveness of remediation and its impact on water levels and groundwater quality in the valley. Three types of data will be collected in the course of groundwater monitoring: water level elevation measurements (annual to monthly measurements on 317 wells), groundwater chemistry from well sampling (29 different analytes on samples collected on a semiannual to every two year sampling frequency on samples from 100 wells) and ground surface elevation monitoring (annual survey from 7 different well sites) . Annual monitoring reports completed as part of the Groundwater Characterization and Monitoring Plan will detail significant changes in the plume geometry and chemistry. These reports may include potentiometric maps, potentiometric-change maps, contaminant distribution maps and/or hydrogeologic cross sections. This monitoring plan will be a working plan with flexibility to increase or decrease groundwater-monitoring intensity in response to changes seen in the plume.

3.2.3.2 Purpose

Groundwater monitoring data will be used for several purposes:

1. Monitor the impacts of remedial extraction and natural attenuation on the shape and size of the Zone A contaminant plume. Data will be compared to the pre-remediation (2001) representation of the shape and size of the contaminated groundwater plume created using Baseline Study data.

2. Monitoring results will be used to assure compliance with the stipulations of the Record of Decision for KUCC South Zone Groundwater Plumes (ROD) (EPA and UDEQ, 2000), that is, that groundwater with greater than 1500 mg/L sulfate and/or metals concentrations exceeding state and federal drinking water standards does not migrate outside the area of contamination defined in the Feasibility Study. The ROD also requires the natural attenuation of groundwater with greater than 500 mg/L sulfate be monitored.

Figure 3-4 Typical Sulfate Extraction Well Design

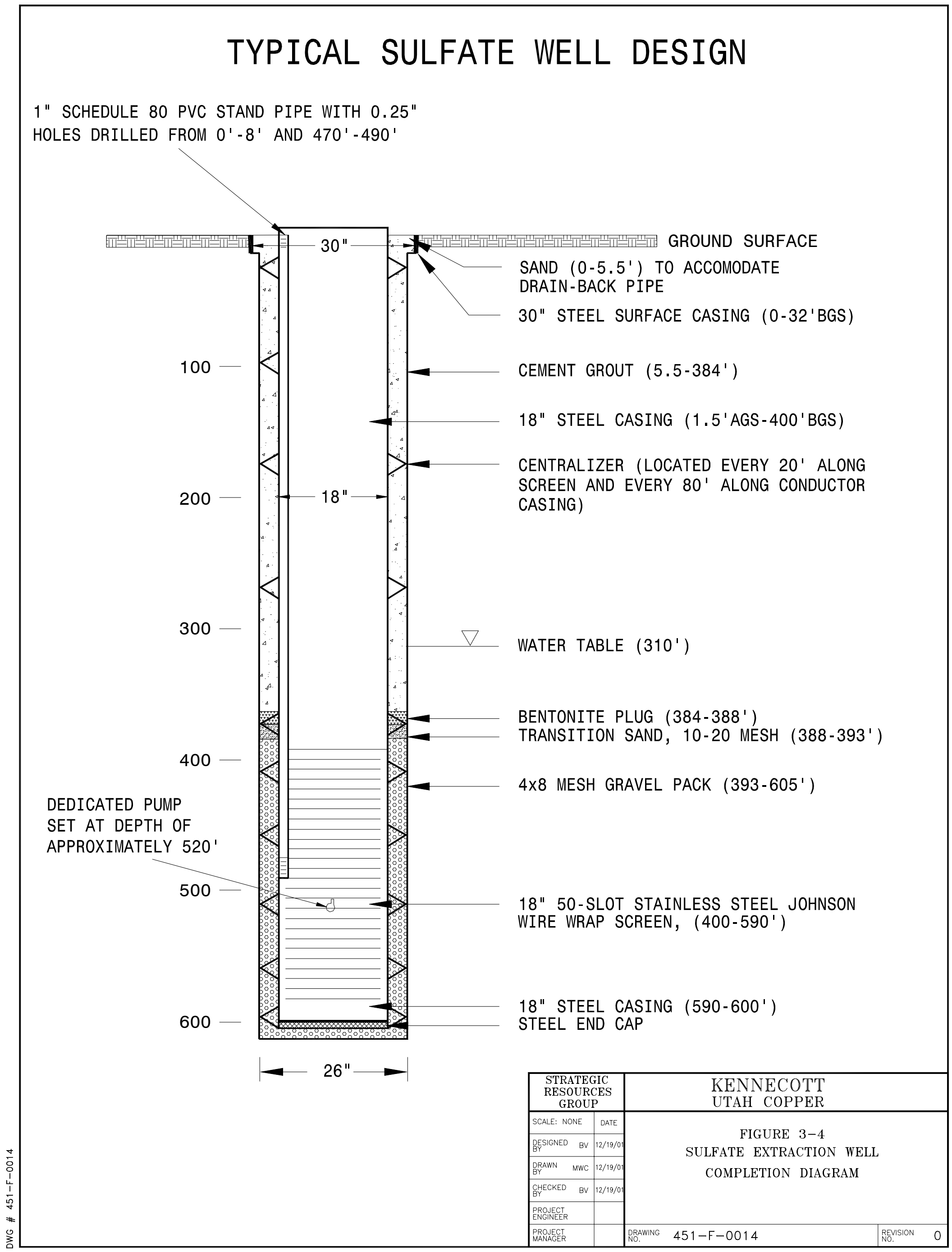
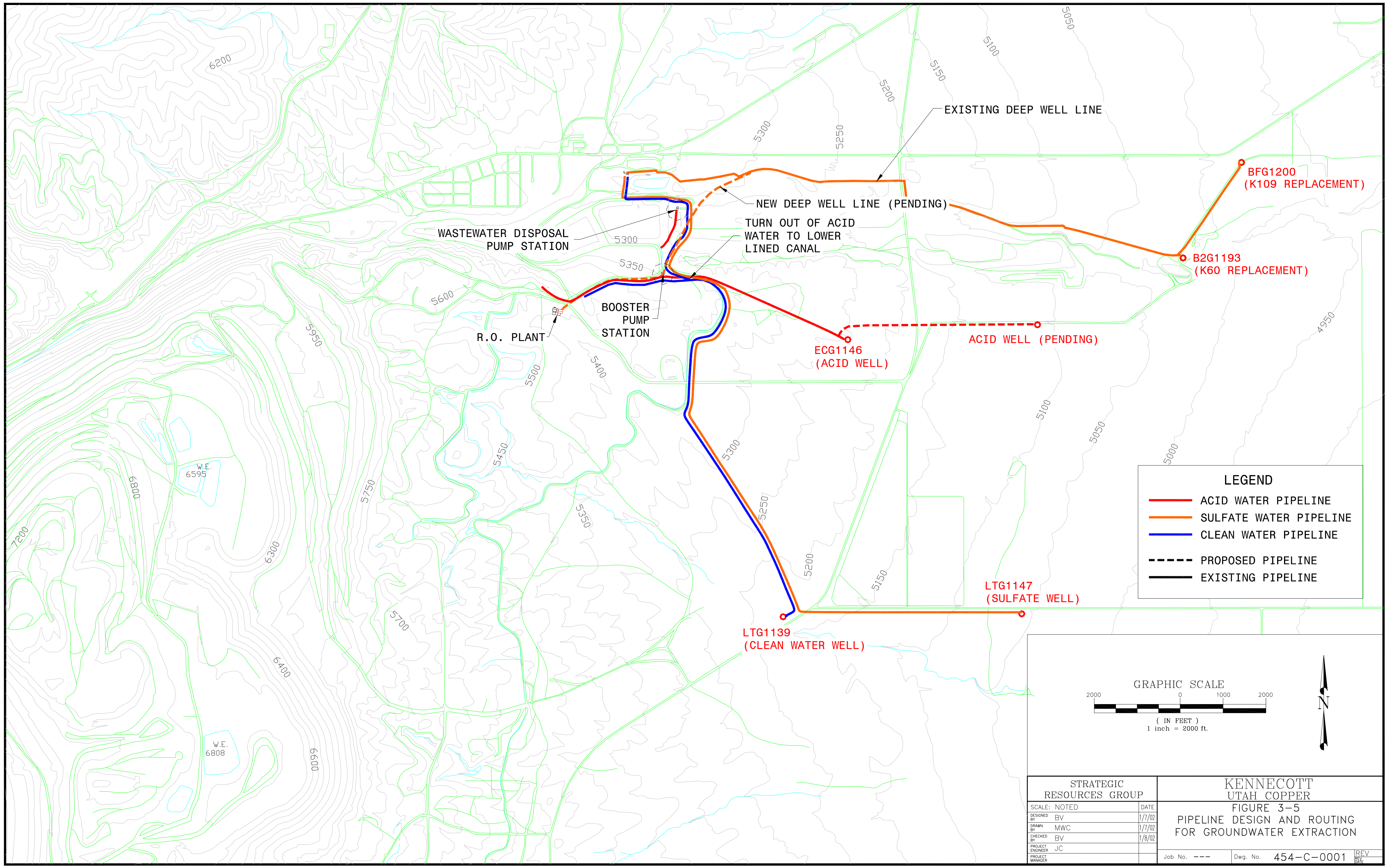


Figure 3-5 Pipeline Design and Routing



3. The data will be added to the historical data set of water level and chemical trends. Some wells in the valley currently show falling water levels, reduced head pressure or contaminant migration. While remediation may exacerbate the head loss because of increased pumping rates, it will be necessary to distinguish trends that existed before remediation from those caused by remedial extraction so that KUCC can mitigate as necessary.

4. Monitor potential land surface subsidence that may be caused from water level declines. Projected draw downs of the water table may cause land subsidence and KUCC will monitor 7 well sites on an annual basis to track changes. If changes are noted, KUCC may increase the number and frequency of monitoring points and mitigate potential structural damage to the extraction capture system (piping and well houses).

5. Data gathered will be used in the on-going groundwater flow and transport models. Groundwater monitoring data will be used to identify where field conditions deviate from the model predictions, thereby allowing refinement of the models.

3.2.3.3 Procedures

Methods

KUCC's Groundwater Monitoring and Characterization Plan (GCMP) (KUCC 2000) and associated Standard Operating Procedures (SOPs) (KUCC 1999a) will be followed for all sampling, surveying and water level measurements. The GCMP has been approved by the Division of Water Quality (DWQ) and is updated on an annual basis. Procedures for documentation and sample handling, equipment maintenance and decontamination, quality control sampling, field measurements, and groundwater sampling are detailed in the SOPs.

Data Management

The GCMP specifies how field and laboratory data are managed from the point of collection, through sampling and laboratory handling, to reporting in quarterly and annual reports to the DWQ. In addition to GCMP data management, the Data and Records Management Plan for the Remedial Design (KUCC 2001) provides more detail on how data will be managed on the project level and how they will be managed after all GCMP procedures are complete.

There may be certain types of data that do not go through the complete GCMP data-management procedure. We anticipate that all the site-wide water level measurements (those not collected immediately before well sampling) will be collected using GCMP water-level measurement protocol, but that these data will be entered into a project database instead of the GCMP database; therefore, they would not be included in GCMP quarterly and annual reports. These data will be reviewed by project personnel in a similar manner to the quality control review conducted under the GCMP program. The two data sets will be combined to evaluate the status of the contaminant plume.

Quality Control/Quality Assurance

Quality control procedures for the GCMP program will be followed for all RD data collection and analysis. These procedures are documented in the Quality Assurance Project Plan (QAPP) for the GCMP (KUCC 1999b). In addition to the extensive quality control/quality assurance performed according to laboratory and GCMP protocol, project personnel will review data by comparison to historical trends within 90 days of receipt of the data from the laboratory. If data outside the expected trend are identified, the measurement will be investigated. The expected trend will be defined as within plus or minus two standard deviations calculated on the previous eight sampling results for that analyte, or from empirical evaluation of the data. Typically, a verification of field data collection and laboratory data reduction would be performed first, followed by re-analysis of the sample, if possible. If these actions do not resolve the issue, the well may be re-sampled. If re-analysis or re-sampling results are similar to the out-of-trend data, the data will stand. If these actions suggest the out-of-trend data may be an outlier, a qualifier will be placed in the database. Quality control problems, necessary corrective actions, and effects on data will be documented in annual reports. Database management is outlined in more detail in the Data Records and Management Plan for the Remedial Design (KUCC, 2001).

3.2.3.4 Monitoring Plan

Water Levels

<u>Coordination with existing programs</u>
Several existing water-level collection programs are underway in areas that overlap the South Facilities Groundwater Plume area to be monitored. Data collected as part of these programs will also be used to evaluate hydraulic changes in and around the contaminant plume.

TransJordan Solid Waste Disposal Facility collects quarterly water levels on five monitoring wells located around their facility, approximately 1-2 miles west of the sulfate extraction area. KUCC has a good working relationship with the management of this facility, and it is anticipated that their water-level information will be available; however, KUCC cannot control when water-level measurement occurs, and so the data may not be as useful for all purposes as data collected according to the KUCC schedule. It should be noted that data collected by the landfill is not part of KUCC's GCMP and will be noted as such.

<u>Frequency</u>
For the first several years of remedial extraction, two complete sets of water levels per year will be collected on shallow completions of the wells identified in Figure 3-6. One set will be collected in May, before seasonal pumping begins, and the other set will be collected in September or October toward the end of the irrigation season but while large wells in surrounding communities are still pumping. The timing is designed to show the impact from seasonal pumping on the water table. Water levels will be collected on all depth completions annually to monitor vertical gradients. Under normal conditions, this amount of data should take about five working days to collect. Weather or ground conditions may prolong this interval up to about two weeks. All measurements will be made in as short a time span as possible.

More frequent water-level monitoring will be conducted around pumping wells when the extent of the cone of depression around those wells is being monitored.

<u>Monitoring Locations</u>
Table 3-2 lists the 317 wells proposed for water level monitoring. The wells include most KUCC monitoring wells and some private wells in Zone A. As seen on Figure 3-6, the spatial distribution of monitoring points is more concentrated in the two main areas of RD extraction (the acidic portion of the plume and the sulfate extraction area of wells B2G1193 and BFG1200), as it will be critical to understand the hydraulics of groundwater flow in these areas. Many of the sites are nested wells that will allow KUCC to monitor vertical hydraulic gradients.

Table 3-2. Wells for Water-level Monitoring

K26	P269	ECG923	HMG1122B	LTG1138C	EPG1165A	B2G1194A
K70	P270	ECG924	HMG1122C	LTG1139	EPG1165B	B2G1194B
K72	P271	ECG925	HMG1123A	LTG1140A	EPG1165C	BFG1195A
K84	P272	ECG926	HMG1123B	LTG1140B	EPG1166	BFG1195B
K105	P273	ECG928	HMG1123C	LTG1140C	LTG1167A	BSG1196A
K106	P274	LTG929A	ECG1124A	LTG1140D	LTG1167B	BSG1196B
K120	P277	LTG929B	ECG1124B	ECG1142A	LTG1167C	BSG1196C
W131A	P279	ECG931	ECG1124C	ECG1142B	BFG1168A	B3G1197A
P190A	BRG286	ECG932	BSG1125A	ECG1142C	BFG1168B	B3G1197B
P190B	BRG287	ECG934	BSG1125B	ECG1143A	BFG1168C	B3G1197C
P191B	BRG288	ECG935	BSG1125C	ECG1143B	WJG1169A	BFG1198A
P192B	BRG289	ECG936	HMG1126A	ECG1143C	WJG1169B	BFG1198B
P193B	BRG290	ECG937	HMG1126B	ECG1144A	WJG1169C	BFG1198C
P194A	BRG291A	ECG938	HMG1126C	ECG1144B	WJG1170A	ECG1199A
P194B	ECG293	ECG939	LTG1127A	ECG1144C	WJG1170B	ECG1199B
P197B	ECG294	ECG940	LTG1127B	ECG1145A	WJG1170C	ECG1199C
K201	ECG296	SRG945	LTG1127C	ECG1145B	WJG1171A	ECG1199D
P208A	ECG297	SRG946	ECG1128A	ECG1145C	WJG1171B	ECG1199E
P208B	ECG299	B1G951	ECG1128B	ECG1146	WJG1171C	ECG1199F
P209B	W403	ECG952	ECG1128C	LTG1147	COG1175A	ECG1199G
P211A	ABC01	BRG999	LTG1129A	BSG1148A	COG1175B	BFG1200
P211B	ABC02	ECG1113A	LTG1129B	BSG1148B	COG1175C	EPG1689
P212A	ABC04	ECG1113B	LTG1129C	BSG1148C	B2G1176A	WJG1980
P212B	ABC04A	ECG1113C	BSG1130A	BCG1150A	B2G1176B	
P214A	ABC05	ECG1114A	BSG1130B	BCG1150B	B2G1176C	
P220	ABC06	ECG1114B	BSG1130C	BCG1150C	BSG1177A	
P225	ABC07	ECG1115A	ECG1131A	BSG1153A	BSG1177B	
P228	ABC08	ECG1115B	ECG1131B	BSG1153B	BSG1177C	
P231	ECG900	ECG1115C	ECG1131C	BSG1153C	COG1178A	
P239	ECG901	ECG1115D	BSG1132A	WJG1154A	COG1178B	
P241B	ECG902	ECG1115E	BSG1132B	WJG1154B	COG1178C	
P241C	ECG903	ECG1116A	BSG1132C	WJG1154C	BSG1179A	
P242	ECG904	ECG1116B	BSG1133A	BFG1155B	BSG1179B	
P243	ECG905	ECG1116C	BSG1133B	BFG1155C	BSG1179C	
P244A	ECG906	ECG1117A	BSG1133C	BFG1155D	BSG1180A	
P244B	ECG907	ECG1117B	HMG1134A	BFG1155E	BSG1180B	
P244C	ECG908	ECG1117C	HMG1134B	BFG1155F	BSG1180C	
P248A	ECG909	ECG1118A	HMG1134C	BFG1156A	ECG1182A	
P248B	LRG910	ECG1118B	BSG1135A	BFG1156B	ECG1182B	
P248C	LRG911	ECG1118C	BSG1135B	BFG1156C	ECG1183A	
P249A	LRG912	BSG1119A	BSG1135C	BFG1156D	ECG1183B	
P249B	LRG914	BSG1119B	BFG1136A	BFG1156E	ECG1184	
P257	ECG915	BSG1119C	BFG1136B	BFG1156F	ECG1186	
P260	ECG916	B1G1120A	BFG1136C	B2G1157A	ECG1187	
P261	ECG917	B1G1120B	BSG1137A	B2G1157B	ECG1188	
P263	BRG919	B1G1120C	BSG1137B	B2G1157C	ECG1189	
P264	BRG920	ECG1121A	BSG1137C	BCG1158A	ECG1190	
P267B	BRG921	ECG1121B	LTG1138A	BCG1158B	LTG1191	
P268	ECG922	HMG1122A	LTG1138B	BCG1158C	B2G1193	

Surface Elevation Monitoring

Seven different monitoring well sites have been selected for re-survey on an annual basis (Table 3-2a and Fig 3-6). The elevation will be surveyed with a Global Position System (GPS) unit. Elevations will be read to the nearest centimeter and reported in the annual monitoring report. The well sites to be included in the survey include 4 monitoring wells located in the acid plume area and 3 monitoring wells in the sulfate plume area. Each of the monitoring well sites has a pre-established marker point in the cement pad around the surface casing as the survey point.

Table 3-2a. Wells for Surface Level Monitoring

Well Site ID	Location/Frequency
K105	West of acid plume/Annual
ECG1116	West edge of acid plume/Annual
ECG1124	Acid plume/Annual
BSG1180	Acid plume/Annual
BFG1156A,B,C	Sulfate plume/Annual
WJG1170	Sulfate plume/Annual
BSG1137	Sulfate plume/Annual

3.2.3.5 Water Chemistry

Coordination with Existing Programs

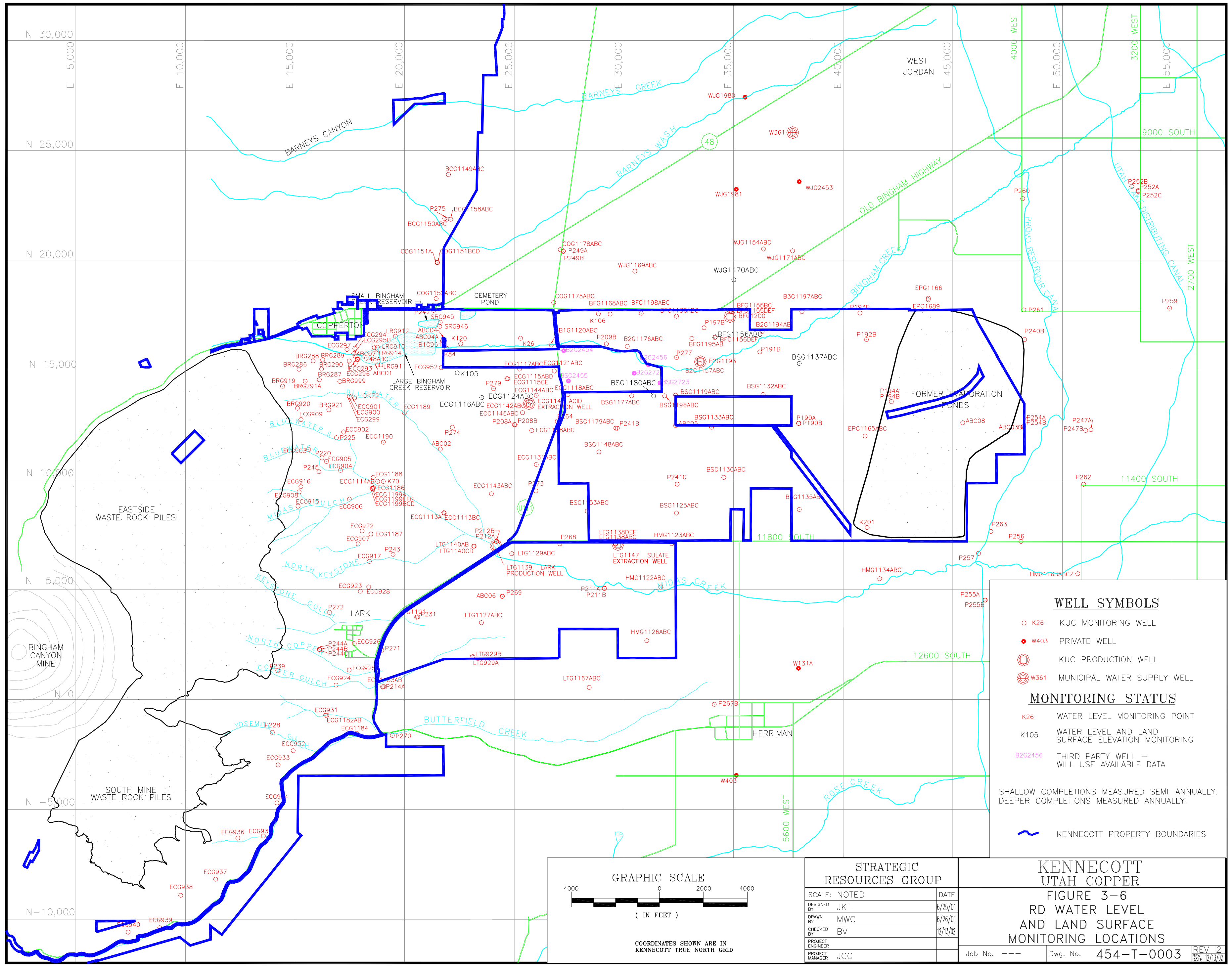
Some of the wells selected for baseline water chemistry are routinely sampled as part of the GCMP, and many of the wells along the range-front near the Eastside Leach Collection System are sampled quarterly as part of the Bingham Canyon mine and Leach Collection System Groundwater Discharge Permit. Data collected as part of these programs will be used to identify changes within the plume and surrounding groundwater.

TransJordan Solid Waste Disposal Facility also collects quarterly water samples on five monitoring wells located around their facility. Their water-quality information may be available; however, KUCC cannot control when sampling occurs or what elements are analyzed. Data collected from the landfill will be noted as data collected outside of KUCC's GCMP.

Analytical Suite

Samples will be analyzed for the parameters given in Table 3-3. The rationale for selecting these specific parameters is also listed in the table. The suite includes general water-quality parameters, major and minor analytes and trace metals. General parameters like pH, alkalinity/acidity, TDS and major analytes are needed for general chemistry and to calculate charge and mass balance to check the quality of the analyses. Some of the analytes listed in Table 3-3 were identified as being present in the Bingham Reservoir plume area at concentrations above baseline concentrations in an independent study done as part of the RI (Shepherd Miller, Inc., 1997, page 50). Sulfate, TDS, magnesium, cadmium, nickel and zinc were identified in that study as indicators of impacts related to mining activities.

Figure 3-6 RD Water Level Monitoring Locations



Fluoride was found at elevated concentrations during baseline study sampling and therefore it will be analyzed during at least the first years of long-term monitoring. Selenium, lead and chromium were found at levels slightly greater than the respective drinking water standard and will stay on the analytical suite. Nitrate, silver and barium were not found at concentrations above the drinking water standards and, therefore, will not be analyzed on a regular basis.

The primary or secondary drinking-water standards and whether or not the analyte has a surface-water quality standard for the Jordan River (because groundwater from Zone B may discharge to the river) are given in Table 3-3. Also given are the analytical method(s) and target detection limits for each parameter as given in the QAPP. Analytical methods are selected by laboratory personnel to meet the target detection limits where possible. All analyses will be conducted according to test procedures specified under Utah Administrative Code R317-6-6.3.L for groundwater. KUCC Environmental Laboratory, a state-certified lab, will analyze samples.

Table 3-3. Analytical Suite for Groundwater Samples.

Parameter	T/D	Rational For Sampling	Primary Drinking H20 Std.	Secondary Drinking H20 Std.	Has Aquatic Std?	Analytical Method	Target Detect. Limit
FIELD							
PH	-	general chemistry		6.5-8.5	Y	E 150.1	N/A
Temperature	-	general chemistry			Y	E 170.1	N/A
Conductance	-	general chemistry				E 120.1, Std 2510B	10 µmho
Depth to Water	-	indicator of hydraulic changes				N/A	0.01 ft
LABORATORY							
TDS	-	general chemistry, plume indicator	2000 mg/L*	500 mg/L	Y	E 160.1	10 mg/l
Chloride (Cl^-)	T	general chem., indicator of water source		250 mg/L		E 325.2	5 mg/l
Fluoride (F^-)	T	lack of baseline data, may occur at elevated levels	4 mg/L	2 mg/L		Std 4500F- E C/300.0	0.2 mg/l
Sulfate (SO_4^{2-})	T	plume indicator	1000 mg/L*	250 mg/L		E 375.2, 375.3, 9036	5 mg/l
Nitrate (NO_3^--N)	T	has drinking water standard, to document low levels	10 mg/L		Y	E 353.2 0.	2 mg/l
Calcium (Ca)	T	general chemistry				E 200.7	1 mg/l
Magnesium (Mg)	T	plume indicator				E 200.7	1 mg/l
Potassium (K)	T	general chemistry				E 200.7	0.1 mg/l
Sodium (Na)	T	general chemistry				E 200.7	1 mg/l
Alkalinity (ALK)	-	general chemistry				Std 2320B, E 310.1	10 mg/l
Acidity (ACD)	-	general chemistry				Std 2310B	10 mg/L
Aluminum (Al)	TD	above background conc., needed for mineral acidity calculation		0.05 to 0.2 mg/L	Y	E 200.7, 200.8	200 µg/l
Arsenic (As)	TD	above background concentration	0.05/0.01 mg/L **		Y	E 200.7, 200.8, 200.9, 6010B, 6020	5 µg/l
Barium (Ba)	TD	to document low levels	2 mg/L			E 200.7, 200.8, 200.9, 6010B, 6020	10 µg/l
Cadmium (Cd)	TD	plume indicator	0.005 mg/L		Y	E 200.7, 200.8, 200.9, 6010B, 6020	2 µg/l
Chromium (Cr)	TD	above background concentration	0.1 mg/L		Y	E 200.7, 200.8, 6010B, 6020	10 µg/l

Table 3-3. Analytical Suite for Groundwater Samples.

Parameter	T/D	Rational For Sampling	Primary Drinking H20 Std.	Secondary Drinking H20 Std.	Has Aquatic Std?	Analytical Method	Target Detect. Limit
Copper (Cu)	TD	above background concentration	1.3 mg/L	1 mg/L	Y	E 200.7, 200.8, 220.1, 6010B, 6020	20 µg/l
Iron (Fe)	TD	plume indicator, needed for mineral acidity calculation		0.3 mg/L	Y	E 200.7, 236.1, 6010B	300 µg/l
Lead (Pb)	TD	above background concentration	0.015 mg/L		Y	E 239.1, 200.8, 200.9, 200.7, 6010B, 6020	5 µg/l
Manganese (Mn)	TD	plume indicator		0.05 mg/L		E 200.7, 243.1, 243.2, 200.8, 6010B, 6020	10 µg/l
Mercury (Hg)	T	to document low levels	0.002 mg/L		Y	E 245.1, 200.8	0.2 µg/l
Nickel (Ni)	TD	plume indicator	0.1 mg/L		Y	E 200.7, 200.8, 200.9, 6010B, 6020	30 µg/l
Selenium (Se)	TD	to document low levels	0.05 mg/L		Y	E 200.7, 200.8, 200.9, Mod7742, 6010B, 6020	3 µg/l
Silver (Ag)	TD	to document low levels		0.1 mg/L	Y	E 272.1, 272.2, 200.8, 200.9, 200.7, 6010B, 6020	1 µg/l
Zinc (Zn)	TD	plume indicator		5 mg/L	Y	E 289.1, 289.2, 200.7, 200.8, 200.9, 6010B, 6020	10 µg/l

NOTES: N/A = Not Applicable; E = EPA Method Number; Std = Standard Methods, 20th edition, method number. T/D = Total or Dissolved concentrations.
*If sulfate is >500 mg/L or TDS is > 1000 mg/L, it must be demonstrated that no better quality water is available.
**The MCL for As has been lowered from 0.05 mg/L to 0.01 mg/L, but implementation of the change is scheduled over several years.

Monitoring Locations

One-hundred wells have been selected for long-term water quality sampling. Wells were selected based on (a) their three-dimensional location in relationship to the acid and sulfate plumes and (b) their historical water-quality trends. The name, location, screen depth and rationale for sampling for each site are given in Table 3-4. Monitoring locations are denser in the acid plume and the sulfate extraction areas than in less contaminated areas because these are the areas that will be critical to monitor for changes during plume extraction (Figure 3-7). The margin of the sulfate plume between the sulfate extraction area and West Jordan's municipal well field also will be monitored. Other areas to be monitored include the Herriman area, around the clean water production well (well ID LTG1139) where clean water production is critical, and along the base of the Oquirrh Mountains where recharge to the alluvial aquifer occurs.

Monitoring locations may be added or subtracted as necessary to monitor the acid and sulfate plumes with respect to vertical and lateral migration and based upon historical water level trends.

Sampling Frequency

The sampling frequency for each well listed in Table 3-4 is the minimum frequency at which these wells will be monitored in the beginning of the monitoring program. Some of the wells listed are sampled more frequently as part of existing monitoring programs, but the frequency listed is that which we think needs to be in place to successfully monitor the remedial action. For wells sampled more frequently than shown in Table 3-4, all additional data will be included in groundwater evaluations and annual reports. Frequency may increase or decrease in subsequent years based on data gathered from this monitoring program. Recommendations for changes to the monitoring frequency, location or analytical suite will be included in annual reporting.

Sampling frequency was determined using several criteria: 1) wells near pumping centers will be sampled more frequently than areas more distant from pumping, 2) wells with historically more rapid or frequent water quality changes will be sampled more frequently than those with stable water quality, and 3) wells in areas where the degradation of water quality would be most serious (i.e. near drinking water wells; at the property boundary).

Table 3-4. Locations and Frequency for Groundwater Chemistry Monitoring

Site ID	Freq.	Sampling Rational	KUC northing	KUC easting	Screen Top	Screen Bottom
W22	A	Herriman water quality	-1534	23091	80	350
K26	A	source area (large reservoir)	16448	25287	204	224
K72	A	alluvium near recharge area	13841	18189	10	240
W107	2	property boundary	20440	43285	215	460
W189	A	property boundary	18943	39481	350	637
P190A	A	1500 mg/L SO4 contour, property boundary	12580	37968	286	296
P190B	2	1500 mg/L SO4 contour, property boundary	12570	37976	529	539
P193B	A	1500 mg/L SO4 contour, property boundary	17606	40766	224	234
P208A	A	acid plume margin	12512	25005	300	308
P208B	A	acid plume margin	12512	25036	401	412

P241B	A	acid plume margin	12351	29699	530	570
P241C	A	1500 mg/L SO4 contour, property boundary	9804	32427	385	405
P244A	A	alluvium near recharge area	2285	16110	37	47
P244B	A	bedrock recharge	2278	16123	63	73
P244C	A	bedrock recharge	2266	16139	107	127
P248A	A	alluvium near recharge area	15485	17875	80	100
P248B	A	bedrock recharge	15491	17849	120	140
P248C	A	bedrock recharge	15496	17828	175	195
P279	A	acid plume core	14156	24053	395	415
W361	A	West Jordan well field	25805	37702	225	620
W363	A	West Jordan well field	23509	37928	380	590
W387	A	West Jordan well field	23373	35197	379	690
W409	A	Herriman water quality	-4079	27132	140	505
LRG910	A	source area (large reservoir)	16038	18754	77	136
LRG911	A	source area (large reservoir)	15231	18914	77	136
LRG912	A	source area (large reservoir)	16539	19577	77	136
ECG917	A	alluvium near recharge area	6289	18385	150	190
ECG922	A	alluvium near recharge area	7677	18058	142	181
SRG946	A	source area (small reservoir)	16988	21598	120	179
B1G951	A	source area (large reservoir)	16322	21727	92	131
ECG1113A	A	clean water source area	8508	21783	138	178
ECG1115A	A	acid plume core	14603	24663	538	578
ECG1115B	A	acid plume core, base	14603	24663	838	858
ECG1115C	A	acid plume core, base	14601	24700	898	938
ECG1117A	A	acid plume core	15047	25243	438	478
ECG1117B	A	acid plume core, base	15047	25243	758	798
ECG1118A	A	acid plume core	13882	27446	598	638
ECG1118B	A	acid plume core, base	13882	27446	818	858
BSG1119B	A	acid plume, leading edge	13853	32358	538	558
B1G1120A	A	acid plume core	16141	26693	493	532
ECG1121A	A	acid plume core	14957	26824	600	640
BSG1125A	A	1500 mg/L SO4 contour, property boundary	8494	32397	280	320
HMG1126A	2	Herriman water quality	2682	31045	280	320
HMG1126B	2	Herriman water quality	2682	31045	380	420
ECG1128A	A	acid plume margin	12249	25795	418	458
BSG1130A	A	1500 mg/L SO4 contour	10114	34557	340	380
BSG1133A	A	1500 mg/L SO4 contour	12400	34000	390	410
BSG1133B	A	1500 mg/L SO4 contour	12400	34000	600	620
HMG1134A	A	Herriman water quality	5503	41670	160	180
BSG1137A	A	1500 mg/L SO4 contour	15300	38000	377	397
BSG1137B	A	1500 mg/L SO4 contour	15300	38000	637	657
LTG1139	A	clean water source area	6989	24166	330	980
LTG1140A	A	clean water source area	6984	23149	220	240
LTG1140B	A	clean water source area	6984	23149	330	350

ECG1144A	A	acid plume core	13855	26003	440	460
ECG1144B	2	acid plume core	13855	26003	560	580
ECG1145A	A	acid plume core	13049	25373	420	440
ECG1145B	A	acid plume core	13049	25373	760	780
ECG1145C	A	acid plume core, base	13049	25373	810	830
ECG1146	Q	acid plume core	13467	25673	500	750
LTG1147	S	1500 mg/L SO4 contour	7067	29725	400	590
BSG1148A	A	acid plume margin	11276	28859	510	530
BSG1148B	2	acid plume margin	11276	28859	580	600
WJG1154A	S	SO4 extraction area, West Jordan well field	20510	36367	310	350
WJG1154B	A	SO4 extraction area, West Jordan well field	20510	36367	400	420
WJG1154C	A	SO4 extraction area, West Jordan well field	20510	36367	730	750
LTG1167B	2	Herriman water quality	553	28415	300	320
WJG1169A	A	1500 mg/L SO4 contour, West Jordan well field	19501	30501	400	420
WJG1169B	A	1500 mg/L SO4 contour, West Jordan well field	19501	30501	470	490
WJG1170A	A	SO4 extraction area, West Jordan well field	19110	35012	375	395
WJG1171A	S	SO4 extraction area, West Jordan well field	20426	37696	430	450
COG1175A	2	acid plume margin	18070	26823	390	410
COG1175B	A	acid plume margin	18070	26823	600	620
B2G1176A	A	acid plume margin	16148	30121	555	575
BSG1177A	A	acid plume margin	13826	30357	525	545
BSG1177B	A	acid plume margin	13826	30357	680	700
COG1178A	2	sulfate plume margin	20468	27158	390	400
BSG1179A	A	acid plume margin	12358	29633	440	460
BSG1179B	A	acid plume margin	12358	29633	685	705
BSG1179C	A	acid plume margin	12358	29633	805	825
BSG1180B	A	acid plume, leading edge	13817	31356	660	680
BSG1180C	A	acid plume, leading edge	13817	31356	798	818
ECG1183A	A	alluvial bedrock contact	579	18992	35	65
ECG1184	A	Butterfield Canyon alluvial recharge to Herriman	-1538	17816	60	80
ECG1186	A	alluvium near recharge area	9647	18578	36	136
ECG1187	A	alluvium near recharge area	7540	18458	54	164
ECG1188	A	alluvium near recharge area	10109	18567	38	118
ECG1189	A	alluvium near recharge area	13054	19990	205	265
ECG1190	A	alluvium near recharge area	11715	19026	118	198
LTG1191	A	alluvium near recharge area	3749	20549	20	100
B2G1193	S	SO4 extraction	15378	33485	451	881
BFG1195A	A	SO4 extraction area	16434	33104	558	578
BFG1195B	A	SO4 extraction area	16434	33104	679	699
BSG1196B	S	acid plume, leading edge	13825	31860	470	490
BSG1196C	A	acid plume, leading edge	13825	31860	650	670
B3G1197A	S	SO4 extraction area, West Jordan well field	17661	38129	340	360
B3G1197B	A	SO4 extraction area, West Jordan well field	17661	38129	460	480
BFG1198A	A	1500 mg/L SO4 contour, property boundary	17580	30793	400	420
BFG1200	S	SO4 extraction	17570	34841	420	800

HMG1856	2	Herriman water quality	657	33611	200	280

Note: Under frequency "A" means annual sample, "2"semi-annual.

3.2.3.6 Analysis and Results

Data will be compiled into data sets and analyzed by project personnel. Analysis may include the application of statistical methods and computer-software contouring programs. Results of long-term groundwater monitoring will be reported in the annual report for the GCMP. Figures to illustrate the status of the contaminant plume may include iso-concentration contour maps of sulfate, pH, and selected trace metals and potentiometric maps. Also included will be an analysis of changes in vertical hydraulic gradients, if any, and the status of water level changes in the Southwestern Jordan Valley. Hydrogeologic cross-sections depicting water quality may be used to show the vertical distribution of groundwater contamination.

3.3 Water Treatment and Delivery System for Treated Waters and Concentrates

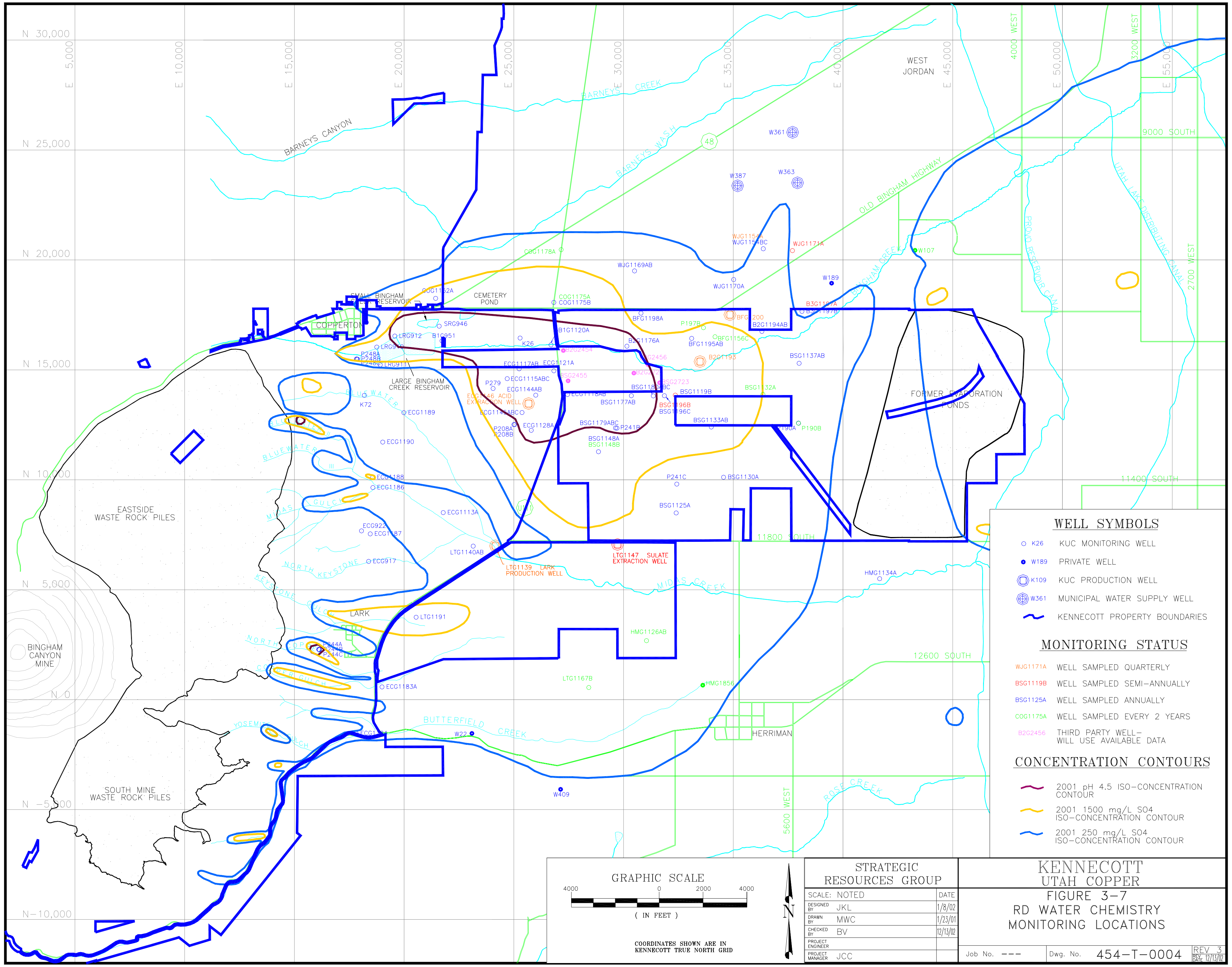
3.3.1 Introduction

From 1995 through 1997, KUCC conducted a RI/FS of mining-related groundwater contamination in the southwestern Jordan Valley. As part of this work, KUCC studied various technologies for treating contaminated groundwater. One of the treatment technologies investigated by KUCC was membrane filtration (MF). During the last ten years, membrane filtration, especially reverse osmosis (RO), has become an established water treatment process. However, the chemistry of the sulfate plume water is significantly different from typical municipal and seawater desalination RO Plants used to provide drinking water. The near saturation conditions for calcium sulfate and silica make scaling and its prevention a more tedious task. Therefore there was limited external experience available with these critical aspects of processing this water using RO technology and producing drinking water.

In 1995, a bench and pilot scale test program was started, which led to the purchase of a small-scale RO system (capacity 800 gallons per day). This system was installed at the South End Engineering Services offices near Copperton and has been in use since then. The unit provided the opportunity to gain first-hand experience with RO filtration of sulfate plume water, in addition to producing low conductivity water for the laboratory.

In 1999, KUCC modified the design of its nanofiltration pilot plant for leach water and acid plume water. As a result, nine pressure vessels (with six membranes each) of the former stage two of the nanofiltration skid became available for additional RO demonstration-scale testing of sulfate plume water treatment. These vessels were arranged in a two-stage configuration, six vessels in first stage, and three vessels in second stage. High-pressure feed pump, prefiltration, and antiscalant dosing were added, and the demonstration unit was started up in July 1999 with water from the deep wells K60 and K109 being fed to the plant by submersible pump from the Yosemite pump station. In the first year of operation, the original nanofiltration membranes were used. In May 2000, these membranes were replaced with RO membranes. The RO system has been in operation since then with feed rates of up to 312 gpm. The design of the Zone A Reverse Osmosis Plant presented in this document is based on the experience gained from this pilot and demonstration scale operation.

Figure 3-7 RD Water Chemistry Monitoring Locations



3.3.2 Design Criteria

In compliance with the ROD, which was issued by the USEPA on December 13, 2000 and the NRD settlement from 1995, the Zone A Reverse Osmosis Plant is designed to produce 3,500 acft of treated municipal quality water per year. The produced water will meet, at a minimum, Municipal Water Quality standards (MWQ) and will be delivered to the distribution system of JVWCD or other water purveyor(s). The membrane filtration concentrate from the Zone A RO Plant will be conveyed by system pressure to KUCC's Eastside Reservoir, where it will be mixed with a small volume of meteoric leach water to precipitate calcium sulfate. The combined concentrate/leachwater will flow by gravity to the WDPS, where it will be pumped to the tailings line.

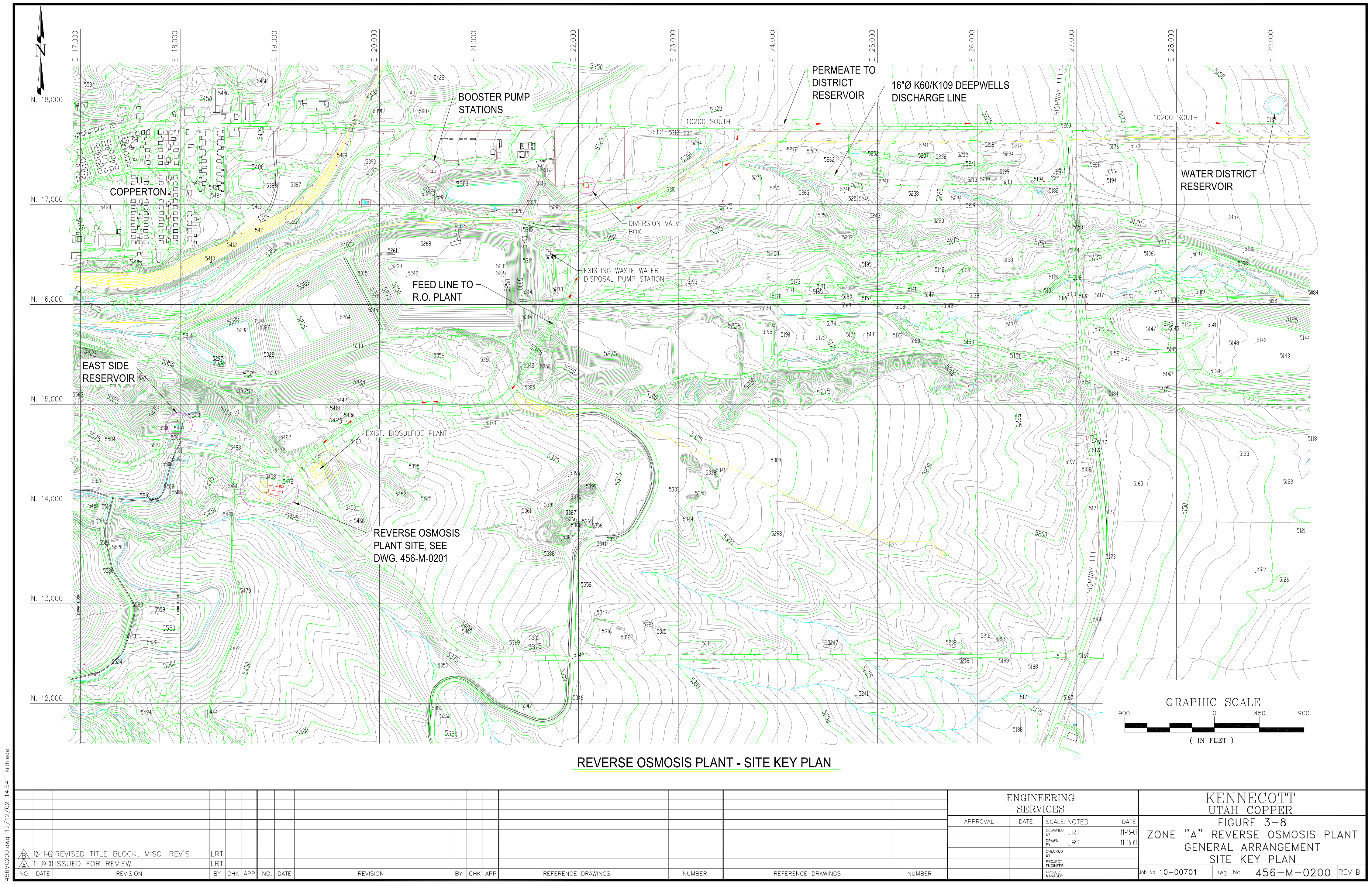
A stream factor of 85% is used as basis for the RO system design. The core of the plant are two RO skids with a feed water capacity of 1,500 gpm each. The skids are each arranged in two-stage arrays in which the concentrate of the first stage becomes the feed to the second stage, which uses half the number of pressure vessels as the first stage. An average permeate flux rate of 13 gallons per square foot per day (gfd) was used as design basis for the required membrane area for Rack 3 (11.1 gfd for Rack 4). The permeate recovery will be in the range of 75% to 80%, depending on the feed water quality as shown in the demonstration plant in operation from May 2000 to date.

The process design of the Zone A RO Plant incorporates the experience from process optimization learned from operating membrane filtration facilities on KUCC specific waters for the last seven years. During design, construction, and operation of KUCC's membrane filtration plants, extensive consultations with experts from membrane and RO system suppliers as well as manufacturers of antiscalants and wash chemicals took place. The members of the Technical Review Committee reviewed the Preliminary Design for the plant. An independent third party engineering review by Montgomery Watson Harza endorsed the design.

The site for building the Zone A plant (Figure 3-8 Site Key Plan, Dwg. 456-M-0200) is adjacent to the existing nanofiltration plant. This is a central location for the various water sources to be processed at the plant, namely deep wells B2G1193 (K60), BFG1200 (K109) and the sulfate extraction well LTG1147.

The feed water pipeline from the tie-in near the Copperton cemetery to the feed water tank at the RO Plant will be built in compliance with applicable National Sanitation Foundation (NSF) and American Water Works Association (AWWA) standards. The permeate pipeline from the RO Plant to the distribution system of the JVWCD will also comply with these standards.

Figure 3-8 Zone A RO Plant General Arrangement



3.3.3 Project Delivery Strategy

The project delivery strategy for the Zone A Reverse Osmosis Plant foresees three phases. Phase 1 consists of constructing and installing the first full-scale RO skid (Rack 3) in the existing KUCC membrane filtration building. Components of the shut down nanofiltration system, such as pressure vessels, prefiltration feed pump and vessels, instrumentation and control system, wash system, permeate tank and pump, will be used as feasible. A Feed water pipeline (supplying water from the deep wells (B2G1193 & BFG1200) to the plant), the feed water tank and pump will be installed. A portion of the permeate pipeline will be installed in a common trench with the feed water pipeline to reduce costs of Phase 3, when this pipeline will be completed. The first degasifier will also be installed in this phase. Upon completion of Phase 1, the first RO skid will be operated at 1,500 gpm feed flow. The produced permeate will be delivered to the Copperton Concentrator to be used as mill water but will be continually monitored to confirm operations performance and compliance with drinking water standards. Existing piping with minor modifications will be used to convey permeate and concentrate. The RO concentrate will be conveyed by system pressure to KUCC's Eastside Reservoir, where it will be mixed with a small volume of meteoric leach water to precipitate calcium sulfate. The combined concentrate/leachwater will flow by gravity to the WDPS, from where it will be pumped to the tailings line. Preoperational testing and start-up of the first RO skid (1500 gpm) are scheduled for the third quarter of 2003.

Phase 2 consists of erection of the new building for the Zone A RO Plant, the installation of the second RO skid (Rack 4) and the related prefiltration equipment, and relocation of Rack 3 and its prefiltration system and feed pumps into the new building. The feed water tank and pump will also be relocated in this phase. Upon completion of this phase, the process capacity will be 3,000 gpm and will be operated from the existing control room with the existing programmable controller and color graphics interface. The produced permeate will be delivered to the Copperton Concentrator to be used as mill water. The existing wash system will be used for membrane washing. The design of Phase 2 is scheduled to start in fall of 2003, construction will take place in 2004, and the start-up is scheduled for the fourth quarter of 2004.

Two options for implementation of Phase 3 are being considered. Phase 3a assumes that KUCC or a subcontractor continue to operate the Zone A RO Plant. Phase 3b describes additional activities required if JVWCD took over the operation of the plant after completion of the negotiated optimization period.

Phase 3a consists of relocation of the first degasifier, the installation of the second degasifier, chlorination and corrosion control systems, and the preparation of the plant for delivering drinking water to the JVWCD. In this option, the plant will continue to be operated from the existing control room in the membrane plant building using the existing PLC system. The control room and other auxiliary facilities in the new building would not be completed in this option. Permeate and concentrate pipelines will be completed. The design for Phase 3a is scheduled to begin in the first quarter of 2004, and start-up will be in March of 2005.

In Phase 3b, all facilities would be finalized and the plant would be completed to function in a stand-alone fashion. A new PLC system would be installed in the electrical room and the whole plant operation will be controlled from the new control room. A separate wash system would be installed and the plant water tank would be relocated. The power supply will be resourced from Utah Power & Light to provide power to the facility, as KUCC is restricted from selling power to third parties.

A detailed time schedule is presented in Section 3.3.6.

3.3.4 Results of Demonstration Plant Operation

3.3.4.1 Process Description

In August of 1999, nine pressure vessels of the original second stage of Nanofiltration Skid # 1 were rearranged in order to test membrane filtration of sulfate plume water. Figure 3-9 presents a process block diagram of the Demonstration Plant. A two-stage configuration was selected with six vessels in the first stage and three vessels in the second stage (ref. Figure 3-10: Membrane Array). Originally, nanofiltration membranes from Osmonics-Desal were used in this skid. In May of 2000, these membranes were replaced with Hydranautics CPA3 reverse osmosis membranes in order to provide an opportunity to gain operating experience with the RO filtration of sulfate plume water. The RO membranes experienced an abnormally short life due to chlorine damage from a chlorinated water source that was not intended to feed into the water supply to the demonstration plant. The chlorinated water damaged the membranes and made them more susceptible to damage by chemical washing. Chlorine exposure is prevented now by administrative control. In March 2002, the CPA3 membranes were replaced with Hydranautics ESPA2 membranes.

A submersible pump feeds water from wells K60 (B2G1193) and K109 (BFG1200) from the Yosemite Pump Station to the membrane plant. Bag and cartridge filters are used for pre-filtration. After injection of an antiscalant, the water is fed to the RO skid by a vertical turbine pump. The combined permeate from both stages is pumped via the Bingham Tunnel Booster Pump Station to the Copperton Concentrator to be used as mill water. The concentrate is conveyed by system pressure to the Bingham Creek pipeline and from there via WDPS to the tailings line.

3.3.4.2 Production Data

The total volume of sulfate plume water processed through the membrane filtration demonstration plant was 993 acft (331 acft in 2000, 332 acft in 2001, and 330 acft in 2002). The 2001 production data cover the time from January 1st through September 25th. At the end of September refurbishing of the electrical switchgear and control system at the deep wells was started. This required the shutdown of each of the two wells for about six weeks. As a result there was insufficient water available for the continuous operation of the RO demonstration plant for the remainder of 2001. The 2002 data cover the time from January through November, the time of finalizing this report.

The total volume of permeate produced was 765 acft (247 acft in 2000, 269 acft in 2001, and 249 in 2002). In the frame of on-going process development, feed rate and permeate recovery were increased gradually throughout this time in order to establish optimal operating parameters. Feed rates of 260 to 312 gpm and permeate recoveries of 75% to 85% were tested. The operating stream factor was 69% in 2000, 91% in the operating period of 2001, and 83% in 2002. Table 3-5 presents an overview of production and average performance data for the demonstration plant.

Typical analyses of Sulfate Plume Water, RO permeate, and concentrate are summarized in Table 3-6. Maximum Contaminant Levels (MCLs) and Utah Pollutant Discharge Elimination System (UPDES) Limits are included for comparison.

Table 3-5. Production and Average Performance Data

Year	Production Data										Average Process Data							
	Run Time hrs	Down Time hrs	Stream Factor %	Feed Flow gpm	Feed Vol. acft	Permeate Flow gpm	Permeate Vol. acft	Concentrate Flow gpm	Concentrate Vol. acft	Permeate Recovery %	Temp. (°F)	Feed Pressure psi	Diff. Pressure Stage 1 psi	Diff. Pressure Stage 2 psi	Avg. Flux gfd	Conductivity Feed mS/cm	Conductivity Conc. mS/cm	Conductivity Perm. mS/cm
2000	6,045	2,739	69%	297	331	223	247	75	83	76%	59.4	190	25	19	14.9	2.5	8.8	0.10
2001	5,940	611	91%	304	332	246	270	58	63	81%	58.6	211	30	20	16.4	2.6	10.0	0.24
2002	6,683	1,327	83%	271	330	205	249	57	31	75%	58.7	194	32	17	13.1	2.7	9.6	0.02
Total	18,669	4,678			993		765		177									
Avg.			81%	291	331	225	255	63	59	77%	58.9	198	29	19	15	2.6	9.5	0.12

Notes:
1) 2001 data are for the time from January through September (plant was shut down for the rest of the year due to maintenance work on the deep wells.
2) 2002 production data are for the period from January through November; average process data are for the ESPA2 membranes (March - November).

Demonstration Plant for RO Filtration of Sulfate Plume Water

Table 3-6: Typical Water Analyses
Comparison to MCLs and UPDES

		Sulfate Plume Water	RO Permeate	*Maximum Contaminant Levels* [2]	RO Concentrate	*UPDES* 30-day Avg.	*UPDES* Daily Max.
Alkalinity	mg / l	**189**	**5**	*UR*	**861**		
Arsenic	µg / l	**< 5**	**< 5**	*50*	**23**	*250*	*500*
Calcium	mg / l	**452**	**1**	*UR*	**2,054**		
Cadmium	µg / l	**< 1**	**< 1**	*5*	**< 1**	*50*	*100*
Chloride	mg / l	**150**	**5**	*250*	**680**		
Copper	µg / l	**< 20**	**< 20**	*1,300*	**27**	*150*	*300*
Iron	µg / l	**< 300**	**< 300**	*300*	**< 300**		
Lead	µg / l	**< 5**	**< 5**	*15*	**< 5**	*300*	*600*
Magnesium	mg / l	**136**	**1**	*UR*	**620**		
Manganese	µg / l	**< 10**	**< 10**	*50*	**< 10**		
Potassium	mg / l	**4**	**< 1**	*UR*	**19**		
Selenium	µg / l	**3**	**< 2**	*50*	**14**	*na*	*54*
Sodium	mg / l	**65**	**6**	*UR*	**294**		
Sulfate	mg / l	**1,314**	**5**	*1,000*	**5,971**		
Zinc	µg / l	**5**	**< 10**	*5,000*	**22**	*224*	*500*
TDS	µS / cm	**2,270**	**33**	*2,000*	**10,317**		
pH	su	**7.1**	**5.4** [1]	*6.5 - 8.5*	**7.3**	*6.5 - 9.0*	

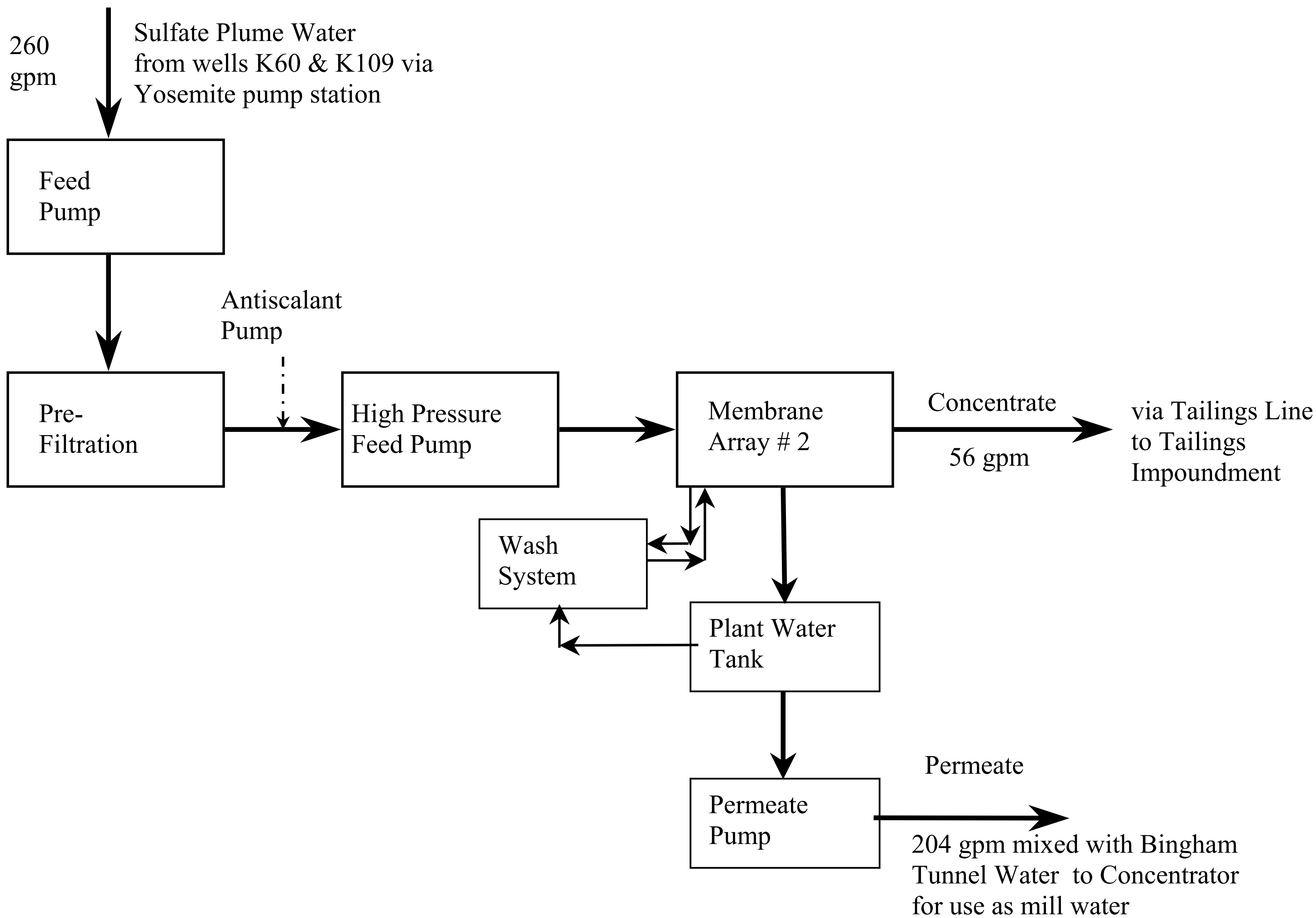
Notes:

UR = unregulated; UPDES = Utah Pollutant Discharge Elimination System

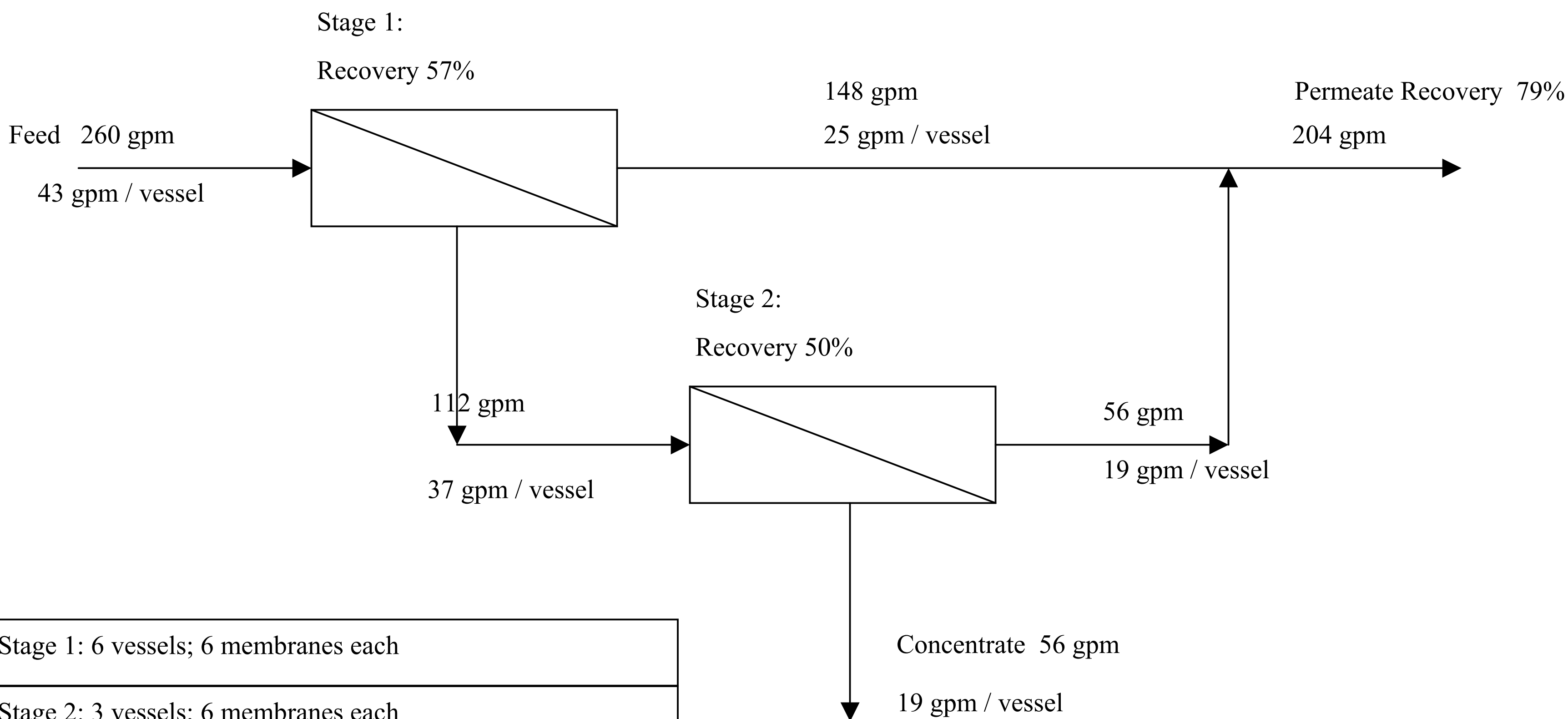
1) The pH of the RO permeate averaged 5.4 without decarbonation. Pilot tests showed that decarbonation will raise the pH above 6.8.

2) Water Quality Maximum Contaminant Levels (MCLs) as in effect on August 1, 2001 (Rule R309-103, Utah Administr. Code).

RO Filtration of Sulfate Plume Water
Figure 3-9: Demonstration Plant Block Diagram



RO Filtration of Sulfate Plume Water
Figure 3-10: Demonstration Plant Membrane Array



Stage 1: 6 vessels; 6 membranes each
Stage 2: 3 vessels; 6 membranes each

3.3.5 Final Design of the Zone A Reverse Osmosis Plant

3.3.5.1 Building

The site for building the Zone A RO Plant (ref. Figure 3-11, General Arrangement Site Plan, Dwg. 456-M-0201) is adjacent to KUCC's existing membrane filtration plant. This is a central location for the various water sources to be processed at the plant, namely deep wells B2G1193 (K60), BFG1200 (K109) and the sulfate extraction well LTG1147. In the phased development of the plant this site also provides synergies with KUCC's existing membrane filtration plant operation.

The building will be a pre-engineered style steel building with an eave height of 20'0". The roofing and siding material will be high tensile steel with a silicon polyester finish. The structure shall be closed and sealed for weather tightness. Building finish color shall match the existing structures in the area. The roof shall have a slope of a minimum of 2" rise to 12" run. There will be a covered breezeway between the existing membrane filtration building and the Zone A RO Plant building. A 12' x 12' roll-up door provides weather-protected access from the breezeway on the west side of the building. Chemical deliveries can also be received at access doors on the north side of the building.

The interior of the building shall be insulated with a fiberglass batt insulation system. A control room, electrical room, conference/lunch room, mechanical room, lab, locker room, and restroom facilities will be constructed inside the building. The building shall be adequately lighted, vented, heated and all normally occupied areas air-conditioned. A concrete utility service trench will be cast into the floor of the main operations area. All operation floors will slope to the service trench. The trench shall serve as a pipe way and spill containment basin for the process. The RO building utility service trench shall be sloped and connected to the existing Membrane Filtration utility service trench. The trench floor will be at an elevation to stop liquid from flowing back from the Membrane Filtration utility service trench. All wastewater will be pumped and disposed of by the existing Membrane Filtration building sump pump. There is a 15" diameter emergency gravity overflow line connected to the existing Membrane Filtration utility service trench to ensure that no wastewater will overflow the service trench. The overflow gravity line drains to KUCC's desilting basin located in Bingham Canyon.

Facility design and construction shall comply with federal, state, and local regulatory agencies for items such as design, earthquake, flood, fire, safety, and handicap access requirements. A septic tank / leach field system will be provided for waste water (sewage) from the plant.

The building layout is shown on the general arrangement plan Figure 3-12 (Drawing No. 456-M-0202). The general building dimensions are summarized in Table 3-7. Building elevations are presented in Figure 3-13 (Dwg. No. 456-M-0203).

Table 3-7. Zone A RO Plant - Building Dimensions

		Length ft	Width ft	Area ft^2
Main Process Area		106	48	4,800
Wash System / Antiscalant		100	20	2,000
Chlorination		25	20	500
Electrical Room		60	20	1,200
Control Room		20	20	400
Laboratory		20	11	220
Auxiliary Facilities	1.	52	20	1,040
	2.	20	20	400
Degasifier & UV Disinfection		28	42	1,176
Total				11,736

Figure 3-11 Zone A RO Plant General Arrangement Site Plan, Dwg. 456-M-0201

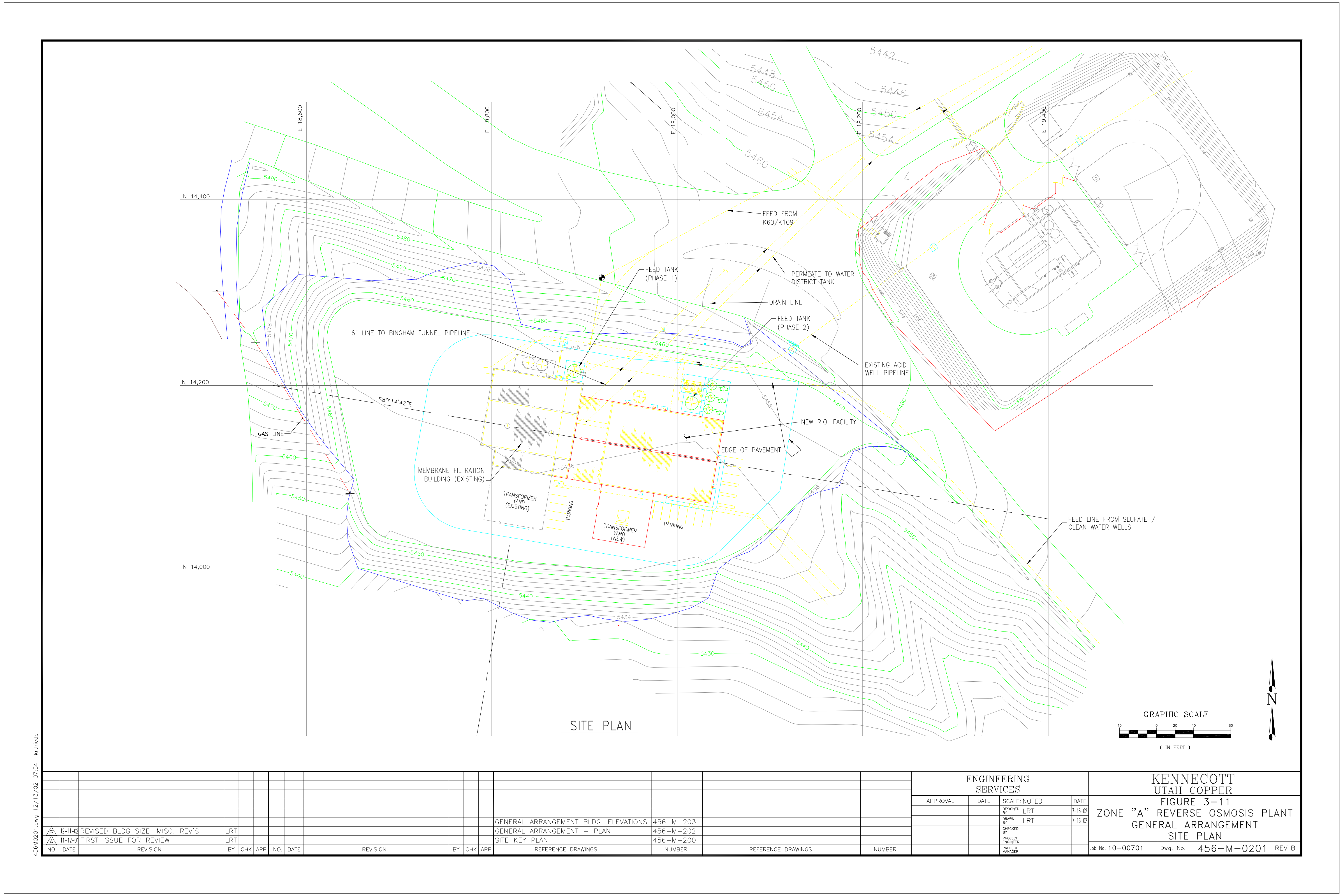


Figure 3-12 Zone A RO Plant Arrangement Plan, Dwg. No. 456-M-0202

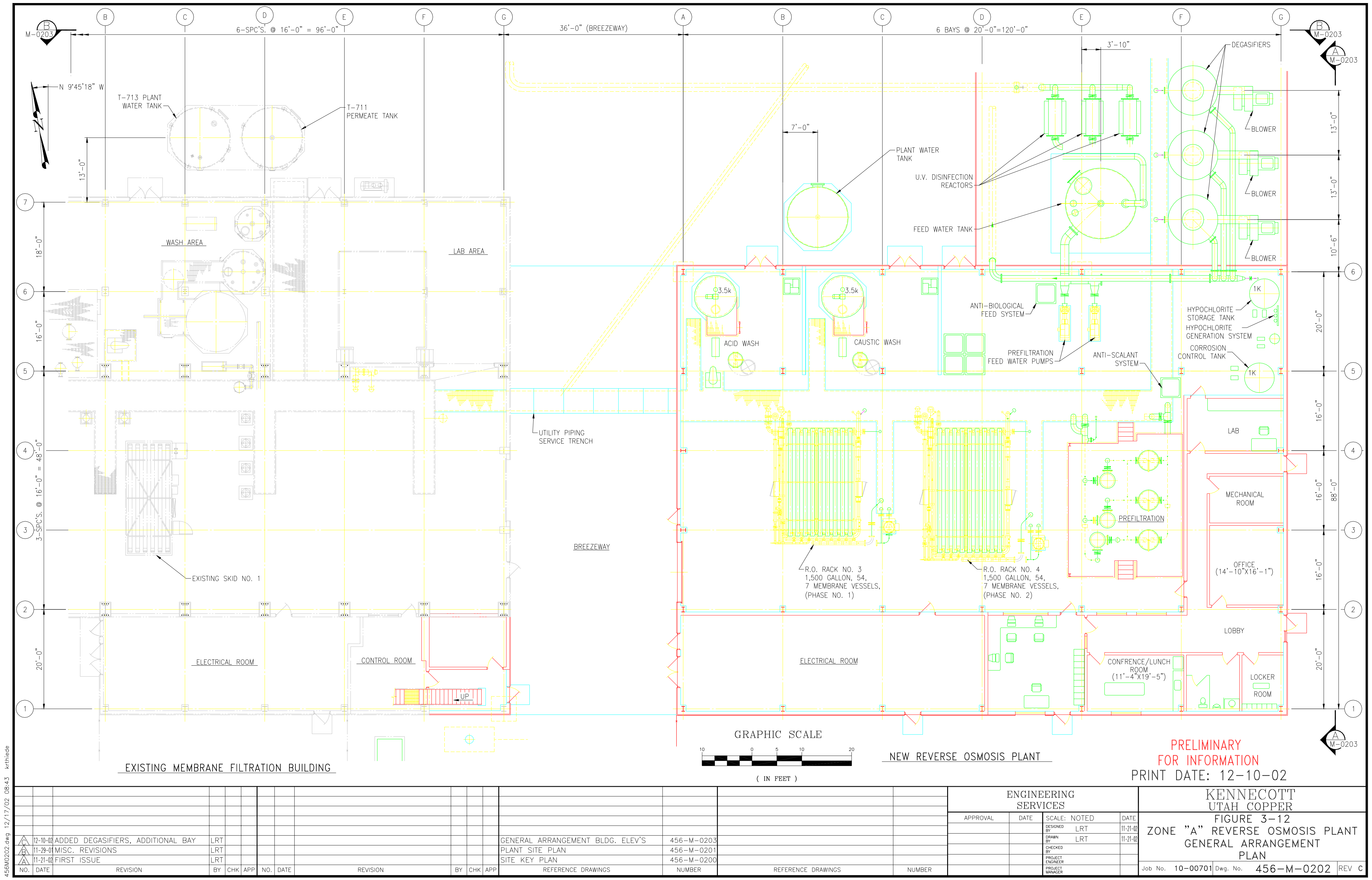
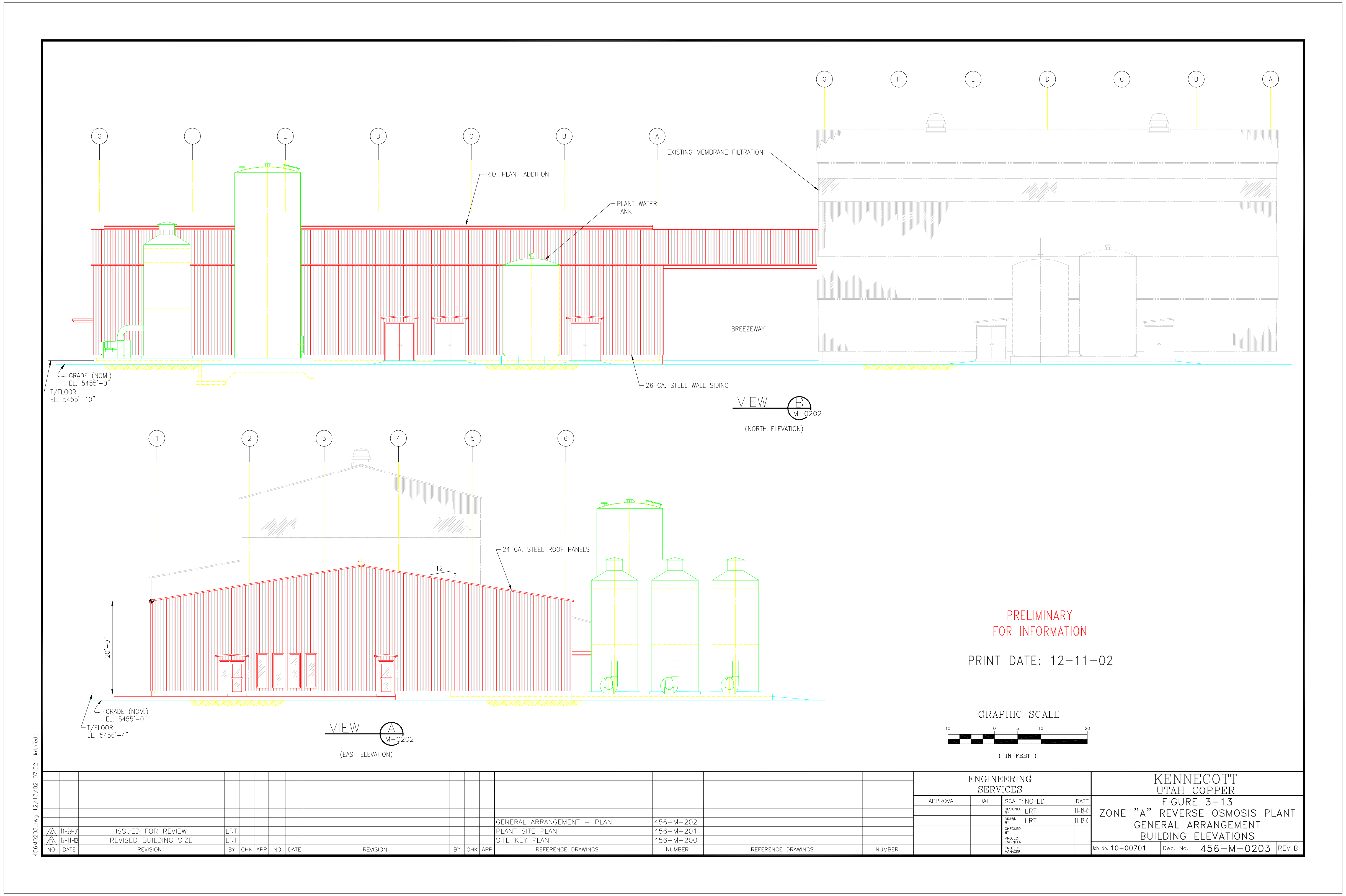


Figure 3-13 Zone A RO Plant Building Elevations, Dwg. No. 451-M-0203



3.3.5.2 Process

This section describes the major process steps and the respective equipment. The process flow diagram is presented in Figure 3-14 (Drawing No. 456-F-0101).

The following design parameters were used:
Stream Factor: 85%;
Feed Water Quality Limits: TDS < 3,000 ppm; Sulfate < 1,500 ppm; Turbidity < 0.5 NTU; SDI < 0.3.
RO recovery rate: 75 – 80%;
Permeate flux rate: Rack 3: 13 gfd; Rack 4: 11.1 gfd;
Process Flows: well water 3,216 gpm; RO feed 3,000 gpm; by-pass water 216 gpm; permeate 2340 gpm; product water: 2,556 gpm; concentrate 660 gpm;
Antiscalant dosage: 7 ppm;
Chemical cleaning frequency: 6 – 12 times per year;
Chemical cleaning: flow rate 40 – 50 gpm per vessel; wash tanks: 3,500 gal;
Degasifier: efficiency > 80%; air: water ratio 22 – 30 : 1 ft^3 / ft^3;
Product water will meet appropriate drinking water standards and will have a slightly positive Langlier Saturation Index (LSI).

The presently foreseen water sources for the Zone A RO Plant are deep wells B2G1193 (K60), BFG1200 (K109), and the sulfate extraction well LTG1147. The clean water well LTG1139 will be piped to the plant as an additional source for blending if needed. Water from these wells will be delivered to the feed water tank at the plant by the well booster pumps. The focus of blending the waters from three wells is to keep the sulfate concentration in the feed water to the Zone A RO Plant below 1,500 ppm. During Phases 1 and 2, the produced permeate will be pumped through existing piping to the Copperton Concentrator. In Phase 3, the permeate pipeline will be constructed from the Zone A plant to a mutually agreed upon point of delivery with the JVWCD. After completion of Phase 3 and an initial process optimization phase, delivery of municipal quality product water to JVWCD will begin. The produced concentrate will be conveyed by system pressure to KUCC's Eastside Reservoir, where it will be mixed with a small volume of meteoric leach water to precipitate calcium sulfate. The combined concentrate/leachwater will flow by gravity to the WDPS, where it will be pumped to the tailings line.

Deep well water from the feed water tank will be pumped through prefiltration for removal of suspended solids to the high-pressure pumps, which convey the water through the RO system. Sodium bisulfite may be injected upstream of the prefilters in case biological fouling cannot be controlled sufficiently by UV disinfection. The RO filtration process uses spiral wound polyamid membranes, which separate the pressurized feed water stream into two streams, namely permeate and concentrate. The permeate passes through the semipermeable membranes and is characterized by very low TDS concentrations, as the RO membranes reject dissolved solids at rates of 95-99%. The balance of the feed water passes across the outer surface of the membrane and becomes the concentrate, which contains the constituents that have been rejected by the membranes. An antiscalant is injected into the feed water to the RO system in order to minimize scale formation in any of the piping and equipment that it contacts.

The RO permeate is chlorinated using on-site produced sodium hypochlorite. Water analyses performed by JVWCD have shown that Sulfate Plume Water from the deep wells has no organic contamination and therefore chlorination is only required to provide the residual chlorine needed to avoid microbiological growth in the distribution system. Then the RO permeate is degasified to remove carbon dioxide and radon and lower the corrosivity. Subsequently, the permeate is blended with filtered feed water to achieve the desired product water TDS and the pH is raised by injecting a small amount of sodium hydroxide to lower the corrosivity.

The membrane wash system consists of tanks for alkaline and acidic wash solutions, the wash pump, and a bag filter to remove suspended solids from the circulating wash solution. Depending on the type of foulant, either alkaline or acidic wash solutions will be prepared in their respective tanks and heated to 40ºC. The skid that requires washing will be taken off line and flushed with RO permeate. Then the spool pieces that guarantee the separation of wash water and wash permeate from product water will be installed. Subsequently, the wash solution will be circulated through the membranes for several hours. An alkaline wash may be followed by an acidic wash or vice versa. Permeate flushes will be performed between and after washes. For this purpose, a plant water tank is installed in order to store RO permeate for washing and flushing.

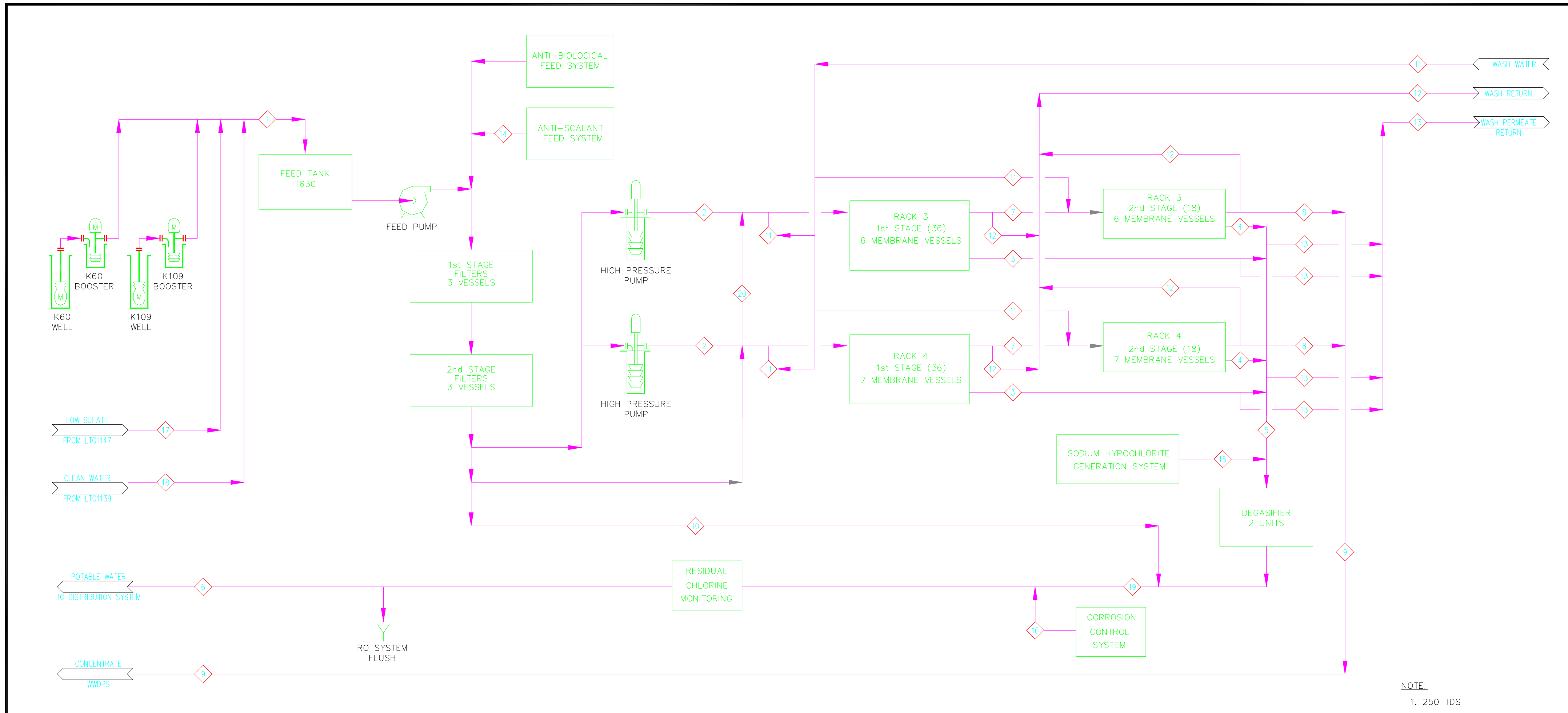
Feed Water Blending

Water from deep wells B2G1193 (K60) and BFG1200 (K109) and the sulfate extraction well LTG1147 will be delivered to a feed water tank at the RO Plant by well pump pressure. Pressure control valves will be installed in the existing pipelines for these waters in order to maintain sufficient line pressure to deliver the waters to the feed tank. The intention is to maintain TDS concentration in the feed water to the Zone A Plant below 3,000 ppm by blending the waters from these wells. Table 3-8 shows a potential blending scenario with recent water chemistries for these wells. Wells K60 and K109 are expected to increase in TDS over time as the acid plume moves towards these wells. The blending ratio of the various feed waters will have to be adjusted accordingly. Water from the clean water well LTG1139 will only be used in case the sulfate extraction well LTG1147 is inoperable due to maintenance.

Feed lines from K60/K109 and sulfate/clean water wells will be equipped with flow meters and flow control valves. The flow control valves will achieve the proper blending ratio of the various feed waters resulting in the desired feed water composition. Blending will be controlled to a predetermined conductivity set point. The turbidity of the inflow to the feed water tank will be monitored. In case the turbidity exceeds 0.5 NTU, the feed flow to the RO Plant can be diverted to the KUCC water system and allowed to clear up. Before entering the feed water tank, the water will pass through UV disinfection reactors in order to minimize the potential for biological fouling in the RO Plant. Another possibility for controlling biological fouling is the injection of sodium bisulfite into the feed stream to prefiltration.

The feed water tank provides a reservoir of water, which will be used to automatically purge concentrate from the membrane skids and flush the membranes in case of an automatic shutdown or a power outage. Spring-loaded valves will open the feed water supply to the skids for flushing. The resulting flush water will be dumped into the trench inside the building, from where it can be discharged by sump pump to the Eastside Reservoir.

Figure 3-14 Zone A RO Plant Process Flow Diagram, Dwg. No. 456-F-0101



NOTE:

1. 250 TDS

STREAM		FEED WATER			STAGE 1 FEED			STAGE 1 PERMEATE			STAGE 2 PERMEATE			PLANT PERMEATE			PRODUCT WATER			STAGE 1 CONCENTRATE		
NUMBER		1			2			3			4			5			6			7		
	UOM	MIN	OPER	MAX	MIN	OPER	MAX	MIN	OPER	MAX	MIN	OPER	MAX	MIN	OPER	MAX	MIN	OPER	MAX	MIN	OPER	MAX
FLOW	GPM	500	2,200	3,900	750	1,500	1,800	75	847.5	1080	60	352.5	375	405	2,400	2,910	270	2,600	3,200	600	652.5	720
PRESSURE	PSIG	60	80	100	150	220	600	8	12	16	8	12	16	8	12	16	8	12	16	150	200	580
TEMPERATURE	F	50	58	65	50	58	65	50	58	65	50	58	65	50	58	65	50	58	65	50	58	65
CONDUCTIVITY	mS/cm	2.0	2.6	4.0	2.0	2.6	4.0	0.01	0.15	0.35	0.05	0.4	0.6	0.02	0.2	0.5	0.02	0.5	0.6	2.0	2.6	4.0
pH	su	6.0	7.0	7.5	6.0	7.0	7.5	5.8	6.5	6.8	5.8	6.5	6.8	5.8	6.5	6.8	6.5	7.5	8.5	6.0	7.0	7.5
STREAM FACTOR	%																	85				
MISC.																						

STREAM		STAGE 2 CONCENTRATE			PLANT CONCENTRATE			FILTERED BYPASS			WASH FEED			WASH RETURN			WASH PERMEATE			ANTISCALANT		
NUMBER		8			9			10			11			12			13			14		
	UOM	MIN	OPER	MAX	MIN	OPER	MAX	MIN	OPER	MAX	MIN	OPER	MAX	MIN	OPER	MAX	MIN	OPER	MAX	MIN	OPER	MAX
FLOW	GPM	270	300	540	270	600	1,080	0	200	300	600	700	1,000	600	700	1,000	20	50	150	0.006	0.023	0.030
PRESSURE	PSIG	150	180	560	150	180	560	60	80	100	25	35	50	25	35	50	8	12	16	65	85	105
TEMPERATURE	F	50	58	65	50	58	65	50	58	65	50	100	104	50	100	104	50	100	104	60	68	80
CONDUCTIVITY	mS/cm	2.0	2.6	4.0	2.0	2.6	4.0	2.0	2.6	4.0												
pH	su	6.0	7.0	7.5	6.0	7.0	7.5	6.0	7.0	7.5	2.0		10.2	2.0		10.2	2.0		10.2			
STREAM FACTOR	%																					
MISC.																						

STREAM		HYPOCHLORITE			CORROSION CONTROL			LOW SULFATE FEED WATER			CLEAN WATER			FILTERED WATER PERMEATE MIX			FLUSH WATER			FEED WATER		
NUMBER		15			16			17			18			19			20			21		
	UOM	MIN	OPER	MAX	MIN	OPER	MAX	MIN	OPER	MAX	MIN	OPER	MAX	MIN	OPER	MAX	MIN	OPER	MAX	MIN	OPER	MAX
FLOW	GPM	0.24	0.47	1.00				0	1,000	1,100	0	1,000	1,100	0	1,000	1,100	50	100	120			
PRESSURE	PSIG	30	40	50													2	3	4			
TEMPERATURE	F	60	68	80				50	58	65	50	58	65				50	58	65			
CONDUCTIVITY	mS/cm										1.9	2.3	3.0				0.02	0.2	0.5			
pH	su										7.0	7.3	7.5				5.8	6.5	6.8			
STREAM FACTOR	%																					
MISC.																NOTE 1						

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NO.	DATE	REVISION	BY	CHK	APP
B	12-2-02	MISC. CHANGES	LRT		
A	11-20-02	FIRST ISSUE	LRT		

REFERENCE DRAWINGS | NUMBER

ENGINEERING SERVICES

APPROVAL | DATE

SCALE: NONE | DATE
DESIGNED BY LRT 11-20-02
DRAWN BY LRT 11-20-02
CHECKED BY
PROJECT ENGINEER
PROJECT MANAGER HGB

KENNECOTT UTAH COPPER

FIGURE 3-14
ZONE "A' REVERSE OSMOSIS PLANT
TWO RACK SYSTEM
PROCESS FLOW DIAGRAM

Job No. 10.00701.B | Dwg. No. 456-F-0101 | REV B

Zone A Reverse Osmosis Plant
Table 3-8: Feed Water Blending

Kennecott Engineering Services

	pH	Cond.	Temp.	TDS	Alk	Cl	SO4	Ca	Mg	K	Na	Flow	Volume	Ratio
	su	uS/cm	°C	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	gpm	acft/yr	
K60 (B2G1193)	7.0	3,217	15.8	2,707	213	163	1,757	549	164	4.2	81	1,500	2,056	47%
K109 (BFG1200)	7.3	2,333	16.3	1,923	194	142	1,121	366	100	3.6	71	1,500	2,056	47%
LTG1147	7.3	2,293	15.3	1,707	224	218	734	338	83	5.0	91	200	274	6%
Feed Mix	7.2	2,745	16.0	2,277	204	156	1,395	450	129	4.0	77	3,200	4,387	100%

Stream Factor 85%

Table 3-9: Blending of RO Permeate with Filtered Feed Water to achieve 250 ppm TDS

Kennecott Engineering Services

	pH	Cond	Temp	TDS	Alk	Cl	SO4	Ca	Mg	K	Na	Flow	Volume	Ratio	
	su	uS/cm	^{o}C	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	gpm	acft/yr		
RO Permeate	7.3	200	15.8	102	29	33	7	11	3	0.9	21	2,400	3,290	93%	13.3
Feed Mix	7.2	2,624	15.2	2,125	210	173	1,219	420	117	4.3	81	180	247	7%	1.0
Product Water	7.3	369	15.8	243	41	42	92	40	11	1.1	25	2,580	3,537	100%	

Stream Factor 85%

A typical composition of RO permeate is used in this table. The actual composition will change over the life of the membranes as their salt rejection changes.

Prefiltration

A centrifugal pump delivers water from the feed water tank to the first process step, which is the prefiltration. This will be accomplished in two stages. The first stage consists of polypropylene filter bags (rating: nominal one micron; 7" diameter; 32" length; typical flow capacity 100 gpm per bag). This stage is designed to protect the more expensive second stage prefilters from sudden bursts of suspended solids, which can occur when well pumps are being started and stopped repeatedly or when pipe scale breaks loose. The second stage prefiltration uses polypropylene cartridges (rating: nominal five micron; 2.5" diameter; 39" length; typical flow capacity 20 gpm per cartridge; or 4.5 micron absolute; 6" diameter, 40" length; typical flow capacity 350 gpm per cartridge).

A slip stream of prefiltered feed water (200 – 500 gpm) will be blended with the RO permeate for TDS adjustment (ref. Table 3-9). It is also possible to use separately prefiltered water from the sulfate well or clean water well for blending.

Antiscalant Addition

The concentrations of dissolved calcium sulfate and silica in Sulfate Plume Water approach saturation. As this water becomes more concentrated in the membrane filtration process, gypsum saturation is exceeded up to 700%. Silica saturation will also be exceeded. To avoid membrane fouling due to precipitation of these compounds in the feed spacer of the membranes, antiscalants are being added to the membrane feed. A chemical dosing pump (one operating, one standby) pulls antiscalant from a 275 gal tote bin and injects it into the feed water upstream of the high-pressure pump. The addition rate is monitored by flow meter. The antiscalants to be used are certified under ANSI/NSF Standard 60 for drinking water production. They are compatible with the membranes and have been tested extensively at the Demonstration Plant.

RO System

The RO System consists of the high-pressure feed pumps and the two membrane skids (Racks # 3 & 4). The high-pressure feed pumps (one per skid) are vertical turbine pumps of all stainless steel construction. Totally enclosed fan cooled (TEFC) motors with variable-frequency drives (VFD) will be used.

Two membrane skids of nominal 1,500 gpm feed rate will be installed. The skids will use two-stage arrays, with 36 pressure vessels in the first stage and 18 pressure vessels in the second stage (ref. Figures 3-15a & b: Membrane Array, and Figures 3-16 a & b: Vessel Rack General Arrangement Drawing No. 456-M-0205 & 206). The first stage will consist of six rows of six vessels each. The second stage will have three rows of six vessels each. The pressure vessels will have the ASME Section X Code Stamp. A common feed header from the high-pressure pump will supply the six rows in the first stage. A common header from the concentrate discharges of the first stage shall feed the second stage. By reducing the number of vessels in the second stage, the cross-flow velocity will be increased to minimize membrane fouling. The permeate from both stages will be collected in one common header. The structure to support vessels and piping will be fabricated from carbon steel and will be epoxy coated. The rack will contain feed and discharge piping required for membrane washing. Appropriate means to guarantee the isolation of wash solution and wash permeate from product water will be installed, i.e. removable spool pieces. Pipe connections shall be made by easily removable couplings. All of the pipe on the rack will be stainless steel.

In the first RO skid (Rack 3) pressure vessels from the shut down nanofiltration skid will be used. These vessels have a diameter of 8 inches and house six membranes, providing 2,400 square feet of membrane area per vessel. In the second RO skid (Rack 4) pressure vessels housing seven membranes each will be used. The total membrane area per vessel will be 2,800 square feet. These vessels were not available at the time the nanofiltration skid was built. The seven-membrane units provide a larger membrane surface area at only slightly higher capital cost, thereby giving increased operating flexibility.

The membrane skid will also be equipped with the required instrumentation for fully-automated operation, such as flow and pressure transmitters for feed, permeate, and concentrate, conductivity meters for feed and permeate, and concentrate flow control valve.

Various types of polyamide membranes designed for brackish feed water have been evaluated for their usage in this project. At present, two membranes from Hydranautics are being considered; the energy-saving ESPA and the composite polyamide CPA. Testing of the ESPA2 membranes will continue in the Demonstration Plant. The two skids of the Zone A Plant can be equipped with two different types of membranes and thereby a good comparison of their performance can be achieved. The question of membrane optimization will be an ongoing issue as membrane manufacturers develop new and more effective and less costly products.

Chlorination

Product water disinfection will be achieved by chlorination. Water analyses performed by JVWCD have shown that Sulfate Plume Water from the deep wells has no biological contamination and therefore chlorination is only required to provide the residual chlorine of 0.3 ppm to avoid microbiological growth in the distribution system. The chlorination equipment will be designed to provide 2 ppm for shock chlorination. Disinfection byproducts (DBP) are not a concern due to the lack of organics in the feed water.

Chlorination will be accomplished using an on-site sodium hypochlorite generation system. The principle of operation is the electrolytic conversion of sodium chloride to sodium hypochlorite. This technology has the advantage over the traditional use of chlorine gas that no hazardous materials are involved. The only chemical stored on site will be salt, which will be stored in the chlorination room in 50 lb bags on a pallet. The concentration of the produced sodium hypochlorite solution is < 1.0%. The system consists of a brine tank and proportioning pump, the electrolytic cells, the hypochlorite storage tank (capacity: one day's usage), and the metering pumps. The metering pumps inject the sodium hypochlorite solution into the product water line and the residual chlorine is measured with a respective meter. In case a component failure occurs in the chlorination system and cannot be resolved within a day, commercial sodium hypochlorite solution can be purchased, diluted 15:1, and fed into the system.

Degasification

The degasifier serves two purposes:

1) Removal of excess carbon dioxide from the permeate product water; thereby, reducing the amount and cost of sodium hydroxide needed to bring the product into compliance for release to JVWCD, and
2) Removal of radon to a level that meets drinking water standards.

Zone A Plant for RO Filtration of Sulfate Plume Water
Figure 3-15a: Membrane Array Rack 3

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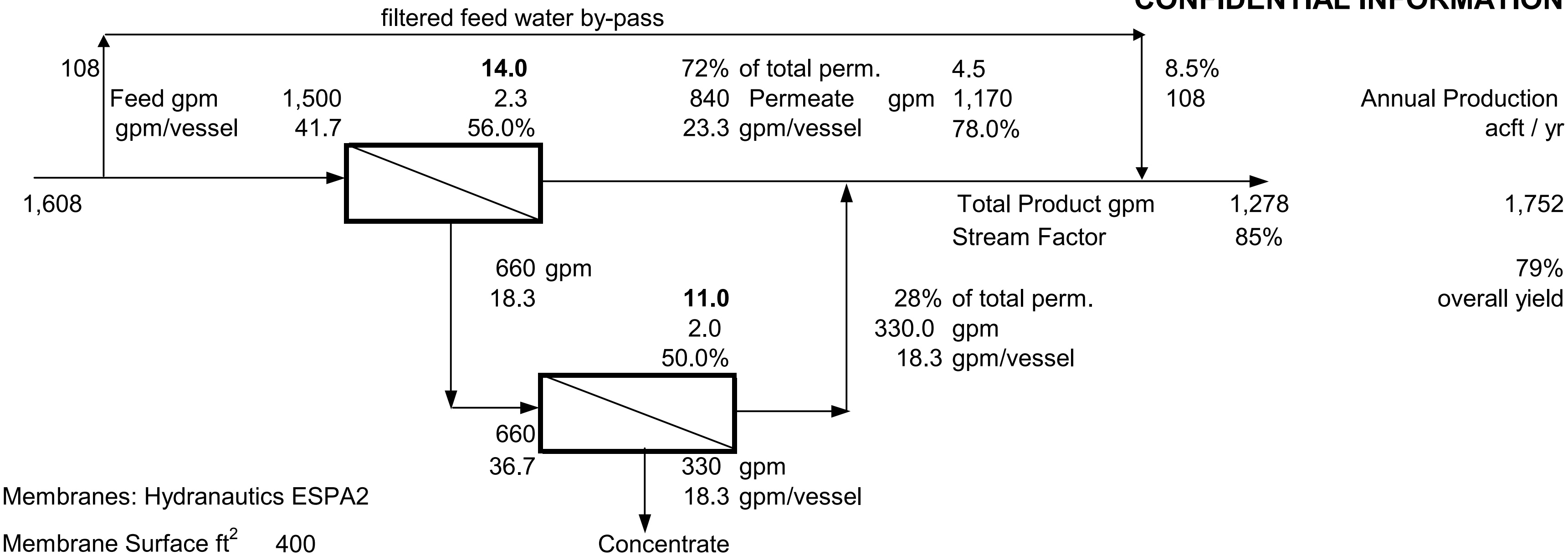

Membranes: Hydranautics ESPA2

Membrane Surface ft^2 400

	Vessels	Membr. / vessel	Membranes	Membrane Area ft^2	Permeate Recovery	Concentration Factor	**Permeate Flux gfd**
Stage 1	36	6	216	86,400	56.0%	2.3	**14.0**
Stage 2	18	6	108	43,200	50.0%	2.0	**11.0**
Total	54		324	129,600	78.0%	4.5	**13.0**

Zone A Plant for RO Filtration of Sulfate Plume Water
Figure 3-15b: Membrane Array Rack 4

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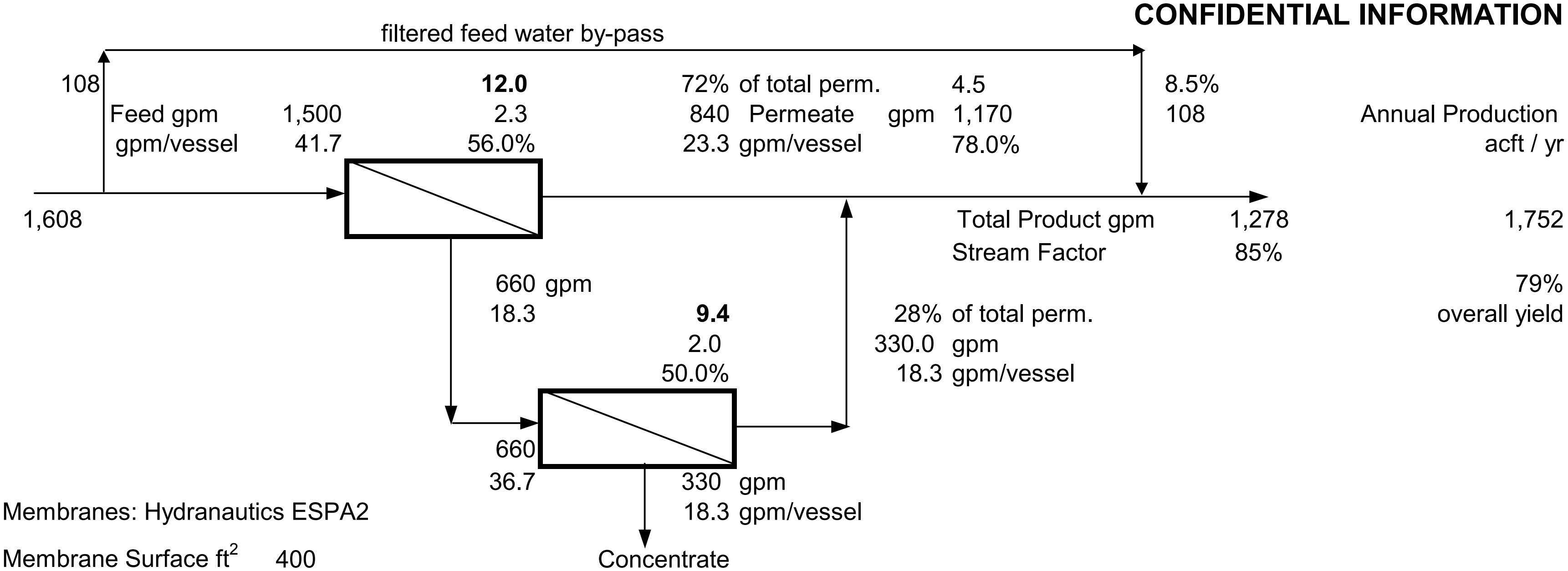


Membranes: Hydranautics ESPA2

Membrane Surface ft^2 400

	Vessels	Membr. / vessel	Membranes	Membrane Area ft^2	Permeate Recovery	Concentration Factor	**Permeate Flux gfd**
Stage 1	36	7	252	100,800	56.0%	2.3	**12.0**
Stage 2	18	7	126	50,400	50.0%	2.0	**9.4**
Total	54		378	151,200	78.0%	4.5	**11.1**

Figure 3-16a Zone A RO Plant Membrane Arrangement – Plan & Elevations, Dwg. No. 456-M-0205

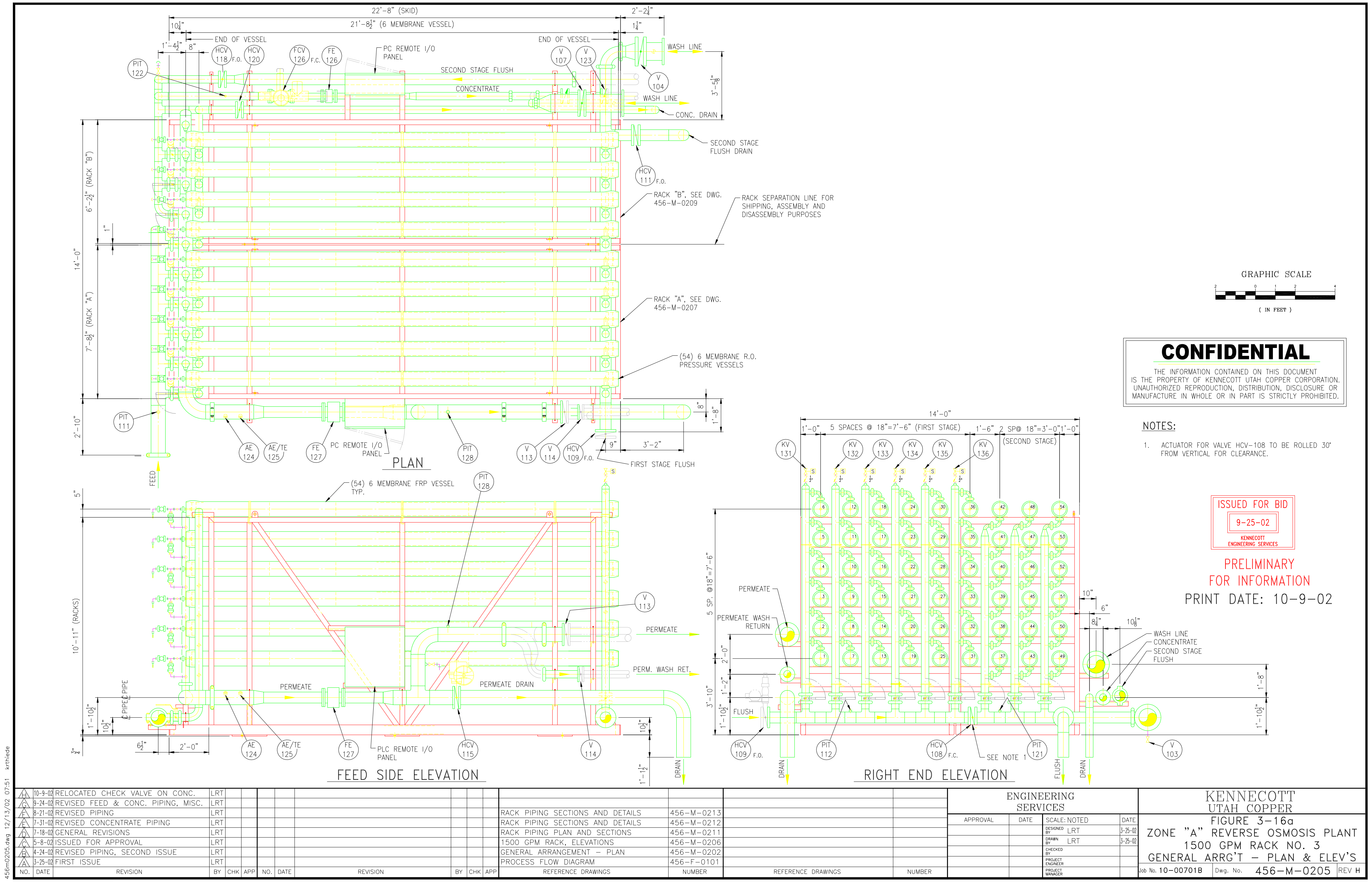
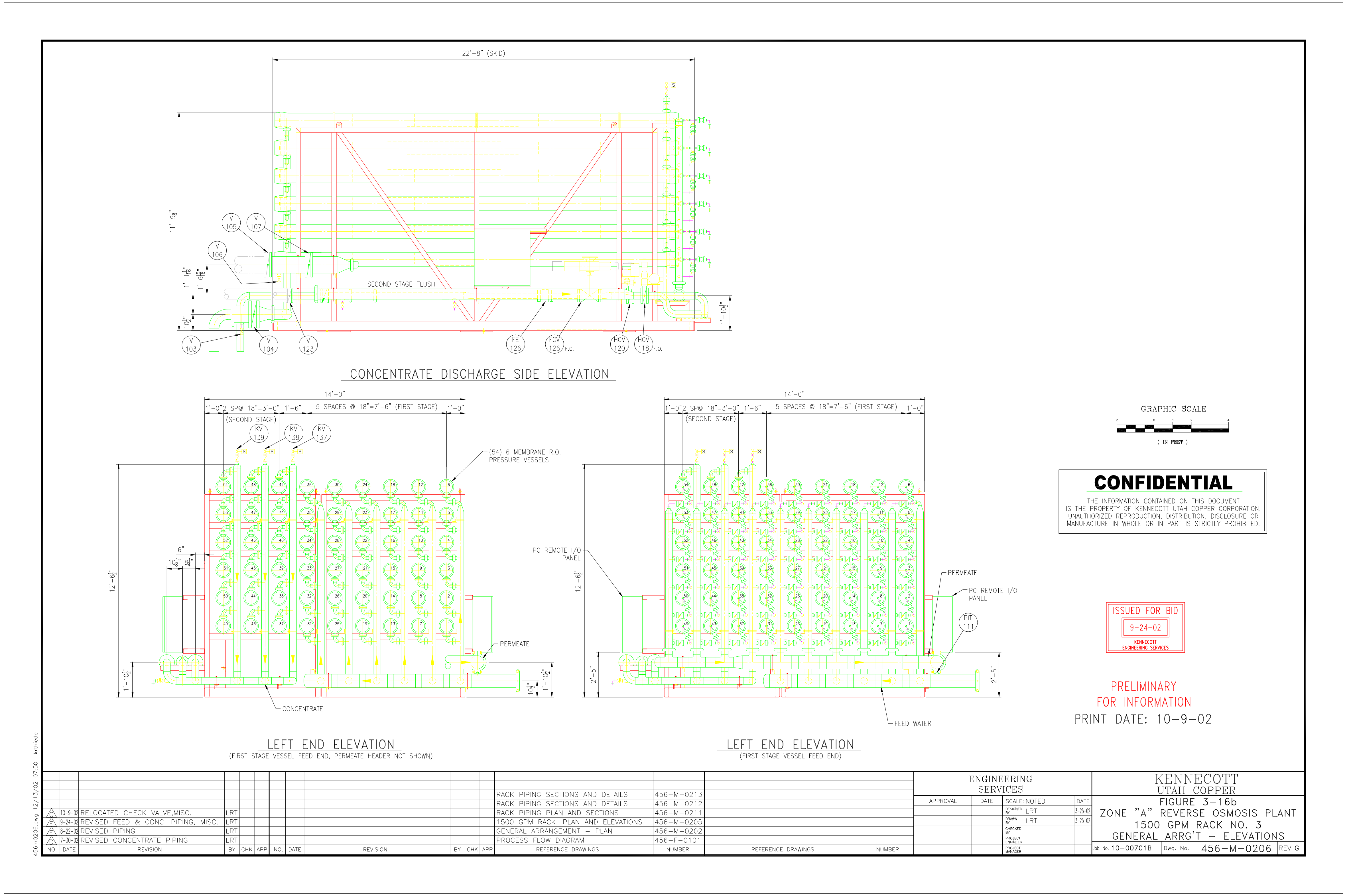


Figure 3-16b Zone A RO Plant Rack 3 General Arrangement – Elevations, Dwg. No. 56-M-0206



Carbon Dioxide Removal

Since the membranes are permeable to gasses, excess carbon dioxide, dissolved in the well water as carbonic acid, passes through to the permeate product. Pilot testing has shown that this excess carbon dioxide can be purged from the permeate by passing water through a packed degasification tower counter current to an air stream.

Radon Removal

Analyses of water samples from the deep wells B2G1193 and BFG1200 indicated radon concentrations of 700 to 840 pico Curies per liter (pCi/L). Pilot testing showed 97% removal of radon. The radon concentration in the degasified permeate was below 20 pCi/L radon, which is the method detection limit.

These results show that degasification will be effective in both excess carbon dioxide and radon removal.

In the Zone A RO Plant, a forced draft degasifier will be used to remove carbon dioxide and radon from the RO permeate. In the degasifier, the inflow is sprayed into the top of a tower filled with packing material. While the water flows in a thin film over the packing material surface, a centrifugal fan (5 HP; 4,500 cfm) blows air into the sump below the packing. The air intake to the fan is filtered with a high efficiency particulate arrestance (HEPA) filter. Carbon dioxide and radon are released and vented through the top of the degasifier. The degasified water flows by gravity from the clear well of the degasifier to TDS adjustment and corrosion control.

Total Dissolved Solids Adjustment

Due to the fact that RO permeate has very low TDS, a slip stream of prefiltered feed water will be blended with the permeate to achieve the desired TDS concentration in the final product water. Table 3-9 presents one possible blending scenario.

Corrosion Control

Based on testing performed at the Demonstration Plant, a small amount of sodium hydroxide is required to neutralize corrosive characteristics of the final product water. A chemical dosing pump pulls NaOH from a 275 gal tote bin and injects it into the blended product water. The addition rate is monitored by pH. The Rothberg, Tamburini & Winsor Model for Water Process & Corrosion Chemistry will be used to assess corrosion and scaling parameters.

Membrane Wash System

The membrane wash system consists of tanks for alkaline and acidic wash solutions (3,500 gal each, FRP), two wash pumps (flow rate up to1,000 gpm; stainless steel), a bag filter (10 bag unit; rating: nominal one micron; 7" diameter; 32" length; typical flow capacity 100 gpm per bag) to remove suspended solids from the circulating wash solution, and PVC wash piping. Depending on the type of foulant, either alkaline or acidic wash solutions will be prepared in their respective tanks and heated up to 40°C. After taking the skid that requires washing off line, the skid will be flushed with RO permeate. Then the spool pieces that guarantee the separation of wash water and wash permeate from product water will be installed. Subsequently, the wash solution will be circulated through the membranes. The first stage can be divided into two sections (18 vessels each), which will be washed separately. The second stage will also be washed separately. An alkaline wash may be followed by an acidic wash or vice versa. Permeate flushes will be performed between and after washes. For this purpose, a plant water tank is installed in order to store RO permeate for washing and flushing. Spent wash solutions will be discharged to the Eastside Collection System where they will be mixed with meteoric leach water and pumped to the tailings pipeline. The amount of wash chemicals is minute in comparison to the tailings stream and no impact on the tailings line is expected as result of this process.

Control System and Instrumentation

An SLC 500 Allen-Bradley Programmable Logic Controller (PLC) with color graphics operator interface will be installed to operate the plant with all its equipment and functions. The plant will be equipped with the appropriate instrumentation to permit fully automated operation with minimum requirements for operator interference. The PLC will also be instrumented with a modem to allow remote control of the operation. In case an alarm condition occurs during unattended operation, the PLC will be programmed to page the operator on call and alert him/her of the alarm condition. The operator on call will have a laptop computer with which (s)he can connect to the plant via modem to determine the cause and nature of the alarm. In most cases the operator will be able to remedy the alarm condition via modem. In case the operator cannot resolve the problem from the laptop computer, (s)he then will drive to the plant to correct the situation. Should the operator on call fail to respond to the alarm, the PLC will page the next person on the call list. In case the alarm condition is not taken care of and the plant operation deviates farther from its set points, the plant can be shut down and put through an automatic permeate flush, after which the equipment will be parked in a stand-by mode until further instructions from the operator are received. This approach allows remote operation and protects the whole plant in case of unusual circumstances.

3.3.5.3 Piping System

Water from wells B2G1193 (K60), BFG1200 (K109), the sulfate extraction well LTG1147, and the clean water well LTG1139, will be delivered to the plant by pressure from the well booster pumps. In Phase 1, a new 20” HDPE feed line will be installed from the existing deep well water pipeline to the feed tank at the plant (5,280 linear feet). In Phase 2, a new 12” pipeline will be installed from the booster pump station to the Zone A RO Plant.

In Phases 1 and 2, existing piping will be used to convey the produced RO permeate to the Copperton Concentrator for use as process water. In Phase 3, the permeate pipeline will be completed to supply the Zone A RO Plant product water to the JVWCD delivery point.

The RO concentrate will be conveyed by system pressure to KUCC’s Eastside Reservoir, where it will be mixed with a small volume of meteoric leach water to precipitate calcium sulfate. The combined concentrate/leachwater will flow by gravity to the Wastewater Disposal Pump Station, from where it will be pumped to the Tailings Line. In Phase 3a, 5,200 linear feet of 8” pipeline will be added to accommodate the higher flow of concentrate.

3.3.6 Time Schedule

The time schedule for the three construction phases of development of the Zone A Reverse Osmosis Plant is presented in Figure 3-17. The scope of the three phases is:

Phase 1:

- installation of feed water pipeline and feed water tank;
- installation of antiscalant injection system;
- modification of existing prefiltration units (bag and cartridge filters);
- installation of prefiltration feed pump and high-pressure RO feed pump;
- installation of the first 1,500 gpm RO Skid (Rack 3) in the existing Membrane Filtration Plant, using existing pressure vessels and instrumentation;
- installation of permeate degasifier for carbon dioxide and radon removal;
- modification of the membrane wash system to meet the requirement of guaranteed separation of wash medium and wash permeate from RO feed and permeate;

Preoperational testing and start-up of the first RO skid are scheduled for the third quarter of 2003.

Phase 2:

- construction of the shell of the Zone A Plant building;
- relocation of feed water tank;
- installation of antiscalant injection system;
- modification of existing prefiltration units (bag and cartridge filters);
- installation of prefiltration feed pump and high-pressure RO feed pump;
- installation of the second 1,500 gpm RO skid (Rack 4) in the new building;
- relocation of Rack 3 to the new building.

Design of Phase 2 is scheduled to start in the fall of 2003, construction will take place in 2004, and the start-up is scheduled for the fourth quarter of 2004.

Phase 3a:

- installation of permeate degasifiers 2 & 3 and relocation of degasifier 1;
- installation of chlorination system;
- construction of the product water pipeline to the JVWCD reservoir;
- construction of the concentrate pipeline to the Waste Water Disposal Pump Station;

Start-up of Phase 3a is scheduled for mid 2005. After an initial optimization period the delivery of municipal quality product water to JVWCD will begin.

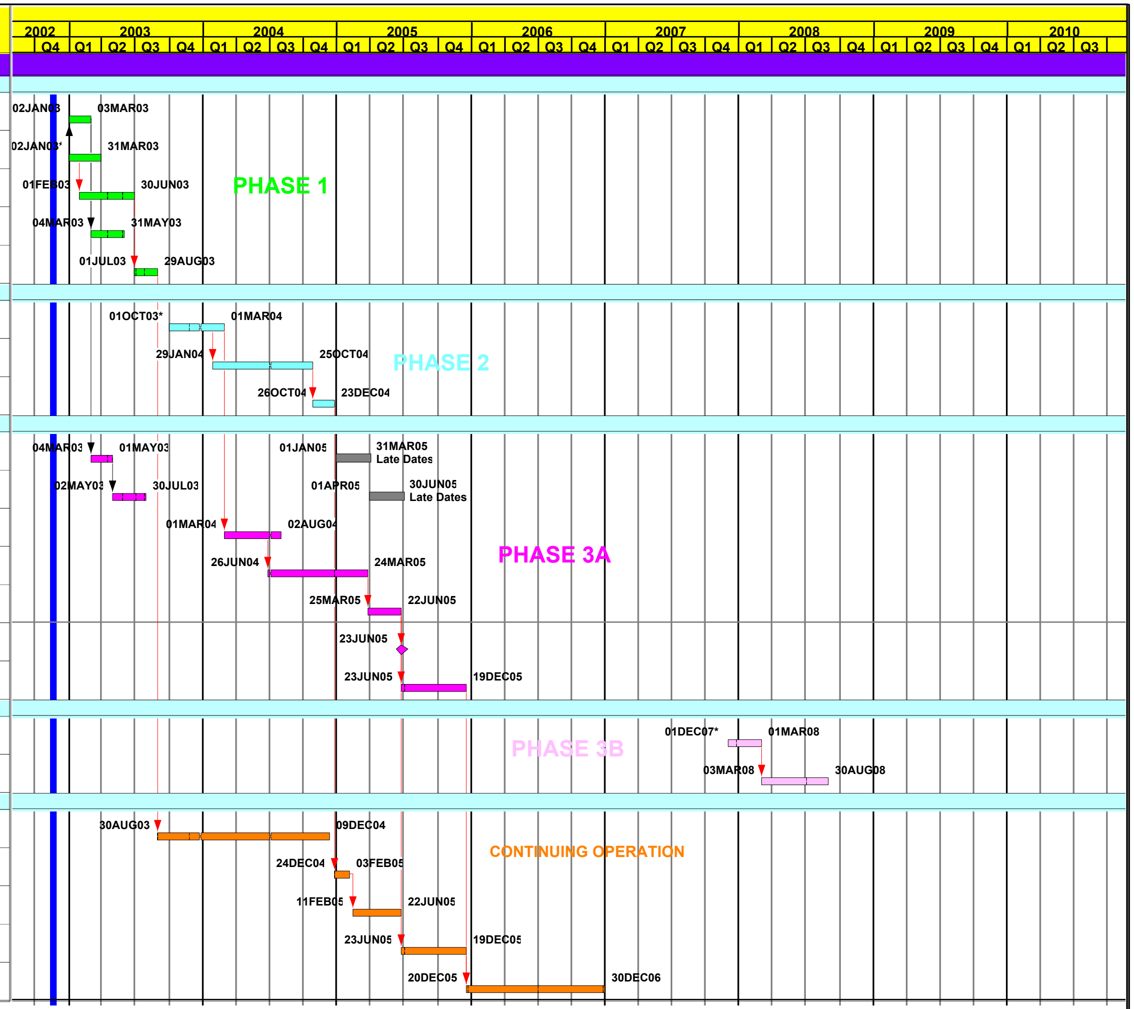
Phase 3b:

This phase is optional and will only be implemented in case the plant operation will be turned over to JVWCD.

- completion of the interior facilities of the new building, including control room, conference/lunch room, laboratory, locker room, and rest room;
- installation of new wash system with tanks, mixers, pumps, and filter;
- relocation of Plant Water Tank;
- installation of separate PLC and color graphics operator interface;
- installation of power line from UP&L grid.

Figure 3-17 Zone A RO Plant – Time Schedule

Activity ID	Activity Description	Start Date	Finish Date	Dur (Days)
ZONE A REVERSE OSMOSIS PLANT				
PHASE 1				
RO001015	COMPLETION OF FEED & PERMEATE PIPING DESIGN	02JAN03	03MAR03	52
RO001000	PHASE 1 COMPLETION OF DETAILED DESIGN	02JAN03*	31MAR03	76
RO001005	PHASE 1 CONSTRUCTION	01FEB03	30JUN03	126
RO001020	INSTALLATION OF FEED & PERMEATE PIPING	04MAR03	31MAY03	75
RO001010	PHASE 1 PRE-OP TESTING & START-UP	01JUL03	29AUG03	50
PHASE 2				
RO001035	PHASE 2 DETAILED DESIGN	01OCT03*	01MAR04	129
RO001040	PHASE 2 CONSTRUCTION	29JAN04	25OCT04	231
RO001045	PHASE 2 PRE-OP TESTING & START-UP	26OCT04	23DEC04	51
PHASE 3A				
RO001025	PIPING DESIGN SULFATE & CW WELLS	04MAR03	01MAY03	50
RO001030	PIPING INSTALLATION SULFATE & CW WELLS	02MAY03	30JUL03	74
RO001050	PHASE 3A DETAILED DESIGN	01MAR04	02AUG04	132
RO001055	PHASE 3A CONSTRUCTION	26JUN04	24MAR05	231
RO001060	PHASE 3A PRE-OP TESTING & START-UP	25MAR05	22JUN05	77
RO001065	START FULL SCALE PRODUCTION OF DRINKING WATER	23JUN05		0
RO001070	PHASE 3A PROCESS OPTIMIZATION	23JUN05	19DEC05	153
PHASE 3B				
RO001105	PHASE 3B DETAILED DESIGN	01DEC07*	01MAR08	78
RO001110	PHASE 3B CONSTRUCTION	03MAR08	30AUG08	155
CONTINUING OPERATION				
RO001085	PHASE 1 OPTIMIZATION & CONTINUING OPERATION	30AUG03	09DEC04	397
RO001090	PHASE 2 OPTIMIZATION & CONTINUING OPERATION	24DEC04	03FEB05	35
RO001140	PHASE 2 OPTIMIZATION & CONTINUING OPERATION	11FEB05	22JUN05	113
RO001100	PHASE 3A PROCESS OPTIMIZATN & CONTINUING OPERATN	23JUN05	19DEC05	153
RO001095	CONTINUING OPERATION	20DEC05	30DEC06	320



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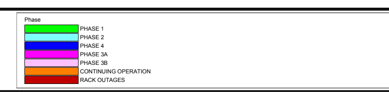
ZONE A REVERSE OSMOSIS PLANT



3.4 Management of Acidic Waters and RO Concentrates in KUCC Tailings Circuit

3.4.1 Overview of Water Management in Tailings Circuit

While the mine is operating, KUCC will convey the following mining-affected waters to the Magna Tailings Impoundment in two existing tailings pipelines:

- Acid plume water;
- Meteoric drainage from the Eastside Collection System;
- RO Concentrates from treatment of the Zone A sulfate plume;
- Mildly acidic waters from dewatering of the open pit.

The first three types of water are commingled in and pumped through the WDPS. The mine dewatering flows are pumped directly to the process circuit through two different lines. Figure 3-18 is a schematic diagram of the process circuit showing the routing of waters and providing recent estimates of water flows in the system. Geochemical studies evaluating the chemical impacts of the proposed disposal method are described in the final geochemical report attached to this document (Appendix C). Appendix C provides all the data for additional field studies and experimental work. KUCC performed the geochemical studies to (a) close data gaps identified after the RI/FS process, (b) demonstrate that KUCC can operate the system in a manner that controls pH and attenuates metals and other solutes to levels that will allow compliance with UPDES permits, and (c) demonstrate that the addition of acidic water will not compromise the long-term geochemistry of tailing in the Magna Impoundment nor re-leach metals that have been controlled by initial reactions in the tailing line.

After mine closure, effluents from the treatment systems will be conveyed to the Great Salt Lake via a concentrate discharge line, provided the water chemistry at that time meets regulatory discharge limits. Bench-scale testing of this alternative is presented in Appendix C, Section 6.3. Results of that test work indicate that disposal of the treated waters to Great Salt Lake is technically feasible without exceeding current UPDES discharge criteria or generating aesthetic issues due to low-density precipitates. If one or both of the concentrates is not suitable for direct discharge, then additional treatment (e.g., lime addition) or alternative disposal (e.g., evaporation) will be needed. If concentrate from treatment of Zone B wells cannot be discharged to the Jordan River, these concentrates may also be delivered to the KUCC system.

For both the operational and post-mining periods, KUCC has developed a performance-based Final Remedial Design for the management of acidic waters and water-treatment concentrates.

3.4.2 Operational Conditions

3.4.2.1 Performance Criteria

<u>A. Flow</u>
When fully operational, the tailing process circuit (see Figure 3-18) must be able to handle the following maximum flows with 90% availability:

- Tailings: 120,000 to 200,000 tpd
- Acid Plume Water: 1000 to 2500 gpm
- Meteoric Leach Water: 800 to 1,500 gpm
- Zone A RO Treatment Concentrates: 600 to 800 gpm

B. Solution Chemistry in the Tailing Line

The system must be able to maintain a fluid pH of 6.7 or greater as measured at the North Splitter Box (Sample Point MCP2536) with 90% availability to ensure dissolved metal precipitation and sequestration in the tailings impoundment.

C. Integration with Tailing Disposal System

1. KUCC will meet all UPDES discharge criteria at Outfall 012 from the North Impoundment to Great Salt Lake (or other permitted outfalls).
2. If the monthly average Net Neutralization Potential (NNP, calculated using the Modified Sobek Procedures) of the Copperton Concentrator General Mill Tailings (GMT) is less than 5 t CaCO3/kt or if the Neutralization Potential Ratio (NPR) is less than 1.1, then the average monthly NNP of samples collected from the tailings North Splitter Box must have an NNP and NPR that are equal to or higher than the Copperton Mill Tailings for the month. If the monthly average NNP of the Copperton Concentrator General Mill Tailings is greater than 5 t CaCO3/kt or the NPR is more than 1.1, then the average monthly NNP of tailings samples collected from the North Splitter Box must have an NNP of at least 5 t CaCO3/kt. The monthly NNP value will be determined based on a rolling six-month average from monthly composite samples collected at the GMT and tailings impoundment discharge locations.

3.4.2.2 Project Delivery Strategy

A. In February 2002, KUCC completed modifications to the tailing discharge line. The new, larger diameter pipe is intended to mitigate the impacts of scale build-up on operations of the discharge lines and to permit simpler, faster and more effective de-scaling in the future. Operational history during 2002 shows that these goals have been met.
B. In Q1 2002, KUCC modified its existing lime-treatment capabilities at the Copperton Concentrator and from the Concentrator to Drop Box NP-6A to permit lime addition on a 24-hr/day basis. For the purposes of this portion of the Preliminary Design, the area from the Concentrator to NP-6A will be called the "Concentrator Complex".
C. In Q1 2002, KUCC established standard operating procedures, including on-going maintenance and calibration tests, for the in-line pH sensors at North Splitter Box and for the telemetry system that connects those sensors to the lime-addition system at the Concentrator complex.
D. By the end of Q4 2003, KUCC will have in place at the Concentrator Complex the capability of adding up to 200 tpd lime (as CaO) to the tailing line.
E. KUCC and its contractors will continue the geochemical studies and sampling program needed to monitor the chemical system performance during Remedial Action.

3.4.2.3 Drawings and Sketches

The configuration of the Tailings Circuit is shown schematically in Figure 3-18. The figure shows the sampling and monitoring locations that have been used in the Remedial Design and will be used for monitoring during the Remedial Action, at least through the operations of the mine.

3.4.2.4 Monitoring

For purposes of performance monitoring during Remedial Action, KUCC proposes four monitoring steps:

- Daily pH monitoring at North Splitter Box (MCP2536). The pH at MCP2536 will be recorded continuously using the South Facilities Water Management System's PI recorders and database. Results will be plotted as time-series using 15-minute averaging and compiled in weekly series. The time-series charts will show the pH 6.7 control limit to show KUCC's compliance with the performance criterion for pH control.
- Monthly chemical monitoring at the monitoring points shown on Figure 3-18 for the following parameters: pH, TDS, Alkalinity/Acidity, Ca, Mg, Cl, SO_4, Al, Cd, Cu, Fe, Mn, Zn. Metals will be analyzed and reported on a dissolved basis.
- Monthly monitoring for Net Neutralization Potential (by GCMP standard methods) from General Mill Tailings and a grab sample from the North Splitter Box (MCP2536).
- UPDES discharge monitoring at Outfall 012 as required by other KUCC permits.

Monitoring data will be maintained in reviewable databases, and KUCC will provide all updated data (including time-series charts for pH and statistical summaries of the analytical data) to EPA and the TRC in annual monitoring reports.

In addition to the performance monitoring, KUCC may establish additional, operational sampling to help understand and control the tailing-discharge system. Such monitoring may be short- or long-term, and the establishment of such sampling does not constitute a commitment by KUCC to long-term sampling. While such sampling is on-going, KUCC will maintain the data in the project database, and those data will be available for TRC, State and EPA review.

3.4.3 Post-Mining Conditions

Because mining will continue until at least 2013 (and perhaps until 2030), it is not necessary at this time to have a plan for post-mining conditions that is developed to the same level of detail as that needed for operational conditions. Appendix A to this report is KUCC's description of the post-mining treatment and management system at the level of a Preliminary Design. The report shows that the acidic water can easily be neutralized with lime, which produces gypsum sludge. The nature and characteristics of the neutralization process and resulting sludge are described in detail in the appendix. What is demonstrated in the report is that water treatment to acceptable levels is easily achieved but the longer-term issue that needs further investigation is the management and disposal of the gypsum sludge. Fortunately, this is not a critical issue until closure. The plan for post-mining water management will be updated formally as part of the 5-Year Reviews during Remedial Action. Through the update process, there will be a final engineering design for all aspects of post-mining conditions prior to the actual end of mining act Bingham Canyon, which is expected to be some time between 2013 and 2030, depending on long-term mine planning.

Management of Zone-A sulfate waters will continue through the reverse-osmosis water-treatment that also applies to the operational period (Section 3.3 above).

The current KUCC plan for post-mining management of acidic flows, which also constitutes a contingency plan were mining to terminate prematurely, is based on alkaline treatment of acidic waters with sequestration of reaction products (i.e., gypsum sludge). Test work to date indicates that lime, applied as milk of lime ($Ca(OH)_2$) slurry is the most cost effective alkaline additive. Gypsum sludge, the resulting by product of neutralization, would be disposed of in a prepared facility. Possible locations for sludge disposal include (a) a disposal cell on the Magna North Impoundment, (b) disposal cells on top of the waste dumps, (c) the Bingham or Melco pits, or (d) new, engineered disposal cells on either the South or North ends of the KUCC property. KUCC will continue to investigate alternative treatment technologies, particularly ones that have the potential to decrease both lime consumption and sludge volumes. Experimental tests conducted to date (Appendix C, Section 6.3) show that clarified lime-treatment overflow solutions and reverse-osmosis concentrates are chemically compatible with disposal in the Great Salt Lake and meet current UPDES permit discharge limits. KUCC will evaluate this matter, too, during the early years of Remedial Action, while operational mining and co-disposal with tailing continues.

4.0 PERMITS AND INSTITUTIONAL CONTROLS

To the extent that facilities associated with the Remedial Action are located on-site and are part of a CERCLA remedy, they are exempt from federal and state permitting requirements pursuant to CERCLA section 121(e)(1), which provides: "No Federal, State or local permit shall be required for the portion of any removal or remedial action conducted entirely on-site, where such remedial action is selected and carried out in compliance with this section." Based on comments received from various State and Federal agencies in correspondence and meetings, it has been determined that various permits and/or revisions to existing permits may be obtained. Based on this foundation, the next steps in the permitting process are:

- Identification and collection of required permit information
- Organization and presentation of the required information as permit application or revision submittals
- Application submittals
- Coordination with jurisdictional agencies during the permit review and approval process

The following sections summarize permit information requirements and timetables (where specified) for each jurisdictional agency and permit.

4.1 New Permits

4.1.1 Drinking Water Permit(s)

Because the Zone A RO treatment facility will be producing drinking water that will be consumed by the public, the most rigorous application of the State Drinking Water Regulations (UAC R309-102) will be applied. Among other things, this will include submittal of Preliminary Evaluation Reports (PERs) and Source Protection Plans (SPPs) which must be approved by the State Division of Drinking Water (DDW). In addition, the RO treatment plant design and construction must be reviewed and approved by the DDW at which time KUCC will receive a permit to operate the facility as designed and provide drinking water to the JVWCD for distribution to affected communities. Assuming that this final design is approved, KUCC will begin the permitting process with DDW during the first quarter of 2003.

4.1.2 County Conditional Use and Building Permit

Salt Lake County Code requires that a building permit be obtained before construction activities may commence on any building or structure. The Development Services Division of the Salt Lake County Department of Public Works is responsible for various aspects of development. It issues Salt Lake

County approval for the construction of buildings or structures, inspects construction for compliance with building codes, and enforces building code requirements. The building permit is issued only after all zoning and conditional use requirements have been satisfied. Phase 1 of the RO treatment facility (~50 percent of the production capacity) will be constructed in an existing building with the majority of the work focusing on piping changes and membrane replacements. During Phases 2 and or 3, a new conditional use and building permit will be obtained for the final building that will house 100 percent of the production capacity.

A Building Permit application will be generated for the RO treatment plant and must contain the Conditional Use information, a detailed site plan showing existing facilities and proposed improvements. The application must demonstrate that the building conforms to all applicable codes and that the building, structure and land use are consistent with zoning ordinances. Typical length of time to obtain a building permit ranges from two to five weeks, depending on the workload in the Development Services Division of the County.

4.1.3 Construction Permit

R309-102-2 details the requirements that pertain to the construction of a public drinking water system. This section lists the approval process for engineering plans and specifications as well as acceptable design and construction methods. Complete plans and specifications for the system, as described in R309-102-2.3, will be approved in writing by the Executive Secretary prior to the commencement of construction. The regulations indicate that a 30 day review period should be assumed. This process will be initiated during the first quarter of 2003.

4.1.4 Well Drilling/Construction Permits

As shown in Figure 3-2 and table 3-1, additional acid extraction wells will be constructed to the east of the current acid extraction well. Additional monitoring wells may also be necessary within and adjacent to the plume(s). Construction of these wells will follow current State rules (R655-4), which require well drilling permits and completion certificates.

4.2 Permit Modifications

4.2.1 UPDES Permit No. UTD0000051

KUCC's UPDES Permit was renewed and modified in May 2001 to include flows from deep wells B2G1193 and BFG1200, the sulfate extraction and Lark wells and water from the acid extraction well into KUCC's process and wastewater systems. No changes in discharge parameters are expected due to these additions. Therefore, no additional modifications are believed necessary at this time.

4.2.2 Air Emissions Permit

Controlling fugitive dust per State rule (R307-215) during construction activities has been identified as a known air emission that must be controlled. As the remedial action is implemented, potential air emission sources will be evaluated and communicated to UDEQ to determine if a permit is required. One potential that has been identified for review with Division of Air Quality personnel is the degasification unit for the RO Plant that will generate carbon dioxide and small quantities of radon.

4.2.3 Division of Oil, Gas and Mining (DOGM) - Notice of Intent

There are several reasons why the Zone A RO treatment plant and associated pipelines will not need to be included in KUCC's existing DOGM permitting and bonding. The Zone A treatment plant serves a dual purpose: 1) to meet the objectives of the NRD consent decree and CERCLA remediation and 2) to make municipal quality water for delivery to the affected communities. As such, it is not a "mining operation" as that term is defined in UCA 40-8-4(8). DOGM has requested, and KUCC has agreed, to provide DOGM with a copy of the joint agreement between KUCC and JVWCD upon finalization, which documents the long term funding for the operation and maintenance of this perpetual water treatment facility whether operated by KUCC or JVWCD.

Impacts of concentrate disposal on the currently approved reclamation plan for the KUCC tailings impoundment (Permit M/035/015) have been shown to be minimal. In fact, the total mass of remediated products (gypsum sludge and metals) is less than two percent of the mass of tails deposited in the impoundment on a daily or annual basis. Section 3.4.2.1 discusses the performance criteria established for the integration of the RO concentrate and neutralization of acidic solutions within the tailings disposal system. The system will be maintained with a minimum fluid pH of 6.7 or greater at the North Splitter Box to achieve permitted water-quality discharge limits. Additionally, the NNP, as calculated using the Modified Sobek Procedures, of tailings discharge at the impoundment (which will include RO concentrate inflows) will be maintained such that they have an NNP and NPR that are equal to or higher than the General Mill Tails (GMT) if the GMT is less than 5 t $CaCO_3$/kt. Therefore, no degradation in tailings geochemistry that could affect the long-term reclamation of the tailings is anticipated due to the addition of concentrate or neutralized acidic waters. KUCC will conduct monitoring described in Section 3.4.2.4 to ensure that RO Plant concentrate and neutralized acid waters and resultant sludges are not having a negative impact on process waters, tailings deposition or waters to be discharged. Should the studies or sampling indicate any unanticipated negative consequences of the concentrate addition to the tailings circuit that would have an impact on final reclamation of the impoundment, KUCC will address the issue with DOGM.

KUCC and DOGM, as well as other agencies, have agreed to continue discussions regarding permitting implications for post closure management of gypsum sludges produced from post-closure water treatment facilities.

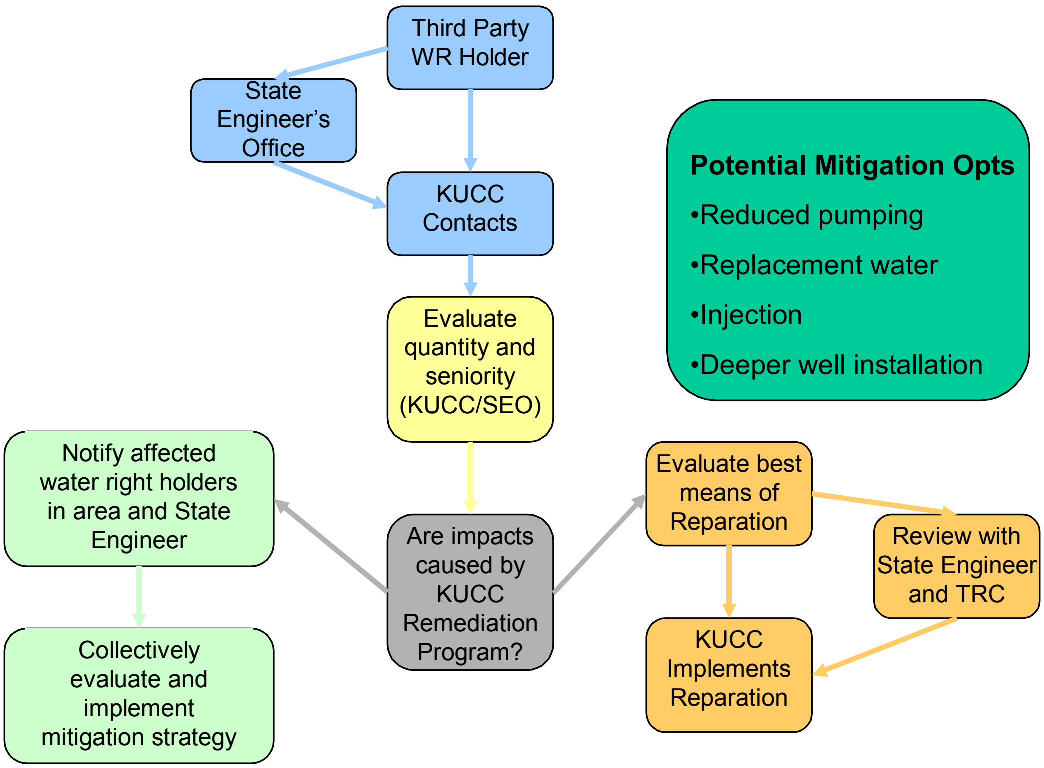
4.3 Groundwater Use Restrictions

Restrictions on the use of water from existing wells, restrictions on the installation of new wells and a moratorium on new water rights within and adjacent to the project area will be established through the State Engineer and Department of Water Resources as needed. KUCC has already petitioned the State Engineer to implement the moratorium on new water rights that will minimize the effects of aquifer drawdown and movement related to the containment and extraction remedial strategy approved in the ROD. KUCC is currently working with the largest extractors of water from the aquifer to manage the current over drafting situation that is occurring.

A related issue that has been expressed by several members of the TRC is the development of a plan to address water right impairment issues related to the Remedial Action extraction program. For example, if someone's well goes dry during the Remedial Action, what is the plan to determine if the decreased water levels are a result of the Remedial Action, other non-KUCC extractions and/or drought conditions and what is KUCC's response going to be if it is related to the Remedial Action. To address this issue, the following flow chart (Figure 4-1, Water Right Management Plan) was prepared and presented at the

November 13, 2002 TRC meeting. The TRC agreed that implementing the options outlined in the flowchart would address this issue.

Figure 4-1 Water Rights Management Plan



4.4 Water Rights

A key element to the containment and extraction program is the necessary water rights to extract and put to beneficial use extracted water. KUCC has obtained or filed applications with the State Engineer for the required water rights to extract the required amount of water for containment and drinking water production. Table 4-1 below lists the applicable water rights, quantities and current status.

Table 4-1. Summary of Water Right Information

Water Right #	Priority Date	Change Application/Date	Volume (acre feet)	Points of Diversion
59-1042	12/13/1962			
59-1653	11/21/1961	a24720/7-12-00 (approved)	6487	Existing K60/109 wells five acid wells ECG1146 already in place
59-5314	12/13/1962			
59-1352	1/22/1958	a25109/4-6-01 (approved)	136.45	Change applications moved WRs to LTG1147
59-1671	4/26/1962	A25110/4-6-01 (approved)	66.13	
a26312	2/5/2002	a26312 (approval pending)	0	Add two points of diversion to a24729 for wells LTG1147 and LTG1139
59-945	5/8/1951	a26074/10-22-01 (approval pending)	2476	Change application moves WR to 4 of the five acid well sites
Total			9165.58	

5.0 DESIGN AND IMPLEMENTAITON QUALITY CONTROL

This is a unique remediation project and remedial design. The majority of the containment and extraction system were designed, installed and tested during the RI/FS process. The first acid extraction well was installed and successfully tested at approximately 500 gpm and is now operating at 900 gpm. Currently the only additional construction associated with the acid plume containment will be new acid wells and associated piping and pumping systems to bring the total acid extraction to 1000 to 2500 gpm. A second acid-extraction well is planned for early 2003 and will initially be tested at approximately 500 gpm.

The containment wells for the sulfate have been in operation for decades supplying process water to the Copperton concentrator. After the design and construction of the RO Plant, these wells will continue to be pumped, but will be routed to the RO Plant rather than the concentrator. Since this system will be producing drinking water, the design and construction of this are subject to the review and approval of the

UDEQ Division of Drinking Water as part of the process of obtaining a drinking water permit. To avoid duplicative oversight, the Division of Drinking Water will provide the primary review for this system as part of the overall remedial action.

QA/QC procedures outlined in the Preliminary Design were followed to ensure that the Final Design is technically sound, cost-effective, biddable, constructible and that the design meets the remedial action goals for the site. Although some detailed engineering remains to be completed for the RO Plant, this Final Design report represents approximately a 95 percent complete design document. It should be noted that some of the detailed design drawings and specification have intentionally been left out of this report for the sake of efficiency. However, these drawings and specifications will be included, as necessary, as part of various permit applications.

To ensure quality control during installation, each contract that is awarded for various tasks (well installation, piping, construction, etc.) will include additional quality control and quality assurance provisions.

6.0 PROGRESS MEETINGS AND REPORTS

6.1 TRC Meetings

At the last TRC meeting (November 13, 2002) it was suggested that the group meet on a minimum basis of every six months or more frequently if needed. TRC meetings will serve as the main form of communication to the group regarding the progress of the Remedial Action. These meetings will be documented with written minutes that will be distributed to the TRC. The TRC meetings will continue on a semi-annual basis during which the following topics will be covered:

- Progress of containment and extraction program (including monitoring results)
- Progress of construction, startup and operation of the Zone A RO Plant
- Progress and results from acid neutralization in tailings system
- Plan for the next six months

6.2 Remedial Action Reports

Previously in this report, several reports were described that will be completed as part of the Remedial Action. In summary, the following written reports will be provided to EPA and DEQ throughout the Remedial Action program.

Report	Frequency
Groundwater Level, Chemistry and Modeling Monitoring Report	Annual
Subsidence Monitoring Report	Annual
Tailings Chemistry Monitoring Report	Annual
Groundwater Extraction Report	Annual
Five Year Remedial Action Review Report	Every 5 Years
Drinking Water Permit Reports	As required by permit

7.0 SCHEDULE FOR REMEDIAL DESIGN ACTIVITIES

7.1 Summary of Deliverables

A list of various deliverables identified during the RDWP and Preliminary Design to be submitted during the remedial design phase is shown on Table 7-1. Those documents not previously submitted have been attached as appendices to this Final Design Report.

7.2 Schedule

- The schedule for implementing the Remedial Action is shown in Figure 7-1. It outlines the timing for the major pieces of the Remedial Action including permitting, construction of the Zone A RO Plant, acid well construction and operation and the monitoring and reporting program.

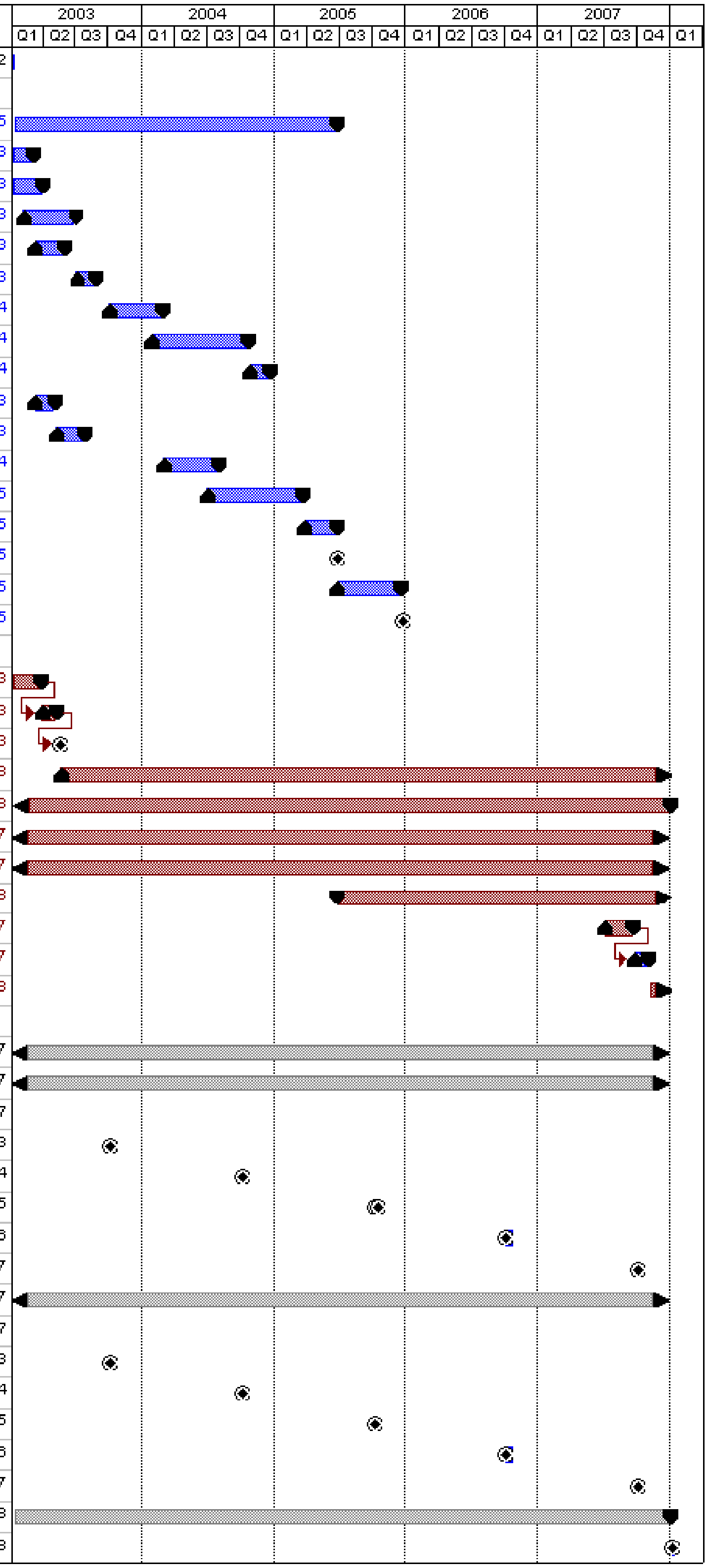
- This schedule focuses on the next five years of operation and is not intended to imply that the project ends in 2008. By 2008, as part of the five-year review process, a revised schedule outlining the next five years will be presented. Essentially the Remedial Action will operate as described in this plan until closure of mining operations, with the exception of constructing additional acid wells. Closure may be as early as 2013 or as late as 2030. Therefore, we have taken the approach of providing a detailed five year schedule recognizing that through semi annual TRC meetings, annual reporting and five year reviews, the schedule will become a living document that is constantly modified. Anticipated elements of the five-year review report include an assessment of the initial success of the Remedial Action program with an emphasis on the containment and extraction of contaminated groundwater. Additional information also will be provided in that report which updates the preliminary post closure water management plan.

Table 7-1. Summary of Remedial Design Phase Deliverables

Document Name	Status
Final Remedial Design Work Plan	Completed 8/6/01
Final Data and Records Management Plan	Completed 10/30/01
Final Work Plan for Tailings Geochem Study	Completed 4/15/02
Final Work Plan for Groundwater Study	Completed 3/21/02
Final Groundwater Monitoring Plan	Completed 8/14/01
Alkali Treatment Plan	Completed 3/21/02
Final Report for Tailings Geochem Study	Attached to this report as Appendix C
Final Report for Groundwater Study	Attached to this report as Appendix B
Baseline Groundwater Monitoring Report	Attached to this report as Appendix D
Preliminary Post Closure Water Management Plant	Attached to this report as Appendix A
Preliminary Remedial Design	Completed 1/31/02
Final Remedial Design	Completed 12/31/02

Figure 7-1 Remedial Action Schedule

ID	Task Name	Start	Finish
1	Final Remedial Design Report	Tue 12/31/02	Tue 12/31/02
2			
3	Permitting for Zone A RO Plant	Tue 1/7/03	Thu 6/23/05
4	Phase I Completion of Feed & Permeate Piping Design	Mon 1/6/03	Mon 3/3/03
5	Phase I Completion of Detailed Design	Mon 1/6/03	Mon 3/31/03
6	Phase I Construction	Mon 2/3/03	Mon 6/30/03
7	Phase I Installation of Feed and Permeate Piping	Tue 3/4/03	Sat 5/31/03
8	Phase I Pre-Op Testing and Start-Up	Tue 7/1/03	Fri 8/29/03
9	Phase II Detailed Design	Wed 10/1/03	Mon 3/1/04
10	Phase II Construction	Fri 1/30/04	Mon 10/25/04
11	Phase II Pre-Op and Start-Up	Tue 10/26/04	Thu 12/23/04
12	Phase III Piping Design Sulfate & CW Well	Tue 3/4/03	Thu 5/1/03
13	Phase III Piping Installation Sulfate and CW Well	Fri 5/2/03	Wed 7/30/03
14	Phase III Detailed Design	Tue 3/2/04	Mon 8/2/04
15	Phase III Construction	Sat 6/26/04	Thu 3/24/05
16	Phase III Pre-Op Testing and Start-Up	Fri 3/25/05	Wed 6/22/05
17	Start Full Scale Production of Drinking Water	Thu 6/23/05	Thu 6/23/05
18	Zone A RO Plant - Optimization	Thu 6/23/05	Mon 12/19/05
19	Deliver Drinking Water To JVWCD	Mon 12/19/05	Mon 12/19/05
20			
21	Install pipeline from Acid Well No.1 to Acid Well 1146	Mon 1/6/03	Wed 3/26/03
22	Install Acid Well No.1	Thu 3/27/03	Wed 5/7/03
23	Begin Operation of Acid Well No.1 at ~500 gpm	Mon 5/12/03	Mon 5/12/03
24	Operation of Acid Well No.1 between 500 gpm and 1000 gpm	Wed 5/14/03	Tue 1/1/08
25	Operation of Acid Well 1146,currently at 900 gpm	Mon 1/6/03	Tue 1/1/08
26	Operation of Sulfate Containment Well BFG1200 at ~1100 gpm	Wed 1/1/03	Thu 12/27/07
27	Operation of Sulfate Containment Well B2G1193 at ~1100 gpm	Wed 1/1/03	Thu 12/27/07
28	Operation of Sulfate Containment Well LTG1147 at ~1100 gpm	Thu 6/23/05	Tue 1/1/08
29	Install pipeline for Acid Well No.2	Mon 7/2/07	Fri 9/21/07
30	Install Acid Well No.2	Mon 9/24/07	Fri 11/2/07
31	Begin Operation of Acid Well No.2 at between 500 gpm and 1000 gpm	Mon 11/5/07	Tue 1/1/08
32			
33	Groundwater Monitoring	Wed 1/1/03	Thu 12/27/07
34	Groundwater Modeling	Wed 1/1/03	Thu 12/27/07
35	Annual Groundwater Monitoring and Modeling Report	Wed 10/1/03	Mon 10/1/07
36	1	Wed 10/1/03	Wed 10/1/03
37	2	Fri 10/1/04	Fri 10/1/04
38	3	Mon 10/3/05	Mon 10/3/05
39	4	Mon 10/2/06	Fri 10/20/06
40	5	Mon 10/1/07	Mon 10/1/07
41	Tailings Monitoring	Wed 1/1/03	Thu 12/27/07
42	Annual Tailings Monitoring Report	Wed 10/1/03	Mon 10/1/07
43	1	Wed 10/1/03	Wed 10/1/03
44	2	Fri 10/1/04	Fri 10/1/04
45	3	Mon 10/3/05	Mon 10/3/05
46	4	Mon 10/2/06	Fri 10/20/06
47	5	Mon 10/1/07	Mon 10/1/07
48	Update Prelim Post Closure Water Mgm Plan	Tue 1/7/03	Wed 1/2/08
49	Five Year Review Report	Wed 1/2/08	Wed 1/2/08



8.0 REFERENCES

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