KAISER
ALUMINUM

MEAD WORKS

Paul Skyllingstad
Washington Department of Ecology
Industrial Section
P.O. Box 47706
Olympia, WA 98504-7706

February 26, 2001

Dear Paul:

Per our February 9, 2001 letter and subsequent communications, Kaiser has prepared a technical memorandum that evaluates potential groundwater extraction alternatives at the Mead Works. Two copies of the technical memorandum are enclosed for your review.

Two groundwater extraction alternatives were investigated as part of this evaluation. The first (identified as Alternative 1 in the technical memorandum) was based on focused groundwater extraction in the immediate vicinity of the source areas as a supplement to the source control measures currently being implemented at the facility. The second (Alternative 2) involved groundwater extraction at a rate sufficient to hydraulically capture the cyanide and fluoride plume downgradient of the source areas. The groundwater modeling results previously submitted to Ecology (*Technical Memorandum – Evaluation of Groundwater Extraction and Re-injection Alternatives*, Kaiser Mead Works, MFG, Inc., December 14, 2000) identified the most appropriate groundwater extraction rates for these purposes as 25 gpm (Alternative 1) and 330 gpm (Alternative 2). These flow rates served as the basis for the evaluation of alternatives presented in this technical memorandum.

The evaluation concluded that focused groundwater extraction at a rate of 25 gpm as a supplement to the proposed source controls was the most economical approach to achieving site groundwater cleanup objectives. The incremental cost associated with the higher groundwater extraction rate required to achieve hydraulic capture of the plume was found to be substantial and disproportionate to the incremental degree of protection such an approach would achieve over the recommended focused groundwater extraction approach.

It should be noted that this technical memorandum primarily addresses the economic justification for selecting 25 gpm as the groundwater extraction rate for the site. The groundwater modeling results presented in the December 14, 2000 technical memorandum clearly indicate that source control measures, supplemented as necessary by focused groundwater extraction at 25 gpm, is capable of achieving groundwater clean-up objectives at the site. We would be happy to meet with you and your staff and provide additional data if necessary to facilitate Ecology's review and approval of the groundwater modeling results.

In addition, the December 14, 2000 technical memorandum concluded that the source control measures currently being implemented at the facility are the primary component of the overall approach to attaining groundwater cleanup objectives at the site. Hydrogeologic conditions at the site suggest that improvements to groundwater quality provided by the source controls should become apparent within two years of implementation. Kaiser recommends that groundwater monitoring continue to be performed at the site for a period of two years after the source control measures have been completed. At that time, construction of a focused groundwater extraction system (sized for 25 gpm) in the vicinity of the source areas will be initiated if necessary to supplement the source controls. Compliance groundwater monitoring recommendations for the site are discussed in detail in the December 14, 2000 technical memorandum.

It is important that Kaiser and Ecology reach agreement regarding the groundwater extraction approach proposed for the site prior to designing the groundwater extraction and treatment system. Kaiser does not believe it would be prudent to proceed further in designing the system until we have received Ecology approval of the proposed groundwater extraction approach. We look forward to reaching an agreement on this issue.

Please do not hesitate to contact me at 509-468-5493 if you have any questions or would like to discuss this information in greater detail. Thank you for your consideration of these issues.

Sincerely,

David A. Sprecher
for

Michael Sawatzky
Laboratory and Environmental Manager

cc:
B. P. Leber, KACC
D. Sprecher, KACC
D. Lambert, MFG Inc.

TECHNICAL MEMORANDUM

BASIS FOR
GROUNDWATER EXTRACTION
RATE

KAISER MEAD WORKS

February 22, 2001

Prepared for:

Kaiser Aluminum & Chemical Corporation
2111 East Hawthorne Road
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Prepared by:

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1.0 INTRODUCTION

Kaiser Aluminum & Chemical Corporation (Kaiser) owns and operates a primary aluminum smelter (Mead Works) located at East 2111 Hawthorne Road in Mead, Washington. Previous studies conducted at the Mead Works have found elevated levels of cyanide and fluoride in soil and groundwater at the facility. As a result of these studies, Kaiser and the Washington Department of Ecology (Ecology) entered into Agreed Order Number DE 99TCPIS-95 on January 10, 2000 which addresses potential cleanup actions at the Mead Works.

Kaiser is currently implementing cleanup actions at the Mead Works in accordance with the agreed order. Kaiser has proposed a combination of source control measures supplemented by groundwater extraction and treatment to achieve the groundwater cleanup objectives identified for the facility. Information regarding proposed source control measures was submitted previously by Kaiser to Ecology (MFG, 2000a; MFG, 2000b). The purpose of this technical memorandum is to identify the most appropriate rate of groundwater extraction for the groundwater extraction and treatment portion of the cleanup action.

2.0 SOURCE CONTROL MEASURES

Kaiser is in the process of implementing source control measures in the vicinity of potential cyanide and fluoride source areas (Rubble Pile, Butt Tailings Pile, Asphalt-covered Potlining Pile) to minimize transport of these constituents to groundwater via infiltration through contaminated soils. Source control measures to be implemented at the facility include:

- Control of infiltration due to leaks in underground utility piping near the piles; and
- Consolidation of the piles and construction of a multi-component cap over the consolidated materials to control surface water infiltration.

Figure 1 shows the approximate extent of the piles and the proposed multi-component cap.

2.1 Underground Piping

Kaiser performed an ultrasonic and video inspection of underground piping near the piles in early 2000 to identify leaking pipes that may be transporting contamination from soil beneath the piles to the underlying groundwater (MFG, 2000a). Pressure piping (water distribution, steam and condensate lines) and gravity piping (stormwater and sanitary sewer lines) near the piles were investigated and segments of deteriorated/leaking piping were identified. Recommendations for repair, replacement and lining of the deteriorated pipe segments were summarized in a technical memorandum to Ecology. Implementation of these improvements is proceeding on an accelerated schedule.

2.2 Multi-component Cap

Kaiser is constructing a multi-component cap over potential cyanide and fluoride source areas to reduce surface water infiltration through these materials (MFG, 2000b). The Rubble Pile, Butt Tailings Pile and Asphalt-covered Potlining Pile will be consolidated, graded to promote drainage away from the area, and covered with a cap equivalent to the requirements specified in Chapter 173-303WAC. The cap will consist of the following:

- A 12-inch (minimum) foundation layer comprised of butt-tailings and sand will be placed to grade the consolidated piles and provide a level foundation for the overlying cap materials;
- A geosynthetic clay liner (GCL) will be placed above the foundation layer. The GCL will consist of a layer of sodium bentonite between two geotextiles and will provide a low permeability layer that is equivalent to a compacted soil liner;

- A geomembrane liner will be placed over the GCL. The liner will be constructed of 60 mil high density polyethylene (HDPE);

- A 2-foot thick drainage layer of course sand and gravel will be placed over the HDPE liner to convey infiltrating water off of the cap;

- A geotextile will be placed over the drainage layer to minimize migration of fine soil particles into the drainage layer; and

- A 12-inch thick gravel and rock cover layer will be placed over the geotextile to prevent erosion and (along with the drainage layer) protect the GCL from frost penetration.

2.3 Effect of Source Controls on Groundwater Quality

Groundwater occurs at the site at approximately 150 feet below ground surface and is present in three transmissive zones. The uppermost zone (Zone A) is comprised of fine to coarse sand. A silty-clay layer separates Zone A from the middle transmissive zone (Zone B) which is comprised of fine to medium sand. A clay layer separates Zone B from the lower transmissive zone (Zone C), which is comprised of medium to coarse sand and gravel.

These transmissive zones are highly conductive (on the order of 1×10^{-2} centimeters per second or greater) and groundwater moves into and out of the area beneath the piles at a relatively high rate (on the order of 8 to 16 feet per day or greater). The large quantity of groundwater that moves through the aquifer beneath the site suggests that contaminants released to the groundwater from overlying source areas should be readily attenuated; however, groundwater beneath the piles consistently exhibits elevated concentrations of cyanide and fluoride. This indicates that an ongoing source of cyanide and fluoride is present in the vicinity of the piles and this source is likely responsible for maintaining the cyanide and fluoride concentrations observed in the groundwater beneath and downgradient of the pile area.

Implementation of the source controls discussed earlier is expected to significantly reduce the mass of cyanide and fluoride that infiltrates into the groundwater beneath the piles. A reduction in the infiltration of cyanide and fluoride into the groundwater should result in a corresponding decrease in groundwater cyanide and fluoride concentrations as groundwater moves through the area. Since both cyanide and fluoride are relatively conservative in groundwater (i.e., they pass through the aquifer leaving little or no residual concentrations sorbed onto the aquifer materials), a complete elimination of ongoing sources (i.e. 100 percent effectiveness for the source control measures) would ultimately result in little or no cyanide or fluoride being present in the groundwater (given sufficient time for the groundwater system to attenuate the contaminants currently present in the groundwater). Decreased source reduction effectiveness may result in measurable concentrations of cyanide and fluoride continuing to be present in the groundwater, but at significantly lower concentrations than under current conditions.

The hydrogeologic conditions in the vicinity of the site suggest that source control measures alone may be able to achieve the groundwater cleanup objectives; however, the effectiveness of the source control measures at reducing infiltration will have a direct effect on long-term groundwater cyanide and fluoride concentrations beneath and down gradient of the piles. Groundwater extraction may be appropriate as a supplement to the proposed source controls in the event that the source controls are not sufficiently effective in lowering groundwater concentrations in the aquifer.

3.0 GROUNDWATER EXTRACTION ALTERNATIVES

Groundwater extraction could be implemented at the Mead Works to address two objectives. The first would be to remove cyanide and fluoride mass from the groundwater in the immediate vicinity of the piles to assist the source control measures in reducing overall contaminant concentrations in the plume. The second would be to extract groundwater at a rate sufficient to hydraulically control the migration of the plume.

Two alternative groundwater extraction scenarios were investigated as part of this evaluation. The first alternative (Alternative 1) focuses on extracting groundwater at a low rate near the piles as a supplement to the proposed source control measures. The second approach (Alternative 2) focuses on extracting sufficient groundwater to capture the cyanide and fluoride plumes downgradient of the piles as a direct means of reducing the potential for migration of these constituents.

3.1 Alternative 1 - Focused Groundwater Extraction

Figure 2 shows the proposed configuration of the first groundwater extraction alternative. Under Alternative 1, groundwater will be extracted at a low rate from a line of five extraction wells installed immediately adjacent to the piles. Extracted groundwater will be treated in an on-site treatment system for cyanide and fluoride removal and reinjected into the aquifer upgradient of the piles. A groundwater extraction rate of 25 gallons per minute (gpm) was assumed for this alternative.

Groundwater data from the site suggest that a degree of chemical stratification may be present at the base of the uppermost transmissive zone (Zone A) in the immediate vicinity of the piles. Higher cyanide, fluoride and dissolved solids concentrations were observed in groundwater samples collected from the base of Zone A compared to samples collected from the upper portions of Zone A. This chemical stratification may be related to density effects associated with the higher dissolved solids content of the groundwater at the base of Zone A and stratigraphic conditions that result in an accumulation of the denser water in this area. Focused groundwater extraction near the piles will address this accumulation of groundwater containing higher cyanide and fluoride concentrations. Extracting groundwater at a low rate near the piles will result in the removal of an appreciable mass of cyanide and fluoride (estimated to be approximately 9,800 pounds per year of cyanide and 13,100 pounds per year of fluoride at typical concentrations (90 mg/L and 120 mg/L, respectively) observed for these constituents in this area of the groundwater plume), while minimizing the extraction of more dilute groundwater that may be pulled into this area under higher extraction rates.

3.2 Alternative 2- Groundwater Extraction for Hydraulic Control

Figure 3 shows the proposed configuration of the components of the second groundwater extraction alternative. Under Alternative 2, a high rate of groundwater will be extracted from a line of eight extraction wells downgradient of the piles. As with Alternative 1, the extracted groundwater will be treated in an on-site treatment system for cyanide and fluoride removal and reinjected into the aquifer upgradient of the piles. A groundwater extraction rate of 330 gpm was estimated to be the minimum rate required to achieve hydraulic control of the plume downgradient of the piles.

3.3 Groundwater Treatment System

Groundwater extracted under either alternative will require treatment prior to reinjection. For the purposes of this evaluation, it was assumed that chemical precipitation will be used to remove cyanide and fluoride from the groundwater. Calcium chloride (CaCl2) will be added to precipitate fluoride from the water and ferrous iron (from either ferrous chloride (FeCl2) of ferrous sulfate (FeSO4)) will be added to precipitate cyanide from the water. Bench-scale testing of various potential treatment technologies indicated that chemical precipitation is the most effective means of treating cyanide and fluoride; however, it should be noted that Kaiser is currently evaluating a promising technology using reverse osmosis that may provide a cost effective alternative to chemical precipitation. Since the effectiveness of reverse osmosis on groundwater at the site has not been determined, chemical precipitation was incorporated as the treatment technology for the purposes of estimating costs associated with the groundwater alternatives. Figure 4 shows a simplified process flow schematic for the chemical precipitation system used as part of this evaluation.

4.0 EVALUATION OF GROUNDWATER EXTRACTION ALTERNATIVES

Alternative 1 is designed to achieve groundwater cleanup objectives through a combination of source control measures and focused groundwater extraction near the source areas. The success of this alternative will be a function of the success of the proposed source controls and the additional cyanide and fluoride mass removal provided by the groundwater extraction system to supplement the source controls. Alternative 2 is designed to achieve groundwater cleanup objectives through hydraulic control of the cyanide and fluoride plume downgradient of the pile area. The success of this alternative will be determined by the rate of groundwater extraction necessary to alter the natural groundwater gradient in the area (The groundwater extraction rate required to achieve this is estimated to be 330 gpm; however, the actual rate could be higher).

There is some degree of uncertainty associated with the overall effectiveness of either of the alternatives due to potential variations in actual field conditions; however, based on information collected to date from the site, both alternatives appear to have a good chance of achieving the cleanup objectives. For the purposes of this evaluation, it was assumed that the effectiveness of the two alternatives would be approximately equivalent, i.e. it was assumed that both would be able to achieve the groundwater cleanup objectives.

The primary difference between the two alternatives is cost. Tables 1 and 2 summarize estimated 30-year present worth costs for Alternatives 1 and 2, respectively. The estimated 30-year present worth costs for the alternatives are as follows:

- Alternative 1 - $13,400,000
- Alternative 2 - $66,300,000

The specific system characteristics which provided the basis for the estimates are summarized in Appendix A.

It should be noted that the costs were estimated based on the following general assumptions. If field conditions are different from the assumptions used, actual system costs could vary significantly from the estimates presented herein.

- The basic design parameters used to develop the cost estimates for the two systems were as follows:

Parameter	Alternative 1	Alternative 2
Flow rate (gpm)	25	330
Influent Cyanide Concentration (mg/L)	90	30
Effluent Cyanide Concentration (mg/L)	1	1
Influent Fluoride Concentration (mg/L)	120	40
Effluent Fluoride Concentration (mg/L)	15	15

- An interest rate of 5 percent was used in estimating the 30-year present worth cost for each alternative.

- Groundwater concentrations (and associated chemical usage and sludge generation rates) are assumed to be constant throughout the 30-year period. If groundwater concentrations decrease with time, annual operating costs will also likely decrease.

- Sludge generated from the precipitation system was assumed to be classified as a non-hazardous industrial waste. If the sludge were classified as hazardous, costs associated with sludge management would increase significantly (Estimated 30-year present worth costs of $19,700,000 and $87,400,000 for Alternatives 1 and 2, respectively, including management of the sludge as a hazardous waste).

- A groundwater extraction rate of 330 gpm was assumed to be sufficient to achieve hydraulic control of the groundwater plume; however, due to the high rate of groundwater movement through the area, higher rates of groundwater extraction may be required. System costs would increase if higher extraction rates are required.

It should also be noted that construction of a chemical precipitation system to treat 330 gpm of water containing cyanide and fluoride would stretch the feasibility limits of the technology. This is primarily due to the large quantities of chemicals required to precipitate cyanide and fluoride and the large volume of sludge generated by the process.

5.0 CONCLUSIONS

This technical memorandum was prepared to present the results of an evaluation of potential groundwater extraction alternatives at the Kaiser Mead Works. Two groundwater extraction alternatives were evaluated. Alternative 1 focused on a low rate of groundwater extraction (25 gpm) as a supplement to the source control measures proposed for the facility. Alternative 2 focused on extracting sufficient groundwater (330 gpm or more) to capture the cyanide and fluoride plume downgradient of the source areas.

The evaluation concluded that the most appropriate groundwater extraction approach for the site is to implement focused groundwater extraction (25 gpm) as a supplement to source controls. This conclusion is supported by the following:

- Both Alternative 1 and Alternative 2 are capable of achieving groundwater cleanup objectives for the site, Alternative 1 through a combination of groundwater extraction and source control and Alternative 2 by achieving hydraulic control of the plume.

- The 30-year present worth cost for each alternative (assuming non-hazardous sludge from the groundwater treatment system) was estimated to be as follows:

  - Alternative 1 - $13,400,000

  - Alternative 2 - $66,300,000

  If sludge generated by the groundwater treatment system was to be classified as a hazardous waste, the 30-year present worth costs for the alternatives increase to $19,700,000 (Alternative 1) and $87,400,000 (Alternative 2).

- Construction of a chemical precipitation plant to treat 330 gpm of groundwater containing cyanide and fluoride stretches the feasibility limits of the technology due to the large quantity of chemicals required and the significant amount of sludge generated.

- Alternative 1 will address areas of high cyanide and fluoride concentrations that may be present at the base of Zone A by focusing groundwater extraction in this area.

- The additional cost of a groundwater extraction system sized to achieve hydraulic control of the plume (Alternative 2) is unlikely to result in a significant improvement in groundwater quality at the facility. A lesser rate of groundwater extraction (Alternative 1) as a supplement to source control measures is expected to achieve an equivalent level of compliance with the groundwater cleanup objectives.

It is recommended that groundwater be extracted at a rate of 25 gpm from the immediate vicinity of the piles to supplement source control measures currently being implemented at the site. This focused groundwater extraction approach will address areas of high cyanide and fluoride concentrations which may be present at the base of Zone A and, in combination with source controls, is capable of achieving site groundwater cleanup objectives. The incremental degree of cost associated with a groundwater extraction rate sufficient to provide hydraulic control at the site is substantial and disproportionate to the incremental degree of protection such an approach would achieve over the proposed focused groundwater extraction approach. In addition, a cyanide and fluoride chemical precipitation system designed for 25 gpm can be implemented within the limits of technical and economic feasibility and sizing the system for this flow rate keeps open the possibility of using alternative groundwater treatment technologies (i.e. reverse osmosis) that would not be feasible under higher groundwater extraction rates. Kaiser will continue to investigate the use of alternative groundwater treatment technologies such as reverse osmosis in an effort to reduce the costs associated with the system; however, any potential reduction in costs realized through the use of an alternative treatment technology are not expected to change the conclusions of this evaluation.

6.0 REFERENCES

MFG, Inc. and Unifield Engineering, 2000a, *Letter report, Kaiser Mead Works Pipe leak and Groundwater Infiltration Evaluation*, May.

MFG, Inc., 2000b, *SPL Remediation Engineering Design Report - Kaiser Mead Works*, September.

TABLES

Table 1

Kaiser Aluminum - Mead, Works
Groundwater Extraction and Treatment
Chemical Precipitation - 25 gpm System
Capital and Annual Cost Summary

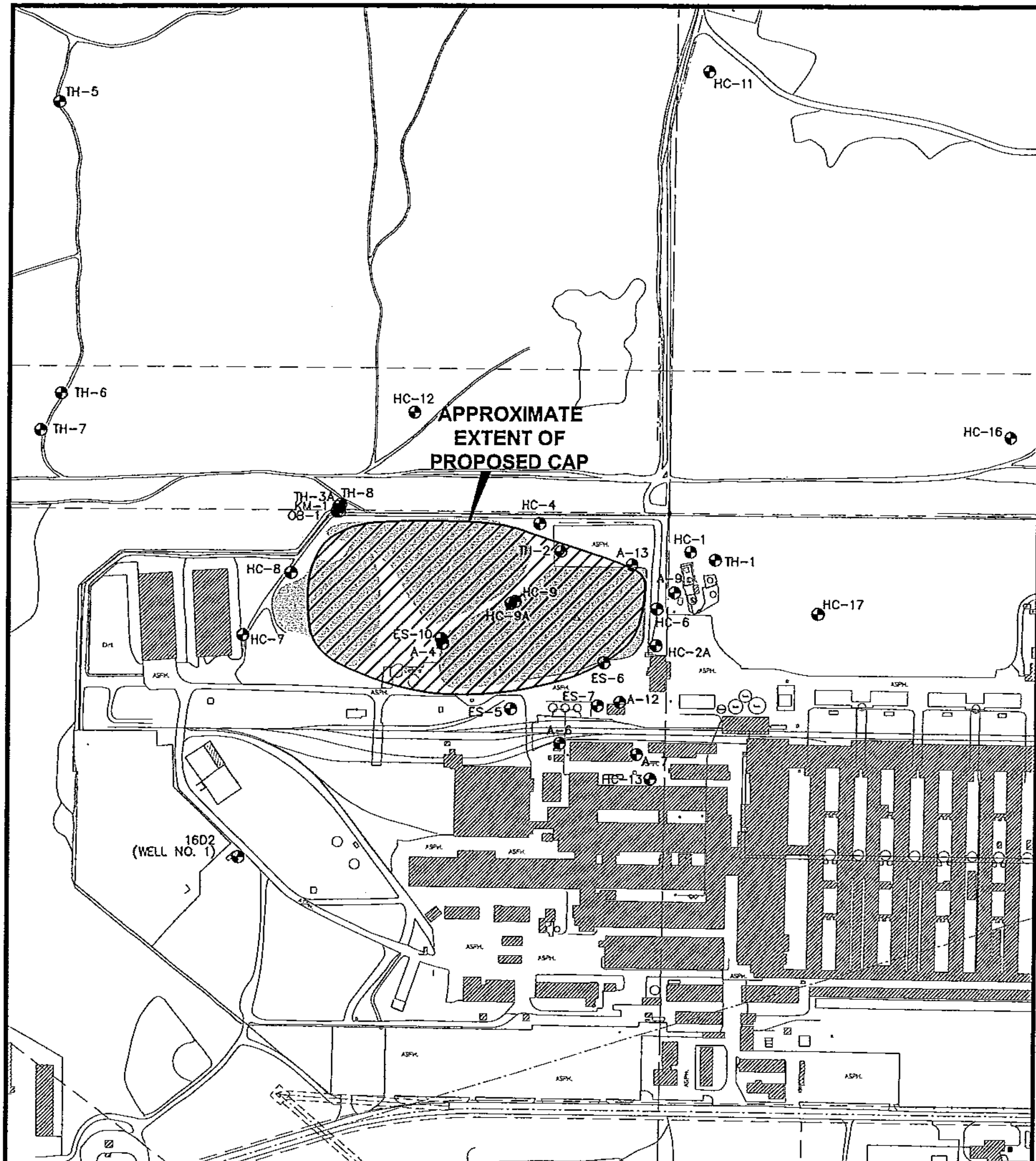
Cost Element	Estimated Costs Capital	Annual O&M	Comments
Contractor Mobilization/ General Costs	$50,000	$0	Assume 5 percent of total cost
Groundwater Extraction System, w/pumps, piping	$120,000	$10,000	25 gpm extraction system, with 5 wells, pumps, and piping
Cyanide and Fluoride Precipitation System	$415,000	$392,000	25 gpm package system, assumes non-haz sludge at $125/ton
Piping, Pumps, Misc.	$50,000	$10,000	Misc. In-plant equip.
Controls	$100,000	$10,000	System controls.
Electrical	$150,000	$99,000	Assumes power available on-site, 100 Hp total system @ $0.15/KWh
Treatment Building	$50,000	$10,000	Modifications to Existing Building
Treated Water Reinjection System	$110,000	$5,000	25 gpm injection system, with 5 wells and piping
Other System Operation & Maintenance	—	$124,000	Operators on-site avg 40 man hrs/week @ $50/hr
Subtotal:	$1,045,000	$660,000	
Construction Oversight (10%):	$100,000	—	
Subtotal:	$1,145,000	$660,000	
Contingency (10%):	$110,000	$130,000	
Total Estimated Costs	**$1,255,000**	**$790,000**	
Total 30-year Present Worth Cost (I=5%)		**$13,400,000**	
30-year Present Worth Cost if Hazardous Sludge		**$19,700,000**	Assumes Sludge is hazardous and can be disposed of for $500/ton

Table 2

Kaiser Aluminum - Mead, Works
Groundwater Extraction and Treatment
Chemical Precipitation - 330 gpm System
Capital and Annual Cost Summary

Cost Element	Estimated Costs Capital	Annual O&M	Comments
Contractor Mobilization/ General Costs	$110,000	$0	Assume 5 percent of total cost
Groundwater Extraction System, w/pumps, piping	$210,000	$20,000	330 gpm extraction system, with 8 wells, pumps, and piping
Cyanide and Fluoride Precipitation System	$1,250,000	$2,018,000	330 gpm package system, assumes non-haz sludge at $125/ton
Piping, Pumps, Misc.	$100,000	$10,000	Misc. In-plant equip.
Controls	$150,000	$10,000	System controls.
Electrical	$400,000	$975,000	Assumes power available on-site, 1000 Hp total system @ $0.15/KWh
Treatment Building	$650,000	$10,000	New Building, 150 ft X 100 ft
Treated Water Reinjection System	$130,000	$5,000	330 gpm injection system, with 5 wells and piping
Other System Operation & Maintenance	—	$352,000	Operators on-site avg 120 man hrs/week @ $50/hr
Subtotal:	$3,000,000	$3,400,000	
Construction Oversight (10%):	$300,000	—	
Subtotal:	$3,300,000	$3,400,000	
Contingency (10%):	$330,000	$680,000	
Total Estimated Costs	**$3,630,000**	**$4,080,000**	
Total 30-year Present Worth Cost (I=5%)		**$66,300,000**	
30-year Present Worth Cost if Hazardous Sludge		**$87,400,000**	Assumes Sludge is hazardous and can be disposed of for $500/ton

FIGURES



EXPLANATION

HC-8 Monitoring Well

Locations of Butt Tailing, Rubble and SPL Piles

N

Scale in Feet

0 250 500

Source:
Base map taken from Adams & Clark, Inc. Surveyed Map, November 8, 2000.

KAISER ALUMINUM - MEAD FACILITY

Figure 1

PROPOSED CAP CONFIGURATION

PROJECT: 020055	BY: ZGK	REVISIONS
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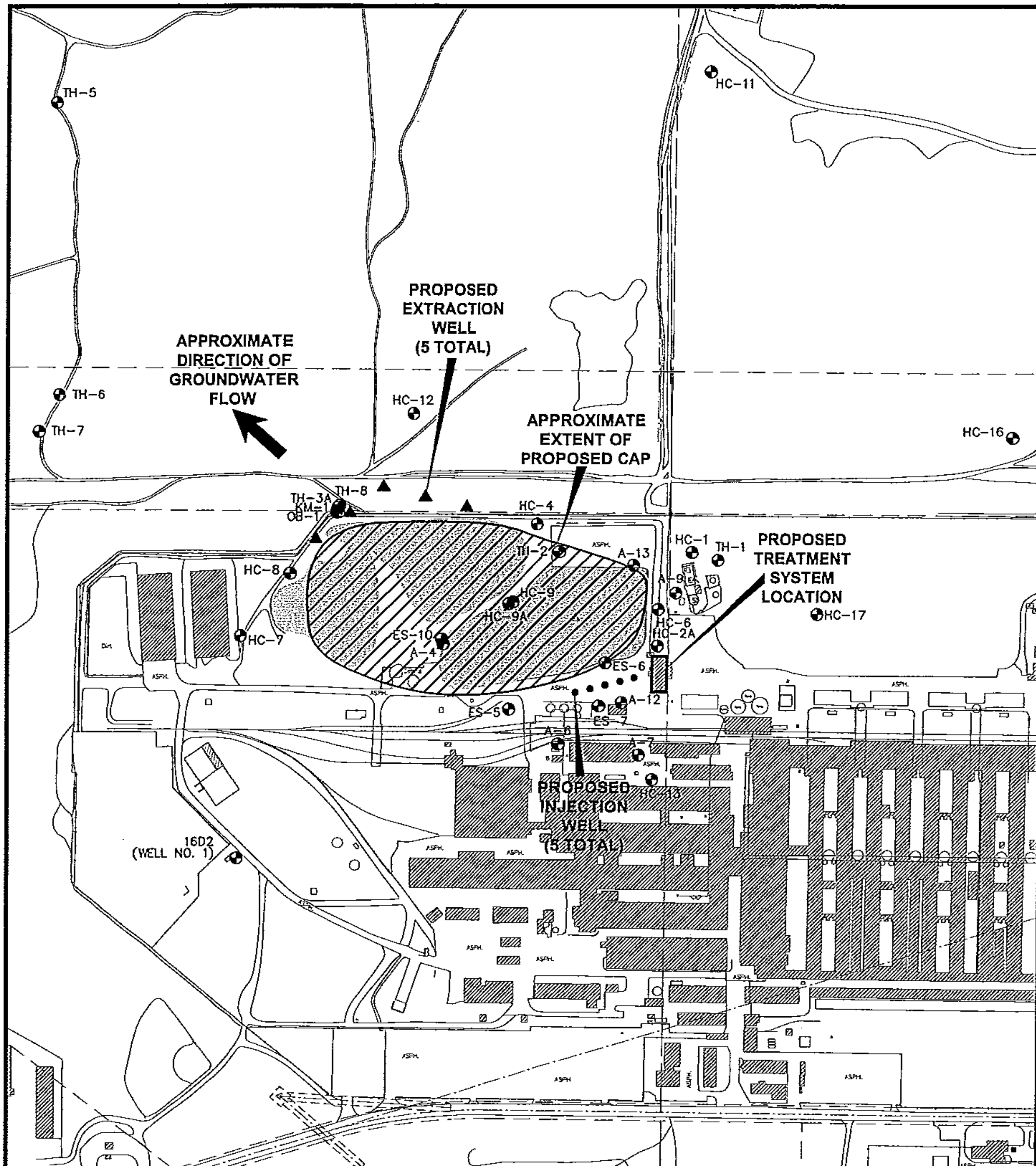

EXPLANATION

HC-8 Monitoring Well

Locations of Butt Tailing, Rubble and SPL Piles

N

Scale in Feet

0 250 500

Source:
Base map taken from Adams & Clark, Inc. Surveyed Map, November 8, 2000.

KAISER ALUMINUM - MEAD FACILITY

Figure 2

ALTERNATIVE 1 FOCUSED GROUNDWATER EXTRACTION

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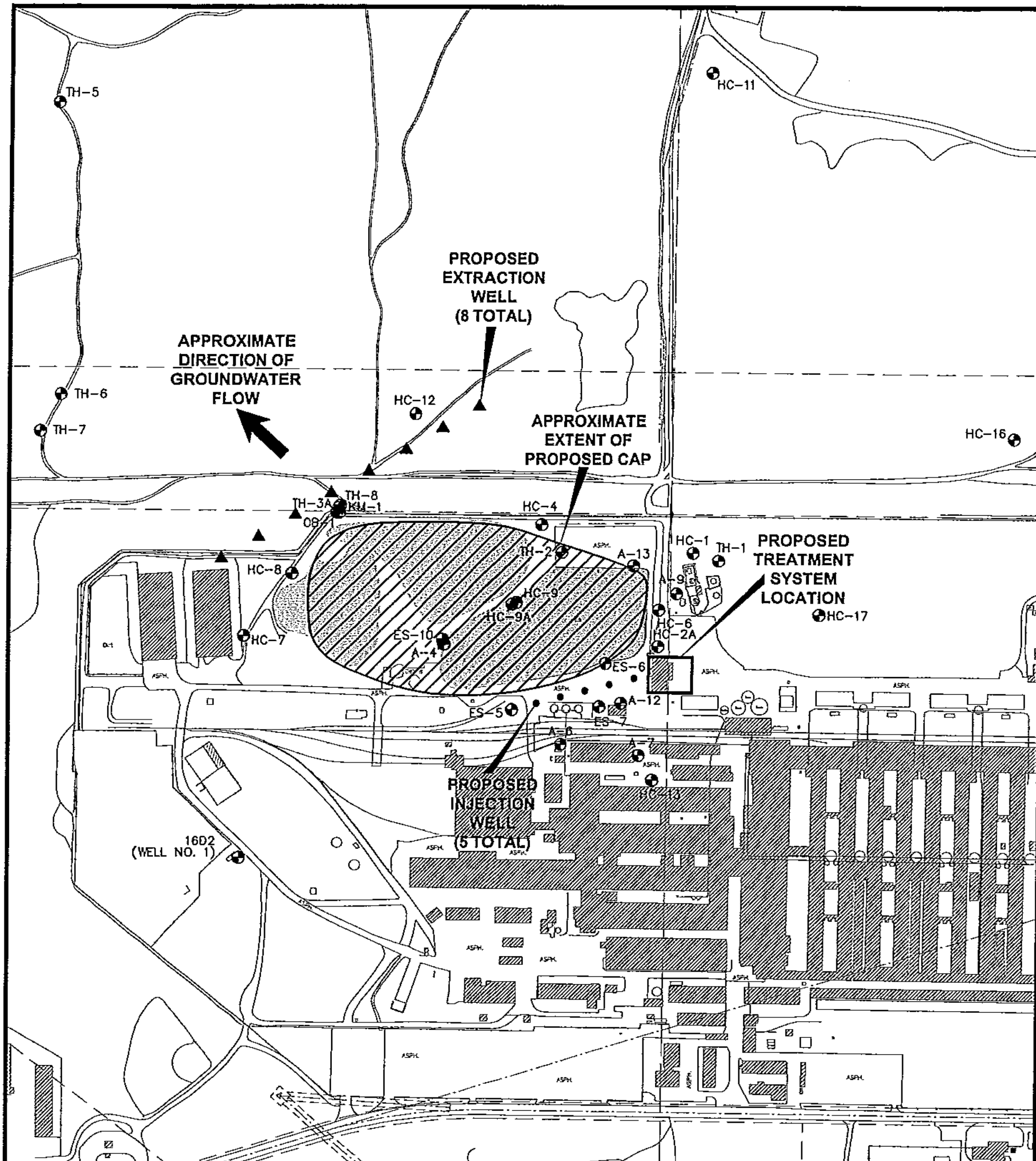

EXPLANATION

HC-8 Monitoring Well

Locations of Butt Tailing, Rubble and SPL Piles

Source:
Base map taken from Adams & Clark, Inc. Surveyed Map, November 8, 2000.

KAISER ALUMINUM - MEAD FACILITY		
Figure 3 **ALTERNATIVE 2 GROUNDWATER EXTRACTION FOR HYDRAULIC CONTROL**		
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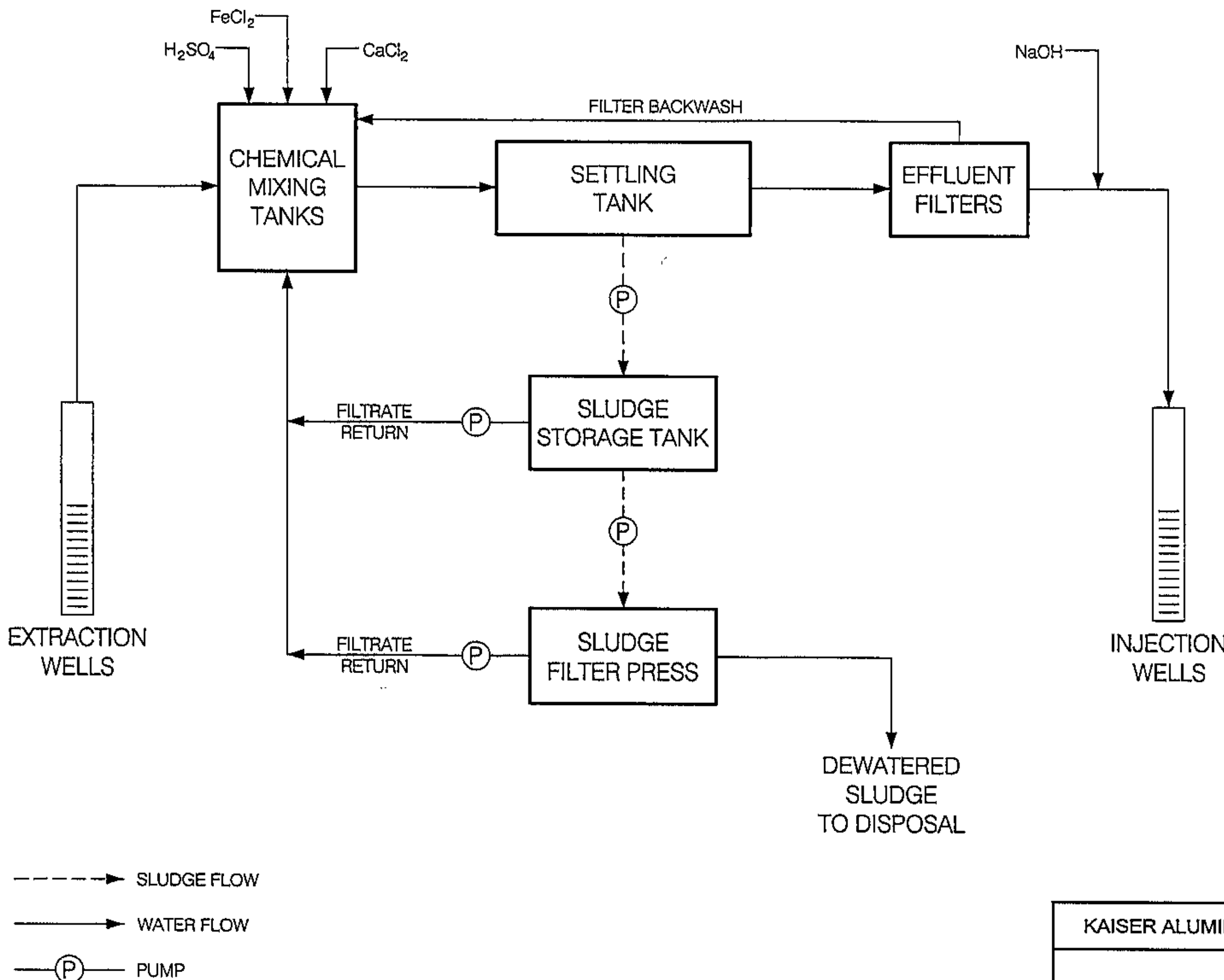

KAISER ALUMINUM - MEAD FACILITY		
Figure 4 **SIMPLIFIED GROUNDWATER TREATMENT SCHEMATIC**		
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APPENDIX A

COST ESTIMATE DETAILS

February 22, 2001

Kaiser Aluminum - Mead, Works
Groundwater Extraction and Treatment
Chemical Precipitation - 25 gpm System
Capital and Annual Cost Details

ITEMS	QUANTITY	UNIT	UNIT COST	ESTIMATED COSTS CAPITAL	ANNUAL O&M
Groundwater Extraction System					
Extraction Wells - 5, 150 ft deep, 8 inch	5	ea	$20,000	$100,000	—
Associated piping and pumps	1	LS		$20,000	—
Maintenance	1	LS		—	$10,000
Subtotal Extraction System				**$120,000**	**$10,000**
Chemical Precipitation System - Cyanide and Fluoride Removal					
Ferrous Chloride (FeCl2) and Calcium Chloride (CaCl2)					
Package System for 25 gpm, Includes chem mix, floc/precip tank, filters, pumps, sludge tank, sludge filter press	1	LS		$250,000	—
Chemical Storage/Feed Systems	1	LS		$100,000	—
Backwash tank, pumps	1	LS		$15,000	—
Equipment Installation	1	LS		$50,000	—
Chemical Usage					
- FeCl2, assume 550 lb FeCl2/day (dry wt), add 1.25 SF	125	TONS	$350	—	$43,750
- CaCl2, assume 1400 lb $CaCl_2$/day (dry wt), add 1.25 SF	325	TONS	$350	—	$113,750
- H2SO4, assume 500 lb 98% H2SO4/day (dry), add 1.25 SF	115	TONS	$300	—	$34,500
- NaOH	1	LS	$15,000	—	$15,000
- Polymer	1	LS	$35,000	—	$35,000
Equipment Maintenance	1	LS	$10,000	—	$10,000
Sludge Disposal, assume 3 tons/day (wet weight) (includes transport and disposal as non-haz waste)	1,100	TONS	$125	—	$140,000
Subtotal Cyanide Precipitation System				**$415,000**	**$392,000**
Piping, Pumps, Misc. Mechanical	**1**	**LS**	**$50,000**	**$50,000**	**$10,000**
Controls	**1**	**LS**	**$100,000**	**$100,000**	**$10,000**
Electrical					
Installation (30% of Equip & Controls)	1	LS	$150,000	$150,000	—
Power Costs (100 Hp = 75 KW total system)	660,000	KWH	$0.15	—	$99,000
Subtotal Electrical				**$150,000**	**$99,000**
Treatment Building					
Assume Use existing Building					
Misc. Bldg Modifications	1	LS	$25,000	$25,000	$5,000
Misc Sitework, Ventilation, Lighting, etc.	1	LS	$25,000	$25,000	$5,000
Subtotal Treatment Building				**$50,000**	**$10,000**
Treated Water Reinjection System					
Injection Wells	5	ea	$20,000	$100,000	$5,000
Associated piping and pumps	1	LS	$10,000	$10,000	—
Subtotal Treated Water Reinjection				**$110,000**	**$5,000**
Other O&M					
Personnel (Kaiser personnel on-site, avg 40 man hrs/wk)	2,080	man-hrs	$50	—	$104,000
Misc. Maint.	1	LS	$20,000	—	$20,000
Subtotal Other O&M				—	**$124,000**
Additional Cost if Sludge is Hazardous					
Sludge Disposal, assume 3 tons/day (wet weight) (includes transport and disposal as hazardous waste)	1,100	TONS	$500	—	**$550,000**

Kaiser Aluminum - Mead, Works
Groundwater Extraction and Treatment
Chemical Precipitation - 330 gpm System
Capital and Annual Cost Details

ITEMS	QUANTITY	UNIT	UNIT COST	ESTIMATED COSTS CAPITAL	ANNUAL O&M
Groundwater Extraction System					
Extraction Wells - 8, 150 ft deep, 8 inch	8	ea	$20,000	$160,000	—
Associated piping and pumps	1	LS		$50,000	—
Maintenance	1	LS		—	$20,000
Subtotal Extraction System				**$210,000**	**$20,000**
Chemical Precipitation System - Cyanide and Fluoride Removal					
Ferrous Chloride (FeCl2) and Calcium Chloride (CaCl2)					
Package System for 330 gpm, Includes chem mix, floc/precip tank, filters, pumps, sludge tank, sludge filter press	1	LS		$750,000	—
Chemical Storage/Feed Systems	1	LS		$300,000	—
Backwash tank, pumps	1	LS		$50,000	—
Equipment Installation	1	LS		$150,000	—
Chemical Usage					
- FeCl2, assume 3400 lb FeCl2/day (dry wt), add 1.25 SF	780	TONS	$350	—	$273,000
- CaCl2, assume 8000 lb $CaCl_2$/day (dry wt), add 1.25 SF	1,800	TONS	$350	—	$630,000
- H2SO4, assume 5000 lb 98% H2SO4/day (dry), add 1.25 SF	1,100	TONS	$300	—	$330,000
- NaOH	1	LS	$100,000	—	$100,000
- Polymer	1	LS	$200,000	—	$200,000
Equipment Maintenance	1	LS	$25,000	—	$25,000
Sludge Disposal, assume 10 tons/day (wet weight) (includes transport and disposal as non-haz waste)	3,650	TONS	$125	—	$460,000
Subtotal Chemical Precipitation System				**$1,250,000**	**$2,018,000**
Piping, Pumps, Misc. Mechanical	**1**	**LS**	**$100,000**	**$100,000**	**$10,000**
Controls	**1**	**LS**	**$150,000**	**$150,000**	**$10,000**
Electrical					
Installation (30% of Equip & Controls)	1	LS	$400,000	$400,000	—
Power Costs (1000 Hp = 746 KW total system)	6,500,000	KWH	$0.15	—	$975,000
Subtotal Electrical				**$400,000**	**$975,000**
Treatment Building					
Foundation (Assume 150ft X 100ft, slab on grade)	800	CY	$200	$160,000	—
Preengineered Blgd (150 ft X 100 ft)	15,000	SF	$30	$450,000	—
Misc Sitework, Ventilation, Lighting, etc.	1	LS	$40,000	$40,000	$10,000
Subtotal Treatment Building				**$650,000**	**$10,000**
Treated Water Reinjection System					
Injection Wells	5	ea	$20,000	$100,000	$5,000
Associated piping and pumps	1	LS	$30,000	$30,000	—
Subtotal Treated Water Reinjection				**$130,000**	**$5,000**
Other O&M					
Personnel (Kaiser personnel on-site, avg 120 man hrs/wk)	6,240	man-hrs	$50	—	$312,000
Misc. Maint.	1	LS	$40,000	—	$40,000
Subtotal Other O&M				—	**$352,000**
Additional Cost if Sludge is Hazardous					
Sludge Disposal, assume 10 tons/day (wet weight) (includes transport and disposal as hazardous waste)	3,650	TONS	$500	—	**$1,830,000**