FEASIBILITY STUDY FOR CLEANUP ACTIONS AT THE KAISER-MEAD NPL SITE

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EXECUTIVE SUMMARY

This report presents a Feasibility Study to evaluate cleanup action alternatives for spent pot liner (SPL) material, soil and groundwater contamination present at the Kaiser Aluminum & Chemical Corporation Facility (KACC) in Mead, Washington. This study has been prepared to comply with the requirements of an Agreed Order signed in September of 1992 between KACC and the Washington Department of Ecology (WDOE).

The Feasibility Study includes the following:

- A summary of previous investigation and remedial actions completed at the facility.
- A description of current conditions.
- Development of appropriate cleanup standards for the site and affected media.
- Estimates of the extent of contamination which exceeds the cleanup levels.
- Identification and screening of potentially applicable cleanup technologies.
- Development and detailed analysis of cleanup alternatives.
- A description of the recommended alternative.

Description of the Facility

The KACC plant is a prebake aluminum smelter which was constructed in 1942. The facility is located approximately seven miles from downtown Spokane and covers approximately 270 acres. The area immediately adjacent to the plant is zoned for industrial use. The nearest residences are situated approximately 1500 feet to the northwest of the plant.

The plant is located in a dry climate with limited recharge. The water table of the surficial aquifer is greater than 150 feet below the plant site. The aquifer discharges to the Little Spokane River, approximately 2.5 miles to the northwest of the plant.

The principal constituents of interest found at the site are complexed cyanide and fluoride. The source of these constituents were spent pot liners (SPL) which are a by-product of aluminum production. The SPL is a carbon based material which contains elevated levels of salts. The SPL was historically managed in outdoor storage piles until 1981. Since 1981, the SPL has been stored inside of buildings prior to off-site disposal. The location of present and former waste management facilities is shown in Figure E-1.

Previous Investigations and Remedial Actions

In 1978, cyanide was detected in several private wells located to the northwest of the plant. With this discovery, KACC initiated a program to evaluate the nature and extent of contamination and implemented a series of independent remedial actions. The site investigations included extensive hydrogeologic, ecological and source characterization studies which formed the basis for a Remedial Investigation report prepared in 1988 (Site Characterization Report, Hart Crowser 1988). Since that time, KACC has continued to monitor groundwater and surface water quality and reports the results on a semi-annual schedule.

A significant number of remedial actions have been implemented since the discovery of the groundwater contamination. These include:

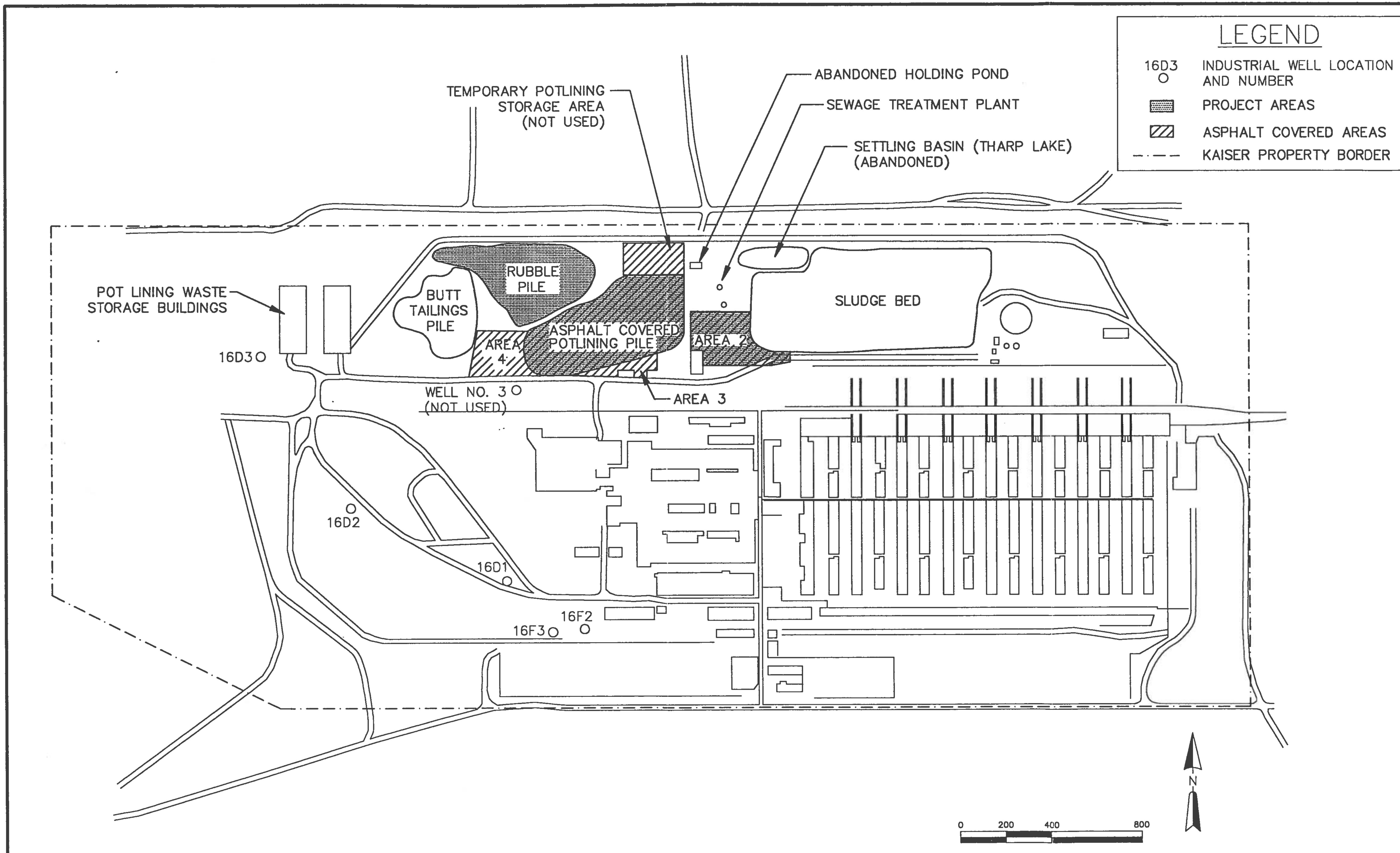
- Alternative Water Supplies - KACC provided alternative water systems for potentially impacted down gradient users.

- Waste Handling Practices - Containment buildings were constructed for indoor storage of as generated SPL material prior to off-site disposal.

- Capping and Drainage Improvements - Exposed SPL material was capped with an asphalt cap and selected areas were graded and capped to prevent ponding and infiltration of precipitation.

- Elimination of Infiltration Sources - A number of potential sources of infiltration water which could mobilize contaminants in the subsoil were eliminated. These included:

    - Elimination of pot soaking operations
    - Elimination of effluent discharges to the sludge bed
    - Drainage and abandonment of a large settling basin (Tharp Lake)



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FACILITY SITE PLAN
KACC – MEAD SITE

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FIGURE E–1

- Repair of known water and wastewater pipe leaks

- Monitoring and Institutional Controls - An updated well inventory was completed to restrict the use of the groundwater and a water quality monitoring program was developed. KACC continues to maintain this program.

Current Conditions

Groundwater quality has significantly improved as a result of the remedial activities which have been implemented at the facility since 1978. Contaminant concentrations have declined over 50% in the most heavily contaminated wells and groundwater quality improvements have been noted in wells located 7000 feet down gradient of the plant.

The majority of contaminant reductions appear to be a result of eliminating potential infiltration sources. One of the primary sources was Tharp Lake which was estimated to leak water (not containing cyanide) at a rate of approximately 50 gpm. Figure E-2 shows the rapid improvement in groundwater quality which was observed in well TH-8 once Tharp Lake was abandoned in September of 1981.

Further decreases in groundwater concentrations, however, have not been observed at TH-8 since approximately 1987 suggesting that the contaminants have reached steady state conditions at this location. Due to the climatic conditions and the capping activities which have been completed at the site, it is unlikely that infiltration of precipitation is a primary mechanism for leaching contaminants. Pipe leakage is considered to be the primary remaining water source for leaching and transporting contaminants to the underlying aquifer.

Approximately 160,000 cubic yards (cy) of SPL material remain on site. The majority of the material has been capped although approximately 45,000 cy are estimated to be present in the Western portion of a rubble pile which remains uncapped.

Contaminated soils are primarily found below the SPL pile, Area 2 and the rubble pile. The contamination is primarily concentrated in the upper 50 feet.

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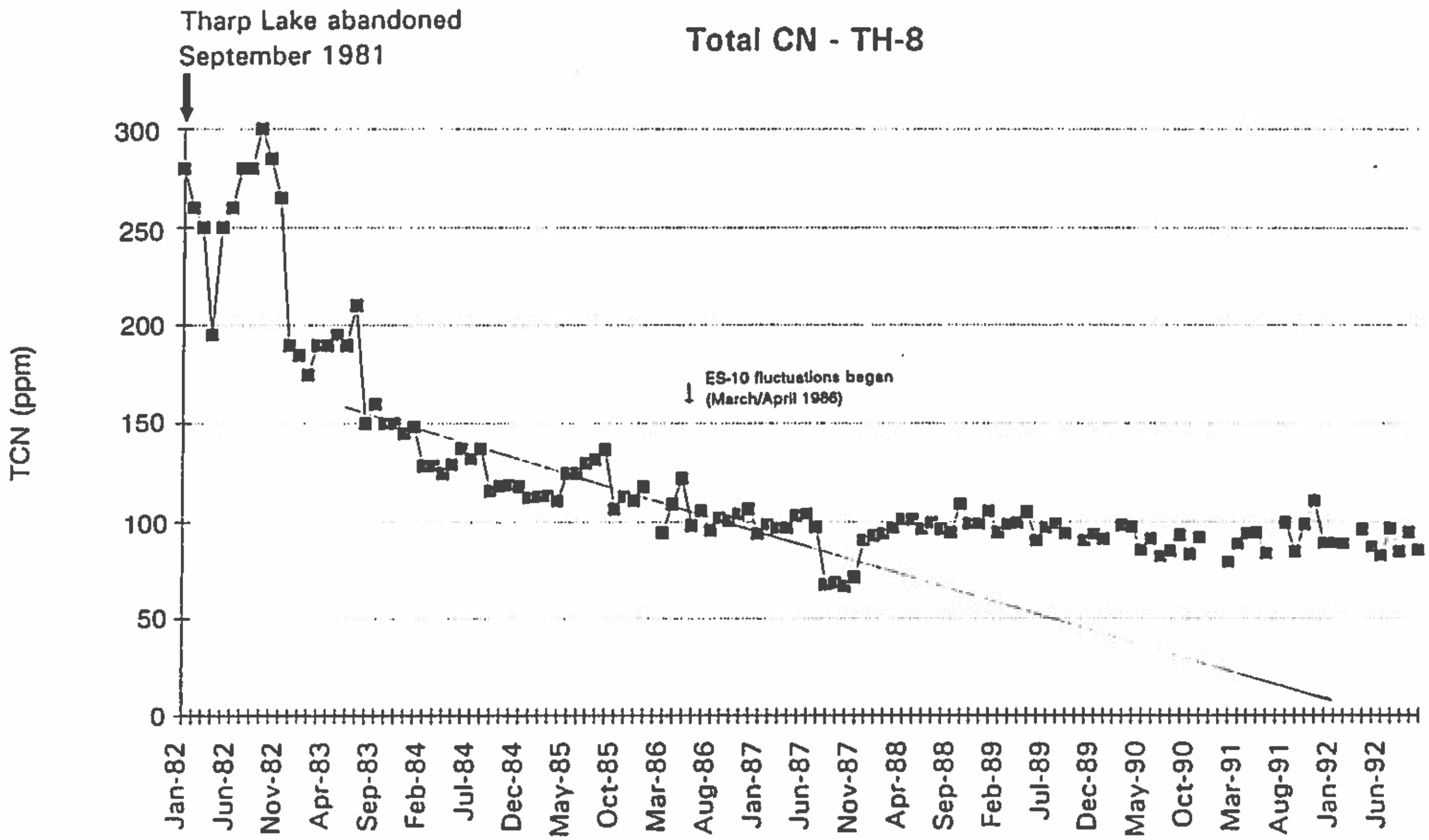

TOTAL CYANIDE CONCENTRATION IN WELL TH-8
KACC - MEAD SITE

FIGURE
E-2

Cleanup Standards

Cleanup standards were developed to be consistent with the Model Toxics Control Act and with the development of cleanup levels for Building 32N at the KACC-Mead site. Cleanup standards include three components:

- numerical cleanup levels,
- points of compliance, and
- applicable or relevant and appropriate requirements (ARAR's).

The cleanup level for groundwater is based on the use of the groundwater as a potable drinking water supply under "Method B". The cleanup level for soils is based on 100 times the drinking water standard for protection of groundwater.

The point of compliance for groundwater is the property boundary. The point of compliance for soils is in soils throughout the site.

The principal contaminant specific ARAR's which affects the development of a cleanup standard for the site are the Maximum Contaminant Levels (MCLs) promulgated under the Safe Drinking Water Act. MCLs exist for both fluoride and cyanide.

Based on these considerations, the cleanup standard for free cyanide in groundwater is 0.32 mg/l based on the "Method B" criteria under the MTCA and the standard for fluoride is 4 mg/l based on the MCL. Soil cleanup levels are based on 100 times the above stated groundwater cleanup levels.

Extent of Contamination Which Exceeds Cleanup Levels

The majority of wells monitored downgradient from the SPL pile are below the cleanup levels for free cyanide. Only three wells currently exceed the cleanup level, of which only one is located beyond the point of compliance (HC-12). Six wells exceed the cleanup level for fluoride, of which only two are located beyond the point of compliance. The existing data indicates that the majority of the groundwater plume which exceeds cleanup levels is contained on the site.

The SPL material exceeds groundwater protection levels for fluoride and cyanide. An estimated 160,000 cy of SPL remain on-site, primarily in the capped SPL pile and Area 2. Only the rubble pile contains uncapped SPL material.

Soils with concentrations of fluoride and total cyanide in excess of the cleanup levels established for groundwater protection level are located beneath the SPL pile, Area 2, the rubble pile and immediately south of the SPL pile. The areas beneath the rubble pile and south of the SPL pile are the only areas with soil contamination which are not currently capped.

The extent of soil which exceeds the groundwater protection level is based on total cyanide analyses rather than free cyanide as there is no analytical data for free cyanide in the soils beneath the SPL and rubble piles. If similar total to free cyanide ratios as those which were measured in soils from Building 32N closure sampling are applied to the known total cyanide in the soil, concentration for free cyanide at the site may not exceed the soil cleanup level of 32 mg/kg.

Screening of Technologies and Development of Alternatives

A broad range of cleanup technologies applicable to SPL material, contaminated soil and groundwater were screened based on implementability, effectiveness and cost. Figures E-3, E-4 and E-5 summarize the technologies and identifies those which were retained. The technologies were then assembled into five alternatives which were then evaluated in further detail.
The alternatives selected for detailed evaluation are:

- Alternative 1 - No Additional Action
- Alternative 2 - Infiltration Control
- Alternative 3 - Off Site Disposal of SPL Material
- Alternative 4 - Infiltration Control and Pump and Treat
- Alternative 5 - Off Site Disposal of SPL Material and Pump and Treat

Detailed Evaluation of Alternatives

WDOE criteria identified under WAC 173-340-360 of MTCA state that the cleanup action shall:

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Cleanup Action Goal: Prevent leaching to soil and groundwater and prevent direct contact and spread of contaminants.

WDOE RANK	CATEGORY (in descending preference)	TECHNOLOGY SCREENING	SCREENING CRITERIA: Effectiveness	SCREENING CRITERIA: Implementability	SCREENING CRITERIA: Cost	RETAINED?
1	Reuse or Recycling	None for SPL	Not Applicable	Not Applicable	Not Applicable	No
2	Destruction or Detoxification	Off-Site Thermal Treatment	Yes, Claim Successful Performance	• One Facility w/ Limited Capacity	$400/ton	No
		On-Site Thermal Treatment	• Poor Performance • Lack of Experience	• Public Opposition • Highly Regulated	Not Applicable	No
		Other Treatment Methods	• Applicable Only to Aqueous Wastes	• Applicable Only to Aqueous Wastes	Not Applicable	No
3	Separation or Volume Reduction	None for SPL	Not Applicable	Not Applicable	Not Applicable	No
4	Immobilization	Chemical S/S	• Unproven for CN • Increase Volume	• Excavation Constraints	$30 - $120/yd³	No
		In-Situ Vitrification	• Limited History • No Experience w/CN	• Not Commercially Available • Proprietary	$275 - $400/yd³	No
5	On-Site or Off-Site Disposal	On-Site Disposal	Yes	• Permitting Difficulty • Anticipated Landban	$10MM total	No
		Off-Site Disposal	Yes	• At Least Two Identified Facilities	$150/ton	Yes
6	Isolation or Containment	Capping	Proven for SPL at KACC-Mead	• Demonstrated Asphalt Caps	$300,000 Capital $42,500/year maint.	Yes
7	Institutional Controls and Monitoring	Continued Monitoring Land-Use Restrictions Fencing	Minimize Exposure to Public and Environment	• Already in Place	$120,000/year	Yes, as Part of other remedial technologies

Technology Screening Summary Addressing Source Control - SPL

FIGURE E-3

Cleanup Action Goal: Prevent leaching to groundwater.

WDOE RANK	CATEGORY (in descending preference)	TECHNOLOGY SCREENING	SCREENING CRITERIA: Effectiveness	SCREENING CRITERIA: Implementability	SCREENING CRITERIA: Cost	RETAINED?
1	Reuse or Recycling	None for Soil	Not Applicable	Not Applicable	Not Applicable	No
2	Destruction or Detoxification	Off-Site Thermal Treatment	• Conventional Thermal Treatment Methods	• Requires Excavation • Lack of Capacity	\$300 - \$500/yd^3	No
		On-Site Thermal Treatment	Yes	• Public Opposition • Requires Excavation	Not Available	No
		Other Treatment Methods	• Applicable Only to Aqueous Wastes	• Applicable Only to Aqueous Wastes • May Require Excavation	Not Applicable	No
		In-Situ Biological Treatment	• Only Effective On Free Cyanide	• Highly Successfull	\$25 - \$100/yd^3	No
3	Separation or Volume Reduction	Ex-Situ Soil Washing	• More Effective For Free Cyanide and Fluoride • Not Applicable to SPL	• Requires Soil Excavation • Handling Concerns	\$200 - \$500/yd^3	No
		In-Situ Soil Washing	• Dependent on Uniformity of Cleanup	• Verification by by Experiment	\$50 - \$120/yd^3	No
4	Immobilization	In-Situ Vitrification	• Limited History • No Experience w/CN	• Not Available Commercially • Proprietary • Up to 40 - ft deep	\$275 - \$400/yd^3	No
5	On-Site or Off-Site Disposal	Soil Excavation	• Prevent Migration of Contaminants to Groundwater	• Requires Excavation • Excess Volumes	\$10 - \$50/yd^3	No
6	Isolation or Containment	Containment and Infiltration Control	• Prevent Migration of Contaminants to Groundwater	• Leak Monitoring Implemented Previously • Cutoff Structures are Difficult to Implement Due to Large Depths	Varies w/Technology	Only Pipe Repair or Replacement
7	Institutional Controls and Monitoring	Continued Monitoring Land-Use Restrictions Fencing	• Minimize Exposure to Public and Environment	• Already in Place	\$120,000/yr	Yes, as Part of Other Remedial Technologies

Technology Screening Summary Addressing Source Control - Contaminated Soils

FIGURE E-4

Cleanup Action Goal: Reduce groundwater concentrations at the point of compliance to <0.32 mg/L free cyanide and 4 mg/L fluoride.

GENERAL CLEANUP ACTIONS	TECHNOLOGY SCREENING	SCREENING CRITERIA: Effectiveness	SCREENING CRITERIA: Implementability	SCREENING CRITERIA: Cost	RETAINED?
Ex-Situ Treatment	Biological Treatment Methods	- Only for Free Cyanide	- Not an Established Technology for Cyanides	---	No
	Thermal Treatment Methods	- Not Applicable to Aqueous Waste	Not Applicable	Not Applicable	No
	Physical Treatment Methods	- Well Established for Cyanide and Fluoride	- Established Technologies	$285,000 Capital	Yes, Fluoride Precipitation
	Chemical Treatment Methods	- Several Well Established Technologies - Some Require Verification - Only for Cyanide	- Readily Available Equipment	$290,000 to $1,300,000 Capital	Yes, Alkaline Hydrolysis
In-Situ Treatment	Physical/Chemical Treatment Methods	- Require In-Situ Testing For Verification	- More Difficult for Deep Formations - No Experience w/CN	Not Available	No
	Biological Treatment Methods	- Free Cyanide Only - Limited for Complex Cyanide and Fluorides	- Well Established - Requires In-Situ Field Testing for Verification Purposes	$150,000 Capital	Yes, Pump-and-Treat
Extraction	Wells	- Effective for High Permeability Formation	- More Applicable for Deep Formations	$10,000/well	Yes
	Interceptor Trenches	- For Shallower Applications - Low Permeability Media	- Not Applicable for Very Deep Formations	Not Available	No

Technology Screening Summary Addressing Groundwater Cleanup

FIGURE E-5

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Cleanup Action Goal: Reduce groundwater concentrations at the point of compliance to <0.32 mg/L free cyanide and 4 mg/L fluoride.

GENERAL CLEANUP ACTIONS	TECHNOLOGY SCREENING	SCREENING CRITERIA: Effectiveness	SCREENING CRITERIA: Implementability	SCREENING CRITERIA: Cost	RETAINED?
Disposal	Soil Flushing	- Cleans Contaminated Soil - Effectiveness Depends on Uniformity of Flushing	- Requires In-Situ Testing - Requires Injection Well Installation	$2,500/well for installation	No
	Re-Injection into Aquifer	- May Accelerate GW Cleanup	- Established Technology - Requires Injection Well Installation	$10,000/well for installation	Yes
	Off-Site Discharge (NPDES)	----	- Current NPDES is very Stringent	Additional Cost is Negligible	No
	Untreated GW to a POTW	- Cyanide will not be Treated	- Permitting - Discharge Criteria - Installation of a Forced Main	Cost of Forced Main	No
Isolation	Slurry Wall	- Not Effective	- Not Applicable at at Depths >50 ft	Not Applicable	No
	Grout Curtain	- Not Effective	- Not Applicable at at Depths >50 ft	Not Applicable	No
	Sheet Piles	- Not Effective - Require Joint Interlocking	- Not Applicable at at Depths >50 ft	Not Applicable	No
Institutional Controls	Continued Monitoring Provide New Drinking Water Sources	- Already in Place	- Minimize Exposure to Public	$120,000/yr	Yes, as Part of Other Remedial Technologies

Technology Screening Summary Addressing Groundwater Cleanup (Continued)

FIGURE E-5

- protect human health and the environment;
- be a permanent solution;
- provide for a reasonable restoration time frame; and
- consider public concerns.

The five cleanup alternatives were evaluated based on the WDOE criteria and preference for cleanup technologies. Tables E-1 and E-2 provides an overall comparison of the five alternatives.

Alternative 1 (No-Additional Action) will not restore groundwater within a reasonable period of time and was rejected based on this evaluation. Infiltration Control (Alternative 2), while not a permanent solution, will result in groundwater quality improvements within a reasonable time frame (< 5 years) following successful implementation. This alternative is retained for further consideration. Excavation and off-site disposal of the SPL (Alternative 3) is extremely costly ($32 million) and will not restore groundwater quality within a reasonable time frame and was rejected. Alternative 4 (Infiltration Control and Pump-and-Treat) addresses SPL, soil and groundwater contamination. This alternative has advantages over Alternative 2 alone as the pump-and-treat system will restore and control groundwater migration at the site. Alternative 5 (Excavation, Off-Site Disposal, Pump-and-Treat) has the added advantage over Alternative 4 of being a permanent solution for SPL. However, this alternative is cost prohibitive ($35 million) and does not remove soil above the cleanup levels at the site. Alternative 5 is rejected on this basis.

Summary of Recommended Alternative

The recommended alternative is Alternative 4, Infiltration Control with Pump and Treat. It is envisioned that this alternative will be implemented in several phases based on groundwater monitoring results. The first phase involves capping the remaining SPL material in conjunction with pipe leak monitoring and replacement. This phase alone may be successful at meeting groundwater cleanup standards.

If groundwater monitoring indicates that cleanup levels will not be met in a reasonable time period, then the second phase of the program will involve installing a groundwater pump and treat system. The combination of the two phases is anticipated to restore groundwater quality within a reasonable time frame.

Appropriate institutional controls and groundwater monitoring will be incorporated into all phases of the cleanup program. Figure E-6 presents a flow chart which demonstrates the relationship between the various phases of the recommended cleanup action.

TABLE E-1
COMPARISON OF CLEANUP ALTERNATIVES ACCORDING TO WDOE PREFERENCE

Alternative	WDOE Preference*	Deficiency	Rank**
Alternative 1: no-additional action	7, 7, 7	does not protect human health and the environment not a permanent solution restoration time is too long	5 (21)
Alternative 2: infiltration control	6, 6, 7	not a permanent solution for soil & SPL	4 (20)
Alternative 3: excavation , off-site disposal	5, 6, 7	not a permanent solution for soil plume restoration time is too long potential short-term exposure	3 (18)
Alternative 4: infiltration control and pump-and-treat	6, 6, 3	not a permanent solution for SPL & soil	2 (15)
Alternative 5: excavation, off-site disposal, pump-and-treat	5, 6, 3	potential short-term exposure not a permanent solution for soil	1 (14)

* WDOE preference list includes seven options ranked from highest to lowest. The first value is related to the SPL, the second value is related to the contaminated soil and the third value is related to the plume.
** Rank is based on the sum of WDOE preference. The lowest sum was assigned the highest ranking (Rank 1), the second lowest sum was assigned the second highest ranking and so on. Values between brackets indicate the sum of WDOE preference.

TABLE E-2
OVERALL SUMMARY OF CLEANUP ALTERNATIVES

Alternative	Performance	Implementability	Total Time	Cost (Present Worth)
1 No-Additional Action	poor for plume control	very good	> 30 years	PW = $1,131,230
2 Infiltration Control	poor for plume control good for soil good for SPL containment	very good	< 5 years	PW1 = $2,079,984 PW2 = $1,930,504 PW3 = 1,826,862
3 Excavation, Off-Site Disposal	poor for plume control good for contaminated soil very good for SPL	good	> 30 years for plume	PW = $32,432,171
4 Infiltration Control, Pump-and-Treat	very good for plume good for contaminated soil very good for SPL containment	very good	2 to 10 years	PW1 = $4,477,190 PW2 = $4,328,568 PW3 = $4,224,926
5 Excavation, Off-Site Disposal, Pump-and-Treat	very good for plume good for contaminated soil very good for SPL	very good for plume good for SPL	2 to 10 years	PW = $35,382,426

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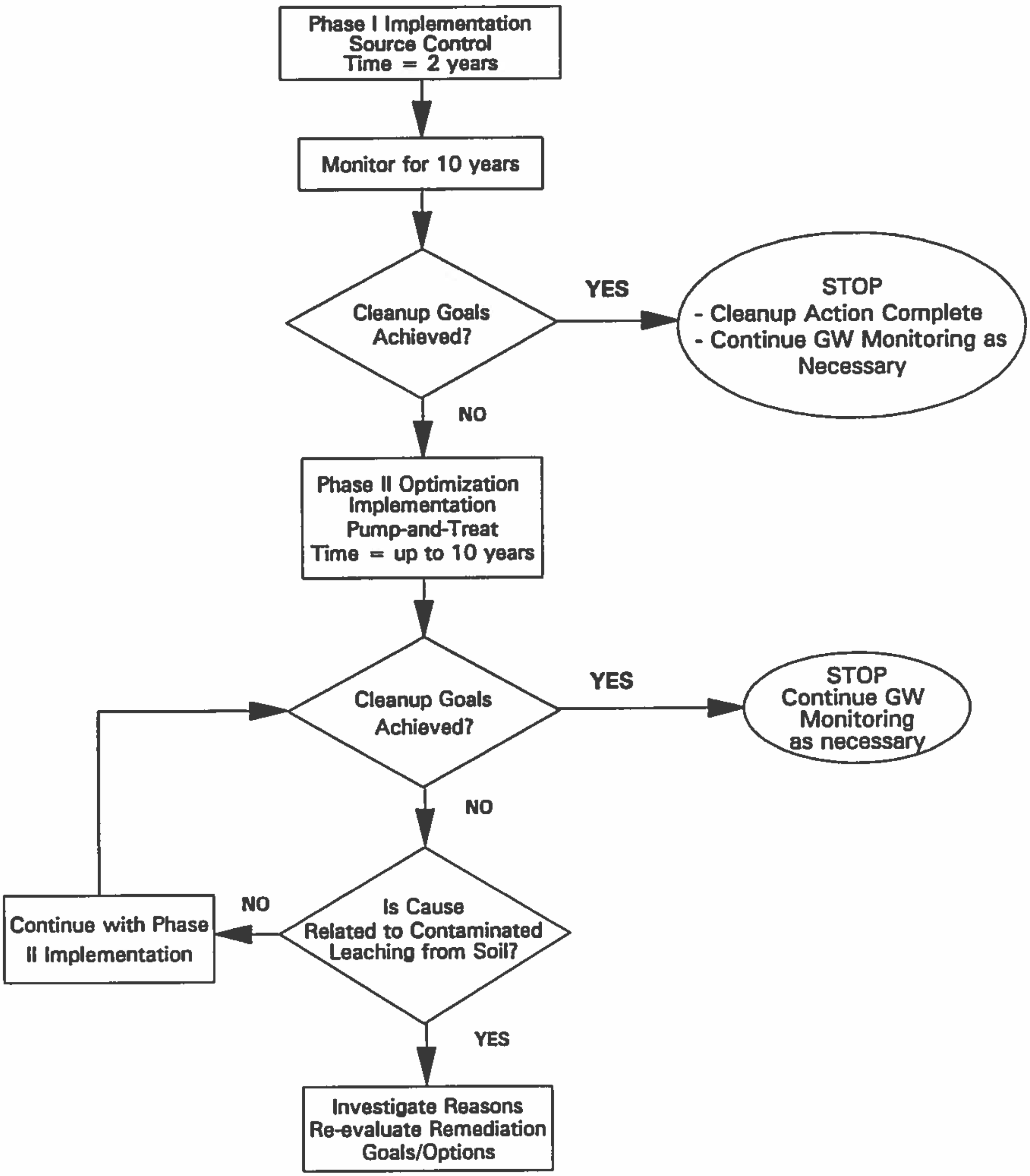

IMPLEMENTATION FLOW CHART FOR THE PROPOSED CLEANUP ALTERNATIVE AT KACC-MEAD SITE

FIGURE E-6

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1.0 INTRODUCTION

1.1 OBJECTIVE

This report has been prepared in fulfillment of the requirements of the Washington Department of Ecology (WDOE) as identified in the Agreed Order (Order) issued for the Kaiser Aluminum & Chemical Corporation Mead Plant (KACC-Mead) on September 22, 1992. The Order calls for a stand alone, final feasibility study (FS) which addresses soil and groundwater contamination at KACC-Mead.

This FS is a document that is based on the outcome of investigative work and reports that KACC-Mead has compiled since contamination was discovered at KACC-Mead site. A summary of the investigative activities conducted at KACC-Mead since 1977 are compiled in Table 1-1. Reports and documents which have been generated for the site are summarized in Table 1-2.

The purpose of the FS is to develop and evaluate cleanup action alternatives for the SPL material, contaminated soils, and groundwater and to recommend a remedial alternative to be implemented to achieve compliance with WDOE requirements. Specifically, this FS has been developed to comply with the Model Toxic Control Act (MTCA) regulations under WAC 173-340-360 and uses the criteria identified in the MTCA regulations for Selection of Cleanup Actions (WAC 173-340-360) as one of the cleanup alternative screening factors.

The following major tasks are included in this FS:

- development of appropriate cleanup standards for the site;
- initial identification and screening of cleanup alternatives;
- detailed evaluation of the retained cleanup alternatives in accordance with the MTCA criteria, and
- selection of a preferred cleanup action.

TABLE 1-1
SUMMARY OF INVESTIGATIVE ACTIVITIES AT KAISER MEAD 1977 TO PRESENT

DATE	ACTIVITY
1977	Kaiser installed groundwater monitoring wells TH-1 and TH-2 at plant site.
April 1978	Robinson and Noble, Inc., report indicating elevated levels of cyanide, fluoride, nitrate, and sulfate in wells TH-1 and TH-2.
May 1978 to August 1978	Groundwater samples collected from network of 18 private wells and springs around the Mead Works and 2 onsite wells (by Robinson and Noble, Inc.). Analyses indicate cyanide present northwest of plant.
August 1978	Spokane County groundwater monitoring network adds to existing network. Analyses indicate cyanide groundwater contamination in the vicinity of the plant site.
October 1978 to December 1978	Six additional monitoring wells constructed (TH-3,3A,4,5,6,7).
July 1979	Monitoring well TH-8 installed at plant site; highest cyanide concentrations found in this well.
August 1980	Ecological survey of the Little Spokane River completed by researchers from University of Michigan. No significant impacts identified.
Summer 1980	Monitoring wells and borings ES-1 through ES-10 completed; samples collected and analyzed to further define sources and extent of groundwater contamination.
April 1981	Completed a study of methods to treat cyanide and fluoride in groundwater.
1981-82	Twenty additional monitoring wells and borings constructed to better define extent of plume and to investigate suspected areas of contamination (wells HC-1, 1A, 2, 2A, 3 through 9, 9A, and 10 through 18 and borings D-1 through D-3).
1981 to Present	Ongoing monitoring of wells to assess effectiveness of remedial actions.
1982	Leak test of storm and sanitary sewer lines on north side of plant and water lines throughout the plant.
1983	Assessment of the potential for uncovered potlining waste to contaminate groundwater beneath the Mead Works.
August 1985	Completed an assessment of alternatives to control infiltration and cyanide and fluoride transport.
1986	A groundwater extraction well inventory update was conducted to supplement the 1978 survey performed by the Spokane County Health Department.
1988	Site Characterization Analysis report prepared (Appendix A of Engineering Assessment Report)
December 1988	Engineering Assessment Report prepared
July 1989	Ground penetrating radar survey conducted around aquitard area to identify buried pipelines and potential pipe leaks.

TABLE 1-1 continued
SUMMARY OF INVESTIGATIVE ACTIVITIES
AT KAISER MEAD 1977 TO PRESENT

DATE	ACTIVITY
September 1989	Aquifer modeling completed to estimate cyanide recharge to the aquifer.
October 1989	Installation of nine aquitard monitoring wells to define the extent of the aquitard.
July 1990	Video survey of storm sewers completed in area of aquitard to identify potential leaks. No obvious leaks were found.
August 1990	Installation of four additional aquitard wells to further delineate the extent of the aquitard.

TABLE 1-2

KACC-MEAD SITE BIBLIOGRAPHY

DATE	REPORT TITLE	AUTHOR
March 1955	Report on Test Well for Well No. 5 at the Kaiser Mead Works	Robinson and Roberts
November 1963	Report on Construction of Well No. 6 for Kaiser Aluminum & Chemical Corp., Mead Works	Robinson & Noble
April 14, 1978	Report on the Effect of Waste Disposal Practices on Groundwater Quality at Kaiser Aluminum & Chemical Corp., Mead, WA	Robinson & Noble
September 27, 1978	Sludge Bed History, Inter-Office Memo	C.M. Kime
October 24, 1978	Estimated Tons of CN in the Existing Potlining Pile and Sludge Pond, Inter-Office Memo	W.B. Eastman
January 8, 1979	Sludge Bed, Estimation of CN Content in Both Water Soluble and Water Insoluble Form, Inter-Office	D. Hirst
March 19, 1979	Letter discussing the Impact of a New Whitworth Water Dist. Well at Fairwood Shopping Center	Robinson & Noble
May 1, 1979	Status Report of Aquifer Contamination at Kaiser Aluminum and Chemical Corp., Mead Works	Robinson & Noble
September 1979	Report on Construction of Test Hole 8: Temperature in Horizontal Drains; Interceptor Well Feasibility for Kaiser Aluminum & Chemical Corp	Robinson & Noble
September 1979	Report on Construction and Testing of Replacement Well for Stephen W. Pope	Robinson & Noble
September 1980	Report Investigation, Mead Works, Groundwater and Facility Yards Cleanup, Phase I, Prepared for Kaiser Aluminum and Chemical Corp.,	Engineering Science, Inc.
September 9, 1980	Hydrogeologic Data Analysis, Kaiser Mead Plant, Spokane, Washington, J-948	Hart Crowser & Associates, Inc
October 8, 1980	Ecological Survey of Little Spokane River in Relation to Cyanide Inputs, Prepared for KACC-Mead	Hartung, R. Dr.
April 1981	Cyanide Treatment Study, Mead Works	CH2M Hill

TABLE 1-2 continued

KACC-MEAD SITE BIBLIOGRAPHY

DATE	REPORT TITLE	AUTHOR
February 26, 1982	Leakage Determination-Assessment and Quantification, Letter Report dated February 26, 1982	CH2M Hill
April 15, 1982	Plant-Wide Leakage Evaluation, Letter Report	CH2M Hill
December 1982	Groundwater Monitoring Summary Report, Kaiser Mead Works, Spokane, Washington (Monitoring Summary through December 1982)	Hart-Crowser & Associates
December 9, 1982	Evaluation of Storm Sewer Leakage Tests, Letter Report	CH2M Hill
1983	Groundwater Monitoring Summary Report, Kaiser Mead Works, Spokane, Washington (Monitoring Summary through June 1983)	Hart-Crowser & Associates
March 29, 1983	Groundwater Contamination Potential from Uncovered Potlining Waste at KACC-Mead	Hart Crowser & Associates, Inc
1984	Groundwater Monitoring Summary Report, Kaiser Mead Works, Spokane, Washington (Monitoring Summary through December 1983)	Hart-Crowser & Associates
1984	Groundwater Monitoring Summary Report, Kaiser Mead Works, Spokane, Washington (Monitoring Summary Report through June 1984)	Hart-Crowser & Associates
1985	Groundwater Monitoring Summary Report, Kaiser Mead Works, Spokane, Washington (Monitoring Summary through December 1984)	Hart-Crowser & Associates
1985	Groundwater Monitoring Summary Report, Kaiser Mead Works, Spokane, Washington (Monitoring Summary through July/August 1985)	Hart-Crowser & Associates
August 1985	Cost-Effectiveness Study of Actions to Control Infiltration Prepared for Kaiser Aluminum and Chemical Corporation, Mead Works	CH2M Hill

TABLE 1-2 continued

KACC-MEAD SITE BIBLIOGRAPHY

DATE	REPORT TITLE	AUTHOR
1986	Groundwater Monitoring Report, Kaiser Mead Works, Spokane, Washington (Monitoring Summary through December 1985/January 1986)	Hart-Crowser & Associates, Inc.
1986	Groundwater Monitoring Report, Kaiser Mead Works, Spokane, Washington (Monitoring Summary through June/July 1986)	Hart-Crowser & Associates, Inc.
May 18, 1987	Groundwater Monitoring Report, Kaiser Mead Works, Spokane, Washington, 1981 through January 1987	Hart-Crowser & Associates, Inc.
1987	Groundwater Monitoring Summary Report, Kaiser Mead Works Period January 1987 to July/August 1987	Hart-Crowser & Associates, Inc.
March 21, 1988	Groundwater Monitoring Summary Report, Kaiser Mead Works, Period January through July 1988	Hart-Crowser & Associates, Inc.
June 17, 1988	Groundwater Monitoring Summary Report, Kaiser Mead Works, Period July/August 1987 through February 1988	Hart-Crowser & Associates, Inc.
1988	Groundwater Sampling Results, Letter to KACC-Mead (September 1988 Sampling Results)	Hart-Crowser & Associates, Inc.
December 1988	Engineering Assessment Report	CH2MHill
December 1988	Site Characterization Analysis	Hart-Crowser & Associates, Inc.
July 1989	The Results of a GPR Survey at the Kaiser Mead Plant	Williamson and Associates, Inc.
September 1989	Aquitard Well Installation Summary - KACC-Mead Works	Hart-Crowser & Associates, Inc.
September 25, 1989	Results of Unsaturated Zone Analyses, KACC-Mead Works	Hart-Crowser & Associates, Inc.
February 14, 1990	Groundwater Monitoring Summary Report, Kaiser Mead Works, Period July through December 1989	Hart-Crowser & Associates, Inc.
August 28, 1990	June 1990-Aquitard Well Installation Summary, Upgradient of Potlining Pile, Kaiser Mead Plant	Hart-Crowser & Associates, Inc.

TABLE 1-2 continued

KACC-MEAD SITE BIBLIOGRAPHY

DATE	REPORT TITLE	AUTHOR
September 19, 1990	Groundwater Monitoring Summary Report, Kaiser Mead Works, Period January through June 1990	Hart-Crowser & Associates, Inc.
May 21, 1991	Groundwater Monitoring Summary Report, Kaiser Mead Works, Period July through December 1990, dated May 21, 1991	Hart-Crowser & Associates, Inc.
December 12, 1991	Groundwater Monitoring Summary Report KACC-Mead Works, Period January through June, 1991	Hart-Crowser & Associates, Inc.
July 1992	Groundwater Monitoring Summary Report KACC-Mead Works, Period July through December, 1991	Hart-Crowser & Associates, Inc.

1.2 BACKGROUND

1.2.1 Facility Description

Kaiser Aluminum & Chemical Corporation - Mead Works (KACC-Mead) plant lies within Section 16, Township 26 North, Range 43 East about seven miles from downtown Spokane and one mile southwest of Mead in Spokane County, Washington (Figure 1-1). The Little Spokane River is situated 2.5 miles northwest of the plant site.

The facility is a prebake aluminum smelter which was constructed in 1942. Among other systems, the plant operates eight potlines, an anode plant with bake ovens, dry scrubbers for air emissions control, pot reworking facilities, indoor storage facilities for (new) spent potlining (SPL), and miscellaneous other essential and peripheral facilities (Engineering Assessment Report, 1988). Figure 1-2 shows a general layout of the plant site.

The plant uses approximately 2.5 to 3.5 million gallons per day of groundwater produced from on-site wells (shown on Figure 1-2) which tap the lower portion of the Spokane Aquifer. The water is used for cooling and other purposes. Water from the plant (mostly cooling and storm water) is routed via buried piping to a settling basin located approximately 2,000 to 2,500 feet north of the plant (Figure 1-3). Water from the basin is discharged to Peone Creek under an National Pollutant Discharge Elimination System (NPDES) permit. Peone Creek eventually discharges into the Little Spokane River.

1.2.2 Physical Characteristics of Study Area

<u>Surface Features</u>

KACC-Mead plant is located within a glacial outwash valley (Figure 1-3) and has a surface elevation of approximately 2,000 feet. The land surface slopes gradually towards the Little Spokane River to the northwest of KACC-Mead to an elevation of less than 1,600 ft.

<u>Meteorology</u>

Average annual precipitation as measured at the Spokane Airport is 16.4 inches. About 70 percent of the rain falls between the first of October and the end of April. Summer temperatures at the airport range between 80 and 90°F during the day and 45 to 60°F during the night. Winter highs range from 25 to 45°F with lows of 15 to 25°F.

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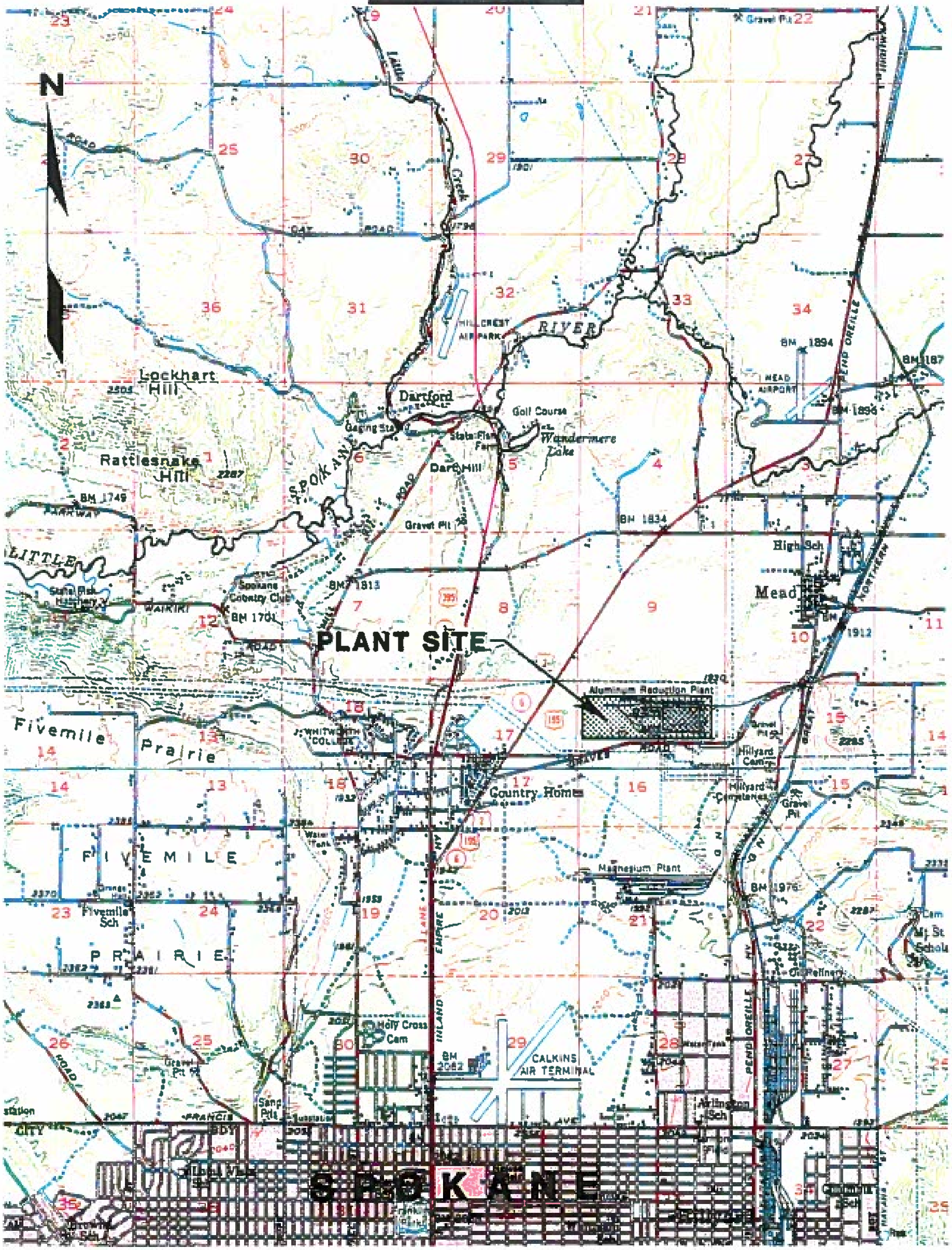


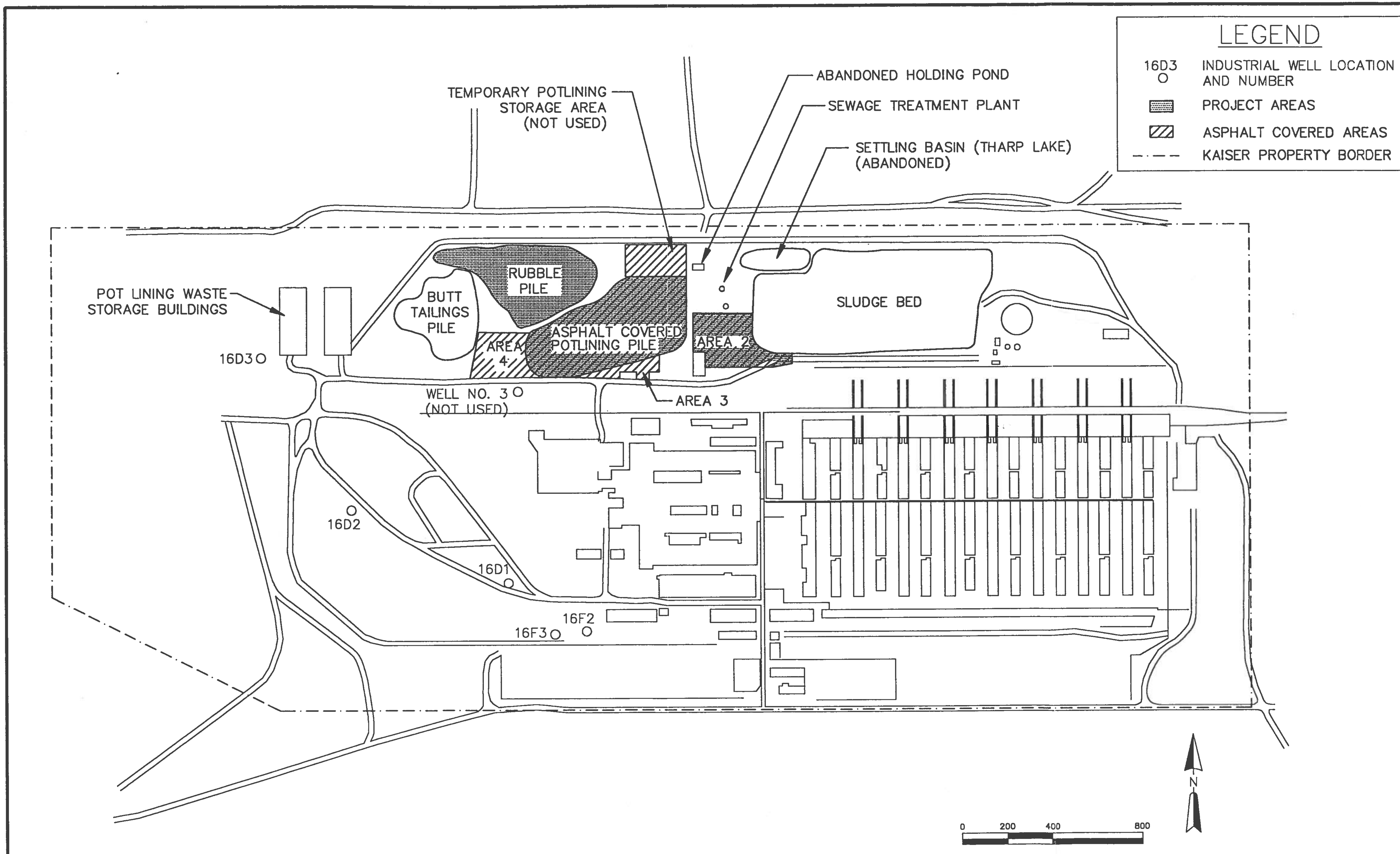
Base map prepared from USGS
15-minute quadrangle of Spokane,
and Deer Park, Washington, dated 1950.

0 1 2

Scale in Miles

PLANT SITE AREA
KACC - MEAD SITE

FIGURE 1-1



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FACILITY SITE PLAN
KACC – MEAD SITE

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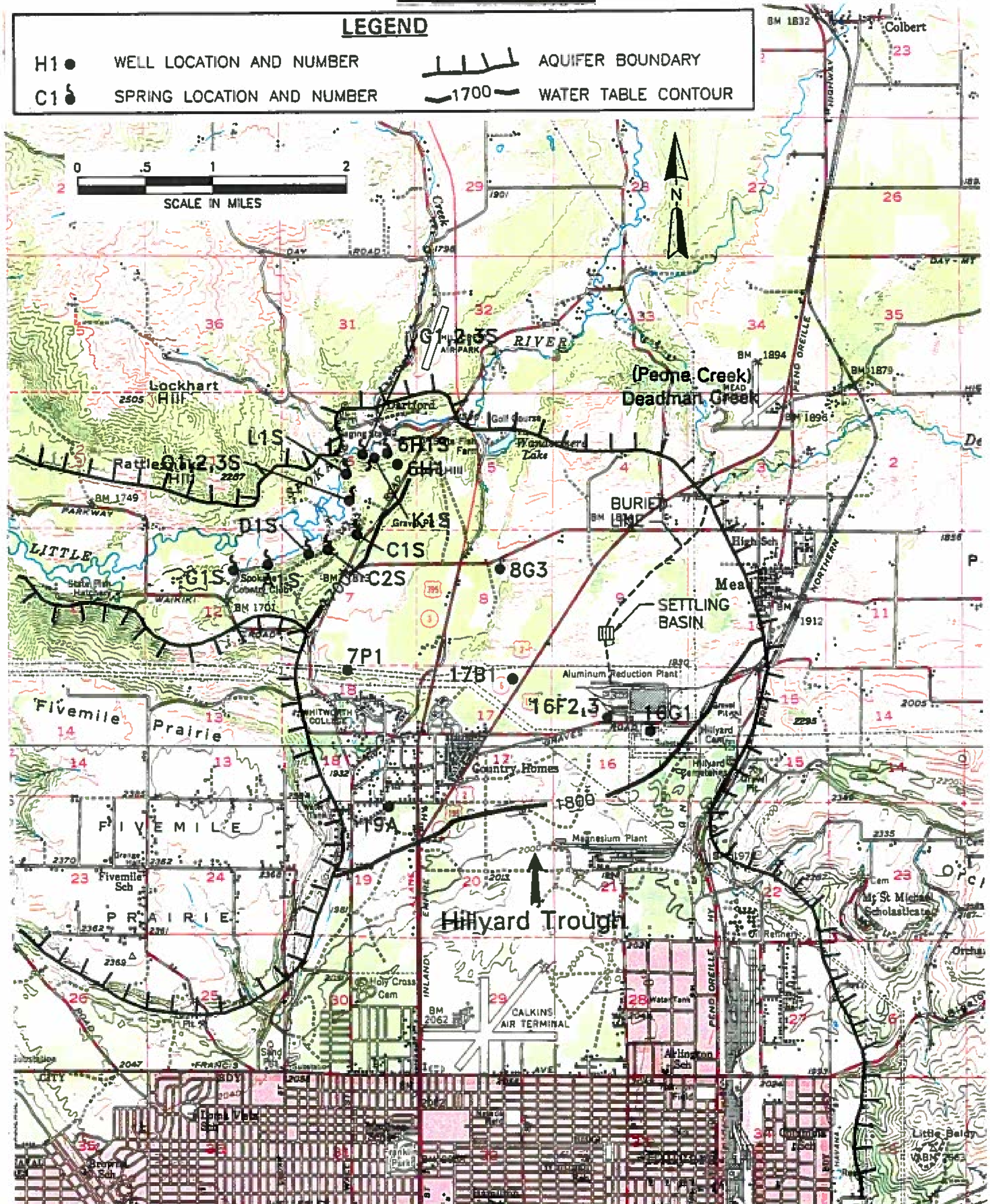
FIGURE 1–2



REGIONAL HYDROGEOLOGIC SETTING
KACC - MEAD SITE

FIGURE 1-3

Surface Water Hydrology

Peone Creek (also known as Deadman Creek) is located to the northeast of the plant (Figure 1-3). This creek flows into the Little Spokane River. KACC-Mead stormwater and non-contact cooling water flows into Peone Creek via a buried discharge pipe. The Little Spokane River is located about 2.5 miles northwest of KACC-Mead. The river flows in a southwesterly direction (Figure 1-1). River flows range between 100 and 300 ft^3/sec (cfs) during dry periods and between 600 and 900 cfs during wet periods.

Hydrogeologic System

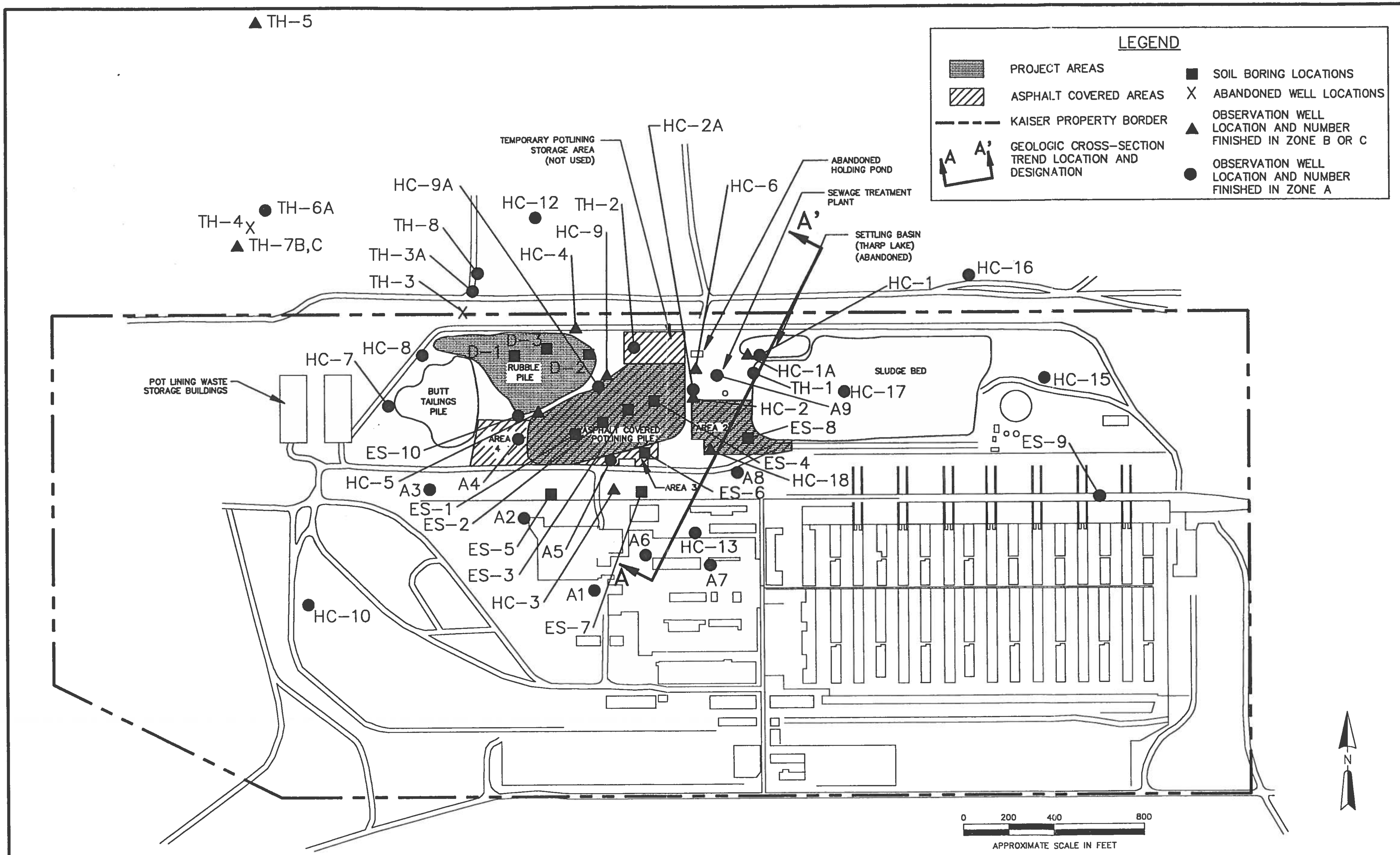
The KACC-Mead plant lies over the Hillyard Trough portion of the Spokane Aquifer (Figure 1-3). Groundwater flows to the northwest where discharge to the Little Spokane River occurs through a series of springs.

The unsaturated (vadose) zone beneath the plant site is composed primarily of fine to coarse sand with interbedded layers of silty clay/clayey silt. Some of these layers may be several feet in thickness as shown in Section A-A' (Figure 1-5). The trend of the section is shown on Figure 1-4. At least one layer appears to be relatively continuous beneath the site. During the drilling of the wells in 1981, perched water was encountered on top of the fine grained layers.

The water table lies at a depth of approximately 150 to 160 feet below the plant site (Figures 1-5 and 1-6). The aquifer thickness is estimated to be over 100 feet thick beneath the plant site and thins to the northwest (Figure 1-6). The top portion of the aquifer is vertically stratified into relatively permeable zones separated by fine grained aquitards. The relatively permeable zones have been termed Zones A, B, and C (with increasing depth) for discussion purposes.

Hydrogeologic analyses indicate that flow velocities within Zone A beneath the northwest portion of the plant range between 3 and 4 feet per day. Much higher flow velocities, on the order of 40 feet per day, have been estimated for the lower portion of the aquifer downgradient of the plant site.

Recharge to the aquifer primarily occurs east of Spokane where runoff from precipitation and snow melts, falling on mountainous areas, infiltrate into the aquifer. Little, if any, recharge occurs locally under natural conditions. However, recharge from pipeleaks and ponded water have been shown to contribute recharge on the plant site. As noted above, aquifer discharge



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WELL AND BORING LOCATIONS
KACC – MEAD SITE

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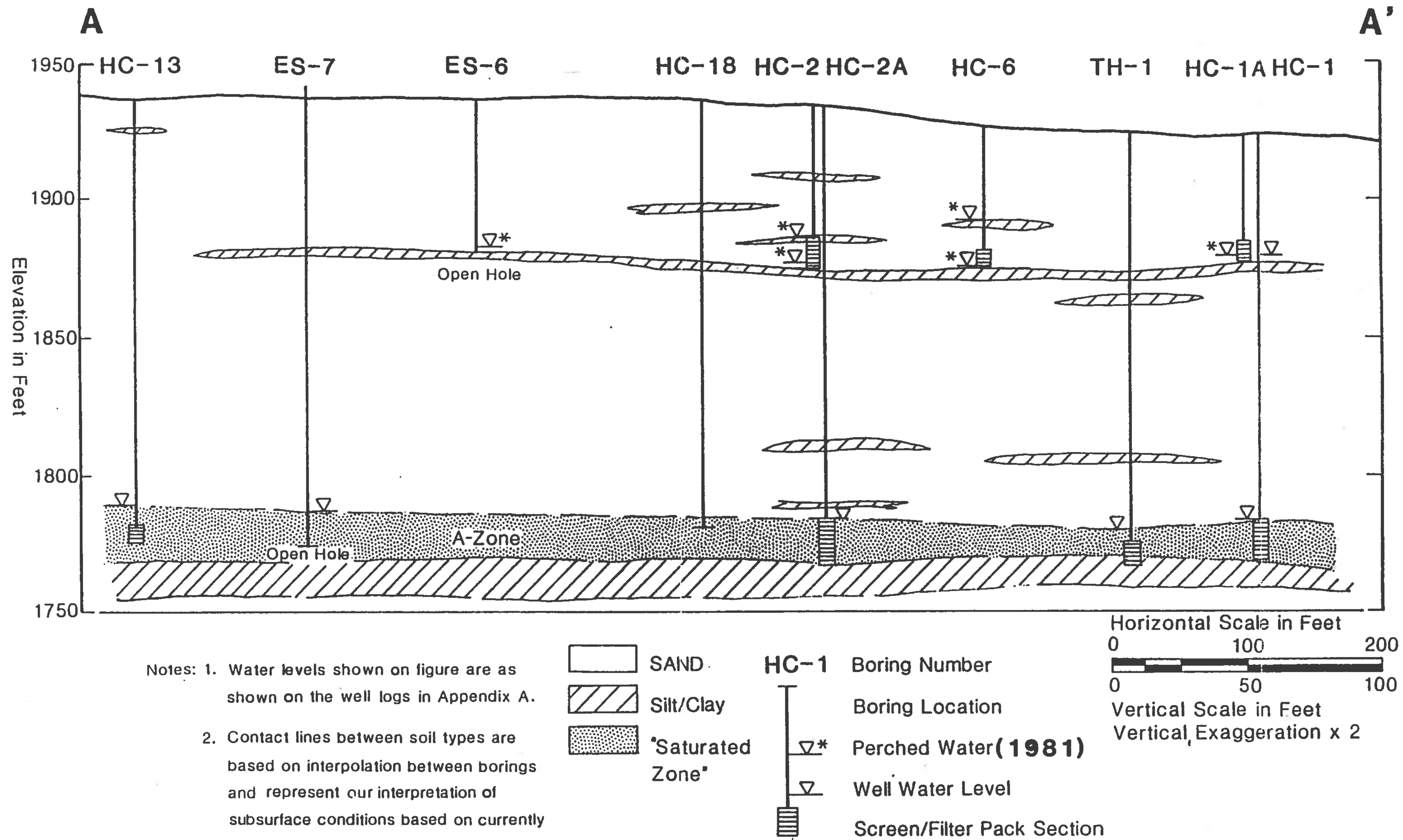
FIGURE 1-4

REITEC

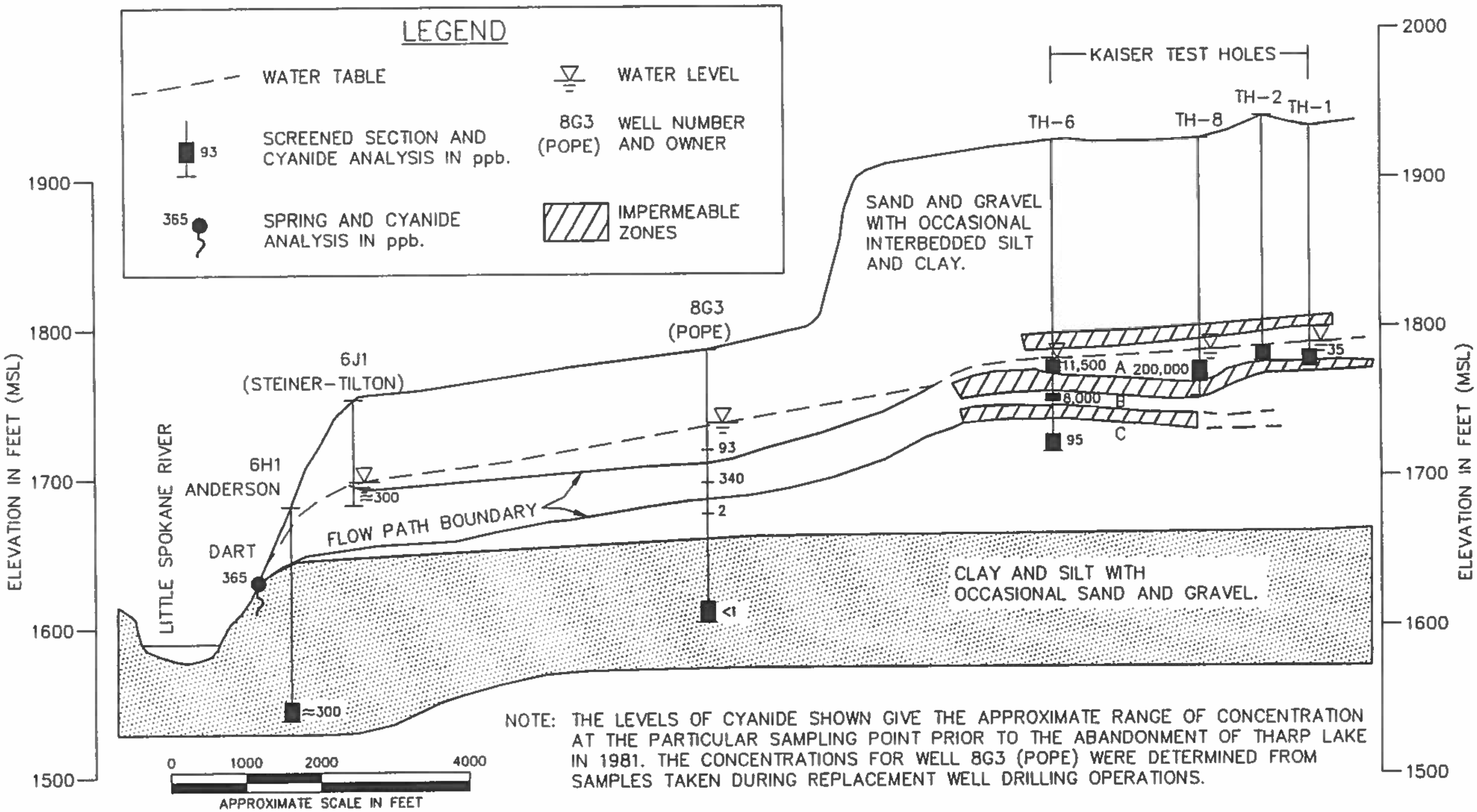


Notes: 1. Water levels shown on figure are as shown on the well logs in Appendix A.

2. Contact lines between soil types are based on interpolation between borings and represent our interpretation of subsurface conditions based on currently available data.

SCHEMATIC GEOLOGIC CROSS SECTION A-A'
KACC - MEAD SITE

FIGURE 1-5



NOTE: THE LEVELS OF CYANIDE SHOWN GIVE THE APPROXIMATE RANGE OF CONCENTRATION AT THE PARTICULAR SAMPLING POINT PRIOR TO THE ABANDONMENT OF THARP LAKE IN 1981. THE CONCENTRATIONS FOR WELL 8G3 (POPE) WERE DETERMINED FROM SAMPLES TAKEN DURING REPLACEMENT WELL DRILLING OPERATIONS.

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DOWNGRADIENT CYANIDE FLOW PATH PROFILE

KACC – MEAD SITE

REMEDIATION TECHNOLOGIES INC

FIGURE 1-6

occurs into the Little Spokane River approximately 2.5 miles northwest of the site. The discharge flow has been estimated by U.S. Geological Survey (USGS) and Spokane County at 150 to 310 cfs.

Demography and Land Use

Land use in the area is mixed consisting of commercial, industrial, and residential. The area immediately adjacent to the plant is zoned industrial. The closest residential neighborhoods are situated approximately 1,500 ft to the northwest of the plant.

Municipal and private wells are used to provide water in the area. Private well systems which may have been impacted by contaminant migration from KACC-Mead site were replaced by municipal supplies as part of the independent remedial actions implemented by KACC-Mead. These systems are located to the northwest of the plant.

1.2.3 Waste Handling Practices

Potlining and other waste materials have been handled on 25 to 30 acres located within the northwest portion of the plant. In this area the major site features (Figure 1-2) include:

- an asphalt covered pile of spent potlining (SPL) materials;
- a rubble pile containing metal, brick, wood, and some potlining material;
- a butt tailings pile;
- a sludge bed where wet scrubber and other effluent were deposited;
- an abandoned settling basin (Tharp Lake);
- an abandoned temporary potlining storage area;
- an abandoned lined holding pond which received runoff from the temporary potlining storage area;
- potlining storage buildings;
- sewage treatment plant; and
- several asphalt paved areas.

In addition, there are buried water supply, sanitary sewer, and stormwater sewer pipelines in the area. An on-site sewage treatment plant is located to the east of the SPL pile. This treatment plant receives only sanitary wastewater from the aluminum production plant and has a capacity of approximately 125 gpm (0.18 MGD). The sanitary treatment system employs two trickling filters to treat the sanitary wastewater. The treated effluent combines with storm/industrial storm water in a 42-inch storm water collection pipeline and enters the settling basin. The settling basin effluent discharges to Peone Creek via a 2-mile long pipeline.

Historically, the primary wastes associated with aluminum production were:

- Spent potlining (SPL) - From the early 1940s to 1979, SPL was removed from the pot shells and deposited on the ground within the northwest portion of the plant. In 1979 the existing potlining was consolidated into a pile, graded, covered with low permeability material, and later covered with asphalt (which is inspected and maintained on a regular basis). The pile is estimated to contain approximately 90,000 cubic yards of SPL with a weight of approximately of 128,000 tons. Potlining was also temporarily stored in small piles adjacent to railroad tracks for loading on to rail cars for processing in western Washington.

  From 1979 to 1981, newly generated SPL was stored on an asphalt paved area immediately north of the asphalt covered pile. An underdrain system was installed beneath the asphalt, and storm water and water collected by the underdrain system was collected in a lined pond (now abandoned). Since 1981, SPL is stored in buildings prior to off-site disposal.

  During preparations for paving of the area (Area 2 on Figure 1-2) between the sludge bed and asphalt covered pile, additional SPL was discovered. Excavation of several test pits indicate that the potlining is on the order of five to six feet in thickness in this area. This potlining was also covered with asphalt at that time (see Site Characterization Analysis Report 1988 (Appendix A) for additional information).

- Pot-soaking liquor - Until late 1978, the pots were soaked with water for the purposes of loosening the potlining material from the steel shells. "Failed" pots were soaked on a concrete slab located on the southeast side of where the asphalt covered pile is now located. The pot soaking water was allowed to drain to the ground or sometimes routed to the sludge bed (between 1965 and 1978).

- Sludges from process off-gas scrubbing systems - Until 1974, wet-air scrubbers were used at the site to remove various constituents, primarily fluoride, from off-gas prior to atmospheric release. A calcium fluoride precipitate formed a sludge which was placed in the sludge bed shown on Figure 1-2. A detailed description of the sludge bed is contained in the Site Characterization Analysis Report (1988)(Appendix A).

- Anode butt tailings - These materials are contained in a pile generated by screening the fines from a tumbling machine that was used to clean anode butts during the period of approximately 1960 to 1982. The pile has not been found to contain any cyanide-bearing wastes, and samples from the pile are not state dangerous waste based on aquatic toxicity and other tests (Engineering Assessment Report, 1988).

- Brick, rubble and other debris - Refractory brick from the carbon bake ovens, general industrial waste, rubble, periodic soil cover, and other materials were placed in a rubble pile adjacent to where SPL was deposited. The pile contains metal, brick, wood, and some potlining material. Rubble covers a relatively small amount of potlining beneath the eastern portion of the pile. Isolated pockets of potlining are also present elsewhere in the rubble pile. A more detailed description of the history of the rubble pile is contained in the Site Characterization Analysis Report 1988 (Appendix A).

1.2.4 Nature and Extent of Contamination

In August of 1978 cyanide was detected in several private wells located to the northwest of the KACC-Mead plant site (Site Characterization Analysis Report 1988, Appendix A). The suspected source of the cyanide was SPL material generated during aluminum production.

After the discovery of the cyanide in groundwater, KACC-Mead implemented a program to assess the sources, migration pathways, nature, and extent of contamination. The work included the drilling of monitoring wells, compilation of historical data on waste handling practices, review of historical aerial photographs, well inventories, collection and analysis of soil and groundwater samples, and completion of hydrogeologic analyses. This work is described in the Site Characterization Analysis Report 1988 (Appendix A) and references cited in the report.

Cyanide and fluoride are the only contaminants of concern. Cleanup actions discussed in this Feasibility Study address cyanide and fluoride contamination at the KACC-Mead site.

Cyanide and Fluoride Concentrations in Potlining Leachate and Groundwater

Cyanide and fluoride are the predominant constituents in leachate from SPL waste. Total cyanide concentrations in leachate have been detected on the order of 700 to 1,000 mg/kg while fluoride has been detected at a concentration over 2,700 mg/kg (Table 1-3).

The highest concentrations of total cyanide and fluoride in groundwater have been detected in well TH-8 (screened in Zone A) which is immediately downgradient of the SPL handling area (Figure 1-4). Total cyanide concentrations over 250 mg/l and fluoride concentrations over 200 mg/l have historically been detected in samples collected from this well. The concentrations of total cyanide and fluoride in this well and other wells in the vicinity of the cyanide plume has decreased gradually with time due to implementation of remedial measures that have reduced the migration of contaminants to the groundwater from the SPL and contaminated soils.

Free cyanide concentrations in groundwater are determined by Kaiser using the micro diffusion method (ASTM D4282-83). This method was developed by Kaiser. The EPA recently promulgated a maximum contaminant level (MCL) under the Safe Drinking Water Act for "cyanide amendable to chlorination" for determining free cyanide (FR July 27, 1992; p. 31786). Free cyanide concentrations determined by either method are assumed equal for the purpose of this Feasibility Study.

The free cyanide concentration in groundwater constitute a small fraction of total cyanide concentration (generally no more than 5 percent). Total cyanide is comprised mostly of iron cyanide complexes. A summary of cyanide and fluoride concentrations measured in groundwater at the site is provided in Appendix B.

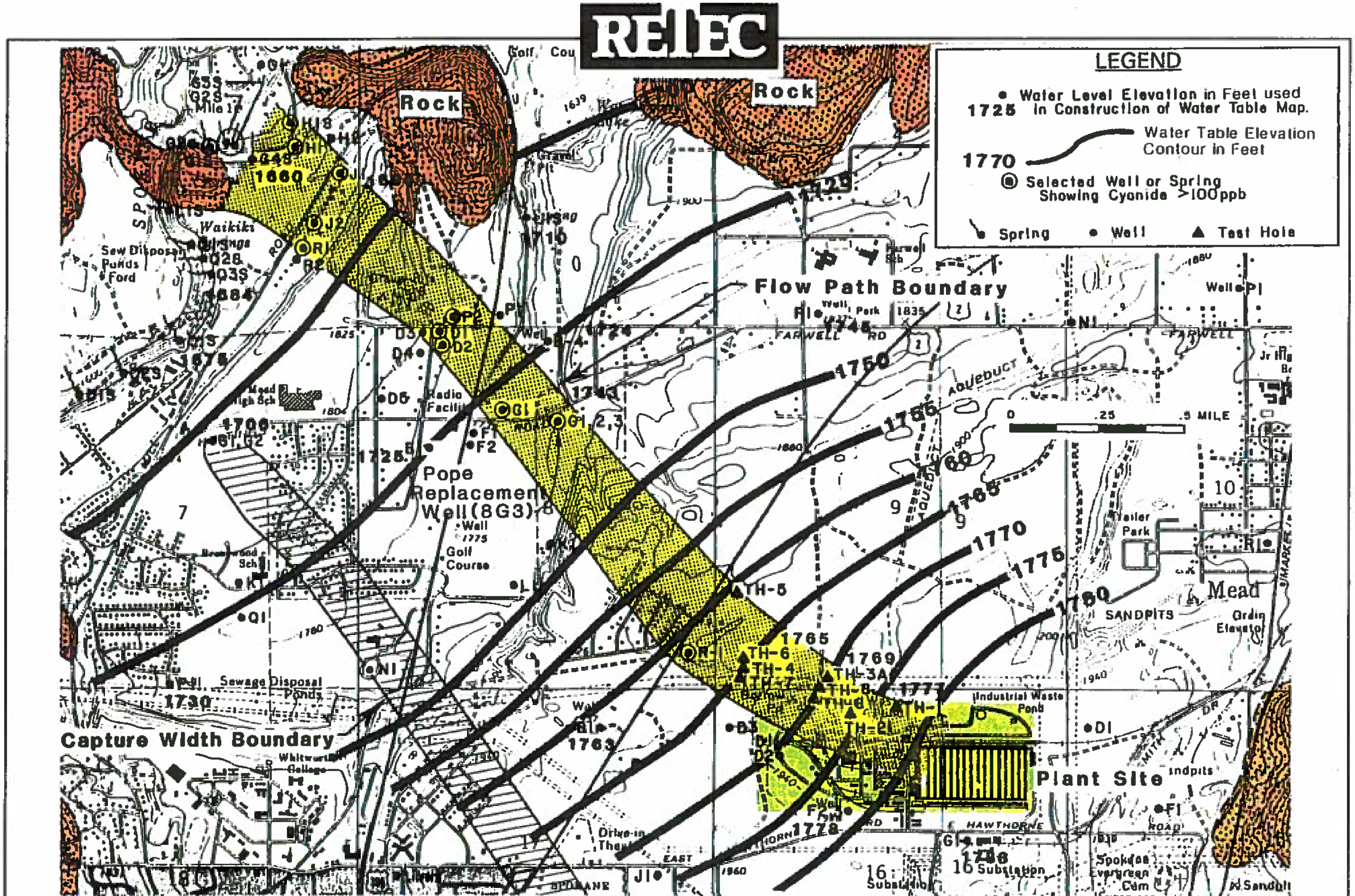
Cyanide and fluoride have migrated off the plant site and to the Little Spokane River. The approximate position of the plume is shown on Figure 1-7. The plume is relatively narrow with a width of about 800 ft at the plant and widens about 1,500 feet where groundwater discharges into the river. In the aquifer discharge area, the highest cyanide and fluoride concentrations have been detected in a spring whose designation is No. 195. Total cyanide has been detected at a maximum concentration of approximately 1.6 mg/l in 1983 and has since decreased to 0.9 mg/l in 1992. Fluoride has been consistently detected at concentrations less

TABLE 1-3
SPL LEACHATE CHARACTERISTICS[1]

Metals	Concentration (mg/L)	Parameter	Concentration (mg/L)
Antimony	0.015	Cyanide*	0.13
Arsenic	0.098	Phenolics	0.005
Cadmium	0.007	Chloride	10
Copper	0.027	Fluoride	2720
Manganese	0.016	Sulfide	44
Nickel	0.025	Ammonia	632
Selenium	0.025	Toluene	0.0004
Silver	0.013	Phenol	0.00002
Thallium	< 0.001		
Beryllium	0.001		
Chromium	0.011		
Lead	0.04		
Mercury	0.00036		
Zinc	0.02		
Calcium	0.25		
Aluminum	94		

[1] Sample collected on December 22, 1978 and analyzed using EP Tox Test (from CH2MHill, 1988).

* Cyanide concentration in the leachate was estimated later at 700 to 1,000 mg/L.



WATER TABLE AND ESTIMATED CYANIDE FLOW BOUNDARY
KACC - MEAD SITE

FIGURE 1-7

than 1 mg/l. The highest total cyanide and fluoride concentrations in spring No. 195 are less than one percent of the maximum concentrations detected in well TH-8. A detailed study by Hartung and Meier (1980) has demonstrated there have been no adverse impacts to the Little Spokane River.

While groundwater migration velocity within the vicinity of KACC-Mead plant site has been estimated at 3 to 4 ft/day, cyanide and fluoride migration velocities are estimated to occur at slower rates as discussed in Appendix C. The estimated migration rate of cyanide was determined from site data to be 0.71 ft/day. Fluoride migration velocity is estimated at 0.37 ft/day. These data indicate that cyanide is migrating approximately twice as fast as fluoride.

Surface Water Quality

Total and free cyanide concentrations have been measured at several locations in the Little Spokane River and in Peone Creek between 1985 and 1988. Total cyanide concentration in Peone Creek did not exceed 0.01 mg/L while free cyanide concentration did not exceed 0.008 mg/L. Total cyanide concentration in the Little Spokane River did not exceed 0.132 mg/L while free cyanide concentration did not exceed 0.025 mg/L. In general, the results of these measurements indicated that cyanide concentrations in surface water have decreased between 1985 and 1988.

Soil and Unsaturated (Vadose) Zone

Soil samples beneath the plant site have been collected for cyanide analysis. The highest contamination was measured within the potlining handling area. Soil cyanide concentrations exceeded 100 mg/kg in several borings beneath the SPL pile and the rubble pile at depths less than 50 feet. Other borings indicated cyanide concentrations of less than 100 mg/kg at depths less than 50 feet. In soils below 50 feet of depth, cyanide concentrations were generally below 100 mg/kg.

1.2.5 Summary of Past Remedial Actions

Numerous independent remedial actions have been implemented by Kaiser which have significantly reduced concentrations of cyanide and fluoride in the groundwater. These measures are summarized in Table 1-4 and include the following:

- 1978: Discharge of pot soaking liquor effluent to the sludge bed was stopped. Alternative water supplies were provided for users of

TABLE 1-4
SUMMARY OF REMEDIAL ACTIONS AT KAISER MEAD 1978 TO PRESENT

DATE	ACTIVITY	REASON FOR ACTION TAKEN
August 1978	Discharge of pot soaking water stopped. Discharge of sewage effluent to sludge bed stopped.	Groundwater contamination discovered beneath the Mead Works. Waste handling practices thought to be responsible were discontinued.
September 1978	Bottled water provided by Kaiser to residents. Physical offered by Kaiser to residents who requested.	Cyanide contamination was discovered in residential wells. Concern for health effects prompted action.
October 1978	Pot soaking operations discontinued.	By order of state (Department of Ecology) and county health department to prevent further pot soaking liquor releases.
January 1979	Potlining waste pile reshaped and covered with plastic.	Suspected primary cyanide source was isolated to prevent leachate generation and transport.
April 1979	Potlining waste pile paved and temporary storage slab with leachate collection constructed for new wastes.	Temporary source isolation converted to permanent design. New potlining waste from ongoing operations temporarily stored on asphalt pad, pending construction of new storage building.
November 1979	Public water supply hookups provided by Kaiser to residences completed.	Public water supply lines extended to vicinity of affected residences. Total abandonment of contaminated wells and bottled water now feasible.
September 1981	New settling basin completed. Old settling basin (Tharp Lake) abandoned and filled.	Covering spent potlining had failed to significantly reduce groundwater contamination. Tharp Lake recognized as source of water transporting cyanide to the regional aquifer.
November 1981	Construction of potlining storage building completed. Waste stored on temporary pad moved into building.	This action was a continuation of Kaiser's plan for isolating cyanide-containing potlining waste begun in January 1979.
June 1983	Pipe leak repaired.	Increasing cyanide concentrations in monitoring wells were caused by a pipe leak.

TABLE 1-4 continued
SUMMARY OF REMEDIAL ACTIONS AT KAISER MEAD 1978 TO PRESENT

DATE	ACTIVITY	REASON FOR ACTION TAKEN
1984	Second potlining storage building put into service.	Spent potlining storage and handling space requirements greater than capacity of a single building.
January 1986	Covered Area 2 with asphalt.	Ponding was observed during heavy runoff events. Area paved to prevent contaminant transport.
April 1986	Abandoned water handling system closed. Paving completed over Area 3 and old pot cleaning slab.	Area 3 paved to prevent infiltration of ponded water during heavy runoff. Abandoned water handling system (old pot soaking facility)closed concurrently.
November 1987	Covered Area 4 with asphalt.	Area 4 paved to prevent infiltration of ponded water during heavy runoff.
November 1979 to present	Public water supply hookups provided to potentially affected residents as needed; water usage costs paid for by Kaiser.	Concern over possible health effects due to ingestion of water containing cyanide.
August 1978 to present	On-going groundwater quality monitoring for total cyanide, free cyanide and fluoride.	On-going evaluation of cyanide and fluoride migration from the KACC-Site.

wells which may have been adversely affected by cyanide migration to and within the underlying aquifer.

- SPL handling practices were changed to minimize the possibility of leachate generation from plant activities or by exposure to precipitation.

  - August 1978: Pot soaking operations and effluent discharge to the sludge bed ceased.
  - January 1979: Exposed SPL material was covered with plastic.
  - April 1981: Exposed SPL was covered with asphalt.
  - September 1981: An unlined and leaking settling basin (Tharp Lake) was drained and abandoned.

- Stored SPL was moved out of the temporary storage area into storage buildings:

  - 1981: Potlining was moved into the first storage building.
  - 1984: A second building was constructed and put into operation.

- Selected areas were graded and covered with asphalt to reduce the possibility of infiltration of concentrated volumes of snowmelt or stormwater runoff. Drainage systems were installed to move surface water out of the SPL handling area.

  - April 1986: Area 2 was paved with asphalt.
  - April 1986: Pot cleaning slab was closed.
  - October 1986: Area 3 was paved.
  - November 1987: Area 4 was paved.

- Several pipe leaks were repaired:

  - June 1983
  - December 1987

- An updated field well inventory was completed by KACC-Mead during 1986. This inventory supplements the inventory of wells completed by the Spokane Health Department in 1978.

- A series of aquitard monitoring wells were installed in September 1989 on the fined grained layer which was found to be perching water which leaked from Tharp Lake (Hart Crowser 1989).

- Water quality is monitored and valuated on an on-going basis. The monitoring program includes wells located both on the plant site, and wells, springs and surface waters (in Little Spokane River) located downgradient of the plant site.

1.2.6 Water Quality Improvement Since 1981

Hydrogeologic analyses of possible contaminant migration mechanisms to the water table indicate that distributed natural precipitation is not sufficient to cause the measured concentrations of cyanide and fluoride in the Spokane Aquifer (Hart Crowser, September 1989). Data collected during site evaluations and monitoring indicate that the infiltration of water into soil containing cyanide and fluoride from pipe leaks or significant ponding of storm water or snow melt is required to cause contaminant migration to the aquifer through the relatively thick unsaturated zone. Since most of the SPL is located above where infiltration could reasonably occur, the primary "source" of contamination is considered to be soil which lies below SPL that contains high levels of cyanide and fluoride. This "model" of the site conditions is the primary basis for independent actions which have been completed at the site. The site "model" is more thoroughly discussed in the Site Characterization Analysis (Appendix A).

Groundwater quality has significantly improved as a result of remedial activities that have been implemented at KACC-Mead since 1978. Table 1-5 shows the reduction in cyanide concentrations at representative wells. Cyanide concentrations in these wells have declined between 20 and 98 percent over several years.

One of the primary remedial measures implemented by KACC-Mead was the abandonment of an unlined settling basin (Tharp Lake) which was leaking water (not containing cyanide) at a rate of approximately 50 gpm. As the water migrated to the water table it leached cyanide (and fluoride) present in the contaminated soil. Once this water reached the water table, cyanide migrated to the northwest in the prevailing direction of groundwater flow.

The unlined settling basin was abandoned in September 1981. Groundwater data collected since this time indicate that a substantial improvement in water quality has occurred. An overall assessment of the data indicates that contaminant concentrations have declined over

TABLE 1-5
TOTAL CYANIDE CONCENTRATION DECREASE IN GROUNDWATER

Well Number	Peak Year	Average Concentration for Peak Year (mg/L)	1991 Concentration (mg/L)	Percent Decline
ES-10	1981	74	1.3	98
HC-7	1981	45	1.0	98
HC-8	1981	56	2.3	96
TH-2	1982	3	1.6	47
HC-12	1984	74	59	20
HC-9A	1984	67	50	26
TH-3A	1982	183	62	66
TH-8	1982	263	89	66

50 percent since 1981. This is illustrated by plots of total cyanide and fluoride concentrations in well TH-8 (Figures 1-8 and 1-9) located downgradient of the waste handling area near the KACC-Mead property line.

Well TH-8 is approximately 1200 feet downgradient from the (now abandoned) Tharp Lake. Concentrations of total cyanide began to steadily decrease in November 1982. This calculates into a groundwater velocity of approximately 3 feet/day which is the estimated groundwater flow rate at the site and indicates that cyanide was moving at approximately the same rate as groundwater between Tharp Lake and TH-8. Total cyanide concentrations decreased from approximately 300 mg/l in November 1982 to 100 mg/l in April 1986. The observed decrease was linear over time and equates to a decrease rate of approximately 4.8 mg/l per month. Concentrations of total cyanide in TH-8 have remained at or near 100 mg/l sine this time.

Free cyanide concentrations in TH-8 did not follow the same linear decrease trend. Instead, free cyanide concentrations varied between 0.25 and 3 mg/l prior to 1987. Since 1987, free cyanide concentrations have remained steady near 0.5 mg/l in TH-8. Free cyanide is only 0.5 percent of the total cyanide concentration measured in TH-8.

Fluoride concentrations in TH-8 responded similarly to total cyanide concentrations following the abandonment of Tharp Lake. Concentrations decreased from nearly 200 mg/l in 1983 to approximately 100 mg/l in 1985. Fluoride concentrations in TH-8 have remained just below 100 mg/l since 1985. The observed decrease was linear over time and equates to a decrease rate of approximately 3 mg/l per month for fluoride.

Water quality improvement extended to wells and springs located 7,000 feet downgradient of KACC-Mead plant site (see Appendix B). Cyanide concentrations in wells TH-5, W-34, W-41, and spring W-195 which are used as downgradient representative wells, have decreased with time.

However, concentrations of cyanide and fluoride have not continued to decrease with time and appear to have reach near steady state concentrations as of 1987. Lack of water quality improvements since this time indicates that small amounts of additional cyanide and fluoride are being continually introduced to the aquifer. As demonstrated in the Site Characterization Analysis (December 1988, Appendix A), infiltration of distributed precipitation to move cyanide and fluoride to groundwater is unlikely. Paving and drainage installation activities completed by Kaiser further reduce this possibility. It is likely other water sources exist which are

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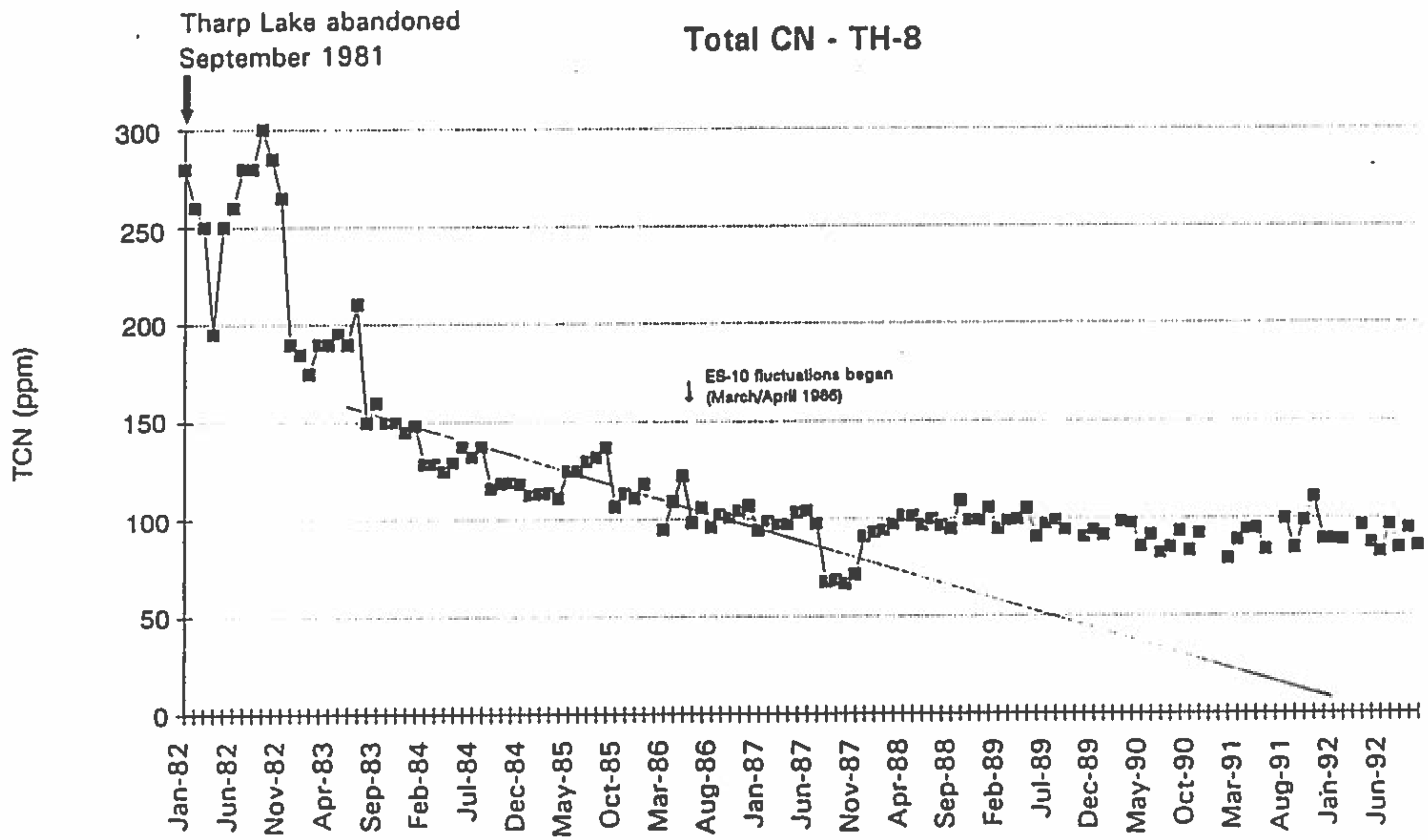

TOTAL CYANIDE CONCENTRATION IN WELL TH-8 KACC - MEAD SITE	FIGURE 1-8

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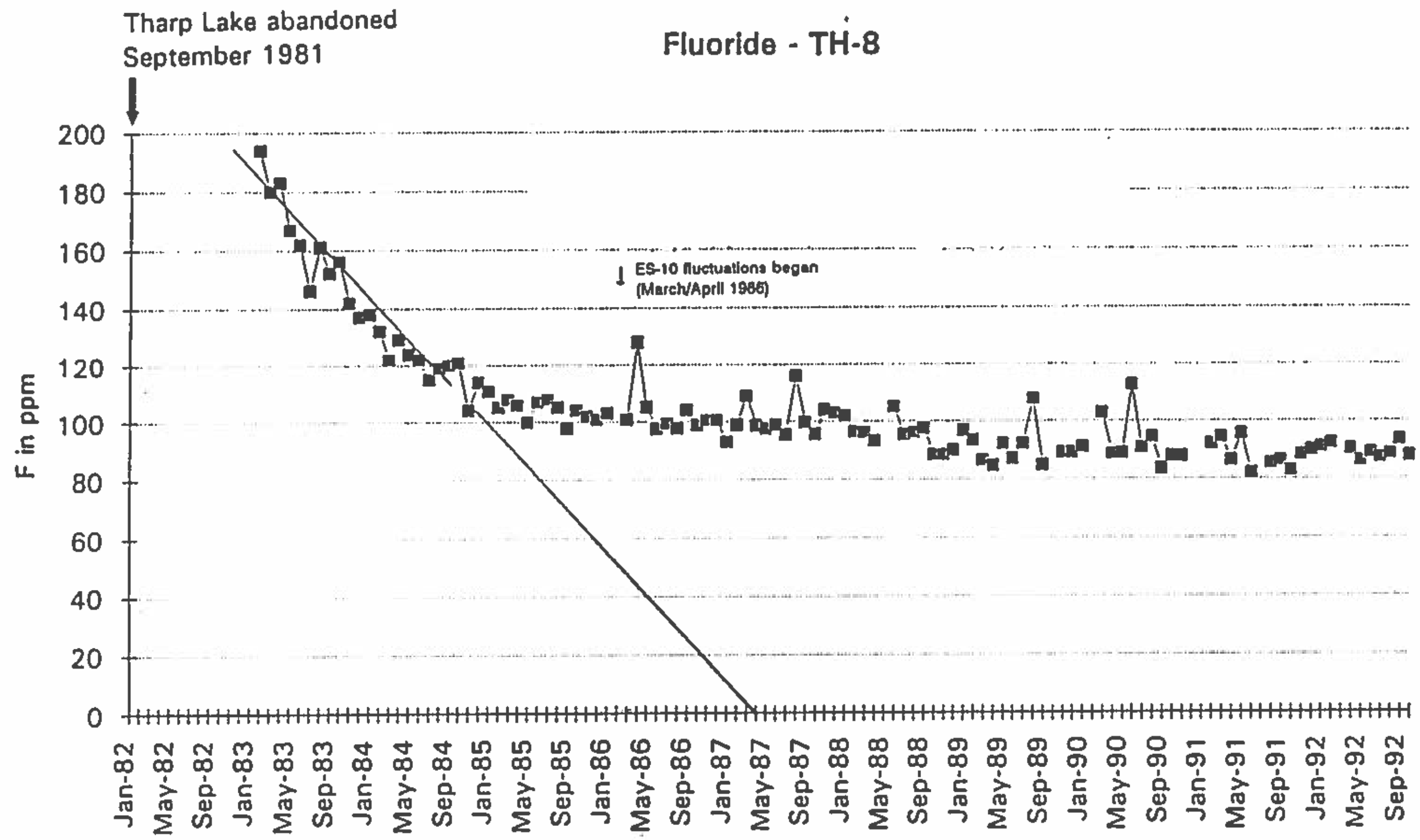

FLUORIDE CONCENTRATION IN WELL TH-8 KACC - MEAD SITE	FIGURE 1-9

introducing additional cyanide and fluoride into groundwater. Pipe leakage which contacts contaminated soil is considered to be the primary remaining water source to leach and transport contaminants to the underlying aquifer. Additional leaching from SPL wastes contained in the SPL and rubble piles is not likely as these materials are generally located above the original ground surface and do not contact water from potentially leaky underground pipes.

1.2.7 Summary

This FS has been completed utilizing information collected during extensive investigations at the site which have been completed since 1978. Cleanup actions which are expected to result in improvements to groundwater quality are evaluated based on an understanding of the site as well as cyanide and fluoride migration mechanisms.

1.3 ORGANIZATION OF REPORT

The FS is organized in seven sections. This section discusses the objectives of the FS, site background, and report organization. Section 2.0 develops appropriate cleanup standards for the site. The site conditions relevant to the implementation and success of the cleanup actions are included in Section 3.0. Section 4.0 is an initial identification and screening of cleanup action technologies generally applicable to this site. Section 5.0 details the most promising cleanup action alternatives specific to KACC-Mead. Each alternative provides a description of a site-specific preliminary design. Section 5.0 summarizes and compares the cleanup alternatives based on the reliability, implementability, and cost criteria and on WDOE criteria established in MTCA. The recommended alternative and selection rationale is presented in Section 6.0. Lastly, references are compiled in Section 7.0.

2.0 IDENTIFICATION OF PROPOSED CLEANUP STANDARDS

The cleanup standards for the KACC-Mead site are derived in this section. Cleanup standards include three components:

- numerical cleanup levels,
- points of compliance, and
- additional regulatory requirements as specified in applicable state and federal laws.

The Washington Model Toxics Control Act (MTCA) provides three methods for developing numerical cleanup levels: Method A (routine sites), Method B (standard method), and Method C (conditional method). Each method included a different process for developing cleanup levels. As stated in WAC Chapter 173-340-705, Method B is the standard method intended for use at all sites and "shall be used to develop cleanup levels unless one or more of the conditions for using Method A or Method C are demonstrated to exist and the person conducting the cleanup elects to utilize that method." Points of compliance are based on the types of exposure expected at the site and are discussed in Section 2.2. Numerical regulatory requirements are considered in the development of cleanup levels and are discussed in Section 2.3.

2.1 METHOD SELECTION

WAC Chapters 173-340-704 and 173-340-130(7) describe MTCA Method A as intended or use primarily at relatively simple sites that require routine cleanup measures. Such sites typically have few specific contaminants present. The following criteria were used to evaluate the potential applicability of Method A for the KACC-Mead site:

- Method A cleanup levels are available for all substances found at the site;

- Ecology has experience with similar sites,

- There is an obvious and limited choice of a cleanup method; and

- Cleanup standards are obvious and undisputed.

MTCA further states that Method A is generally not considered applicable to sites involving cleanup of groundwater. Due to the presence of contaminants in groundwater and the lack of Method A cleanup levels for cyanide and fluoride, Method A is not considered appropriate for this site.

Method C may be used if one of the following conditions exist:

- Method A or B levels are below area background concentrations;
- Method A or B levels are not technically possible to achieve; or
- Meeting Method A or B levels would result in greater harm to the environment.

None of the conditions are considered applicable to groundwater at this site. Therefore, Method B was used to develop groundwater cleanup levels for the KACC-Mead site. Use of Method B for determination of groundwater cleanup levels is consistent with the development of cleanup levels at the KACC-Mead site for Building 32N (Closure Plan Revision, October 1992).

Method C may also be applied to certain industrial sites. To be classified as an industrial site, the following must be demonstrated:

- The site is zoned or has been otherwise officially designated for industrial use;
- The site is currently used for industrial purposes or has a history of use for industrial purposes;
- Adjacent properties are currently used or designated for use for industrial purposes;
- The site is expected to be used for industrial purposes for the foreseeable future due to site zoning, statutory or regulatory

restrictions, comprehensive plans, adjacent land use, and other relevant factors; and

- The cleanup action provides for institutional controls.

The KACC-Mead site meets all of the above criteria. The site is zoned industrial and is expected to remain industrial in the future. The Bonneville Power Administration (BPA) (industrial zoning) owns the land to the North, East and South of the KACC-Mead site. The property to the West is also zoned industrial and is owned by Travis Pattern and Foundry. A parcel of land in the northwest corner of the KACC-Mead property line is owned by Walter Knopp and is currently zoned residential. However, the BPA retained rights to the land under the power lines and it cannot be used for residential construction. Hence, the KACC-Mead site is surrounded by industrial users. Kaiser has implemented several institutional controls as discussed in Section 1.1.4. These controls will be maintained in the future as part of the cleanup action. Therefore, Method C cleanup levels for soil have been developed for the KACC-Mead site.

2.2 REASONABLE MAXIMUM EXPOSURE

MTCA requires that cleanup levels under Method B be based on reasonable maximum exposure (RME) which is defined as the "highest exposure that can be reasonable expected to occur for a human or other living organism at a site under current and potential future use" (WAC Chapter 173-340-200). The first step in determining RME is to address the present and potential future site uses.

RME is defined in the MTCA regulations for each medium of concern, i.e. soil, groundwater, surface water and air. The RME depends on current and future site use and on the exposure pathways present at a site. Exposure assumptions and equations to be used with specific RME are also defined. Applicable laws that will be used in developing cleanup standards for that medium are also based on the determination of RME. The following sections discuss the RME for soil and groundwater at the KACC-Mead site. The cyanide/fluoride plume originating from the KACC-Mead site discharges into the Little Spokane River through a series of springs. The studies to date of the river indicate that there have been no discernible effect on aquatic life (Hartung and Meier, 1980). There is no evidence of cyanide and/or fluoride contamination in the air at the site.

2.2.1 Soil

RME for soil is based on industrial site use (incidental ingestion of soil during work hours). The point of compliance for cleanup standards based on direct contact with soil is throughout the upper 15 feet of accessible soil. Soil and wastes which are below the asphalt cap or other impermeable surface are not considered part of the RME as these soils are not available for incidental ingestion.

2.2.2 Groundwater

The KACC-Mead site is located over the Hillyard Trough portion of the Spokane-Rathdrum Prairie Aquifer (see Figure 1-3). Groundwater flows to the northwest where it discharge to the Little Spokane River. A plume of cyanide and fluoride originating from the KACC-Mead site has been traced to the Little Spokane River as discussed in Chapter 1. The Spokane-Rathdrum Prairie Aquifer has been designated a sole source aquifer by the Environmental Protection Agency. Numerous groundwater wells have been installed in the Hillyard Trough portion of the aquifer for potable water supply. As part of the institutional controls implemented by Kaiser, those wells which were potentially affected by the cyanide/fluoride release have been connected to the public water supply. Kaiser will continue these controls in the future.

Although exposure to contaminated drinking water for off-site receptors will be restricted due to the institutional controls, designation of the Spokane-Rathdrum Prairie Aquifer as a sole source aquifer constitutes ingestion from a residential scenario as the RME.

The point of compliance for groundwater is proposed as a conditional point of compliance, represented by the property boundary. Hazardous substances are expected to remain on-site as part of the cleanup action and the property boundary is immediately north of the SPL and rubble piles.

2.3 DEVELOPMENT OF CLEANUP LEVELS UNDER MTCA

The following general considerations are used in developing cleanup levels under both the Method B and Method C approaches:

- Applicable state and federal laws - State and federal laws are reviewed for each medium at the site. All state and federal laws, proposed laws, guidance and criteria are considered.

- Risk-based concentrations - Risk-based concentrations based on the RMEs described above are calculated using the equations and exposure assumptions provided in the MTCA regulations.

- Natural background concentrations - In general, the lowest of the above concentrations is chosen as the cleanup level. However, if that cleanup level is lower than natural background concentrations in the area, the natural background concentration is used as the standard. Natural background concentrations are not expected to be an issue at this site.

- Effects on other media - Media specific cleanup levels must be protective of cleanup levels for other media. For soil, cleanup levels must be equal to or less than one hundred times the groundwater cleanup level unless it can be demonstrated that a higher soil concentration is protective of groundwater at the site.

- Unique site characteristics - The cleanup level must be protective when the unique site characteristics are considered.

- Analytical considerations - The cleanup level must be greater than the practical quantitation limit such that attainment of cleanup levels can be quantified. Analytical considerations are not expected to be an issue at this site.

The process for developing medium specific cleanup levels is shown in Figure 2-1 and discussed in detail below.

2.3.1 Applicable State and Federal Laws

The Safe Drinking Water Act (SDWA) has developed maximum contaminant levels (MCLs) for cyanide and fluoride based on human use of water for drinking, cooking, bathing, etc. Economic considerations and technical feasibility of treatment processes are included in the

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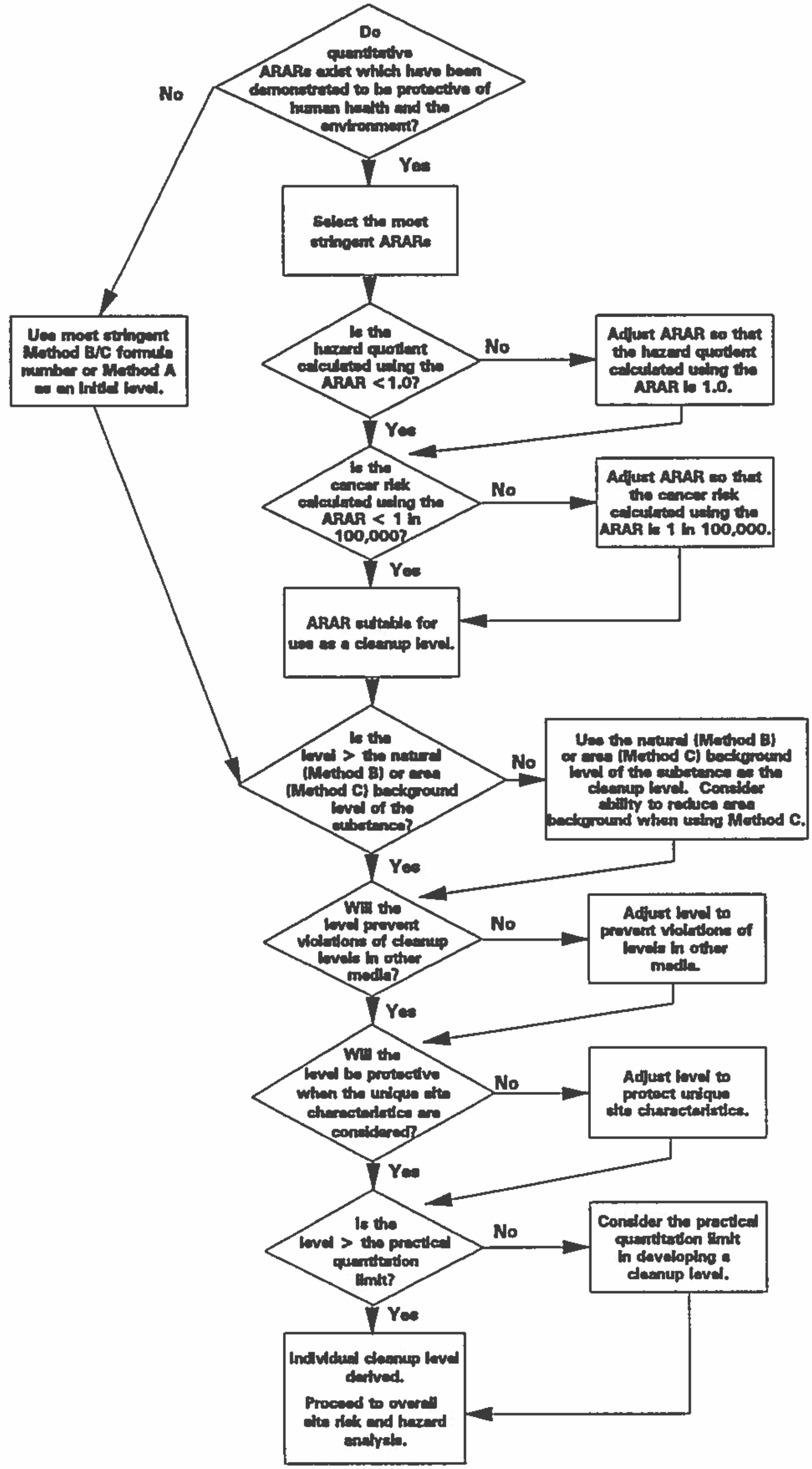

FLOWCHART FOR DEVELOPING MEDIUM SPECIFIC CLEANUP LEVELS FOR INDIVIDUAL SUBSTANCES USING METHOD B OR C

FIGURE 2-1

justification for these levels. These are enforceable standards that may by applicable to the discharge of water to surface water or groundwater that can be classified as a source or potential source of drinking water. The MCL for cyanide is 0.2 mg/l as "free" cyanide (cyanide amendable to chlorination). A MCL of 4 mg/l has been set for fluoride.

No applicable state or federal laws related to soil are available for cyanide or fluoride.

2.3.2 Human Health Risk-Based Concentrations

Risk-based concentrations for soil, groundwater and surface water were developed for cyanide and fluoride using the equations and assumptions provided in MTCA. Current carcinogenic potency factors and reference doses (RfDs) were obtained from EPA's Integrated Risk Information System (IRIS). IRIS printouts are provided in Appendix D.

MTCA specifies acceptable risk levels that must be used when developing risk-based concentrations. For individual contaminants, Method B concentrations are calculated based on an acceptable risk of 1×10^{-6} (for carcinogens) or a hazard quotient of 1.0 (for noncarcinogens). MTCA also requires that risks from contaminants with effects on similar target organs be considered additive. For carcinogens, the overall target risk level under Method B is 1×10^{-5}. For noncarcinogens, the overall target hazard index is 1.0, combining risks from all contaminants with similar health effects. Using this process, risk-based concentrations calculated for individual contaminants are lowered to meet the overall risk limits for the site. Risk-based concentrations for cyanide and fluoride in each media are presented below along with a summary of the health effects associated with each of these compounds.

<u>Cyanide</u>

EPA has classified cyanide as a class D compound which implies there is not adequate evidence of carcinogenicity. Cyanides are readily absorbed by ingestion, inhalation and across by skin by animals and humans. Hydrogen cyanide (HCN) is reported to be rapidly absorbed by the gastrointestinal tract due to its weak acidity while inhalation of HCN is the most rapid route of entry. Toxicity of cyanides is highly dependent on the form, with free cyanide (CN), hydrogen cyanide and its simple salts the most toxic form. The toxicity of complexed cyanides related to the degree which they disassociate to free cyanide. The form of cyanide at the KACC-Mead site is iron complex cyanide that only weakly disassociates to free cyanide.

Acute toxicity is of greatest concern of cyanide exposure with symptoms of rapid breathing, gasping, tremors, convulsions and death. Subchronic toxicity occurs over longer durations of exposure and cause headache, weakness, changes in smell and taste, throat irritation, vomiting, difficulty in breathing and psychosis. Chronic effects include disorders of thyroid, high incidence of amblyopias, and neuropathies in humans.

A chronic oral RfD of O.O2 mg/kg/day has been derived for cyanide (see IRIS printout, Appendix C). The subchronic oral RfD is also 0.02 mg/kg/day. No RfD has been established for the inhalation route of exposure for cyanide.

Soil

The procedures for developing Method C risk-based cleanup levels for industrial sites are outlined in WAC 173-340-745(4). Concentrations which are anticipated to result in no acute or chronic toxic effects on human health via direct contact with contaminated soil are determined using the following equation and standard exposure assumptions:

$$\text{soil cleanup levels (mg/kg)} = \frac{RfD \times ABW \times UCF2 \times HQ}{SIR \times AB1 \times FOC} \qquad 2\text{-}1$$

where:

RfD = Reference dose (mg/kg/day)
ABW = Average body weight over the period of exposure (70 kg)
UCF2 = Unit conversion factor (1,000,000 mg/kg)
SIR = Soil ingestion rate (50 mg/day)
AB1 = Gastrointestinal absorption rate (1.O)
FOC = Frequency of contact (0.4)
HQ = Hazard quotient (1).

A Method C soil cleanup level for cyanide of 70,000 mg/kg is calculated using Equation 2-1.

Groundwater

The procedures for developing Method B risk-based cleanup levels for groundwater are outlined in WAC 173-340-720(3). Concentrations which are estimated to result in no acute or chronic toxic effects on human health are determined using the following equation and standard exposure assumptions:

$$\text{groundwater cleanup level (ug/l)} = \frac{RfD \times ABW \times UCF \times HQ}{DWIR \times INH} \qquad (2\text{-}2)$$

where:

RfD	= Reference Dose (mg/kg/day)
ABW	= Average body weight during the period of exposure (16 kg)
UCF	= Unit conversion factor (1,000 ug/mg)
HQ	= Hazard quotient (1)
DWIR	= Drinking water ingestion rate (1.0 liter/day)
INH	= Inhalation correction factor (1.0 for cyanide)

A Method B cleanup level for cyanide of 0.32 mg/l is calculated using Equation 2-2.

Fluoride

Fluoride has not been evaluated by the EPA for evidence of human carcinogenic potential but is generally accepted as being noncarcinogenic. A critical effect of objectionable dental fluorosis has been measured in children. This is a cosmetic effect and is not a toxic and/or adverse health effect. Dental fluorosis results from excess exposure to fluoride during the age of calcification of the teeth (up to about 8 years of age for anterior teeth). Dental fluorosis in its mild form is characterized by white opaque areas covering 50 percent of a given tooth; in its severe form, dental fluorosis is characterized by brown to black stains and pitting.

Based on epidemiological studies of children, the NOAEL for objectionable dental fluorosis is approximately 1.0 mg/l fluoride in drinking water. Assuming that a child weights 20 kg, drinks 1.0 liter of water per day and ingests fluoride at 0.01 mg/kg/day in the diet, a NOAEL of 1 mg/l fluoride in drinking water corresponds to the published RfD of 0.06 mg/kg/day.

An adverse health effect of crippling skeletal fluorosis occurs at higher consumption rates of fluoride. No cases of crippling skeletal fluorosis has been observed in the United States associated with the consumption of 2 liters of water per day containing 4 mg/l fluoride. While the NOAEL for crippling skeletal fluorosis in humans is unknown, a safe level of fluoride exposure of 0.12 mg/kg/day has been determined. The MCL of 4 mg/l is based on epidemiological studies of crippling skeletal fluorosis.

Because the published RfD for fluoride is based on the cosmetic effect of objectionable dental fluorosis and not on acute or chronic toxic effects, Method B cleanup levels are not calculated. Instead, a cleanup level of 4 mg/l based on prevention of crippling skeletal fluorosis is appropriate for the KACC-Mead site.

2.3.3 Adjustment of Risk-Based Concentrations

Noncarcinogenic contaminants (cyanide and fluoride) are considered to elicit additive effects when the effects used to generate the RfD values for those contaminants occur in the same target organ. Cyanide has been shown to affect the thyroid gland, sight and nervous system in humans. Fluoride affects the skeletal system. These effects are not considered additive as they do not occur to the same target organ or system.

2.3.4 Effects on Other Media

Media specific cleanup levels must be protective of cleanup levels for other media. For soil, cleanup levels must be equal to or less than one hundred times the groundwater cleanup level unless it can be demonstrated that a higher soil concentration is protective of groundwater at the site. It is likely that soil concentrations of free cyanide above 100 times the groundwater standard are protective of groundwater. However, due to the lack of specific information for the KACC-Mead site, soil cleanup levels are established based on 100 times the groundwater cleanup level.

2.4 PROPOSED CLEANUP STANDARD

Under MTCA, establishing cleanup standards for individual sites requires the specification of the following:

- Hazardous substance concentrations that protect human health and the environment ("cleanup levels");
- The location on the site where those cleanup levels must be obtained ("points of compliance");and

- Additional regulatory requirements that apply to a cleanup action due to the type of action and/or the location of the action. These requirements are generally established when a specific cleanup action is selected and are not addressed herein.

Potential cleanup levels for cyanide and fluoride at the KACC-Mead site are summarized in Table 2-1. The groundwater cleanup level for cyanide of 0.32 mg/l is based on noncarcinogenic risks to humans and is consistent with cleanup levels determined under MTCA for Building 32N at the KACC-Mead site (Closure Plan Revision, October 1992). The groundwater cleanup level for fluoride of 4 mg/l is also based on noncarcinogenic risks to humans as established by the MCL. Soil cleanup levels based on protection of groundwater are 32 and 400 mg/kg for free cyanide and fluoride, respectively.

The point of compliance for groundwater is proposed as a conditional point of compliance represented by the property boundary as hazardous substances are expected to remain on-site as part of the cleanup action and the property boundary is in close proximity to the SPL and rubble piles. For soil cleanup levels based on the protection of groundwater, the point of compliance is in soils throughout the site. The soil cleanup levels will not be met in soils throughout the site if containment of hazardous substances is selected as part of the cleanup action. As specified in WAC 173-340-740(6)(d), the cleanup action can comply with the cleanup standards, provided the compliance monitoring program is designed to ensure the long-term integrity of the containment system and other containment requirements. Containment of hazardous substances is likely to be a part of the selected cleanup action at the KACC-site.

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TABLE 2–1
CLEANUP LEVELS
KAISER ALUMINUM MEAD WORKS

	Groundwater Ingestion (mg/l)		Soil Ingestion (mg/kg)		Soil – GW Protection (mg/kg)[1]	
	Free Cyanide	Soluble Fluoride	Free Cyanide	Soluble Fluoride	Free Cyanide	Soluble Fluoride
MTCA Method B (residential)	0.32	nc	--	--	32	--
MTCA Method C (industrial)	--	nc	70,000	nc	--	--
MCL	0.2	4	na	na	--	400

(1) – based on a factor of 100.

nc – not calculated as oral RfD is based on cometic effects, not acute or chronic toxic health effects.

na – not applicable

3.0 SITE CONDITIONS

3.1 INTRODUCTION

Since the discovery of cyanide and fluoride in the groundwater in 1978, extensive monitoring and investigations have provided a large volume of data related to the KACC-Mead site. This information is disseminated in various reports and was summarized in the Engineering Assessment Report (December 1988). Since this time, Kaiser has maintained a groundwater quality assessment program and submits groundwater monitoring reports to WDOE on a semiannual basis.

Cyanide and fluoride are the constituents of concern at the site. Groundwater cleanup levels of 0.32 mg/l free cyanide and 4 mg/l for fluoride were developed in Chapter 2. A soil cleanup level of 32 mg/kg based on protection of groundwater has been established for free cyanide at the site. Based on ingestion of soil at an industrial site, free cyanide soil concentrations of 70,000 mg/kg are protective of human health. Site areas which exceed these cleanup levels and areas which exceed the cleanup standard are summarized below.

3.2 GROUNDWATER

Total cyanide and fluoride are analyzed as part of the KACC-Mead groundwater monitoring program. Free cyanide has been analyzed on a less frequent, although regular, basis using the Kaiser microdiffusion method (ASTM D4282-83). EPA has recently promulgated an MCL for free cyanide measured as "amendable to chlorination" (FR July 27, 1992; p. 31786). Free cyanide concentrations determined by either method are assumed equal for the purpose of this Feasibility Study.

Water quality data collected from three sampling locations are emphasized in the following discussion. These locations have been selected as they are representative of water quality at the property line (TH-8), immediately downgradient (TH-6) and at the discharge point to the Little Spokane River (W-195). Well TH-8 is located immediately downgradient of the waste handling area within the plume head and is the well where the highest cyanide and fluoride concentrations have been detected. Wells TH-6A, TH-6B, and TH-6C are located in the approximate horizontal center of the plume and are screened across Zone A, B, and C, respectively. Spring location No. 195 (W-195) has the highest cyanide concentration in the area where the aquifer discharges to the Little Spokane River.

3.2.1 Free Cyanide

Based on data collected in May and August of 1992, only three wells contain free cyanide concentrations above the cleanup level of 0.32 mg/l: TH-3A, TH-8 and HC-12 (Figure 3-1). Free cyanide concentrations in these wells ranged between 0.45 to 0.48 mg/L (Table 3-1). Only one well (HC-12) exceeds the cleanup level beyond the point of compliance.

A time-series plot of free cyanide concentrations is presented in Figure 3-2 for samples from well TH-8. Since 1987, free cyanide concentrations at this location have ranged between 0.2 and 0.7 mg/L.

The most recent data from wells TH-6A, TH-6B, and TH-6C indicate that free cyanide concentrations are below the free cyanide cleanup level as summarized below:

	November 1990	May 1991
TH-6A	0.131	0.188
TH-6B	0.161	0.167
TH-6C	N/A*	N/A*

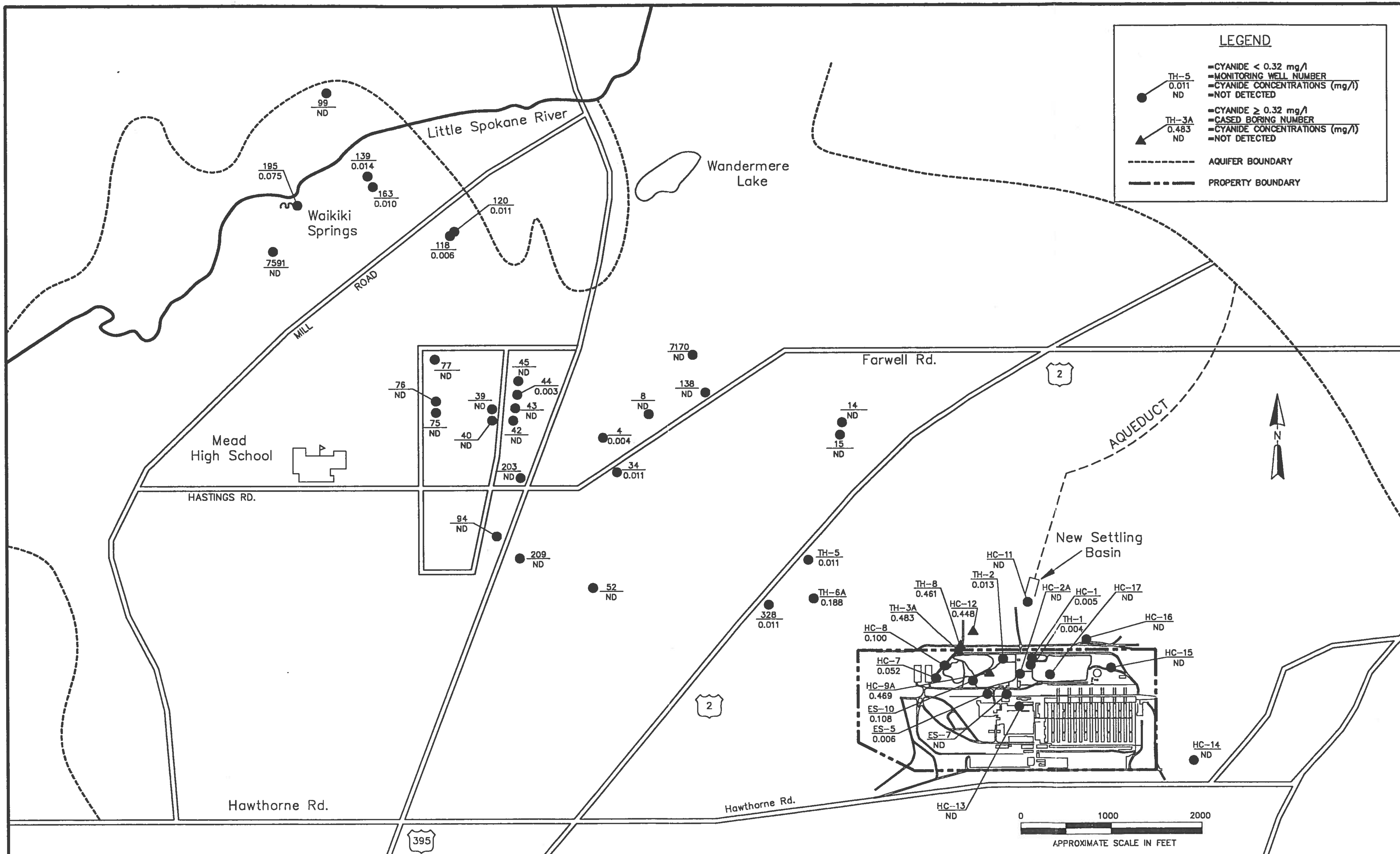
* Total cyanide concentrations were below 0.010 mg/L.

Time series plots of free cyanide concentrations from wells TH-6A, TH-6B, and TH-6C are presented in Figures 3-3, 3-4, and 3-5, respectively. The data indicates that although free cyanide has migrated to and beyond the site boundaries, the concentration of free cyanide does not exceed the cleanup levels at these locations.

Free cyanide concentrations at the outfall to the Little Spokane River (W-195) have generally been below 0.1 mg/L since 1986 and have always been below the cleanup level. A time series plot of concentrations from this sampling location are shown on Figure 3-6.

3.2.2 Fluoride

Six wells within the property boundary exceed the cleanup level of 4 mg/l for fluoride: ES-5, ES-7, HC-7, HC-9A, TH-3A and TH-8 (Figure 3-7). Fluoride concentrations vary from 9 to 88 mg/l. Only two wells, HC-12 and TH-6A, exceed the cleanup level beyond the point of compliance. Concentrations in both of these wells as measured in October 1992 are approximately 21 mg/l. Groundwater quality data for fluoride as measured in August and October 1992 is summarized in Table 3-2.



DRAWN BY	E.F.
DATE	2/10/93
CHK'D BY	J.R.C.
DATE	2/10/93
SCALE	NOTED
CAD FILE:	1012/938002

REGIONAL FREE CYANIDE CONCENTRATION MAP
MAY/AUGUST 1992
KACC – MEAD SITE

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FIGURE 3–1

TABLE 3-1
Summary of Selected Water Quality Data

Location No.	Other Designation	Depth (feet)	Portion of Aquifer	Date	Total CN (mg/l)	Free CN (mg/l))	Fluoride (mg/l))
TH-1	Monitoring Well	155	Zone A	10-92(5-91)	0.054(0.044)	N.A.(0.004)	3.1(2.9)
TH-2	Monitoring Well	155	Zone A	10-92(5-91)	5.15(0.18)	N.A.(0.01)	2.8(1.5)
TH-3A	Monitoring Well	153	Zone A	10-92(5-91)	68.45(68.87)	N.A.(0.48)	63.8(65.5)
TH-5	Monitoring Well	160	Zone A	10-92(5-91)	0.57(0.19)	N.A.(0.01)	0.41(0.48)
TH-6A	Monitoring Well	148	Zone A	10-92(5-91)	5.2(6.01)	N.A.(0.19)	20.6(24.4)
TH-6B	Monitoring Well	169	Zone B	10-92(5-91)	4.38(5.12)	N.A. (0.15)	1.3 (1.4)
TH-6C	Monitoring Well	197	Zone C	10-92(5-91)	0.006(N.D.)	N.A. (N.A.)	0.12 (0.17)
TH-8	Monitoring Well	156	Zone A	10-92(5-91)	85.3(94.75)	N.A.(0.46)	87.6(95.7)
ES-5	Monitoring Well	170	Zone A	10-92(5-91)	1.62(1.33)	N.A.(0.006)	9.3(11.0)
ES-7	Monitoring Well	165	Zone A	10-92(5-91)	0.17(0.24)	N.A.(N.D.)	14.6(24)
ES-10	Monitoring Well	165	Zone A	10-92(5-91)	19.42(2.53)	N.A.(0.11)	3(3.3)
HC-1	Monitoring Well	151	Zone A	10-92(5-91)	0.06(0.12)	N.A.(0.005)	2.5(2.6)
HC-2A	Monitoring Well	162	Zone A	10-92(6-91)	0.05(0.04)	N.A.(N.A.)	0.58(0.64))
HC-7	Monitoring Well	159	Zone A	10-92(5-91)	0.86(0.94)	N.A.(0.05)	22(20.2)
HC-8	Monitoring Well	158	Zone A	10-92(5-91)	1.15(3.09)	N.A.(0.10)	0.95(2.0)
HC-9A	Monitoring Well	157	Zone A	10-92(5-91)	51.13(67.71)	N.A.(0.47)	36.5(31.5)
HC-11	Monitoring Well	157	Zone A	10-92(5-91)	N.D.(N.D.)	N.A.(N.A.)	0.17(0.35)
HC-12	Monitoring Well	145	Zone A	10-92(5-91)	67.67(60.31)	N.A.(0.45)	20.9(26)
HC-13	Monitoring Well	157	Zone A	10-92(5-91)	0.02(0.005)	N.A.(N.D.)	0.33(0.56)
HC-14	Monitoring Well	156	Zone A	9-92(5-91)	N.D.(N.D.)	N.A.(N.A.)	0.06(0.16)
HC-15	Monitoring Well	140	Zone A	10-92(5-91)	0.007(N.D.)	N.A.(N.A.)	0.87(0.98)
HC-16	Monitoring Well	136	Zone A	10-92(5-91)	0.005(N.D.)	N.A.(N.A.)	0.81(1.6)
4	L. Lessig	48	Top	8-92(6-91)	0.15(0.11)	0.004(N.A.)	0.63(0.11)
8	R. Brinson	51	Top	8-92(6-91)	0.007(0.004)	N.A.(N.A.)	0.15(0.22)
14	D. Reames	128	Top	8-25-92	N.D.	N.A.	0.04
15	R. Thain	380	?	8-25-92	N.D.	N.A.	0.08
34	S. Pope	47	Top	8-92(6-91)	0.16(0.17)	0.01(0.01)	0.44(0.48)
39	G. Procunier	70	Top/Middle	8-25-92	N.D.	N.A.	0.04
40	D. Grandfield	86	Middle	8-24-92	N.D.	N.A.	0.04
42	R. Rockser	85	Middle	8-25-92	N.D.	N.A.	0.03
43	K. Ritchie	75	Middle	8-25-92	N.D.	N.A.	0.03
44	W.E. Airth	N.A.	N.A.	8-92(6-91)	0.02(0.02)	0.003(N.D.)	0.08(0.06)
45	G. Weismann	N.A.	N.A.	8-92(6-91)	N.D.(0.06)	N.A.(0.004)	0.03(0.39)
52	B. Nelson	27	Top	8-25-92	N.D.	N.A.	0.05
75	Franklin/Fulsaas	115	Bottom	8-25-92	N.D.	N.A.	0.05
76	P. Platz	119	Bottom	8-25-92	N.D.	N.A.	0.03
77	W. Downey	106	Bottom	8-25-92	N.D.	N.A.	0.03
94	WSDOT	50	Top	8-25-92	N.D.	N.A.	0.03
99	J. Barrett	25	Top	8-24-92	N.D.	N.A.	0.06
118	E. Pechia	50	Top	8-26-92	0.1	0.006	0.04
120	C. English	N.A.	N.A.	8-24-92	0.19	0.01	0.46
138	S. Kyllo	85	Top	8-92(6-91)	N.D.(N.D.)	N.A.(N.A.)	0.2(0.19)
139	B. Rubbright	45	Top	8-24-92	0.17	0.01	0.06
163	G. Ludesher	spring	---	8-92(6-91)	0.16(0.17)	0.01(0.01)	0.09(0.08)
195	H. Ludesher	spring	---	8-92(6-91)	0.95(0.88)	0.08(0.05)	0.85(0.94)
203	Northgate Bap. Church	78	Top	8-25-92	N.D.	N.A.	0.04
209	M. Billberg	43	Top	8-25-92	N.D.	N.A.	0.05
328	S. Merritt	185	Top	8-92(6-91)	0.13(0.12)	0.01(0.006)	0.24(0.34)
7170	P. Kelsey	N.A.	N.A.	8-25-92	N.D.	N.A.	0.05
7591	Schoessler	120	Middle	8-92(6-91)	N.D.(N.D.)	N.A.(N.A.)	0.05(0.03)

N.D. - Not Detected (<0.004 mg/l); N.A. - Not Available

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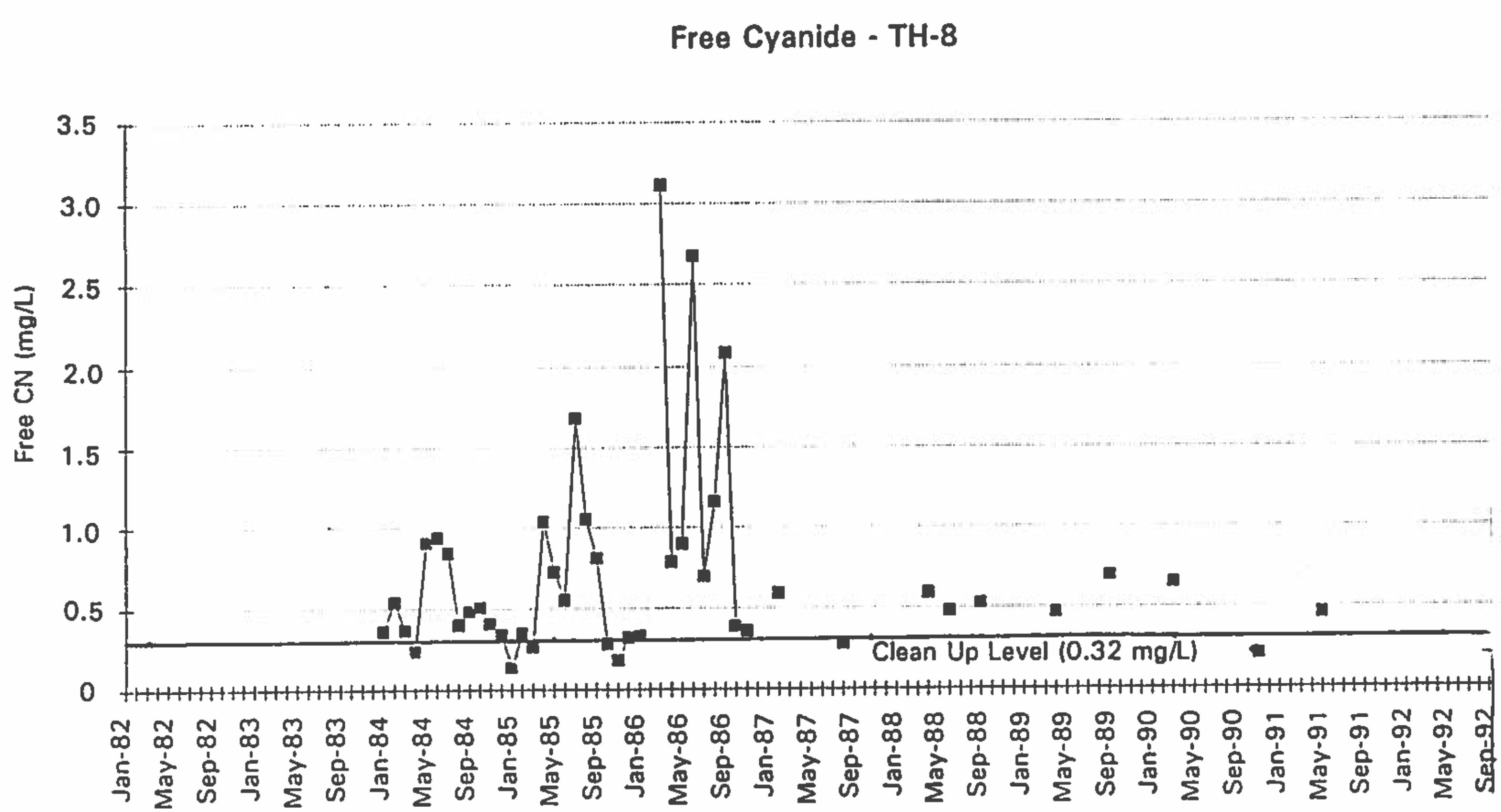
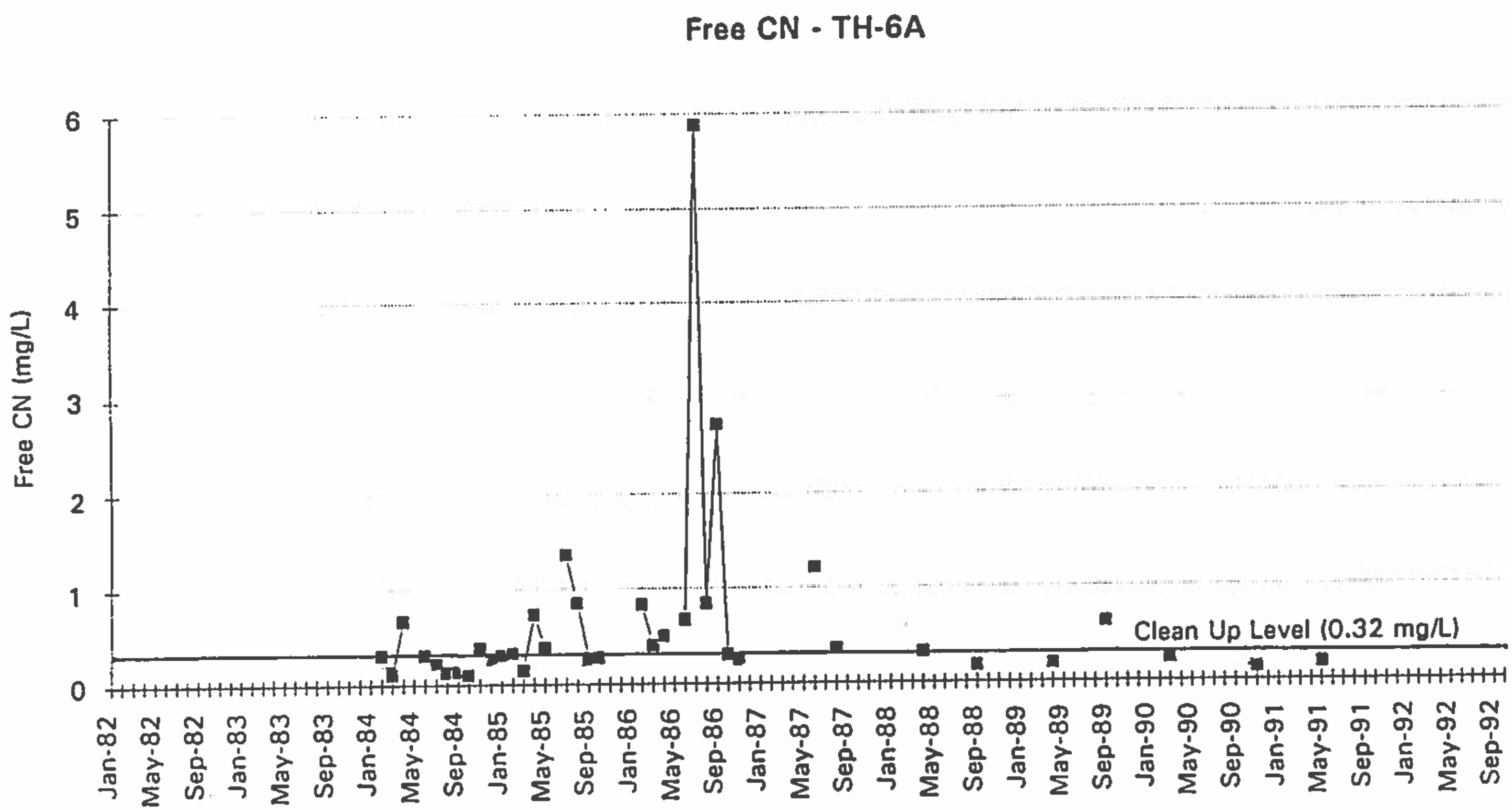


FREE CYANIDE CONCENTRATION IN WELL TH-8
KACC - MEAD SITE

FIGURE
3-2



FREE CYANIDE CONCENTRATION IN WELL TH-6A
KACC - MEAD SITE

FIGURE 3-3

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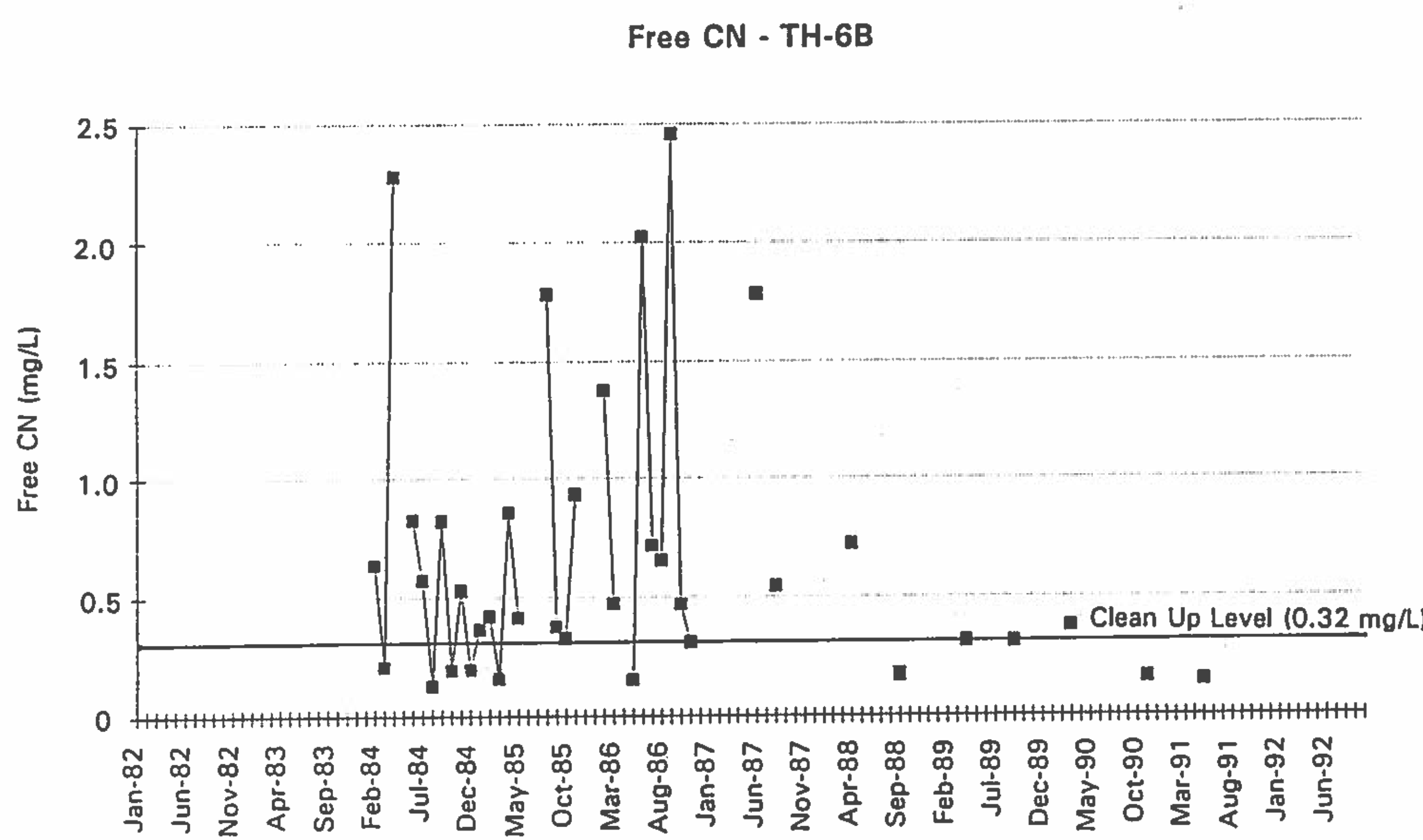
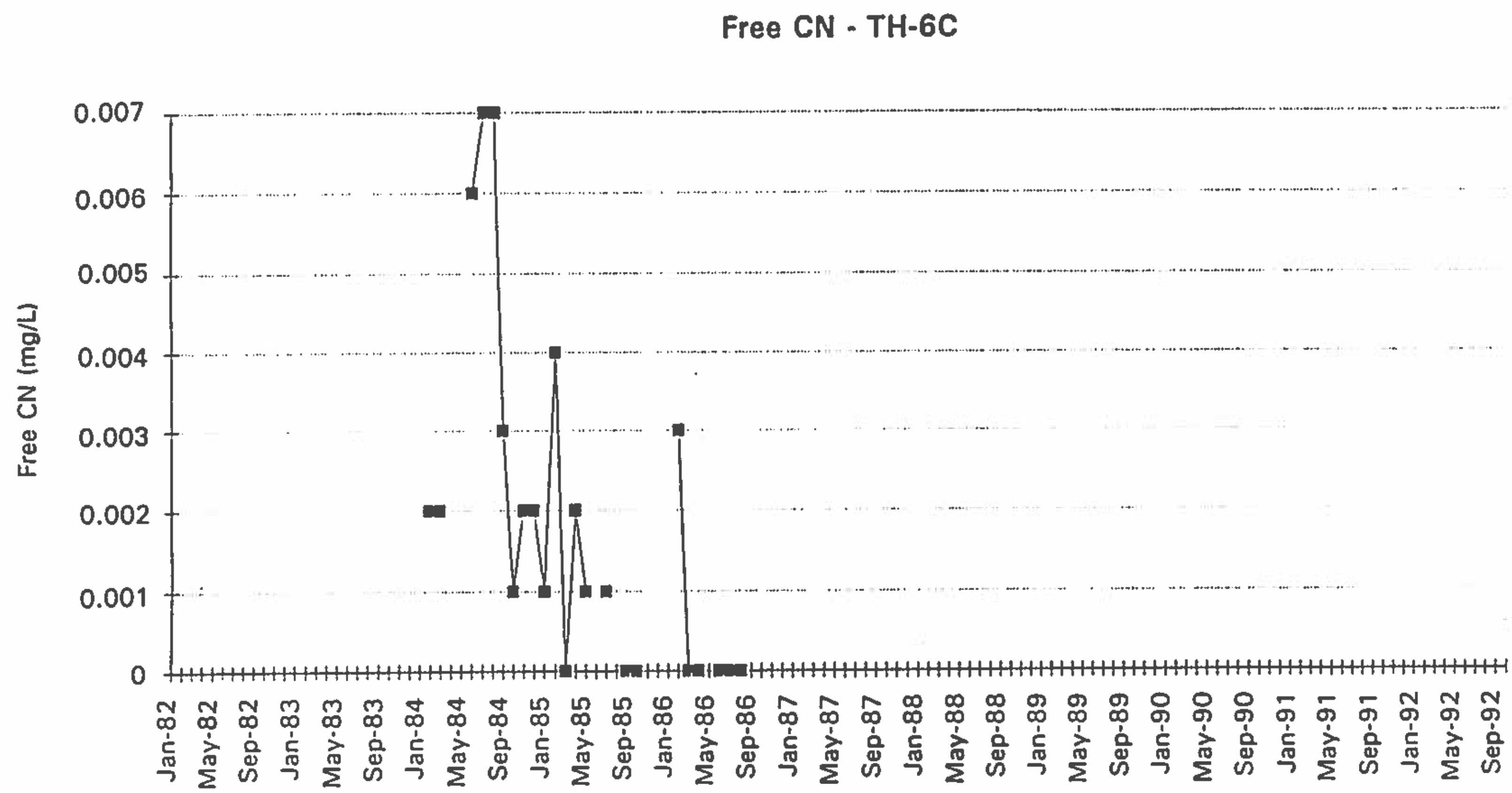


FREE CYANIDE CONCENTRATION IN WELL TH-6B
KACC - MEAD SITE

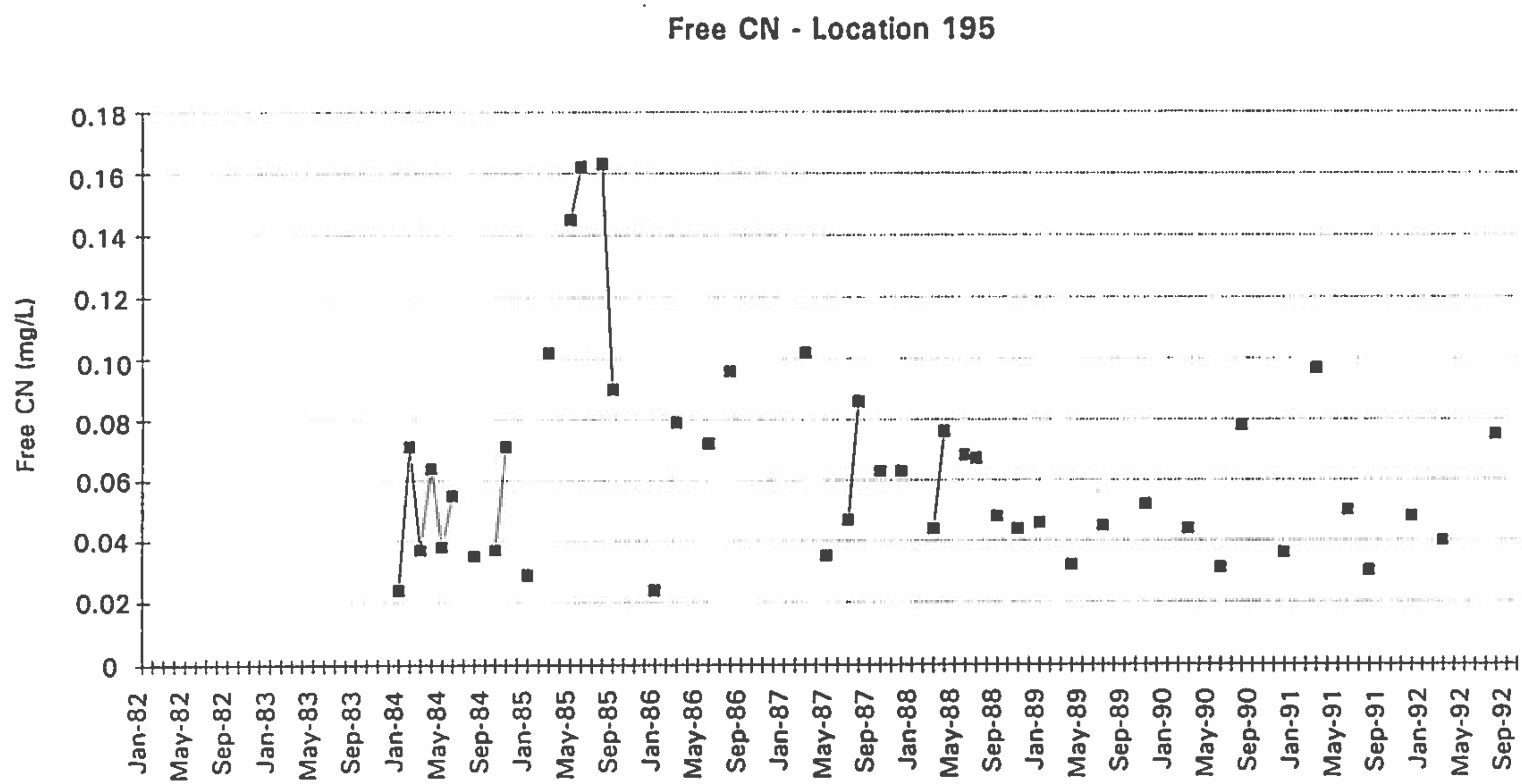
FIGURE 3-4



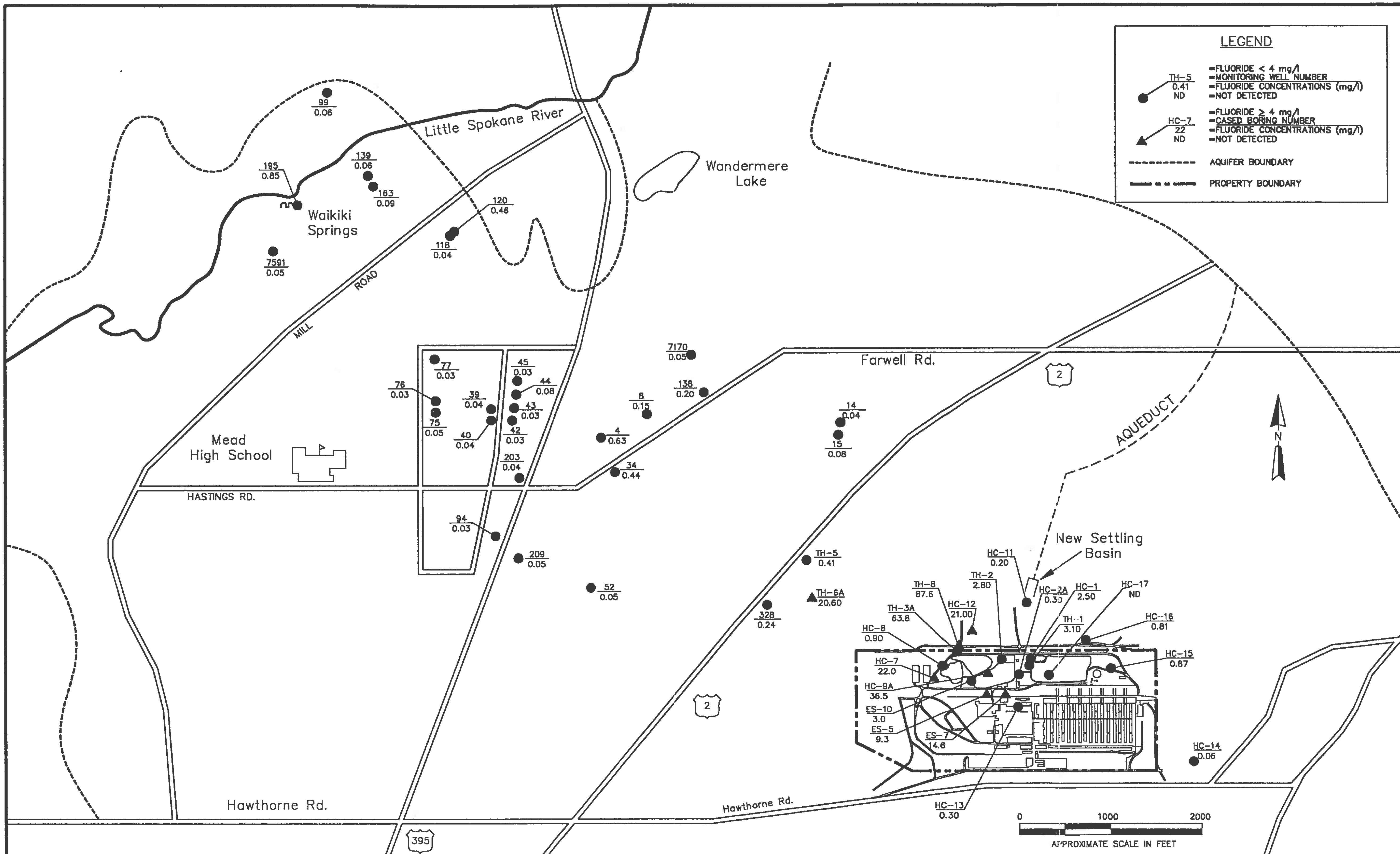
FREE CYANIDE CONCENTRATION IN WELL TH-6C
KACC - MEAD SITE

FIGURE 3-5

RETEC



FREE CYANIDE CONCENTRATION IN WELL 195 KACC - MEAD SITE	FIGURE 3-6



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REGIONAL FLUORIDE CONCENTRATION MAP
AUGUST/OCTOBER 1992
KACC – MEAD SITE

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FIGURE 3–7

TABLE 3-2
CYANIDE CONCENTRATIONS IN SPENT POTLINING
KACC-MEAD FACILITY

BORING	LOCATION (1)	DEPTH (feet)	CYANIDE CONC. (mg/kg)
HC-18	AREA 2 (capped)	2.5	171
		5	761
ES-1	SPL pile (capped)	10	4690
		20	29250
ES-2	SPL pile (capped)	10	5420
		20	1320
		40	10140
ES-3	SPL pile (capped)	10	4260
		20	4240
		30	5880
ES-4	SPL pile (capped)	10	4760
		20	2660
		30	2200
		38	1080
D-3	Rubble Pile (not capped)	37	515
Average	---	---	5200

(1) See Figure 1-4

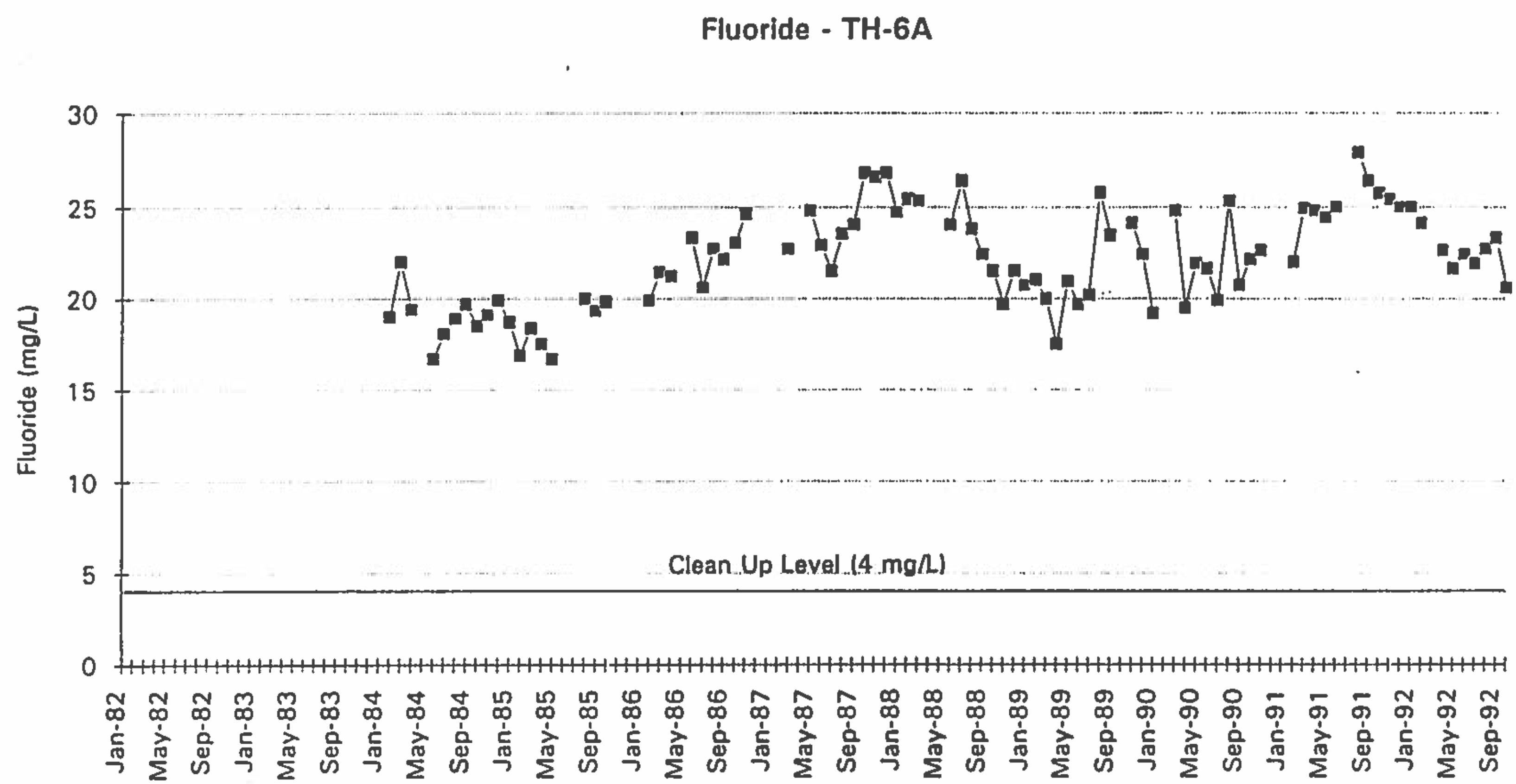
A time-series plot of fluoride concentration in well TH-6A is shown in Figure 3-8. Fluoride concentrations in this well have fluctuated between 15 and 30 mg/l since monitoring began in 1984. Groundwater data collected from all other downgradient sampling points were less than 1 mg/L fluoride. Concentrations at the discharge point to the Little Spokane River have been consistently less than 1 mg/l (Figure 3-9).

Samples collected from wells TH-6B and TH-6C indicate that fluoride concentrations are below the 4 mg/L cleanup level in portions of the aquifer below Zone A. Fluoride concentrations in samples obtained in October 1992 were 1.3 mg/L in well TH-6B and 0.12 mg/L in well TH-6C. Time-series plots of fluoride in these wells are shown in Figures 3-10 and 3-11.

3.3 SOILS

The MTCA Method C free cyanide industrial soil cleanup level is 70,000 mg/kg. A review of site data indicated that neither soil or SPL material exceed this health-based level. SPL material was encountered in borings HC-18, ES-1, ES-2, ES-3, ES-4, and D-3 (see Figure 1-4). Total cyanide concentrations in SPL samples ranged between 171 mg/kg and 29,250 mg/kg, and averaged approximately 5,200 mg/kg. The highest concentration of total cyanide measured at the KACC-Mead site was a sample of SPL material from boring ES-1 drilled in the SPL pile itself. Total cyanide concentrations in this sample were near 30,000 mg/kg, which is less than half of the Method C value for free cyanide. Free cyanide values can not exceed the total cyanide concentrations and are typically only a fraction of the total values. Table 3-2 summarizes total cyanide concentrations in SPL materials.

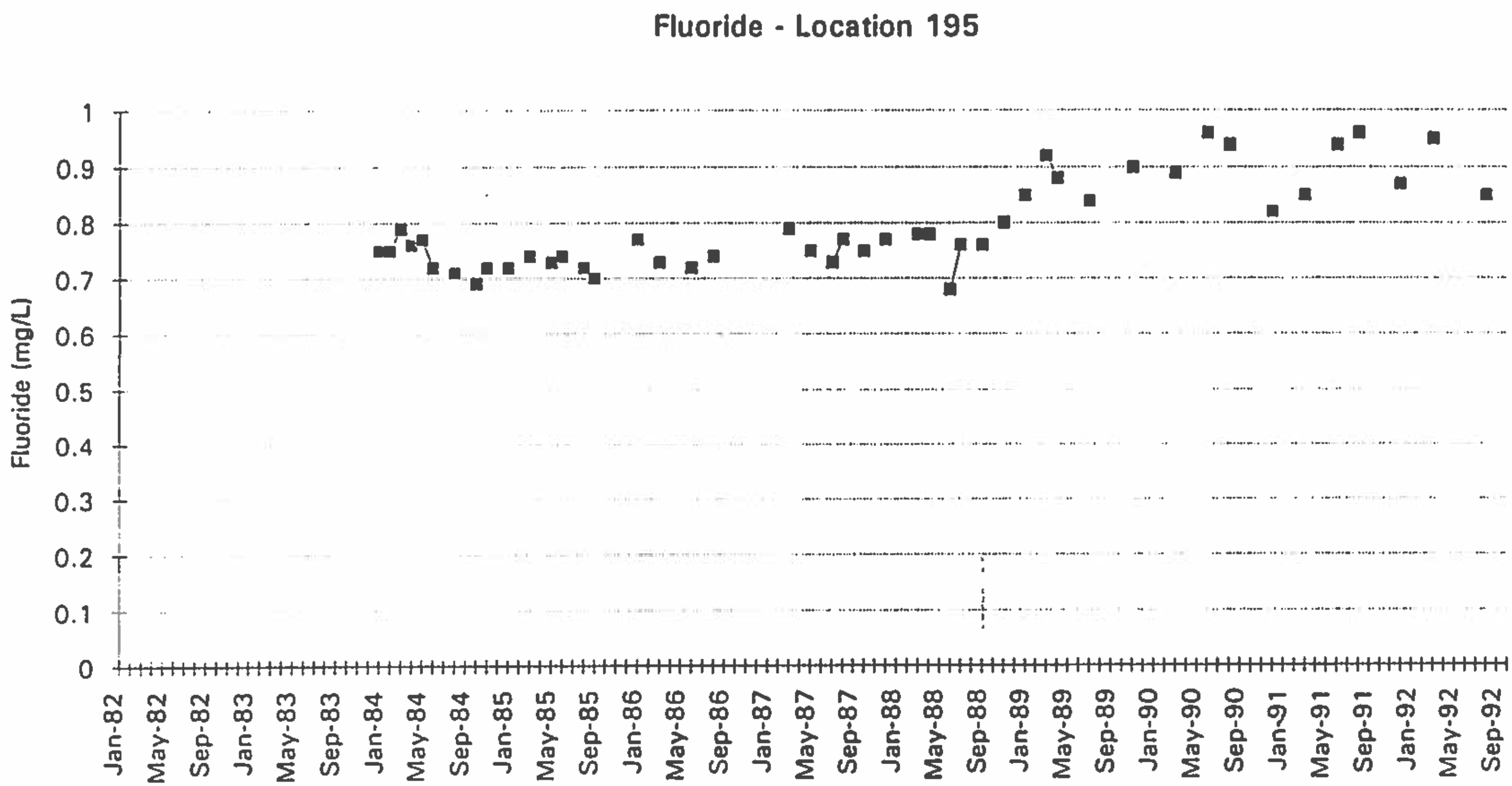
Total cyanide concentrations in the soil and SPL do exceed 32 mg/kg in certain locations. A cleanup level of 32 mg/kg for free cyanide was determined based on protection of groundwater. Figures 3-12 and 3-13 indicate the site areas which may contain materials above the cleanup level. Only areas beneath the rubble pile and one small area to the south of the SPL pile contain soils which are above a level of 32 mg/kg total cyanide. Contaminated soil areas covered with asphalt are considered protected from the elements and have a smaller risk of leaching to the groundwater than uncovered areas. A summary of soil total cyanide concentrations measured in the upper 50 feet are provided in Table 3-3.



FLUORIDE CONCENTRATION IN WELL TH-6A
KACC - MEAD SITE

FIGURE
3-8

REIEC



FLUORIDE CONCENTRATION IN WELL 195
KACC - MEAD SITE

FIGURE
3-9

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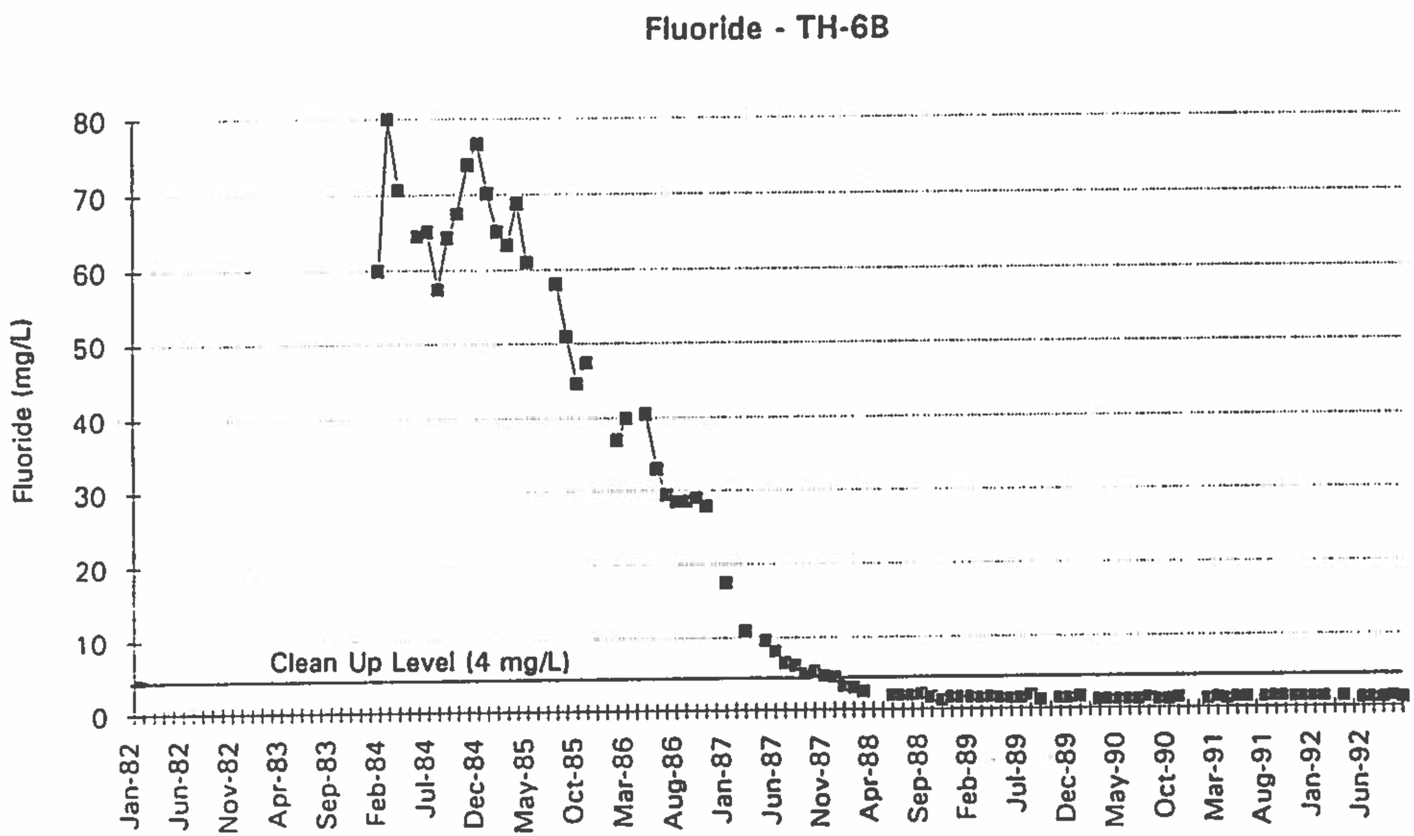

FLUORIDE CONCENTRATION IN WELL TH-6B
KACC - MEAD SITE

FIGURE
3-10

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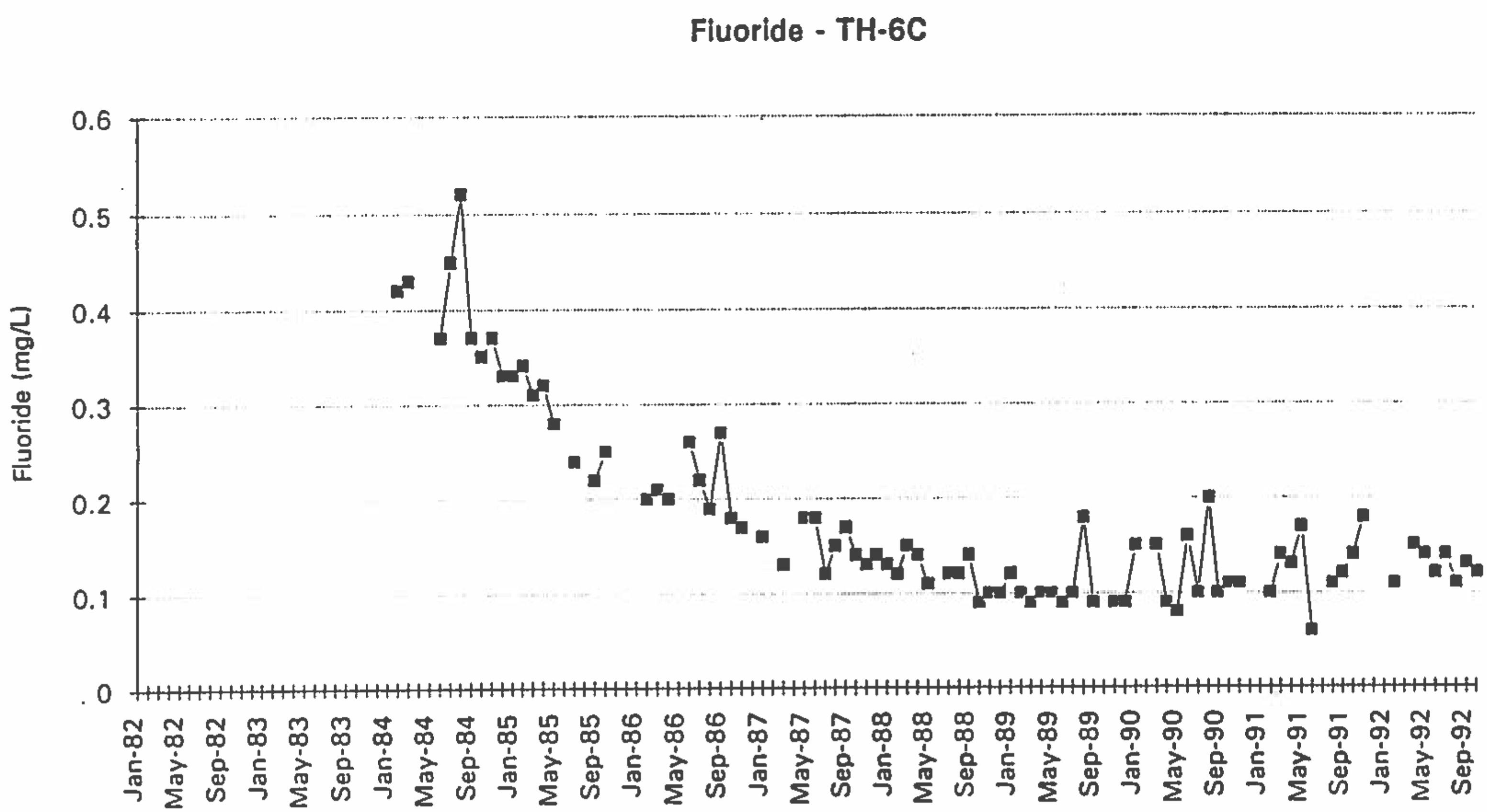
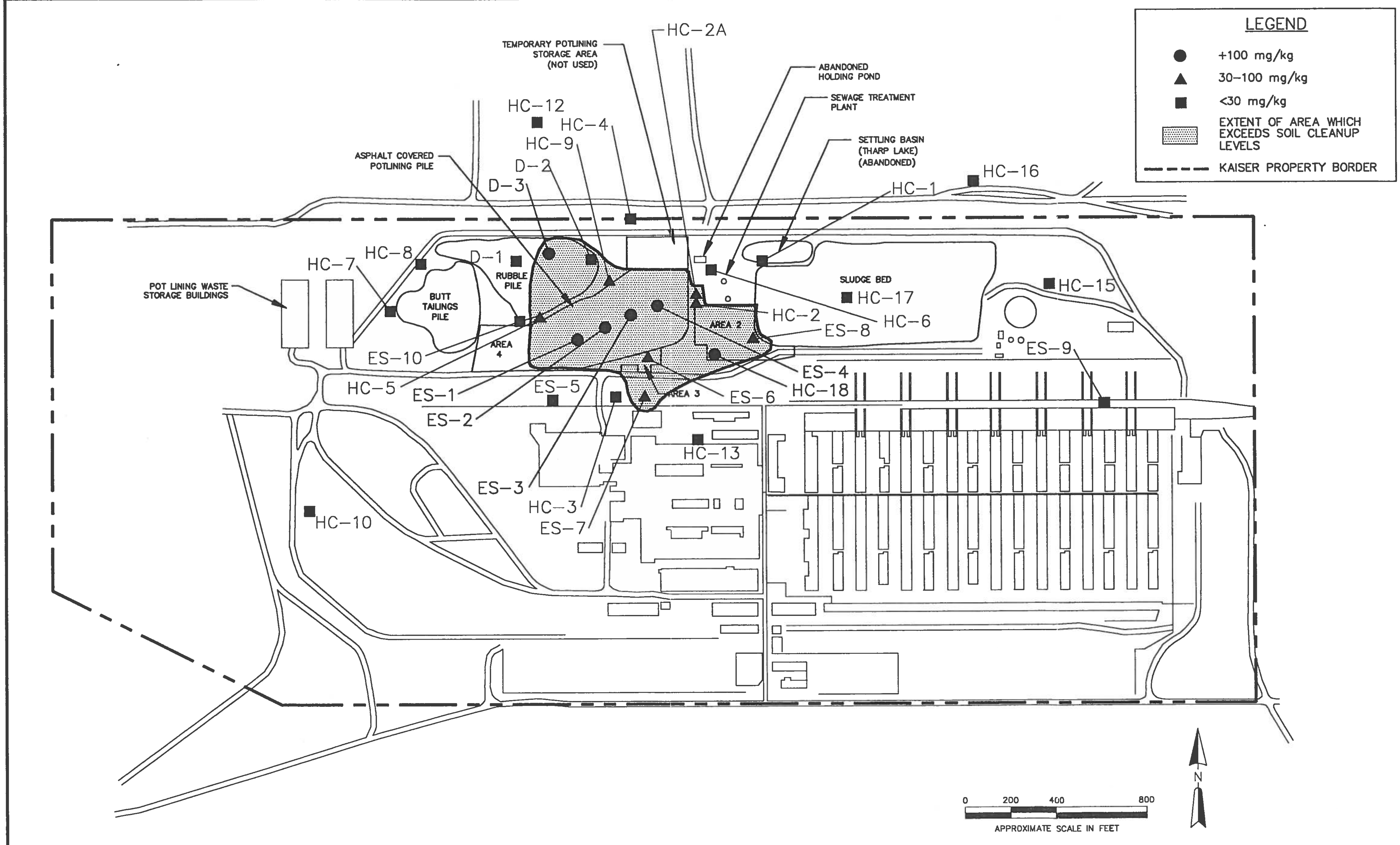


FLUORIDE CONCENTRATION IN WELL TH-6C KACC - MEAD SITE	FIGURE 3-11



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EXTENT OF SPENT POTLINING MATERIAL AND SOIL
TOTAL CYANIDE CONCENTRATIONS ABOVE 50 FEET DEPTH
KACC – MEAD SITE

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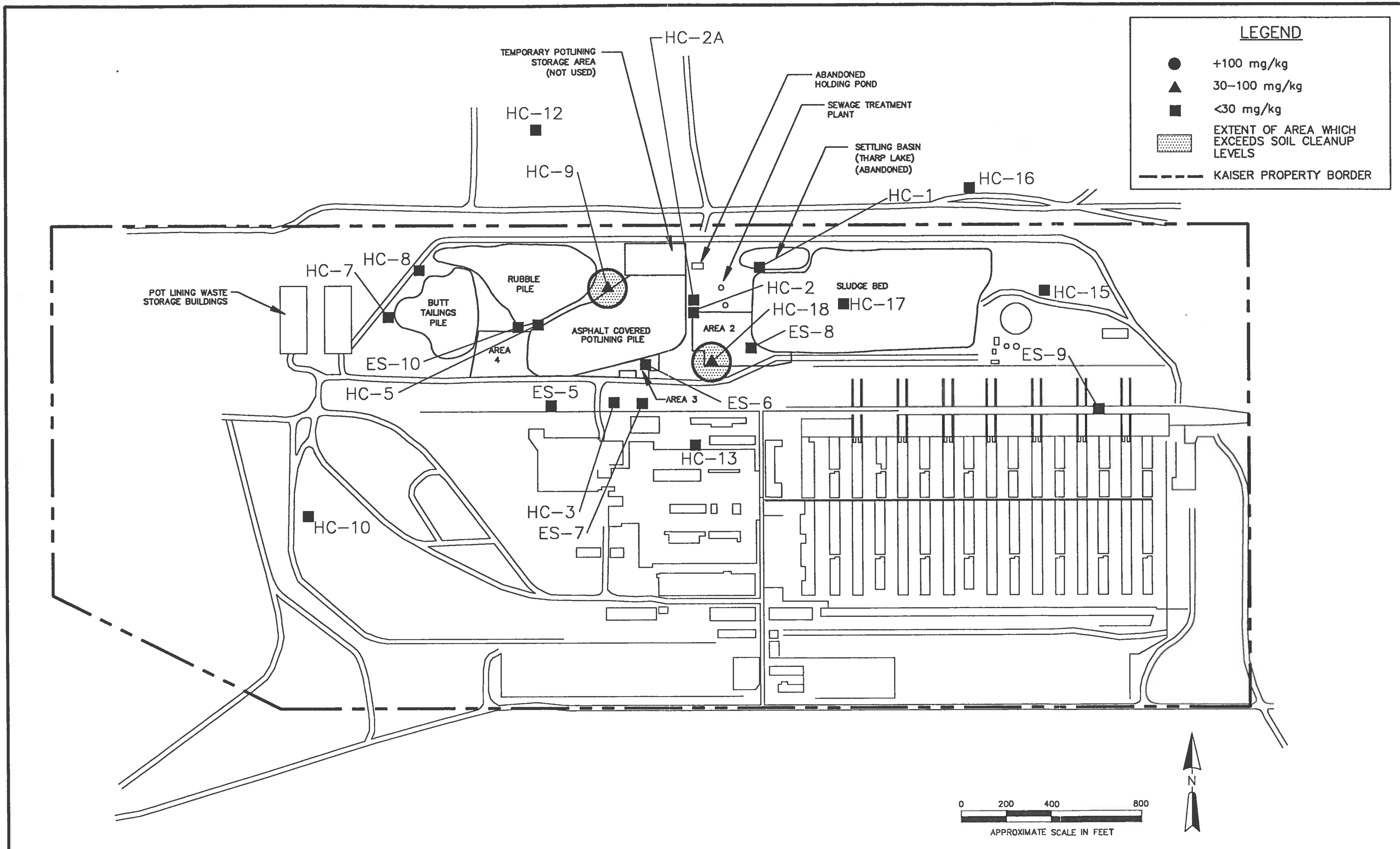
FIGURE 3-12



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EXTENT OF SPENT POTLINING MATERIAL AND SOIL
TOTAL CYANIDE CONCENTRATIONS BELOW 50 FEET DEPTH
KACC – MEAD SITE

RETEC
REMEDIATION TECHNOLOGIES INC

FIGURE 3–13

TABLE 3-3
SUMMARY OF SURFICIAL SOIL CYANIDE CONCENTRATIONS
KACC-MEAD FACILITY

BORING	LOCATION (1)	DEPTH (feet)	TOTAL CYANIDE CONC. (in mg/kg)	COMMENT
ES-1	SPL Pile (capped)	40	600	Soil below potlining
ES-2	SPL Pile (capped)	40	660	Soil below potlining
ES-4	SPL Pile (capped)	50	540	Soil below potlining
ES-5	S of SPL Pile	10	26	
ES-6	AREA 3 (capped)	2.5	211	
ES-7	S of SPL Pile	2.5	985	
ES-8	AREA 2 (capped)	2.5	45	
ES-9	S of Sludge Bed	10	8	
ES-10	S of Rubble Pile	11	5	
HC-1	S of Tharp Lake	10	10	
HC-2	AREA 2 (capped)	7	36	
HC-3	S of SPL Pile	7	4	
HC-4	NE of Rubble Pile	11	2	
HC-5	S of Rubble Pile	10	5	
HC-6	E of Rubble Pile	30	<1	
HC-7	W of Butt Tailings Pile	11	<1	
HC-8	W of Rubble Pile	7	<3	
HC-9	Between Rubble & SPL Piles	11	9.5	
HC-10	SW of Disposal Areas	10	<1	
HC-11	Adjacent to Settling Basin	10	<1	
HC-12	N of Rubble Pile	10	<1	
HC-13	S of Disposal Areas	10	<1	
HC-14	SE of Plant	10	<1	
HC-15	E of Sludge Bed	7	<1	
HC-16	N of Sludge Bed	8	<1	
HC-17	Sludge Bed	10	<1	
HC-18	AREA 2 (capped)	40	65	Soil below potlining
A-1	S of SPL Pile	2.5	<0.25	
A-2	S of SPL Pile	2.5	<0.25	
A-3	S of Rubble Pile	2.5	<0.25	
A-4	W of SPL Pile	2.5	7.8	
A-5	S of SPL Pile	2.5	1.7	
A-6	S of SPL Pile	2.5	<0.25	
A-7	S of SPL Pile	2.5	<0.25	
A-8	SE of SPL Pile	2.5	<0.25	
A-9	Sewage Treatment Plant AREA	2.5	<0.25	

(1) See Figure 1-4

As previously stated, the cleanup standard is based on free cyanide. SPL and soils beneath the SPL and rubble piles at KACC-Mead have only been analyzed for total cyanide. However, free cyanide concentrations in soil can be estimated using data collected for closure of Building 32N at the KACC-Mead site (Closure Plan Revision, October 1992). Ratios of free cyanide as measured by weak and dissociable cyanide to total cyanide are provided in Table 3-4. An average ratio of 25 percent was calculated for the 24 samples collected in Building 32N in May and June 1991. Those areas in Building 32N with total cyanide concentrations in excess of 32 mg/kg were resampled and analyzed for amenable cyanide. Amenable cyanide concentrations were all nondetectable at a detection limit of 0.6 mg/kg. A maximum amenable to total cyanide ratio of 1.3% is determined from these analyses. In addition to these soil analyses, the average ratio of free cyanide to total cyanide in groundwater measured at the plume head was 3.1 percent (Appendix B). These analyses indicate that the ratio of free to total cyanide in soil is probably less than 25% and most likely less than 10%. Based on similar ratios, the free cyanide concentration measured in soil at the site may not exceed 32 mg/kg within boring ES-7 which had the highest total cyanide concentration in the soil.

The final evaluation is that the soil cleanup levels for ingestion (70,000 mg/l free cyanide) are definitely not exceeded, and the soil cleanup levels for groundwater (32 mg/l free cyanide) may not be exceeded anywhere on or off the KACC-Mead site.

3.4 SUMMARY

Groundwater concentrations in two wells have been determined to exceed cleanup levels beyond the point of compliance. Concentrations in well HC-12, located due north of the rubble pile, exceeded the cleanup levels for free cyanide and fluoride. Groundwater concentrations measured in TH-6A, immediately downgradient from the site, exceed the cleanup level of 4 mg/l for fluoride. Concentrations in all other wells downgradient from the site and at the discharge point to the Little Spokane River are well below both cleanup levels.

The SPL itself will consistently exceed soil cyanide cleanup levels based on the groundwater protection (32 mg/kg). However, the majority of the SPL has been capped through previous remedial actions. The only SPL which has not been capped remains in the eastern portion of the rubble pile.

TABLE 3-4

RATIO OF TOTAL TO "FREE" CYANIDE IN SOIL BUILDING 32N CLOSURE SAMPLING

Sample I.D	Total Cyanide (mg/kg)	Weak and Dissociable Cyanide (mg/kg)	RATIO	Amenable Cyanide (mg/kg)	RATIO
	5/29/91	6/24/91		10/29/92	
1	9.1	2.5	27.5%		
2	41	3	7.3%	<0.6	1.5%
3	1.6	1.6	100.0%		
4	8.6	3.5	40.7%		
5	15	2.2	14.7%		
6	17	3.2	18.8%		
7	62	3.7	6.0%	<0.6	1.0%
8	51	9	17.6%	<0.6	1.2%
9	39	4.6	11.8%	<0.6	1.5%
10	3.8	0.62	16.3%		
11	3.3	0.49	14.8%		
12	12	3.9	32.5%		
13	3.7	0.63	17.0%		
14	2.3	0.6	26.1%		
15	2.2	1.3	59.1%		
16	2.7	0.57	21.1%		
17	2	0.12	6.0%		
18	2.2	0.48	21.8%		
19	2.2	0.58	26.4%		
20	2	0.11	5.5%		
21	2	<0.01	0.0%		
22	2	1.3	65.0%		
23	2	0.61	30.5%		
24	1.9	0.34	17.9%		
AVERAGE RATIO			25.2%		1.3%

SOURCE: "Building 32N Closure Plan Kaiser Mead Aluminum and Chemical Corporation", CH2M Hill, October 1991; "Closure Plan Revision", October 1992.

NOTE: concentrations of amenable cyanide assumed present at the detection limit for ratio calculations.

The only locations where soils at the KACC-Mead site exceed a level of 32 mg/kg for total cyanide are located beneath the SPL pile, Area 2, rubble pile and immediately south of the SPL pile. Only areas beneath the rubble pile and one small area to the south of the SPL pile contain soils which are not currently capped.

Soil and SPL concentrations in all existing data are based on an analysis of total cyanide whereas the cleanup level is based on free cyanide. Using similar total to free cyanide ratios as measured in soil and groundwater, soil concentrations at the site are not expected to exceed the cleanup level of 32 mg/kg free cyanide.

4.0 IDENTIFICATION AND SCREENING OF CLEANUP TECHNOLOGIES

4.1 INTRODUCTION

The following chapter details cleanup technologies which may be applicable to the KACC-Mead site. Cleanup actions that protect human health and the environment by eliminating, reducing or otherwise controlling risks posed through each exposure pathway and migration routes are evaluated. Each technology is described in general terms and then discussed relative to KACC-Mead site conditions. The site-specific discussions will include an analysis of the technical feasibility of achieving the cleanup levels given the hydrogeology, soil matrix, contaminant composition, contaminant sources, and climatic conditions present at the site.

Cleanup levels were established in Chapter 2 as 0.32 mg/l free cyanide and 4 mg/l fluoride in groundwater and 32 mg/kg free cyanide and 400 mg/kg fluoride in soil. When possible, the discussion will include estimates of the length of time required both to initiate and to achieve cleanup. Each alternative is screened based on it's effectiveness, implementability and cost. Those technologies that show potential for good performance at the KACC-Mead site, or that are useful for comparative purposes, are carried forward to Section 5.0, where they will be discussed in detail as part of cleanup alternatives.

4.2 IDENTIFICATION AND SCREENING OF CLEANUP TECHNOLOGIES

Based on site characteristics and the distribution of cyanide and fluoride, the potential cleanup technologies were divided into source-related and plume-related technologies. As discussed previously, the source-related contaminants include: 1) the spent potlining (SPL) pile, 2) the SPL below the rubble pile, 3) SPL beneath Area 2, and 4) contaminated soil, mainly below the SPL pile. In addition, potential water infiltration sources either from ponding after precipitation or from pipe leaks are included in source-related contaminants. Plume-related cleanup technologies focus on groundwater remediation for free cyanide and fluoride in zone A of the aquifer.

WDOE identifies preference criteria for cleanup technologies in WAC 173-340-360 of the Model Toxics Control Act (MTCA). These criteria are listed in the following order of preference:

1. reuse or recycling,

2. destruction and detoxification,

3. separation or volume reduction followed by reuse, recycling, destruction or detoxification of the residual hazardous substances,

4. immobilization of hazardous substances,

5. on-site or off-site disposal at an engineered facility designed to minimize the future release of hazardous substances and in accordance with applicable state and federal laws,

6. isolation or containment with attendant engineering controls, and

7. institutional controls and monitoring.

The cleanup technologies are ranked according to this preference for comparison purposes.

4.2.1 Identification and Screening of Source Related Cleanup Technologies

Those technologies applicable to treating contaminated SPL material and contaminated soils are identified in Table 4-1. These technologies can be described by the following general response action: no-additional action, institutional controls, containment, removal, treatment, and disposal. Under each general response action, one or more remediation technology can be identified. Information from previous site assessments is used in this report as part of an initial screening effort. The detailed screening assessment of the technologies identified in Table 4-1 is provided in Appendix E.

Results from the initial screening effort identified several cleanup technologies which may be effective in reducing source concentrations to below the cleanup levels (Table 4-2). Those cleanup technologies which are retained for further consideration include:

- No-Additional Action - retained for comparison purposes;

- Institutional Controls - already implemented by Kaiser;

TABLE 4-1
SOURCE-RELATED CLEANUP TECHNOLOGIES EVALUATED IN THIS FEASIBILITY STUDY

No-Additional Action
Institutional Controls
Containment
Capping
Grouting
Sheet Piles
Slurry Walls
Grout Curtain
Reroute, Replace, or Repair Leaking Pipes
Leak Monitoring
Removal
Treatment
Recycle/Reuse
Thermal Treatment
In-Situ Vitrification
Chemical Solidification/Stabilization (S/S)
Washing
Catalytic Oxidation
Alkaline Hydrolysis
UV/Chemical Oxidation
Ex-Situ Bioremediation
In-Situ Bioremediation
Disposal
On-Site
Off-Site

TABLE 4-2
SUMMARY OF INITIAL SCREENING OF SOURCE-RELATED CLEANUP TECHNOLOGIES EVALUATED IN THIS FEASIBILITY STUDY

TECHNOLOGY	RETAINED	REASON FOR EXCLUSION
No-Additional Action	YES	
Institutional Controls	YES [1]	
Containment		
Capping	YES	
Grouting	NO	Ineffectiveness/Non-implementability
Sheet Piles	NO	Excessive Depth to Subsoil
Slurry Walls	NO	Excessive Depth to Groundwater
Grout Curtain	NO	Excessive Depth to Groundwater
Reroute, Replace, or Repair Leaking Pipes	YES	
Leak Monitoring	YES	
Removal	NO/Soil YES/SPL	Excessive Volumes
Treatment		
Recycle/Reuse	NO	No Capacity or Demand
Thermal Treatment	NO	Limited Experience/Capacity
In-Situ Vitrification	NO	Limited Experience/Patented
Chemical S/S	NO	Requires Excavation/Unproven CN^-
Washing	NO	Unproven CN^-
Catalytic Oxidation	NO	Experimental Stages Only
Alkaline Hydrolysis	NO	Limited Treatment Capacity
UV/Chemical Oxidation	NO	Not Applicable for Solid Matrix
Ex-Situ Bioremediation	NO	Requires Excavation
In-Situ Bioremediation	NO	Unproven CN^-
Disposal		
On-Site	NO	Permitting/LDRS
Off-Site	YES	

[1] currently implemented.

- Additional Capping - capping of areas which potentially contain SPL and soil above the cleanup level;

- Infiltration Control - consisting of leak monitoring, pipe rerouting, replacement and/or repair; and

- Removal and Off-Site Disposal of SPL.

There are currently no reuse or recycling technologies for SPL and SPL contaminated soil. Destruction and/or detoxification of SPL is also unproven for SPL at the KACC-Mead site. No methods exist for separation or volume reduction of SPL materials and immobilization technologies are also unproven. Only technologies which include off-site disposal (of SPL only), isolation or containment and institutional controls and monitoring are considered feasible for the KACC-Mead site. A summary of the initial screening effort for SPL and contaminated soil are provided in Figures 4-1 and 4-2, respectively.

4.2.2 Identification and Screening of Plume-related Remedial Technologies

Those technologies included in the initial screening effort that are applicable to controlling groundwater contamination at the KACC-Mead site are identified in Table 4-3. These technologies can be described by the following general response action: no-additional action, institutional controls, containment, treatment, and disposal. Under each general response action, one or more remediation technology can be identified. Some of these technologies were considered in the Engineering Assessment Report (CH2MHill, 1988). That information is used in this report as part of an initial screening effort. The detailed screening assessment of the technologies identified in Table 4-3 is provided in Appendix E.

Results from the initial screening effort identified several cleanup technologies which may be effective in reducing groundwater concentrations to below the cleanup levels (Table 4-4). Those cleanup technologies which are retained for further consideration include:

- No-Additional Action - retained for comparison purposes;

- Institutional Controls - already implemented by Kaiser; and

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Cleanup Action Goal: Prevent leaching to soil and groundwater and prevent direct contact and spread of contaminants.

WDOE RANK	CATEGORY (in descending preference)	TECHNOLOGY SCREENING	SCREENING CRITERIA: Effectiveness	SCREENING CRITERIA: Implementability	SCREENING CRITERIA: Cost	RETAINED?
1	Reuse or Recycling	None for SPL	Not Applicable	Not Applicable	Not Applicable	No
2	Destruction or Detoxification	Off-Site Thermal Treatment	Yes, Claim Successful Performance	- One Facility w/ Limited Capacity	$400/ton	No
		On-Site Thermal Treatment	- Poor Performance - Lack of Experience	- Public Opposition - Highly Regulated	Not Applicable	No
		Other Treatment Methods	- Applicable Only to Aqueous Wastes	- Applicable Only to Aqueous Wastes	Not Applicable	No
3	Separation or Volume Reduction	None for SPL	Not Applicable	Not Applicable	Not Applicable	No
4	Immobilization	Chemical S/S	- Unproven for CN - Increase Volume	- Excavation Constraints	$30 - $120/yd³	No
		In-Situ Vitrification	- Limited History - No Experience w/CN	- Not Commercially Available - Proprietary	$275 - $400/yd³	No
5	On-Site or Off-Site Disposal	On-Site Disposal	Yes	- Permitting Difficulty - Anticipated Landban	$10MM total	No
		Off-Site Disposal	Yes	- At Least Two Identified Facilities	$150/ton	Yes
6	Isolation or Containment	Capping	Proven for SPL at KACC-Mead	- Demonstrated Asphalt Caps	$300,000 Capital $42,500/year maint.	Yes
7	Institutional Controls and Monitoring	Continued Monitoring Land-Use Restrictions Fencing	Minimize Exposure to Public and Environment	- Already in Place	$120,000/year	Yes, as Part of other remedial technologies

Technology Screening Summary Addressing Source Control - SPL

FIGURE 4-1

REITEC

Cleanup Action Goal: Prevent leaching to groundwater.

WDOE RANK	CATEGORY (in descending preference)	TECHNOLOGY SCREENING	SCREENING CRITERIA: Effectiveness	SCREENING CRITERIA: Implementability	SCREENING CRITERIA: Cost	RETAINED?
1	Reuse or Recycling	None for Soil	Not Applicable	Not Applicable	Not Applicable	No
2	Destruction or Detoxification	Off-Site Thermal Treatment	- Conventional Thermal Treatment Methods	- Requires Excavation - Lack of Capacity	$\$300 - \$500/yd^3$	No
		On-Site Thermal Treatment	Yes	- Public Opposition - Requires Excavation	Not Available	No
		Other Treatment Methods	- Applicable Only to Aqueous Wastes	- Applicable Only to Aqueous Wastes - May Require Excavation	Not Applicable	No
		In-Situ Biological Treatment	- Only Effective On Free Cyanide	- Highly Successfull	$\$25 - \$100/yd^3$	No
3	Separation or Volume Reduction	Ex-Situ Soil Washing	- More Effective For Free Cyanide and Fluoride - Not Applicable to SPL	- Requires Soil Excavation - Handling Concerns	$\$200 - \$500/yd^3$	No
		In-Situ Soil Washing	- Dependent on Uniformity of Cleanup	- Verification by by Experiment	$\$50 - \$120/yd^3$	No
4	Immobilization	In-Situ Vitrification	- Limited History - No Experience w/CN	- Not Available Commercially - Proprietary - Up to 40 - ft deep	$\$275 - \$400/yd^3$	No
5	On-Site or Off-Site Disposal	Soil Excavation	- Prevent Migration of Contaminants to Groundwater	- Requires Excavation - Excess Volumes	$\$10 - \$50/yd^3$	No
6	Isolation or Containment	Containment and Infiltration Control	- Prevent Migration of Contaminants to Groundwater	- Leak Monitoring Implemented Previously - Cutoff Structures are Difficult to Implement Due to Large Depths	Varies w/Technology	Only Pipe Repair or Replacement
7	Institutional Controls and Monitoring	Continued Monitoring Land-Use Restrictions Fencing	- Minimize Exposure to Public and Environment	- Already in Place	$\$120,000/yr$	Yes, as Part of Other Remedial Technologies

Technology Screening Summary Addressing Source Control - Contaminated Soils

FIGURE 4-2

TABLE 4-3
PLUME-RELATED CLEANUP TECHNOLOGIES EVALUATED IN THIS FEASIBILITY STUDY

No-Additional Action

Institutional Controls

Containment
- Physical Containment
- Hydraulic Containment

Groundwater Treatment
- Ex-Situ Treatment Methods
  - Biological Treatment Methods
  - Physical Treatment Methods
  - Chemical Treatment Methods
- In-Situ Treatment Methods

Pump-and-Treat
- Treatment with On-Site Wastewater Treatment System
- Treatment in a POTW
- On-Site Ground Water Treatment

Disposal
- Discharge to Settling Basin
- Use for In-Situ Soil Flushing
- Reinjection into Aquifer

TABLE 4-4
SUMMARY OF INITIAL SCREENING OF PLUME-RELATED CLEANUP TECHNOLOGIES EVALUATED IN THIS STUDY

TECHNOLOGY	RETAINED	REASON FOR EXCLUSION
No-Additional Action	YES	
Institutional Controls	YES [1]	
Containment		
Physical Containment	NO	Excessive Depth to Groundwater
Hydraulic Containment	NO	Pump-and-Treat is a more Aggressive Option
Groundwater Treatment		
Ex-Situ Methods		
Thermal Methods	NO	Inappropriate for Dilute Aqueous Wastes
Biological Methods	NO	Ineffective for Complexed CN^-
Physical Methods	NO	Precipitation Methods Work But Produce CN-Sludge
Chemical Methods	YES	
In-Situ Methods	NO	Unproved for CN^-
Pump-and-Treat		
Treatment in Existing Wastewater Treatment System	NO	Hydraulically Overloaded
Treatment in a POTW	NO	Not Suitable for Cyanide-Contaminated Water
On-Site GW Treatment	YES	
Disposal		
Discharge to Settling Basin	NO	May Not Meet Discharge Criteria
Use for In-Situ Soil Flushing	NO	Unproven
Reinjection into Aquifer	YES	

[1] currently implemented.

- Groundwater Pump and Treat - with on-site treatment of groundwater using chemical methods followed by reinjection into the aquifer.

A groundwater pump and treat system utilizing extraction and injection wells was determined to be the most effective solution for groundwater restoration at the site. Extraction wells would be placed near the point of compliance (property line) downgradient of the source areas. Ex-situ treatment of groundwater using fluoride precipitation followed by alkaline hydrolysis was determined to be the most effective water treatment method. Those technologies which were evaluated in the initial screening effort and a summary of the screening criteria is provided in Figure 4-3.

4.3 SUMMARY OF APPLICABLE TECHNOLOGIES

Eight representative technologies have been retained for the remediation of contaminated material at KACC-Mead. These technologies were selected based on their effectiveness in reducing cyanide or potential cyanide migration and on their implementability. Some of these technologies are applicable only to the source (SPL and contaminated soil) while others are applicable to groundwater. These technologies are as follows:

- No-Additional Action - (SPL, soil, groundwater). This technology is retained in order to provide a baseline for comparison with other technologies.

- Containment - (SPL, soil, groundwater). Capping also provides for source isolation from human exposure, from human exposure, from natural events, for proper site drainage, and for proper dust controls. Capping provides a long term barrier to contaminant migration via precipitation and infiltration routes although these transport mechanisms are not considered significant at the KACC-Mead site.

  Extraction of contaminated groundwater occurs as part of hydraulic containment via a series of recovery and injection wells. This option will be capable of limiting plume migration within its current boundary. The concentration of cyanide in the plume will diminish with time due to extraction of contaminants.

- Reroute, Replace, Repair Pipes\Leak Monitoring (soil). These measures provide for control of contaminant migration from the subsoil as enhanced by water infiltrating through the contaminated soil to the groundwater.

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Cleanup Action Goal: Reduce groundwater concentrations at the point of compliance to <0.32 mg/L free cyanide and 4 mg/L fluoride.

General Cleanup Actions	Technology Screening	Screening Criteria: Effectiveness	Screening Criteria: Implementability	Screening Criteria: Cost	Retained?
Ex-Situ Treatment	Biological Treatment Methods	• Only for Free Cyanide	• Not an Established Technology for Cyanides	---	No
	Thermal Treatment Methods	• Not Applicable to Aqueous Waste	Not Applicable	Not Applicable	No
	Physical Treatment Methods	• Well Established for Cyanide and Fluoride	• Established Technologies	$285,000 Capital	Yes, Fluoride Precipitation
	Chemical Treatment Methods	• Several Well Established Technologies • Some Require Verification • Only for Cyanide	• Readily Available Equipment	$290,000 to $1,300,000 Capital	Yes, Alkaline Hydrolysis
In-Situ Treatment	Physical/Chemical Treatment Methods	• Require In-Situ Testing For Verification	• More Difficult for Deep Formations • No Experience w/CN	Not Available	No
	Biological Treatment Methods	• Free Cyanide Only • Limited for Complex Cyanide and Fluorides	• Well Established • Requires In-Situ Field Testing for Verification Purposes	$150,000 Capital	Yes, Pump-and-Treat
Extraction	Wells	• Effective for High Permeability Formation	• More Applicable for Deep Formations	$10,000/well	Yes
	Interceptor Trenches	• For Shallower Applications • Low Permeability Media	• Not Applicable for Very Deep Formations	Not Available	No

Technology Screening Summary Addressing Groundwater Cleanup

FIGURE 4-3

RETEC

Cleanup Action Goal: Reduce groundwater concentrations at the point of compliance to <0.32 mg/L free cyanide and 4 mg/L fluoride.

General Cleanup Actions	Technology Screening	Screening Criteria: Effectiveness	Screening Criteria: Implementability	Screening Criteria: Cost	Retained?
Disposal	Soil Flushing	- Cleans Contaminated Soil - Effectiveness Depends on Uniformity of Flushing	- Requires In-Situ Testing - Requires Injection Well Installation	$2,500/well for Installation	No
	Re-Injection into Aquifer	- May Accelerate GW Cleanup	- Established Technology - Requires Injection Well Installation	$10,000/well for Installation	Yes
	Off-Site Discharge (NPDES)	----	- Current NPDES is very Stringent	Additional Cost is Negligible	No
	Untreated GW to a POTW	- Cyanide will not be Treated	- Permitting - Discharge Criteria - Installation of a Forced Main	Cost of Forced Main	No
Isolation	Slurry Wall	- Not Effective	- Not Applicable at at Depths >50 ft	Not Applicable	No
	Grout Curtain	- Not Effective	- Not Applicable at at Depths >50 ft	Not Applicable	No
	Sheet Piles	- Not Effective - Require Joint Interlocking	- Not Applicable at at Depths >50 ft	Not Applicable	No
Institutional Controls	Continued Monitoring Provide New Drinking Water Sources	- Already in Place	- Minimize Exposure to Public	$120,000/yr	Yes, as Part of Other Remedial Technologies

Technology Screening Summary Addressing Groundwater Cleanup (Continued)

FIGURE 4-3

These measures are combined with the containment technologies to improve the reliability of the containment system.

- Removal (SPL, groundwater). Excavation of SPL material for treatment and disposal was evaluated. This option will not result in more control over cyanide migration than other measures such as capping and grading the entire area where the potential for migration exists.

  Removal of groundwater is performed as part of a pump-and-treat system. In such a case, groundwater is extracted and will require treatment and disposal. Disposal of groundwater via reinjection is recommended.

- Off-Site Disposal (SPL). This option is applicable only for removal of SPL.

- Pump-and-Treat (groundwater). A method employed to recover as much of the groundwater contaminant as possible. Extracted groundwater will require treatment and subsequent disposal.

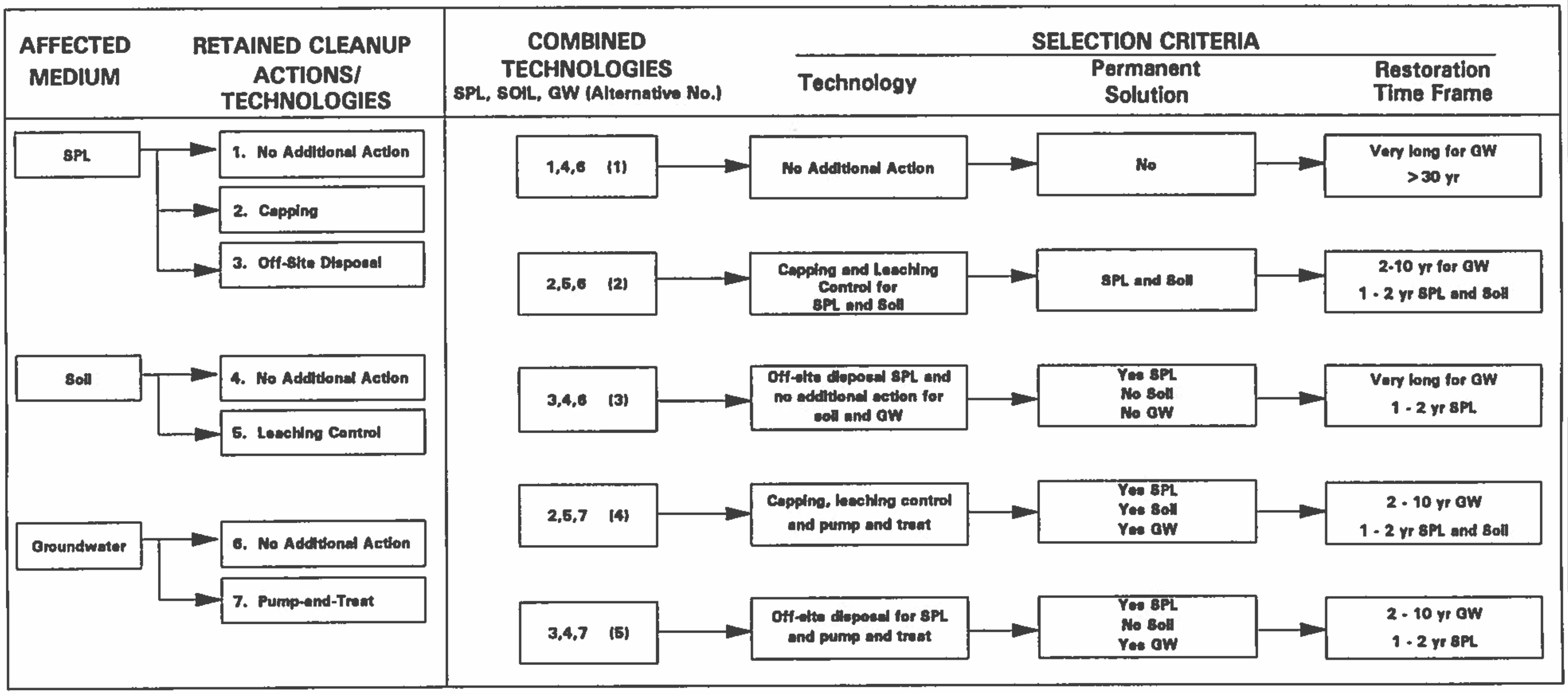
- Groundwater Treatment (above ground). Several treatment systems were identified as potentially viable for the treatment of groundwater. These systems are: precipitation only, precipitation with UV/chemical oxidation, precipitation with reverse osmosis, ion exchange with alkaline hydrolysis of the reject stream, precipitation with alkaline hydrolysis of the sludge, and catalytic oxidation. Some of these candidate treatment systems will require bench and pilot-scale testing to verify removal efficiencies and to provide an operating protocol. After further evaluation of these treatment methods, alkaline hydrolysis was selected as the candidate treatment technology based on its effectiveness, implementability, and cost.

- On-Site Disposal (groundwater). Disposal of treated groundwater would occur by reinjection into the aquifer.

4.4 DEVELOPMENT OF CLEANUP ALTERNATIVES

Five alternatives have been identified as feasible for use at the KACC-Mead site. Some of these alternatives address source control only, while others address plume migration control only. Several combinations of these alternatives were created that address both source control and plume migration control. A summary of these alternatives is presented in Figure 4-4.

These identified cleanup alternatives were developed from technologies that were screened in Appendix E. As shown in Figure 4-4, three cleanup technologies were retained for SPL control. These technologies are no-additional action, capping, and off-site disposal. These



SUMMARY OF CLEANUP ACTIONS AND COMBINED ALTERNATIVES

FIGURE 4-4

technologies cover a wide range of cleanup actions for SPL (i.e., from no action to removal and off-site disposal in a RCRA-facility). Two cleanup technologies were retained for contaminated soils. These are no-additional action and leaching control (infiltration control). Similarly, the retained cleanup technologies for groundwater are no-additional action and pump-and-treat. Pump-and-treat is considered the technology of choice at the KACC-Mead site for groundwater remediation.

The identified alternatives cover a wide spectrum of remediation options. They range from no-additional action for all three media (SPL, soil, and groundwater) to off-site disposal for SPL, leaching controls for soils, and pump-and-treat with in-situ bioremediation for groundwater. A summary of the combined alternative is provided below. A detailed discussion of these alternatives is presented in Section 5.0. Section 6.0 describes the recommended cleanup alternative for the KACC-Mead site.

Alternative 1

No-Additional Action. This alternative is retained to form a basis for comparing the other alternatives. The no-additional action alternative allows for continued monitoring of the groundwater plume, continued maintenance of the caps, and routine monitoring of pipe leaks and repair or replacement as needed. In addition, under the no-additional action alternative, deed restrictions and site fencing will be enforced and supply of new drinking water sources to the affected community will continue. This alternative allows for natural attenuation of the plume to continue.

Alternative 2

Infiltration Control. This alternative addresses the source only (SPL and contaminated soils). Infiltration control is performed by providing additional capping of exposed areas, and pipe leak control to avoid leaching of the contaminated soils. Containment is related to capping areas where SPL is present but is not currently capped. For example, areas where SPL exist under the rubble pile would be capped. This alternative addresses surveying the area in the vicinity of the SPL pile, Area 2, and the SPL beneath the rubble pile. Exposed areas would be capped and would be graded to enhance proper run-off. This area would be considered a single water proof zone preventing infiltration into the groundwater. In addition, this alternative allows for continued monitoring for pipe leaks and repair or replacement as needed. Pipe repair may entail pipe replacement or pipe sliplining.

Alternative 3

Excavation and Off-Site Disposal for SPL. This alternative addresses one source only (SPL). The SPL pile, SPL in Area 2, and SPL beneath the rubble pile would be excavated and disposed off-site. Excavated areas would be backfilled and the surface capped to prevent infiltration. During excavation, the exposed areas would receive temporary covering to prevent infiltration and provide for dust control. Groundwater monitoring will continue throughout the duration of this alternative. Ambient air monitoring will also be provided during excavation. Institutional controls that are already in-place will continue to be implemented.

Alternative 4

Infiltration Control and Pump-and-Treat. This alternative addresses the plume and the source (SPL and contaminated soil). Infiltration control is the same as discussed under Alternative 2. In addition, this alternative provides for plume control. Groundwater would be recovered via a series of extraction wells. The number, location, and spacing of the wells would be determined based on computer modeling that would optimize recovery of the plume. The total pumping rate is estimated to be a minimum of 200 gpm. The pumped groundwater would be treated on-site using a newly constructed treatment system. The treatment system would consist of filtration for removal of particulate matter, alkaline hydrolysis process for cyanide destruction, and a chemical precipitation step for defluoridation. The treated groundwater would be injected into the aquifer downgradient of the extraction site. Groundwater monitoring would continue during the implementation of this alternative.

Alternative 5

Excavation, Off-Site Disposal for SPL, and Pump-and-Treat. This alternative addresses the plume and the source. Under this alternative, SPL would be excavated and disposed off-site. Groundwater extraction would take place followed by on-site treatment. Disposal of treated groundwater would be through injection into the aquifer as in Alternative 4.

The excavated areas would be backfilled and the surface capped to prevent infiltration. During excavation, the exposed areas would receive temporary covering to prevent infiltration and provide for dust control. Groundwater monitoring will continue throughout the duration of this alternative. Ambient air monitoring will also be provided during excavation. Institutional controls that are already in-place will continue to be implemented.

The five alternatives presented above are described in detail and are critically evaluated in Section 5.0 of this document. The above alternatives cover a wide spectrum of cleanup actions for the KACC-Mead site.

5.0 EVALUATION OF CLEANUP ALTERNATIVES

5.1 INTRODUCTION

A set of five alternatives were identified in Section 4 which represent the possible combinations of feasible technologies for each of the three types of contaminated materials found at the site (SPL, contaminated soils and groundwater). The alternatives are evaluated in this section according to the requirements identified in WAC 173-340-360 (Selection of Cleanup Actions). Threshold requirements include:

- protection of human health and the environment,
- compliance with cleanup standards,
- compliance with applicable State and Federal laws.

These requirements form the baseline for selecting cleanup actions. In addition the cleanup action should meet the following requirements:

- the use of permanent solutions to the maximum extent practicable,
- reasonable restoration time frames,
- consideration of public concerns.

5.1.1 Cleanup Technologies, Order of Preference and Expectations

In meeting the requirements presented above, WDOE has identified a set of technologies which should be considered and given preference. The types of technologies and order of preference were identified in Section 4.2. The order of preference stresses the use of technologies which would result in a "permanent solution" (i.e.: one which limits the need for long term care and results in reuse, recycle, destruction or detoxification of the hazardous substances below cleanup levels). WDOE does not expect that one type of technology will be used for all sites and that lower options will be appropriate for some sites.

5.1.2 Permanent Solutions

WDOE recognizes that at complex industrial sites such as the KACC-Mead site, permanent solutions may not be practicable. In these cases, the regulations define a set of criteria to be used for comparison purposes in selecting a cleanup action between a number of technically feasible alternatives. These criteria are:

- overall protection of human health and the environment,
- long term effectiveness,
- short term effectiveness,
- reduction of toxicity mobility and volume,
- implementability,
- cleanup costs, and
- community concerns.

The first six criteria are used in this section to evaluate each of the five alternatives. Community concerns will be addressed through a public comment period.

<u>Long Term Effectiveness</u>

The performance of the alternative is evaluated based on its effectiveness in controlling the spread of contamination; its reliability of achieving cleanup objectives; and experiences at other sites with similar setting and waste characteristics. Effectiveness will be judged based on the ability of the alternative to achieve compliance with the proposed concentration goals of cyanide and fluoride in the groundwater plume and to maintain compliance after active remediation is discontinued.

Processes which have been demonstrated at similar sites or on similar contaminants will be ranked higher than those which have not been demonstrated. For example, asphalt capping for infiltration control from SPL would be ranked higher than a more rigorous capping method because it has been demonstrated to be effective in eliminating water infiltration and to be compatible with the SPL material.

<u>Short Term Effectiveness</u>

This criteria evaluates the time to achieve end points and safety considerations during construction.

The time to achieve the end point for an alternative is defined as the time required to construct and operate the specified alternative until the desired treatment goals are met. Treatment goals for KACC-Mead include eliminating infiltration to the soil and groundwater and restoration of the aquifer to meet free cyanide concentration of 0.32 mg/l and fluoride concentration of 4 mg/l or less at the property boundary.

Almost all construction work is inherently associated with risks. Risks posed to nearby residents, to the environment, and to remediation workers are considered in alternatives evaluation. Precautions during construction and alternative implementation to minimize the risk to the public health and the environment are discussed.

Reduction of Toxicity, Mobility and Volume

For each alternative an assessment of the overall reductions in the volume of hazardous materials or the reductions on the toxicity or mobility of the hazardous constituents will be completed.

Implementability

Implementability refers to the technical and regulatory feasibility of implementing the cleanup alternative. Factors evaluated to determine remediation implementability are: ease of construction; operation and maintenance requirements; and regulatory issues and permit requirements.

For each alternative, a description of the construction requirements is presented. Those alternatives which have unique construction problems and require specialized construction equipment or construction techniques have been assigned a lower relative rank.

Alternatives that minimize O&M requirements are given preference. This includes equipment maintenance and replacement costs. Permitting requirements will also be addressed for each alternative.

In general, RCRA permitting is not required for implementing cleanup actions at KACC-Mead site. Because the site is considered an NPL site, then cleanup alternatives need only to comply with Applicable or Relevant and Appropriate Requirements (ARARs). Permits are required in certain occasions. For example NPDES permit is required for groundwater discharge.

Environmental and Public Health Effects

Environmental and public health effects refer to the reduction of risk to the environment and to public exposure during and after completion of site remediation. This includes the continued implementation of institutional controls to prevent current and future access to the site by unauthorized personnel and to continue to provide alternative drinking water to the affected community. The affected community would include downgradient water users which are within areas of the plume that may exceed health based levels in the reasonably foreseeable future. For each alternative, efforts will be exerted during implementation to prevent the spread of contaminants, to minimize the impact on the surrounding community, and to involve public participation in the process of choosing and implementing a cleanup alternative.

Costs

Costs refer to the capital and operating and maintenance (O&M) costs required to implement the cleanup alternative. Costs will be estimated based on vendor quotes and knowledge of process material and labor requirement. The annual worth of each alternative is determined. This annual cost is termed the equivalent uniform annual cost (EUAC). All costs will be normalized to the same basis (present worth) for ease of comparison. Additional cost information is provided in Appendix F.

Capital costs include equipment purchase and installation, instrumentation and controls, site work, engineering, and utilities. Water treatment materials and well installation costs were obtained as vendor quotes. Other capital costs were estimated as a percentage of purchased equipment costs.

Operating parameters included labor, utilities, materials, facility maintenance, and waste disposal costs. Labor costs were included for on-site operations, engineering, hydrogeologic, and project management support. In most cases the cost of electricity was assumed to be $0.05 per Kwhr. Maintenance was assumed to be a percentage of installed equipment costs. Analytical costs were not included and were assumed to be a part of the current analytical effort conducted by KACC-Mead personnel. Waste disposal included excavation, transportation, and disposal. The amount of generated fluoride solids (from groundwater treatment plant) were considered negligible, relative to the amount of SPL requiring disposal and the cost of their disposal was generally neglected.

5.1.3 Relationship to CERCLA Criteria

The criteria used for evaluating whether a cleanup action is "permanent to the maximum extent practicable" are the same criteria used to address CERCLA requirements. In addition, CERCLA includes compliance with Applicable or Relevant and Appropriate Requirements (ARARs) and State acceptance.

Compliance with chemical specific ARARs is demonstrated during the establishment of cleanup levels. Compliance with action specific or location specific ARARs is demonstrated through an analysis of administrative and permitting requirements completed under the evaluation of implementability.

Since this study is being completed under an Agreed Order with the WDOE, State acceptance of the final cleanup is integral to this program.

5.1.4 Evaluation of Alternatives

Each of the five alternatives are evaluated in terms of their ability to meet threshold requirements. In addition, the alternatives are ranked according to the WDOE order of preference for cleanup technologies and evaluated according to the criteria established for permanent solutions. Restoration time frames to achieve groundwater cleanup levels are estimated where possible.

5.2 ASSESSMENT OF THE CLEANUP ALTERNATIVES

Five cleanup alternatives are proposed for the KACC-Mead site. Some of these alternatives are applicable to the remediation of the SPL or contaminated soil, while others are applicable to remediation of contaminated groundwater.

5.2.1 Alternative 1: No-Additional Action

Process Description

Several actions were implemented at KACC-Mead since 1978 that lead to controlling cyanide release from the surface to the subsurface. Measures that were implemented included: covering waste piles with a cap to prevent contact with water, monitoring for pipe leaks, replacing or repairing leaking pipes, abandoning the leaky settling basin, installation of many monitoring wells along the plume, and conducting periodic monitoring of soluble cyanide and fluoride concentrations in groundwater. In addition, an alternative water supply was provided to the impacted community. All of these measures have resulted in eliminating further soil and groundwater contamination (see Appendix A).

The no-additional action alternative relies on the natural attenuation of the plume. At least three mechanisms are at work to control the long-term removal of cyanide from the contaminated groundwater. These are, vapor phase transport of hydrocyanic acid, dissolved phase transport of ionic cyanide (simple and complex), and biodegradation of bioavailable cyanide. These mechanisms in turn are dependent on the molecular interaction of cyanide with the subsurface environment. Mechanisms such as volatilization, dissolution, sorption, and biodegradation also affect cyanide fate and long-term plume control.

There are three components of transport of hydrocyanic acid in the vapor phase: advection, dispersion, and diffusion. Advective transport is associated with the movement of air present in the soil pore due to pressure differential. In general, the discharge of hydrocyanic acid from soil matrices deeper than three feet is insignificant. Dispersion is the movement of air associated with mechanical mixing, and diffusion is the movement or mixing associated with molecular movement. The overall transport of hydrocyanic acid by these mechanisms is negligible, especially because cyanide would be present in the form of cyanic ion at the high pH of the leachate.

Transport of cyanide in the subsurface with the groundwater is retarded by the interaction of cyanide and its constituents with the subsurface soil. Free and simple cyanides are generally soluble and may migrate at a rate equal to that of groundwater. Migration of complex cyanides, which comprise the majority of the cyanide constituency, is hindered by the electrostatic attraction and other surface interactions with the aquifer medium. It is difficult to determine the magnitude of transport hinderance by soil sorption mechanisms because there are limited data regarding complex cyanide behavior in the subsurface. The plume data that have been collected since 1978 indicate that complex cyanide is migrating downgradient with groundwater but at a slower rate than groundwater.

Biodegradation of cyanide may be responsible partially for limiting further plume dispersion. Cyanide biodegradation at the plume boundaries where oxygen may be available results in reducing the speed of plume migration and limiting the rate of plume widening. Biodegradation of complex cyanide in the subsurface is not considered an important factor for plume attenuation, however. Complex cyanide is generally not biodegradable even under optimized conditions. Biodegradation is not considered an important mechanism of determining cyanide fate. In summary, the most important mechanism controlling natural plume attenuation is the interaction of complex cyanide with the aquifer matrix.

Fluoride is governed only by dissolved phase transport of the fluoride ions. Interaction of fluoride with aquifer media, generally through ion exchange and precipitation reactions, results in hindering fluoride migration with groundwater.

Long Term Effectiveness

Effectiveness. Natural attenuation of the cyanide plume has occurred to a certain extent at the KACC-Mead site (CH2MHill, 1988). Natural attenuation of the cyanide and fluoride is not expected to achieve the cleanup levels in a reasonable period of time based on groundwater data collected to date. Nonetheless, only a limited area outside the site boundary exceed the cleanup levels of 0.32 mg/l free cyanide and 4 mg/l fluoride. Natural attenuation probably would reduce the free cyanide concentrations to the cleanup levels at the point of compliance in a reasonable time.

Reliability. The natural attenuation processes has been demonstrated through groundwater monitoring since 1978. The plume has migrated 2.8 miles to the Little Spokane River, and concentrations of cyanides in the plume have decreased downgradient. Well data for 1991 indicate that the maximum concentration of total cyanide determined in Well TH-8 was 94 mg/l compared to nearly 300 mg/l in 1982. This indicates that independent remedial measures implemented by Kaiser have been effective in reducing concentrations of cyanide in groundwater. However, reductions in total cyanide and fluoride concentrations have leveled off since 1987. Further reductions are not expected in the near future based on the groundwater data collected to date.

Experience at Other Sites. Natural degradation of dissolved constituents in groundwater has been documented at several sites.

Short Term Effectiveness.

Safety. There are limited short term safety concerns related to this alternative. The principal concern would be to continue to provide an alternate water supply to downgradient residences. The current system of monitoring and institutional controls is adequate to address this concern.

Response Time Frame: Time to achieve the end point will be defined as the time required to decrease free cyanide and fluoride concentrations in the aquifer to below 0.32 and 4 mg/l respectively. As discussed in Section 1.2.6., groundwater concentrations of total cyanide and fluoride appear to have leveled off after a steady decline for several years. Additional decreases in groundwater concentrations are not anticipated without other remedial measures in the near future.

Reduction of Toxicity, Mobility and Volume

This alternative does not result in a substantive reduction of cyanide and fluoride present in the soil and groundwater.

Implementability

Ease of Construction. No construction is required for this alternative. No new monitoring wells are required.

Operation and Maintenance. In addition to periodic monitoring, the monitoring wells will require occasional maintenance.

Regulatory Issues/Permit Requirement. The no-additional action alternative would not require a permit. This option is not expected meet the cleanup goal of 4 mg/l fluoride although it may meet the 0.32 mg/l free cyanide goal. Deed restrictions and alternative water supply have been provided.

Environmental and Public Health Effects

Groundwater concentrations are expected to remain relatively constant if no additional action is implemented at KACC-Mead based on the data collected to date. The new source of drinking water will continue to be important as long as restoration of the aquifer to its original conditions has not been accelerated by aggressive remediation. The impact of contaminated groundwater on the Little Spokane River is negligible based on the minute quantities of contamination reaching the surface water. Migration of contaminants from the source to the groundwater may occur occasionally if no additional controls are implemented. Therefore, the current impact of contamination on the environment and the nearby community would remain unaltered.

Cost

The costs for the no-additional action option are related to the sampling and analysis costs required to verify the progress in natural attenuation of cyanide and fluoride in the groundwater. Samples are typically collected on a semi-annual basis or more frequently and are analyzed for total cyanide, free cyanide and fluoride. The total cost of sampling and analysis are estimated at $120,000 per year (CH2MHill, 1988) which is the same as the EUAC. Assuming that monitoring is required for the next 30 years, the total equivalent present worth would be $1,131,230 at an interest rate of 10 percent.

Summary

The no-additional action alternative relies on the controls that have been implemented since 1978 and on natural attenuation of the plume. The instituted controls have resulted in reducing further leaching of SPL contaminants into the soil and migration to the groundwater. New sources of potable water were provided to the impacted community. Contaminants reaching the Little Spokane River had no impact on aquatic life in the river (Hartung and Meier, 1980).

The no-additional action alternative is also coupled with continuing monitoring of groundwater. Groundwater monitoring helps redefine the plume on continuous basis and track cyanide and fluoride migration with time. While monitoring does not accelerate plume attenuation, the results could help identify a plan of action as required to remove any threat the plume may pose at any future date.

5.2.2 Alternative 2: Infiltration Control

Infiltration control refers to controlling the migration of contaminants from the sources (SPL and contaminated soil) to the groundwater. Infiltration control is implemented by containment and pipe leak control. Containment refers to capping exposed areas and addresses the source only; i.e., the SPL pile, Area 2, and contaminated soil. Hydraulic containment is not addressed here. Pipe control refers to continued monitoring for pipe leaks and repair, replacement, or sliplining as needed.

Process Description

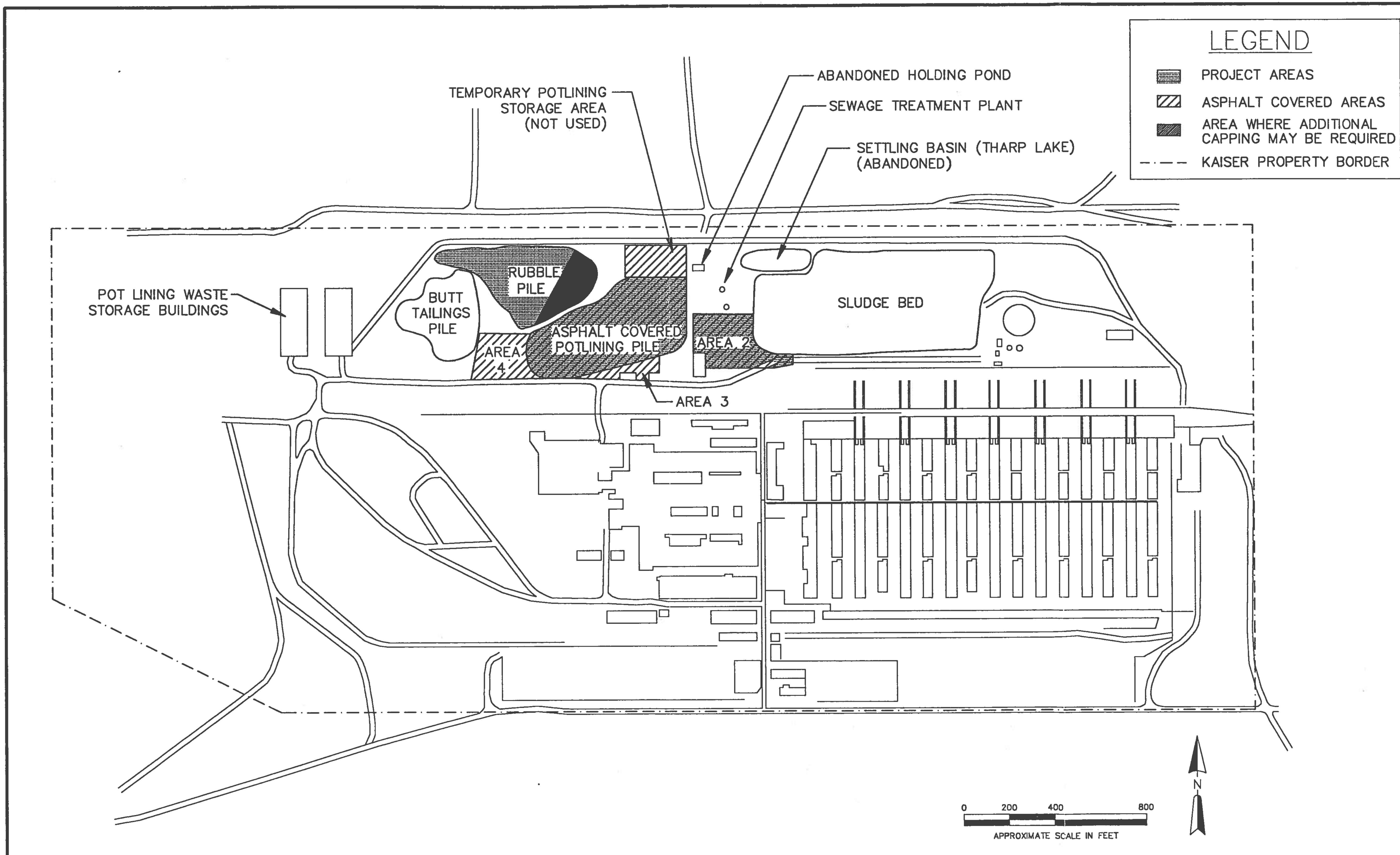
Containment as defined here addresses the need to complete placing asphalt caps over all the infiltration areas of the site. This includes portions of the rubble pile were SPL is deposited (Figure 5-1).

The new caps will be tied into the existing caps to provide a complete waste containment. The caps will maintain at least a 2 percent grade to encourage proper control of run-ons and run-offs. Drainage would be diverted to the stormwater collection system. The caps will provide, in addition to waste containment, percolation, vapor, and dust control.

As discussed in Section 1.2.6, leakage from pipes through contaminated soil is considered to be the primary water source to leach and transport contaminants to the underlying aquifer. Pipe monitoring entails determining which pipes are leaking in order to take corrective actions to eliminate the leak. Pipes that are located within 600 ft upgradient from the area of highest soil contamination (under the SPL pile) are considered for leak testing (Figure 5-2). Those pipes beginning within the 600 ft zone but extending outside this area are also included. A survey of these pipes serving stormwater, sewage, and potable water supplies obtained from layout maps dated 1971 are listed in Table 5-1.

Pipe leak detection can be performed in one of several methods. For gravity pipes, the pipe under investigation would be isolated from the rest of the system, filled with water, and the water level monitored. A leaky pipe would result in decrease in the water level in the pipe with time. Disadvantages of this method of testing includes: difficulty of pipe containment from the system due to lack of adequate controls by which the pipe can be isolated such as valves; impracticality of discontinuing the service of the pipe to be tested (even for a short period of time); and difficulty of determining the presence of a leak within a reasonable testing time when the leak is extremely small. The results of pipe monitoring using this method are valid only at the time of the test. Leaks occurring after the test would not be discovered until the next testing period which more likely would be conducted on an annual or biannual basis.

For pressurized water pipes, leak testing can be determined by either measuring the pressure at the nodes, back calculating the pressure drop across the pipe, and comparing the results with the theoretical pressure drop based on the hydraulic grade line; or by isolating a portion of the system and determining the flow rate of pressurized water from elsewhere in the system that is required to maintain a nominal pressure within the isolated section. Leak test determined with this method also may have the disadvantages mentioned above for testing



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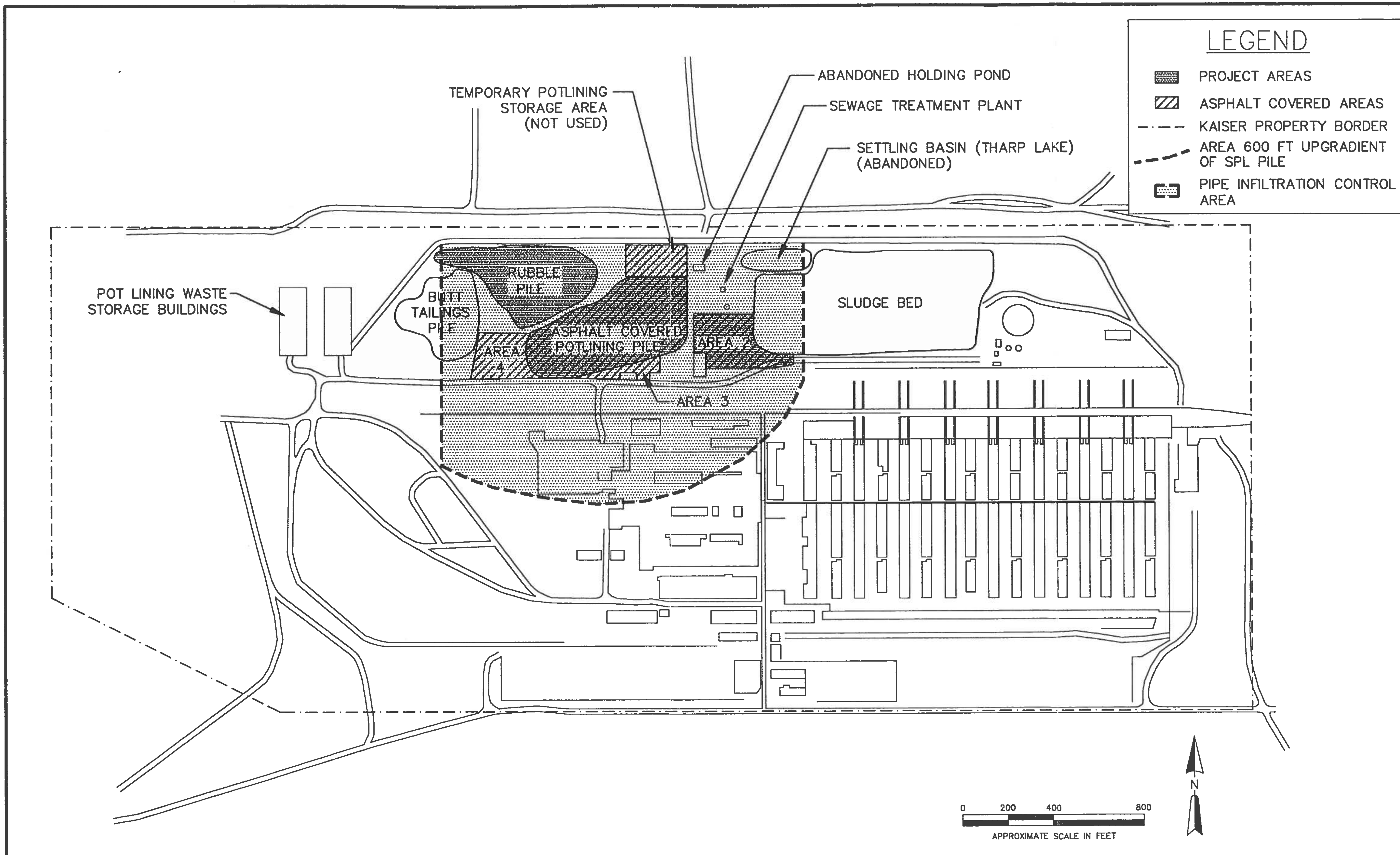
AREAS WHERE ADDITIONAL CAPPING MAY BE REQUIRED
KACC – MEAD SITE

RETEC
REMEDIATION TECHNOLOGIES INC

FIGURE 5-1



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SITE AREA WHERE PIPES ARE TO BE CONSIDERED FOR LEAK TESTING,
PIPE REPLACEMENT OR SLIP LINING
KACC – MEAD SITE

RETEC
REMEDIATION TECHNOLOGIES INC

FIGURE 5–2

TABLE 5-1
PIPES IDENTIFIED WITHIN 600 FEET OF SPL PILE

Pipe Description	Pipe Diameter (in)	Pipe Length (ft)
Stormwater	42	150
	36	1193
	30	758
	27	224
	21	283
	18	466
	15	691
	12	1009
	8	432
	6	279
Sanitary	12	561
	10	983
	6	1911
	4	52
Water	10	2520
	8	100
	6	300
	3	650
	1.5	200
	1	100

Data collected from maps dated 1971.

gravity flow pipes. Soil moisture determination can be employed; however, the leakage volume would not be quantified. In addition, for adjacent pipes or pipes crossing one another, soil moisture determination may not identify the leaking pipe.

Pipe sliplining or replacement without conducting leak tests include the same pipes identified in Table 5-1. Typically replacement refers to installing new pipes parallel to or in place of old pipes. Parallel pipe replacement will be conducted when the service of the old pipe line cannot be interrupted. In such a case the old pipe would remain in place and a new pipe would be installed parallel to the old pipe. The service of the old pipe would cease once the new pipe is tied to the system. Installation of new pipes and removal of old pipes (when feasible) require excavation, pipe placement (or removal), end connection to the system, pipe testing, refilling, grading, and site restoration. In certain instances, structural obstructions prevent parallel installation of new pipes. In such cases, the pipe would be routed around the obstruction. Excavation would result in major ground surface disruptions requiring major restoration work. An alternative solution to pipe replacement is pipe sliplining. Sliplining entails the placement of a high density polyethylene pipe (HDPE) inside of the existing pipe. Because this action would result in a decrease in pipe capacity, pipes considered for this option are 3 inches or greater in diameter.

<u>Long Term Effectiveness</u>

<u>Effectiveness</u>. Asphalt caps previously installed over the SPL pile and Areas 2, 3, and 4 proved effective in reducing infiltration and thus reduced cyanide and fluoride transport from the SPL and/or contaminated soil to the groundwater. The installation of additional caps over portions of the rubble pile would add an additional safeguard against potential contaminant mobilizing factors.

Leak tests at KACC-Mead were conducted for gravity and pressurized pipes in 1982. Leaking pipes were discovered and repaired in June 1983 and December 1987. Therefore, methods of pipe leak detection are effective in determining location of leaks.

Replacement or sliplining leaking pipes in the vicinity of the SPL pile, in conjunction with capping potential infiltration areas, would eliminate any possible recharge of contaminated leachate to the groundwater. This program could be phased over several years, by first completing replacement or sliplining of the pipes most likely to result in significant leakage volumes.

Infiltration control has been demonstrated to be highly effective at the KACC-Mead site in reducing groundwater concentrations of cyanide and fluoride. One year after the abandonment of Tharp Lake, concentrations in downgradient well TH-8 decreased rapidly. Total cyanide concentrations in this well decreased from nearly 300 mg/l to 100 mg/l in 3.5 years. Similarly, fluoride concentrations decreased from nearly 200 mg/l to 100 mg/l in 2.5 years. Concentrations have leveled off since 1987 presumably due to additional infiltration sources most likely related to leaky underground piping. Based on previous experience at the KACC-Mead site, controlling infiltration will effectively reduce overall groundwater concentrations of cyanide and fluoride.

<u>Reliability</u>. The asphalt caps would have good reliability with little maintenance as was experienced with the original SPL cap installed in 1978. The reliability of the cap to prevent surface water infiltration has been observed since 1978. Therefore, it is anticipated that the newly constructed caps would extend the reliability of isolating the SPL and contaminated soil from the environmental elements. A program of systematic leak monitoring and pipe replacement would further improve the reliability of a containment system for preventing recharge through the contaminated zone.

<u>Experience at Other Sites</u>. Caps have been used in a large number of projects as part of closure activities of hazardous waste sites. Caps have been used at sites associated with spent potliners, wood treating, coal-tar distillation, coke manufacturing, manufactured gas plants, petroleum refining, and chemical manufacturing. The experience at KACC-Mead with the reliability and protectiveness of asphalt caps indicates that these caps are compatible with the SPL material.

Leak tests for municipal water distribution and sewage collection systems have been conducted for many years at numerous locations. Leak tests have been successfully conducted at KACC-Mead. This knowledge and experience can be applied as part of this alternative to the KACC-Mead site.

Replacement of old pipes with new pipes is a process that is continuously conducted in major cities on daily basis. Any experienced contractor would be capable of implementing this option.

Short Term Effectiveness

Safety. The primary safety concern associated with capping is the movement of heavy equipment and the generation of asphalt fumes and contaminated dust during cap construction. Workers' exposure would be minimized through the use of proper protective equipment during construction.

There are no safety concern issues associated with pipe leak testing. Pipe replacement or repair may require the use of heavy machinery to excavate and place the new pipe and perhaps remove the leaking pipe. Dangers associated with the use of heavy equipment relate to noise and potential heavy equipment accidents. Safety procedures would be identified and personnel would be trained to follow these procedures.

Response Time Frame. Infiltration controls previously implemented at the KACC-Mead site resulted in a rapid improvement in groundwater quality. The response observed at TH-8 following the abandonment of Tharp Lake can be used to predict the time to achieve cleanup levels, assuming effective infiltration control. Well TH-8 is located near the Kaiser property line. The point of compliance for groundwater is a conditional point of compliance represented by the property boundary as discussed in Chapter 2.

Tharp Lake was abandoned in September 1981. Concentrations of cyanide and fluoride began to steadily decline approximately one year later. As discussed in Section 1.2.6, the observed decrease of total cyanide and fluoride was linear over time and equates to loss rates of 4.8 mg/l per month total cyanide and 3 mg/l per month fluoride. Concentrations at TH-8 are conservatively estimated at this time as 100 mg/l for both constituents. Free cyanide concentrations in TH-8 are approximately 0.5 mg/l and are therefore already near the cleanup level of 0.32 mg/l. Assuming concentrations of total (and also free) cyanide are to be reduced by 50 percent in order to achieve the cleanup goals, this empirical model suggests less than one year would be required. Hence, the free cyanide cleanup goal could be met at TH-8 within two years after infiltration controls are implemented. Because fluoride concentrations must be reduced from 100 mg/l to 4 mg/l to achieve the cleanup levels identified in Chapter 2, a total time of 4 years would be required based on this linear extrapolation.

Reduction of Toxicity Mobility and Volume

This alternative does not result in the removal or destruction of any hazardous constituents. However, this alternative minimized the mobility of any hazardous constituents remaining in the SPL or underlying contaminated soil by eliminating the pathway (i.e.: infiltration of water from precipitation and pipe leaks). The alternative does not remove or destroy any of the hazardous constituents currently present in the groundwater.

Implementability

Ease of Construction. Asphalt caps can be easily installed in most cases using typical road paving equipment. Installation of the cap over portions of the rubble pile may pose some difficulties associated with the irregularities of the pile and due to presence of voids. As such, these portions of the rubble pile require regrading and consolidation to eliminate the presence of large voids and to provide for slope stability and minimize subsidence. The use of heavy equipment such as bulldozers in order to regrade the rubble pile would be required. During cover installation, there would be additional nuisance dust from the use of heavy machinery and the fumes from asphalt melting. Asphalt vapors and dust would be controlled by installing temporary windbreaks. In general, cap installation would not cause major difficulties.

There is no construction associated with leak testing. However, construction of new pipelines to replace the leaking pipes would be conducted as necessary. Construction of certain pipelines may not be possible in some locations due to the presence of buildings, structures, or underground obstructions. In such cases the new pipe would have to be routed elsewhere. Construction of underground pipelines would follow typical construction practices which include integrity and leak testing prior to initial use.

Operation and Maintenance. Once installed, the caps require only periodic maintenance. Maintenance would be required to prevent vegetative growth, to prevent cover sagging and the formation of local ponding, and to maintain cover integrity. Experience on this site has shown that maintenance of the asphalt covers is minimal.

Once installed, pipes do not require routine maintenance. Leak tests would be extended to include the newly installed pipes to ensure they do not become a source for infiltration in the future.

Regulatory Issues/Permit Requirements. Several issues must be addressed in evaluating the regulatory feasibility of in-place capping of SPL and the cyanide and fluoride affected soils.

Although the SPL is a RCRA listed waste, no RCRA permits would be required for this alternative since the material was placed in the piles prior to the date of the effective listing. Capping the SPL would not result in waste generation and the activities would occur within an "Area of Continuation" or "Corrective Action Management Unit" hence not requiring any permits.

No regulatory requirements for conducting leak tests or pipe repairs or replacement are identified. Further, there are no permitting procedures that an owner must follow prior to making such tests, repairs, or replacements.

Environmental and Public Health Effects

Exposure of the adjacent community is negligible due to distance of the nearest community to the site. Capping the exposed areas of the site would not have an adverse impact, even short-term, on groundwater quality. The long-term impact of capping is positive, due to the provision of a better assurance that further migration of contaminants to the groundwater is prevented.

Pressurized leak tests may result in short-term increase in contaminant mobilization with the increased infiltrating water from leaking pipes. However, effects of leak tests on groundwater is minimal due to the short-term duration of the tests and the anticipated small number of leaking pipes. The effect of such leak tests on the adjacent community is nil, especially since groundwater is not being used as a drinking water supply.

Pipe replacement or sliplining would not have any adverse impact, short-term or long-term, impact on the groundwater, the Little Spokane River, or on the adjacent community.

Cost

The capital cost for capping portions of the rubble pile is estimated at $187,779. The estimated maintenance cost of all the capped area would be $5,633 per year (at 3 percent of the capital cost). At a 10 percent interest rate, and for a 30-year maintenance program, the equivalent present worth of capping is $240,877.

The cost of conducting leak test for the pipes identified in Table 5-1 is estimated at $75,000. If there is a need to conduct leak tests once every year, then the cost of $75,000 would be incurred on yearly basis. Assuming that leak tests were to be conducted for 30 years at $75,000 per year, then the equivalent present worth would be $707,019 at 10 percent interest.

Table 5-2 indicates the estimated cost for piping only using 1992 estimates using vendors quotes, RETEC's experience, and the Engineering Cost Index. Using these values, a total cost of $558,397 was projected. This includes material, labor, equipment, engineering, supervision, mobilization, demobilization, and contingency. Pipe sliplining costs for pipes greater than 3 inches in diameter are estimated at $203,650 as given in Table 5-3. The total costs including material, labor, equipment, engineering, supervision, mobilization, demobilization, and contingency is estimated at $454,755. There is no O&M cost associated with pipe replacement or sliplining. A summary of these costs is provided below.

Action	Capital	O&M	EUAC*	# of Yrs.
- monitoring	$0.00	$120,000	$120,000	1-30
- capping	$187,779	$5,633	$25,552	1-30
- leak testing	$0.00	$75,000	$75,000	1-30
- pipe replacement	$558,397	$0.00	$59,234	< 1
- pipe sliplining	$454,755	$0.00	$48,240	< 1
- Total 1	$187,779	$200,633	$220,552	1-30
- Total 2	$746,176	$125,633	$204,786	1-30
- Total 3	$642,534	$125,633	$193,792	1-30

- Present Worth 1	$2,079,984
- Present Worth 2	$1,930,504
- Present Worth 3	$1,826,862

* EUAC is amortized for 30 years @ 10 percent.

where Total 1 = monitoring, capping and leak testing,
Total 2 = monitoring, capping and pipe replacement, and
Total 3 = monitoring, capping and pipe sliplining.

<u>Summary</u>

Alternative 2 addresses the source of cyanide and fluoride contamination (SPL and contaminated soil). The use of asphalt caps as a means to eliminate infiltration has been proven since the first asphalt cap was installed in 1978. Caps not only prevent infiltration and further contaminant migration, but it also minimizes dust formation and increases the aesthetics of the site.

TABLE 5–2
COSTS OF PIPES IDENTIFIED WITHIN 600 FEET OF SPL PILE

Pipe Description	Pipe Diameter (in)	Pipe Length (ft)	Unit Cost* ($/ft)	Cost ($)
Stormwater	42	150	$83	$12,450
	36	1193	$57	$68,001
	30	758	$43	$32,594
	27	224	$24	$5,376
	21	283	$24	$6,792
	18	466	$16	$7,456
	15	691	$13	$8,983
	12	1009	$11	$11,099
	8	432	$7	$3,024
	6	279	$6	$1,674
Sanitary	12	561	$11	$6,171
	10	983	$7	$6,881
	6	1911	$6	$11,466
	4	52	$2	$104
Water	10	2520	$20	$50,400
	8	100	$16	$1,600
	6	300	$11	$3,300
	3	650	$10	$6,500
	1.5	200	$6	$1,200
	1	100	$4	$400
Total				$245,471

Data collected from maps dated 1971.

* Unit cost includes material, labor, and equipment.

TABLE 5-3
COSTS OF PIPE SLIPLINERS IDENTIFIED WITHIN 600 FEET OF SPL PILE

Pipe Description	Pipe Diameter (in)	Pipe Length (ft)	Unit Cost* ($/ft)	Cost ($)
Stormwater	42	150	$70	$10,536
	36	1193	$57	$67,582
	30	758	$41	$31,294
	27	224	$25	$5,706
	21	283	$24	$6,883
	18	466	$13	$6,034
	15	691	$9	$6,421
	12	1009	$7	$7,264
	8	432	$5	$2,171
	6	279	$3	$844
Sanitary	12	561	$7	$4,039
	10	983	$5	$5,211
	6	1911	$3	$5,780
	4	52	$1	$63
Water	10	2520	$15	$36,776
	8	100	$11	$1,059
	6	300	$6	$1,794
	3	650	$4	$2,713
	1.5	200	$6	$1,102
	1	100	$4	$386
Total				$203,658

Data collected from maps dated 1971.

* Unit cost includes material, labor, and equipment.

Pipe leak testing and pipe replacement or sliplining, are alternatives to locate and eliminate the sources of infiltration from underground pipes. Sewage, stormwater, and water pipes carry liquids across the site typically upgradient from the area of contaminated soil. Several pipes were identified as potential candidates for pipe testing and repair. These pipes are located within 600 ft from the SPL pile (CH2MHill, 1988; see Table 5-1).

The beneficial impact on the groundwater through eliminating infiltration sources has been proven at this site.

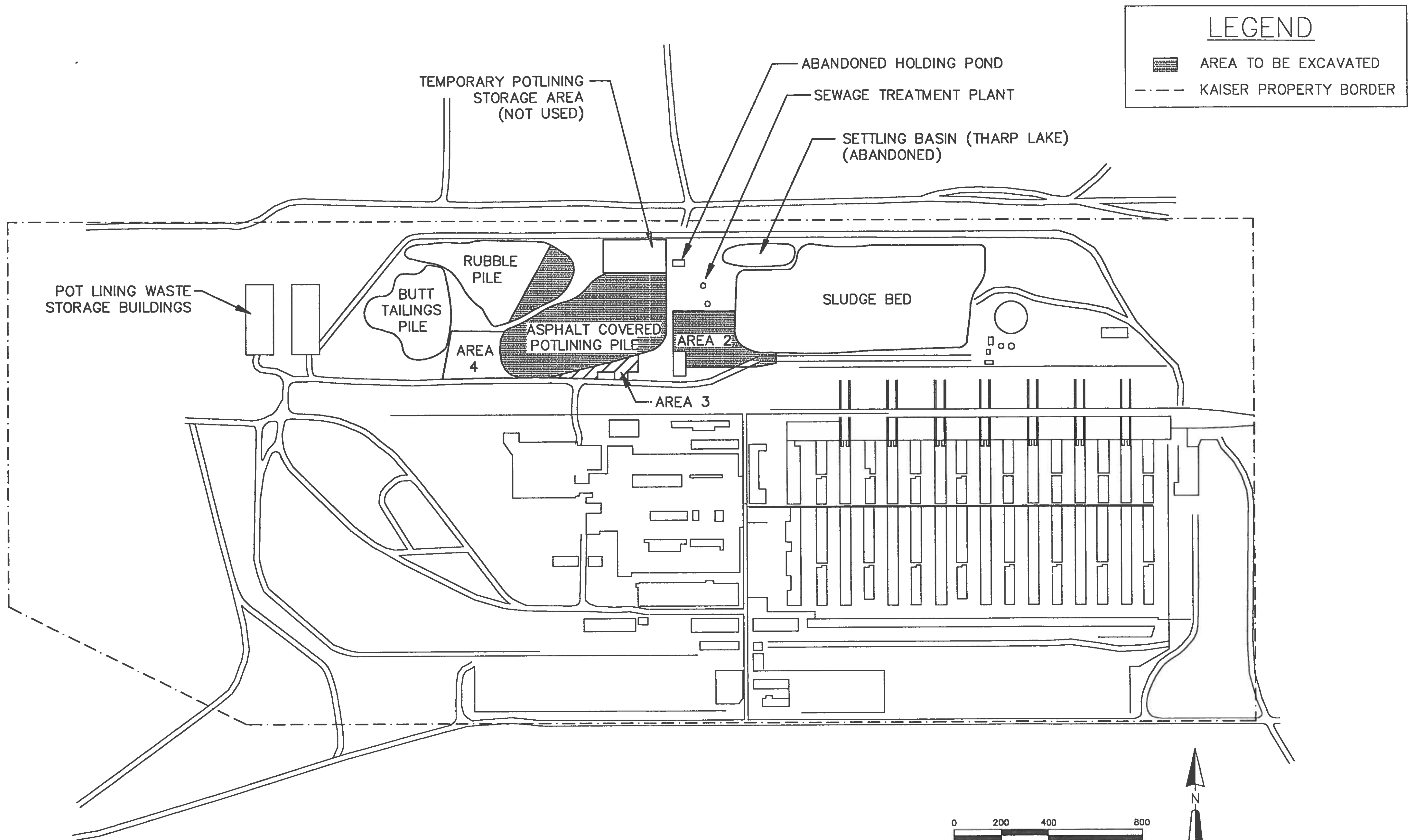
Site capping with pipe leak control is not considered a "permanent solution" under the MTCA. This alternative results in contaminant containment, however contaminants do remain at the site. In addition, this alternative does not address the groundwater contaminants directly. Nevertheless, a rapid response (<5 years), due to the reduced infiltration and subsequent improvement in groundwater quality to at or near the cleanup levels, is predicted based on the implementation of these proven and effective infiltration control measures.

5.2.3 Alternative 3: Excavation and Off-Site Disposal

This alternative addresses the SPL material and underlying soils only. Excavated SPL is transported upon excavation to an off-site land disposal facility. Excavation of the entire contaminated portions of the soil was realized to be impractical due to the large volume of soil and great depths of required excavation. In addition, it was determined that by taking proper institutional and engineering controls, the impact of contaminated soil on the environment and public health is negligible. Thus, the current alternative addresses only the removal and disposal of the SPL followed by capping of the underlying soils.

Process Description

The majority of SPL is located within the SPL pile. The pile is currently covered with asphalt and has an estimated volume of 90,000 yd^3. The SPL pile covers an area of approximately 675 ft x 225 ft, with a height ranging between 10 and 40 ft. The weight of the SPL pile is estimated at 128,000 tons, thus, giving the pile a bulk density of 1.42 g/L. There are other areas where SPL was disposed such as Area 2, and beneath the rubble pile. For the sake of completeness, it is assumed that 45,000 yd^3 of the rubble pile will require excavation and disposal as well as 25,000 yd^3 from Area 2. Figure 5-3 shows the location of SPL requiring excavation.



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DATE	1/19/93
CHK'D BY	J.C.
DATE	1/19/93
SCALE	NOTED
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LOCATION OF SPL POTENTIALLY REQUIRING EXCAVATION
KACC – MEAD SITE

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FIGURE 5–3

Excavation of contaminated material requires a planned sequence for control of ponding, segregation, and containment of material depending on ultimate treatment and disposal methods. The excavation, stockpiling for treatment or disposition, backfilling, regrading, and capping, all must be performed under appropriate health and safety guidelines.

Excavation projects are accomplished by a variety of conventional construction equipment. Due to the presence of bulky material such as scrap iron, excavation may proceed at a slower than usual rate. However, excavation would likely be hindered more by the rate of treatment and the subsequent disposal of the treated residue.

During excavation, the following activities are performed: staging area development, access development, preparation of stockpiling areas with containment features, control of surface water from reaching the exposed area of the SPL and the stockpiled material, excavation at rates dependent on treatment and disposal capacity, transporting of excavated material, and backfilling, regrading, and capping exposed areas to prevent infiltration.

Because SPL is a listed hazardous waste it would require disposal in a RCRA landfill facility. Disposal of the SPL material can be performed without treatment as long as the land disposal restrictions (LDR) for the SPL are not promulgated. LDR are anticipated in 1994 for SPL. Land disposal after the LDR effective date will be prohibited until the waste is treated to meet the Best Demonstrated Available Technology (BDAT) standards which are yet to be determined by EPA. Based on this information, Alternative 3 is a short-lived alternative and may not be possible to implement.

Several permitted commercial landfill facilities are available for disposal of the treated waste (CH2MHill, 1988):

1. Chem-Security, Arlington, Oregon (240 miles)
2. Envirosafe, Grand View, Idaho (420 miles)
3. USPCI, Grassy Mountain, Utah (560 miles)

A new facility operated by Chem Waste has opened recently to specifically receive SPL waste. Any one of the above mentioned facilities can be used to dispose of the residues as long as:

- enough capacity exist at the facility
- the facility would be in operation for the duration of the project
- the waste is compatible with other wastes the facility may be receiving
- a permit is obtained
- landfill operations are completed prior or LDR promulgation.

The transporter of the SPL material must be licensed to transport hazardous material. Often times, the rate of disposal of hazardous waste in a permitted landfill depends on the allowable rate of transporting hazardous waste across state borders. The waste excavation rate would depend on the facility location and waste acceptance rate.

During excavation, the exposed portions of the SPL and/or the surface soil would be covered using temporary covers in order to maintain the integrity of the site against infiltration. After excavation is complete, the exposed areas would be capped with asphalt as described in Section 5.2.2. Backfilling and grading would be required for certain excavated areas. An estimated volume of 45,000 yd^3 would require backfilling prior to capping. Leachate collection and treatment may be necessary and would be accomplished using temporary storage tanks followed by off-site disposal. Monitoring and institutional controls would be a part of this alternative.

Long Term Effectiveness

Effectiveness. Excavation and off-site disposal are effective technologies for eliminating SPL wastes as long as the removal is complete. At KACC-Mead, the location of disposed SPL is known and a thorough excavation and removal would be possible.

Transportation and disposal of SPL material in a RCRA-permitted landfill facility typically would result in good containment of disposed material. Correctly operated landfill facilities provide for proper containment of the waste from the surroundings for an indefinite period of time. A dedicated landfill facility is preferred over a non-dedicated facility. A dedicated facility would not have waste incompatibility problems and waste handling and containment would be performed according to the knowledge of SPL characteristics.

Removal and disposal of the SPL material followed by backfilling, grading, and capping of the exposed areas and continued site monitoring is not an effective technology with regard to the contaminants present within the contaminated soil and in the groundwater. Because migration from the SPL waste has been eliminated due to site capping and other controls, removal of the SPL waste is not necessary in order to remediate the groundwater plume. In fact, during excavation, migration of SPL leachate to the groundwater may occur. Additional pollution may be generated during excavation from the production of dust and noise. Therefore, it is believed that excavation of the SPL may generate more of a hazard than maintaining the pile in its present intact form.

Reliability. Excavation and transportation are short-term technologies and when executed properly can be reliable in achieving the desired objective of source removal. However, on the short-term, this alternative may result in greater cyanide mobilization to the groundwater by creating temporarily exposed site areas. In addition, over on the long-term, this alternative is not expected to result in better groundwater protection than in-place containment, as long as engineering controls are continued to be implemented.

Experience at Other Sites. Excavation, transportation, and disposal of hazardous wastes have been implemented at numerous hazardous waste sites.

Short Term Effectiveness

Safety. Safety issues relate to the use of heavy equipment for excavation, backfilling, and transportation purposes. All workers should be properly trained to conduct the work, should be certified for hazardous waste operations, and should wear protective equipment. Exposure to dust, noise, and excessive weather conditions should be prevented. All equipment should receive proper maintenance to avoid accidents. In general, the chance of accident occurrence during excavation can be minimized as much as possible by following proper operating procedures and using experienced operators.

Off-site disposal of the SPL will require transport of approximately 160,000 yards of material over 200 to 500 miles of secondary roads and interstate. Using 18 cubic yards as the capacity for a truck, this alternative would involve approximately 9,000 round trips or in the vicinity of 4,000,000 to 9,000,000 total road miles depending on the disposal site selected.

The probability of transportation related accidents of deaths associated with this many road miles is very high. A study of transportation risks associated with off-site disposal of large volumes of materials from the Tacoma ASARCO site concluded that 62.08 accidents were expected from 16,000,000 estimated truck miles (see Appendix G). The study predicted that this scenario would result in over 27 injuries and 0.67 fatalities. The relationship of truck miles to injuries is not linear and there are a number of differences between this alternative and those evaluated in the ASARCO. However, it is clear that this alternative has some serious short term safety impacts.

Response Time Frame. Time to achieve the end point will be defined as the time required to decrease free cyanide concentration in the aquifer to below 0.32 mg/l and fluoride concentrations in the aquifer to below 4.0 mg/l. As discussed briefly above, removal of the SPL material from the KACC-Mead site would not impact the site either positively or negatively. In fact, there may be a short-term deterioration of the groundwater quality as precipitation over the exposed areas during excavation and stockpiling may allow more contaminants to leach from the SPL and contaminated soil to the groundwater. This effect can be minimized by covering exposed areas during rainfall events and on a daily basis after excavation and stockpiling. Removal of SPL would not result in reducing the time to achieve the end point over Alternative 2.

<u>Reduction of Toxicity Mobility and Volume</u>

This alternative removes the most highly contaminated material at the site (the SPL). However, the SPL is a small portion of the total volume of contaminated soils estimated to be present at the site. Capping limits the mobility of the contaminants remaining in the soil although pipe leaks are not addressed and therefore infiltration of water is still possible. It should be noted that the SPL is not destroyed, but simply transferred to another disposal site. This alternative does not remove or destroy any of the constituents of concern present in the groundwater.

<u>Implementability</u>

<u>Ease of Construction</u>. There is no major construction associated with transportation and landfill operation, but will require providing access roads and temporary covers of exposed SPL and windbreaks as necessary. Backfilling, grading, and construction of a final cap would also be required. These issues have been discussed under Sections 5.2.2. Transportation and landfilling operations would be subcontracted.

<u>Operation and Maintenance</u>. Vehicles used for transporting the waste and equipment used to perform excavation, backfilling, and final cap installation require routine maintenance.

<u>Regulatory Issues/Permit Requirement</u>. There is no recognized condition that requires removal of the SPL material from the site. The SPL material is a listed hazardous waste (K088). Excavation and transport of this material would constitute generation of hazardous waste.

Transportation and landfilling would be performed by subcontractors. Waste transporter should have a permit and a transporter ID number. The landfill should also have an ID number and should be permitted by the state. A manifest would be required to complete the cycle of waste disposition.

Environmental and Public Health Effects

Removal of the asphalt cover to conduct excavation results in exposing SPL to the elements which may result in increased dispersion to the environment and increased chance for additional migration to groundwater. Windbreaks should be used as much as possible to prevent atmospheric dispersion. Daily cover installation should also be performed to minimize the potential for leachate migration. Leachate would be collected, possibly treated and disposed off-site. Excavation should be suspended during rainfall and snowfall events. After complete removal of the SPL, backfilling and surface grading would be accomplished. Finally, a cap would be installed that would prevent water infiltration.

An increase in dispersion of SPL waste would result during excavation and transportation. Typically air monitoring stations would be utilized around the site in order to determine the effect of site operation on ambient air quality. Significant risks of transportation accidents are related to this alternative due to the large number of trucks involved and long distances traveled.

The effect of site operation on personnel and the public (surrounding community) would be minimal if methods to protect the environment and the operators were implemented. Dispersion of SPL particulates towards a receptor outside the facility is low as long as windbreaks and dust control measures are used. Ambient air quality monitoring should be conducted routinely to verify the effectiveness of the windbreaks.

The impact of this cleanup alternative on the public located along the contaminated plume pathway is negligible because these residents have been provided with another source of water supply.

Cost

Cost estimates for this alternative are based on the following assumptions:

- The total volume of the excavated material is approximately 160,000 yd^3.
- The total mass is approximately 230,000 tons based on a density of SPL of 1.42 tons/yd^3.

- No processing of the SPL is required.

- Disposal of SPL does not require solidification/stabilization.

- No treatment if completed prior to implementation of Land Disposal Restrictions.

- Disposal costs include transportation, state tax (if across state borders), and tipping fees.

- All exposed areas would be capped after excavation, backfilling, and grading.

- Monitoring would continue for 30 years.

Based on the above assumptions, this alternative would be completed in about one year. There is no major capital cost associated with this alternative except for upfront plan preparation and contract negotiations. The total present worth is estimated at $29,793,848 for disposal costs in Envirosafe waste disposal facility. For disposal at ChemWaste facility, the present worth is estimated at $29,103,848. The following is a summary of the costs associated with this alternative.

Action	Capital	O&M	EUAC	# of Yrs.
- monitoring	$0.00	$120,000	$120,000	1-30
- capping and recapping	$1,712,719	$51,382	$233,066	1-30
- excavate, transport, dispose at Chem Waste facility	$0.00	$29,103,848	$3,087,314	< 1
- Total	$1,712,719	$29,275,230 $171,382	$3,440,380	< 1 2-30
- Present Worth	$32,432,171			

<u>Summary</u>

Excavation and off-site disposal is an alternative that addresses one source of contamination, namely, the SPL material. This alternative requires the excavation of the SPL pile for off-site disposal. Additional material considered for removal and disposal along with the SPL pile includes SPL in Area 2, and SPL beneath the rubble pile. For the purpose of the analysis, a total volume of 160,000 yd^3 was estimated.

Removal of SPL material from the site effectively removes a potential contaminant source. Off-site disposal in a RCRA-permitted facility insures proper handling and disposal in a secure environment. No cyanide or fluoride destruction or volume reduction is achieved by implementing this cleanup alternative.

This alternative does not address the groundwater plume. Removal of the SPL material effectively removes a major source of contaminants but does not necessarily result in complete site cleanup. Although this alternative includes capping the underlying soil, additional measures such as pipe leak testing and replacement may be necessary to ensure the effectiveness of infiltration controls. These costs are not included in the analysis.

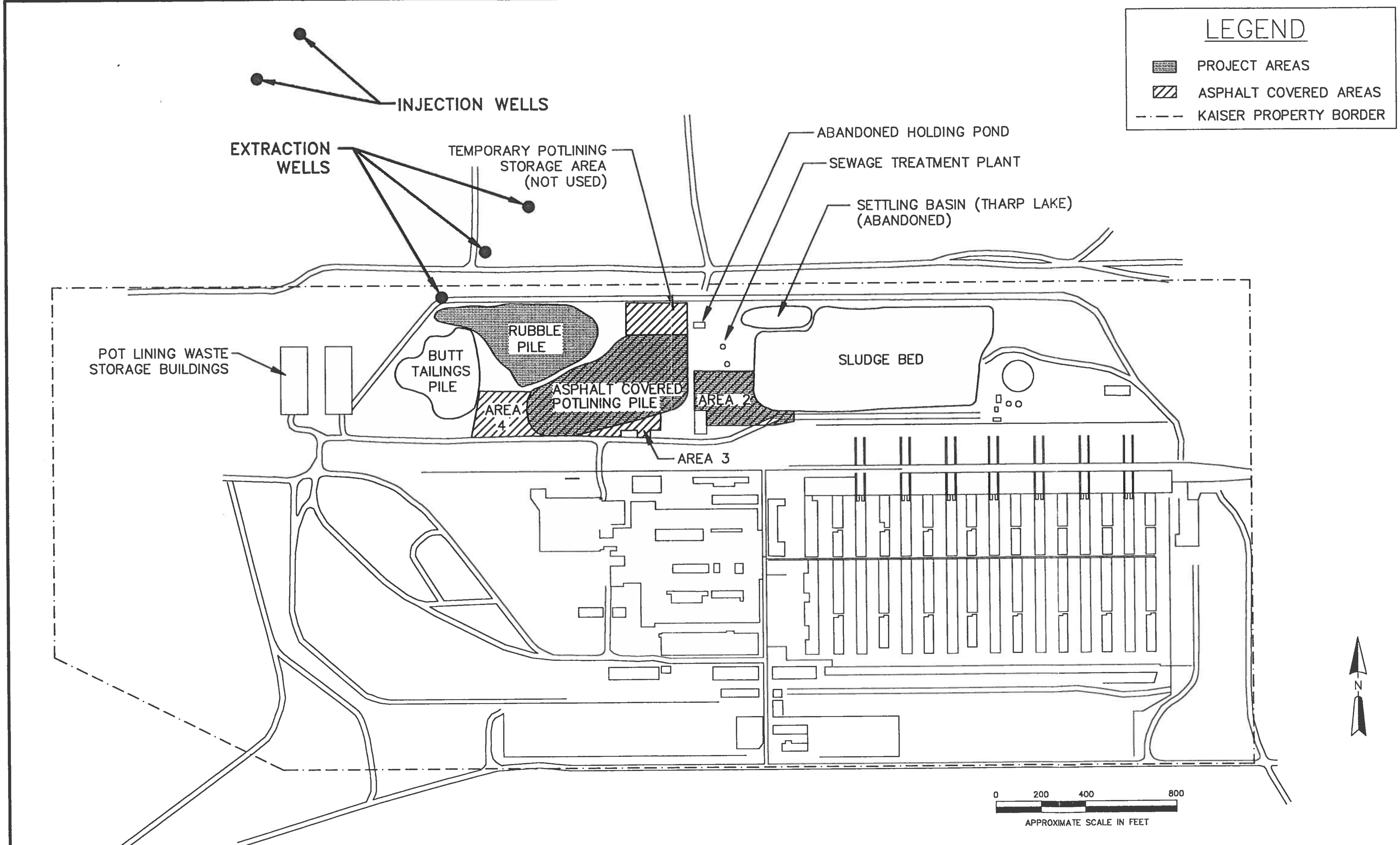
5.2.4 Alternative 4: Infiltration Control and Pump-and-Treat

This alternative addresses both the source and the groundwater plume. Infiltration control is the same as discussed under Alternative 2. Infiltration control refers to controlling the migration of contaminants from the sources to the groundwater, which is implemented by containment and pipe leak control. The pump-and-treat alternative is considered to be suitable for groundwater remediation mainly because cyanide and fluoride are fairly mobile constituents. Thus, they tend to migrate with groundwater to the extraction wells and could be recovered and treated.

Process Description

Infiltration control which includes capping and pipe leak monitoring and control has been described in Section 5.2.2.

Pump-and-treat is a method used to recover as much as possible of the contaminated groundwater and simultaneously prevent contaminated groundwater from escaping between the wells. The well capture zones must overlap under various operational conditions. The design involves placing a line of extraction wells perpendicular to the regional groundwater flow. These wells are best located within or slightly downgradient of the area of highest contamination. This area would be located slightly downgradient of the SPL and rubble piles (Figure 5-4). The advantage of locating the extraction wells in this area is to enhance the recovery of as much contaminants as possible in a short period of time. In addition, these wells would allow the recovery of some downgradient contaminants that preceded the peak of the contaminant plume. The extracted groundwater would require on-site treatment followed by disposal of treated groundwater. Extraction of groundwater would occur continuously.



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APPROXIMATE LOCATION OF EXTRACTION AND INJECTION WELLS
KACC – MEAD SITE

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FIGURE 5-4

Preliminary modeling of extraction wells to capture and recover contaminated groundwater has been performed using the Quickflow^{TM} model (Geraghty and Miller, 1991). After conducting several runs, three wells perpendicular to the groundwater flow direction were chosen to capture groundwater contaminants (Appendix H). Combined pumping rate of 200 gpm was estimated to be sufficient to maximize contaminant capture and minimize the amount of groundwater that requires handling. One of the extraction wells is suggested to be well TH-8 which is located within the most contaminated zone of the plume. After treatment of groundwater, disposal can be through aquifer injection.

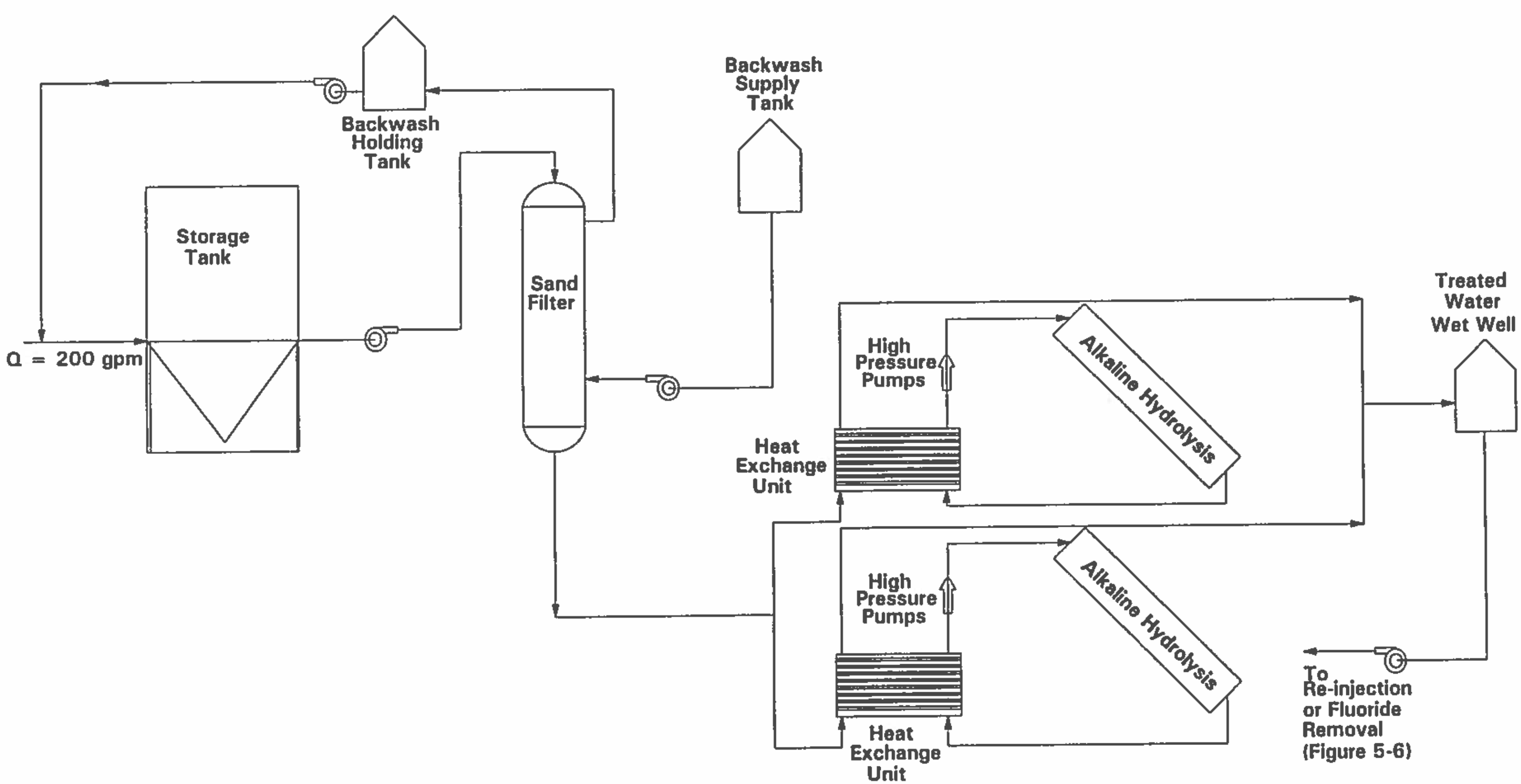
The treated groundwater would be injected directly into the aquifer downgradient from the extraction wells. Three extraction wells would be needed perpendicular to the plume and across the conditional point of compliance (Figure 5-4). Existing wells may be utilized as extraction wells, thus avoiding additional well installation expenses. However, the exact location and number of wells should be determined during the design phase using a series of runs on a groundwater pollutant transport model.

A groundwater treatment system is associated with this alternative. Several groundwater treatment system options were discussed in Appendix E. These treatment options were chosen from among a more comprehensive list of potential treatment technologies based on their applicability to cyanide-laden waters and their availability at full-scale.

Further screening of these options resulted in choosing the alkaline hydrolysis process as the treatment process of choice for contaminated groundwater. The process flow diagram for the treatment process is schematically illustrated in Figure 5-5. The first step in the treatment process would be to remove filterable solids which could result in causing abrasion in the subsequent equipment. The filtered effluent is then heated in a heat exchange unit, then pumped at high pressure through an alkaline hydrolysis vessel. Destruction of cyanide occurs at high temperature and pressure giving residuals such as CO_2 and NH_3 .

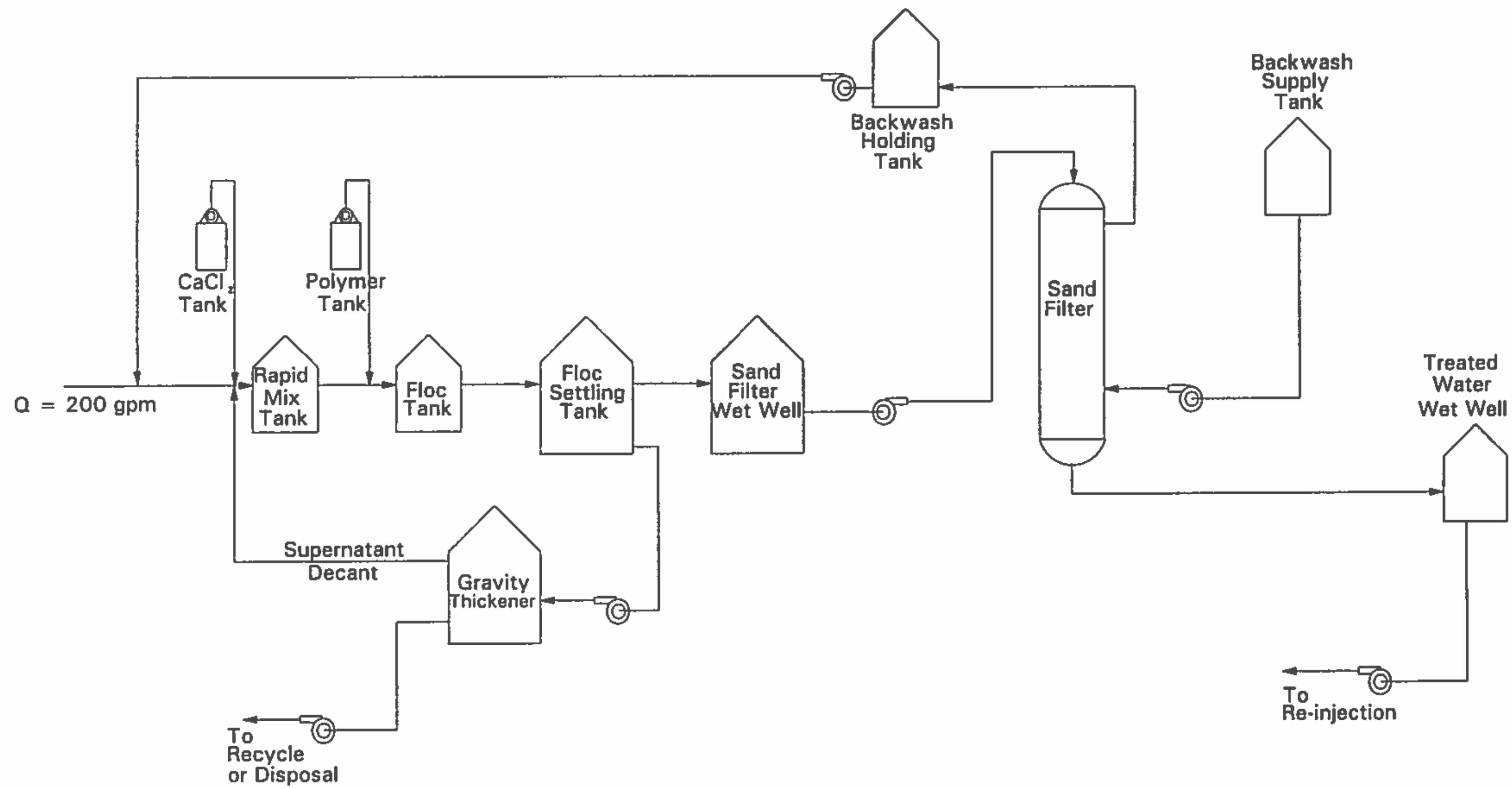
The process diagram of Figure 5-5 does not include fluoride removal which, if necessary, would be removed in a separate precipitation step after the alkaline hydrolysis process. Figure 5-6 identifies a schematic diagram of the fluoride precipitation step. This process includes a coagulation, flocculation and settling steps. Calcium chloride and polymers (as required) are added to enhance the removal of fluoride as calcium fluoride (CaF_2). Overflow from the settling tank would be filtered to remove the fine flocs to prevent well clogging during injection. The sludge produced in this process should not contain cyanides.

REIEC



GROUNDWATER TREATMENT SYSTEM USING THE ALKALINE HYDROLYSIS PROCESS

FIGURE 5-5



GROUNDWATER TREATMENT SYSTEM FOR FLUORIDE REMOVAL

FIGURE 5-6

Bench-scale tests would be conducted to verify and optimize the alkaline hydrolysis and the fluoride precipitation processes. Once optimized, pilot-scale testing of the alkaline hydrolysis process may be conducted based on the manufacturer's recommendations. Pilot-scale testing for fluoride precipitation would not be required because the unit processes involved in this removal step are well established.

Long Term Effectiveness

Effectiveness. The effectiveness of capping and leak testing and pipe repair have been demonstrated at KACC-Mead since 1978. Infiltration control methods as considered effective in reducing or eliminating contaminant migration to the groundwater. Section 5.2.2 covers in more detail the effectiveness of infiltration control methods.

The migration of the plume over the past 12 years indicates that cyanide and fluoride are mobile and therefore will be subject to removal with the extraction wells. The extraction wells would be located in the zone of greatest contamination perpendicular to the plume. This configuration allows for the recovery of the largest contamination during the early stages of the pump-and-treat process. The design as given would be developed further and refined during the design phase of the project.

Groundwater levels of the aquifer would be monitored monthly to ensure capture of the plume. Monitoring would include determining the contaminant concentrations in the pumped groundwater in order to calculate removal rates. The rate of groundwater recharge would be monitored in order to avoid above-average recharge which may result in rise in water levels that may disrupt the proper capture of the plume, and below-average recharge which may result in lowering the water table.

Certain parts of the groundwater treatment system use standard water treatment methods which have been implemented in the past but for different types of contaminants (e.g., precipitation for removal of hardness or iron). Alkaline hydrolysis is a unique process developed mainly for complex cyanide destruction. The processes chosen (Figures 5-5 and 5-6) have equipment vendors (e.g., Cyanide Destruction Systems, Inc. for alkaline hydrolysis).

Reliability. The asphalt caps would have good reliability with little maintenance as was experienced with the original SPL cap installed in 1978. The results of leak testing and the implementation of corrective measures would enhance the reliability of capping. Section 5.2.2 provides a greater discussion of reliability of infiltration control methods.

This alternative relies on several well-established engineering methods for groundwater extraction, treatment, and injection. Periodic servicing of groundwater pumps and the treatment system's mechanical components is a standard O&M procedure. Periodic well redevelopment may be required to remove scale that can form at the well screen and reduce well efficiency. Biological films are not expected to cause screen fouling problems.

The long-term reliability of groundwater treatment system equipment is well understood. Most of this equipment is standard equipment and has been used in many applications. Alkaline hydrolysis equipment is the only equipment manufactured solely for cyanide destruction from spent potlining leachate. This equipment has been in operation at other sites on continuous basis since 1989.

Experience at Other Sites. Caps have been used in a large number of projects as part of closure activities of hazardous waste sites. The experience with the reliability and protectiveness of asphalt caps and use of leak tests have been demonstrated successfully at KACC-Mead. This knowledge and experience can be applied as part of this alternative to the KACC-Mead site. Further discussion on the experience of infiltration control systems is given in Section 5.2.2.

The pump-and-treat method has been used extensively at other sites for remediation of groundwater plumes. Contaminated groundwater treatment using the alkaline hydrolysis process has been implemented on at least two full-scale projects. Cyanide Destruction Systems, Inc. claims that two alkaline hydrolysis systems are in operation for the destruction of cyanide-contaminated groundwater. The equipment has been in operation since 1989 on 24-hr basis. Cyanide destruction of SPL leachate using alkaline hydrolysis has been performed at the laboratory-scale (Kimmerle et al., no date; and Robuck and Luthy, 1989) and at the pilot-scale (Robey and Forrestal, 1985). Precipitation methods have been used to reduce cyanide concentration by as much as 95 percent. Specific applications to SPL leachate have been provided in the literature (Mavis, 1985; Wong-Chong, 1985; and Hohman, 1985).

Short Term Effectiveness

Safety. The primary safety concern associated with capping is the movement of heavy equipment and the generation of asphalt fumes and contaminated dust during cap construction. Workers' exposure would be minimized through the use of proper protective equipment during construction.

There are no safety concern issues associated with pipe leak testing. Pipe replacement or repair may require the use of heavy machinery to excavate and place the new pipe and perhaps remove the leaking pipe. Dangers associated with the use of heavy equipment relate to noise and potential heavy equipment accidents. Safety procedures would be identified and personnel would be trained to follow these procedures.

The primary safety concern when handling large volumes of water containing cyanide is inhalation of cyanide gas by the operator(s) of the water treatment plant. The use of personal protective equipment would minimize this danger. The alkaline hydrolysis process consists of a high temperature, high pressure vessel and therefore, is associated with a certain degree of risk. Proper training and use of safety equipment would minimize this danger.

Restoration Time Frame. The time to achieve cleanup levels utilizing infiltration control is estimated at <5 years as previously discussed under Alternative 2.

Groundwater extraction for treatment and subsequent injection would result in more rapid groundwater restoration. Pollutant recovery would be fast at the onset of groundwater extraction but would slow as time progresses. The end point of treatment is considered to be 0.32 mg/l as free cyanide. Free cyanide is more mobile than total cyanide and would be captured and removed rapidly from the plume. Time to achieve 0.32 mg/l or less within the plume would have to be provided by groundwater modeling which would be implemented in a great detail during the cleanup design phase.

Reduction of Toxicity, Mobility and Volume

This alternative does not remove the majority of the volume of contaminated materials. It achieves substantive reduction in the mobility of contaminants present in the soil and SPL through infiltration control. It also removes and destroys contaminants present in the groundwater to health based levels utilizing a pump and treat system.

Implementability

Ease of Construction. Asphalt caps can be easily installed in most cases using typical road paving equipment. Installation of the cap over portions of the rubble pile may pose some difficulties associated with the irregularities of the pile and due to presence of voids. As such, these portions of the rubble pile require regrading and consolidation to eliminate the presence of large voids and to provide for slope stability and minimize subsidence. There is no construction associated with leak testing. However, construction of new pipelines to replace the leaking pipes would be conducted as necessary. Further discussion of infiltration control construction is presented in Section 5.2.2.

Numerous groundwater wells have been installed throughout the site and around the area. Specific features that would preclude the installation of additional extraction wells and well points are not present. There are no known site constraints that would preclude the implementation of the groundwater treatment installation.

Operation and Maintenance. Once installed, the caps require only periodic maintenance. Maintenance would be required to prevent vegetative growth, to prevent cover sagging and the formation of local ponding, and to maintain cover integrity. Experience on this site has shown that maintenance of the asphalt covers is minimal.

Once installed, pipes do not require routine maintenance. Leak tests would be extended to include the newly installed pipes to ensure they do not become a source for infiltration in the future.

Groundwater extraction and treatment would require regular operator attention. A full-time water treatment operator would be required to insure proper operation and performance. Operator(s) of the sewage treatment plant can operate the water treatment plant as well. Operator's training would be provided by equipment suppliers. Equipment troubleshooting would be performed by vendor representatives during the early stages of operation and then subsequently by the plant operator. Regular maintenance of the mechanical equipment would be performed as required to minimize downtimes. During downtime, groundwater recovery would be suspended until treatment operation is resumed.

Regulatory Issues/Permit Requirements. The regulatory issues for infiltration control were discussed in Section 5.2.2.

For remediation of the saturated sediments and groundwater, a "pump-and-treat" remediation system is considered. Affected groundwater recovered from the aquifer will be treated in an above-ground, tank-based treatment system. The treated groundwater will be reinjected back into its original aquifer.

In order to re-inject the treated groundwater back into the original aquifer, approval must be obtained from both the EPA and the WDOE. Generally, the criterion for re-injection of treated groundwater includes treatment of the groundwater to concentrations which will not harm human health or the environment. These concentrations are expected to be the MCL's for both cyanide and flouride.

Environmental and Public Health Effects

Exposure of the adjacent community is negligible due to distance of the nearest community to the site. Capping the exposed areas of the site would not have an adverse impact, even short-term, on groundwater quality. The long-term impact of capping is positive due to the provision of a better assurance that further migration of contaminants to the groundwater is prevented.

Pressurized leak tests may result in short-term increase in contaminant mobilization with the increased infiltrating water from leaking pipes. However, effects of leak tests on groundwater is minimal due to the short-term duration of the tests and the anticipated small number of leaking pipes. The effect of such leak tests on the adjacent community is nil, especially since groundwater is not being used as a drinking water supply. The effect of pipe leak testing on the Little Spokane River is negligible because no adverse the impact of cyanide on the aquatic life of the river has been demonstrated (Hartung and Meier, 1980).

Pipe replacement or sliplining would not have any negative impact, short-term or long-term, on the groundwater, the Little Spokane River, or on the adjacent community.

Exposure to the adjacent community from operating a groundwater recovery and treatment system is negligible due to the distance of the nearest community to the site.

This alternative will significantly improve groundwater quality through a combination of infiltration controls and groundwater extraction. Over the short term (less than 10 years), this alternative will improve groundwater quality to potable standards based on free cyanide and fluoride. This will also result in net reductions in total cyanide downgradient from the plant site and at the Little Spokane River.

Cost

The cost of infiltration control was previously estimated in Section 5.2.2 as a present worth of $1,826,000 to $2,079,000 depending on the method of leak testing and pipe replacement used.

The costs associated with the pump-and-treat system include the costs associated with installing three extraction wells screened in the A-zone of the aquifer the installation of two injection well at a depth of approximately 150 ft, and installing a groundwater treatment system handling approximately 200 gpm. Costs may be reduced if existing wells are utilized. For a groundwater treatment system utilizing alkaline hydrolysis, the capital cost for this alternative is estimated at $1,081,080. With a defluoridation step the capital cost of the groundwater treatment system increases to approximately $1,366,200. Operating and maintenance expenses are estimated at $211,454 per year. The EUAC is estimated at $ 343,930 for 10 percent interest and 10-year schedule. The groundwater recovery and recharge system is estimated to cost $110,404 to install including labor and equipment. Operating costs are estimated at approximately $28,376 per year. The EUAC for 10 percent interest and 10-year schedule is $46,344. In addition, a yearly monitoring cost of $120,000 will be incurred. The following is a summary of costs for this alternative.

Action	Capital	O&M	EUAC*	# of Yrs.
- monitoring	$0.00	$120,000	$120,000	1-30
- capping	$187,779	$5,633	$25,552	1-30
- leak testing	$0.00	$75,000	$75,000	1-30
- pipe replacement	$558,397	$0.00	$59,234	< 1
- pipe sliplining	$454,755	$0.00	$48,240	< 1
- well installation	$110,404	$28,376	$46,344**	1-10
- GWTP	$1,366,200	$211,454	$343,930**	1-10
- Total 1	$1,664,383	$440,463	$478,534	1-10
		$200,633		11-30
- Total 2	$2,222,780	$365,463	$462,768	1-10
		$125,633		11-30
- Total 3	$2,119,138	$365,463	$451,774	1-10
		$125,633		11-30
- Present Worth 1	$4,477,190			
- Present Worth 2	$4,328,568			
- Present Worth 3	$4,224,926			

where Total 1 = monitoring, capping, leak testing, and pump-and-treat
Total 2 = monitoring, capping, pipe replacement, and pump-and-treat
Total 3 = monitoring, capping, pipe sliplining, and pump-and-treat.

* EUAC is amortized for 30 years @ 10 percent.

** EUAC is amortized for 10 years @ 10 percent.

Summary

Alternative 4 addresses the sources (SPL and contaminated soil) and the groundwater plume. The use of asphalt caps as a means to eliminate infiltration has been proven since the first asphalt cap was installed in 1978. Caps not only prevent infiltration and further contaminant migration, but it also minimizes dust formation and increases the aesthetics of the site.

Pipe leak testing and pipe replacement or sliplining, are alternatives to locate and eliminate the sources of infiltration from underground pipes. Sewage, stormwater, and water pipes carry liquids across the site typically upgradient from the area of contaminated soil. Several pipes were identified as potential candidates for pipe testing and repair. These pipes are located within 600 ft from the SPL pile (CH2MHill, 1988). Infiltration control has been demonstrated to be highly effective in reducing groundwater concentrations of cyanide and fluoride at this site.

Alternative 4 also addresses the groundwater plume. This alternative is composed of the use of three extraction wells approximately 800 ft downgradient of the SPL, the use of a groundwater treatment system, and a series of injection wells installed at approximately 150 ft. A combined extraction rate of 200 gpm was deemed sufficient to capture the plume. A groundwater treatment system consisting of filtration, alkaline hydrolysis for cyanide destruction, and a post-defluoridation step was selected.

5.2.5 Alternative 5: Excavation, Off-Site Disposal, Pump-and-Treat

This alternative combines Alternative 3 and Alternative 4. The SPL material identified under Alternative 3 would be excavated and transported for off-site disposal. Exposed areas would be capped after being backfilled and graded as required. Simultaneously (to the extent possible) groundwater extraction would take place followed by on-site treatment with a dedicated treatment plant (Alternative 4). The treated, groundwater would be reinjected into the aquifer.

This alternative is comprehensive as it addresses the sources of cyanide and the groundwater plume. SPL would be disposed in an off-site landfill without treatment, the material would be secured in a RCRA permitted landfill which is subject to the stringent RCRA regulations and design and safety specifications. The disposed SPL would be contained in the landfill with other compatible material. Liners and capping are a part of the safeguards used in the landfill to prevent migration of contaminants off-site. In addition, leak detection and monitoring is implemented in all RCRA landfills to provide early detection of potential transport off-site so that actions would be taken prior to jeopardizing the public health and the environment. This alternative provides a comprehensive waste control at KACC-Mead because the SPL material is removed off-site and groundwater recovery and treatment would be implemented. Therefore, it provides good protection to the public health and the environment.

The pump-and-treat system associated with this alternative is similar to that described in Alternative 4. Pump-and-treat allows for plume capture and groundwater and soil cleanup.

Process Description

The process has been described under Sections 5.2.3 and 5.2.4. All activities pertaining to this alternative would be performed as described under the above mentioned sections except for the sequencing of events. The procedure would be as follows: excavate the SPL, dispose off-site; meanwhile, construct the water treatment plant, install the extraction wells, install the injection well points pump groundwater, treat, and reinject. Temporary covers and windbreaks would be installed during excavation to minimize dust formation and hazardous material transport to the workers and surrounding communities. Ambient air monitoring would be a part of this alternative. Groundwater monitoring and institutional controls will continue to be implemented under this alternative.

Alternative Evaluation

All evaluation criteria applied to relevant portions of Alternatives 3 and 4 apply to this alternative as well.

Cost

The cost for this alternative would be the sum of the costs of the relevant portions of Alternatives 3 and 4. To implement this alternative the following capital and O&M costs are included:

Action	Capital	O&M	EUAC*	# of Yrs.
- monitoring	$0.00	$120,000	$120,000	1-30
- capping	$1,712,719	$51,382	$233,066	1-30
- excavate, transport, dispose at Chem Waste facility	$0.00	$29,103,848	$3,087,314	< 1
- GWTP	$1,366,200	$211,454	$343,930**	1-10
- well installation	$110,404	$28,376	$46,344**	1-10
- Total	$3,189,323	$29,515,060	$3,753,341	< 1
		$411,212		2-10
		$171,382		11-30
- Present Worth	$35,382,426			

* EUAC amortized for 30 years @ 10 percent.
** EUAC amortized for 10 years @ 10 percent.

5.3 ASSESSMENT OF THE CLEANUP ALTERNATIVES

The threshold requirements for selection of a cleanup action under the Model Toxics Control Act (WAC 173-340-360 (2)) are:

- protect human health and the environment,
- compliance with cleanup standards,
- comply with applicable Federal and State laws, and
- provide for compliance monitoring.

All the alternatives, with the exception of No Additional Action are designed to meet these threshold requirements. In the case of No Additional Action, the alternative is unlikely to meet the cleanup standards in a reasonable period of time. The remaining alternatives, however, are protective of human health and the environment, will meet cleanup levels at the point of compliance, will comply with applicable Federal and State laws and all include some form of compliance monitoring.

In addition, the MTCA identifies several additional requirements for establishing a preference for cleanup alternatives. These are:

- the use of permanent solutions to the maximum extent practicable,
- reasonable restoration time frames,
- consideration of public concerns, and
- a preference for cleanup technologies.

The previous sections evaluated each of the five alternatives in terms of the criteria used to define "permanent to the maximum extent practicable" and restoration time frames. This section ranks each of the alternatives according to the WDOE, order of preference for the implementation of cleanup technology. This hierarchy in descending order of preference is:

1. reuse or recycling,
2. destruction and detoxification,
3. separation or volume reduction followed by reuse, recycling, destruction or detoxification of the residual hazardous substances,
4. immobilization of hazardous substances,
5. on-site or off-site disposal at an engineered facility designed to minimize the future release of hazardous substances and in accordance with applicable state and federal laws,
6. isolation or containment with attendant engineering controls, and
7. institutional controls and monitoring.

Public concerns will be addressed through a public comment period. This section provides a comparison of the alternatives in terms of the selection criteria of "permanent", restoration time frames, and preference for cleanup technologies.

5.3.1 Alternative 1: No-Additional Action

The no-additional action alternative was considered an ineffective solution for the restoration of the contaminated groundwater based on groundwater data collected to date. This alternative is associated with continued plume monitoring, continued provision of alternative water supply to the affected community, and continued implementation of other institutional controls. To date, this alternative has resulted in protection of human health and the environment (lack of impact of groundwater plume on the Little Spokane River). However, according to WDOE preference list, this cleanup alternative is not considered a permanent solution, does not result in a reasonable site restoration time frame, does not result in groundwater restoration, does not result in containment of currently uncovered SPL material, does not detoxify, minimize or destroy any of the wastes present on site, and most likely would not be acceptable to the public. A preference rank of 7 is assigned for SPL material contaminated soil, and groundwater plume control methods associated with this alternative. Thus, this alternative is not acceptable according to WDOE criteria.

5.3.2 Alternative 2: Infiltration Control

Alternative 2 considers extending the SPL containment to include currently uncovered SPL material. It also considers eliminating additional infiltration sources of water. This alternative is associated with continued plume monitoring, continued provision of alternative water supply to the affected community, and continued implementation of other institutional controls. This alternative has resulted in protection of human health and the environment (lack of impact of groundwater plume on the Little Spokane River).

According to WDOE criteria, this alternative presents a more acceptable solution to site restoration than Alternative 1. Containment of SPL material does not constitute destruction or detoxification of the material, but does represent an acceptable level of control that has been demonstrated since 1978 by the application of an asphalt cap over the SPL pile. The asphalt cap resulted in prevention of further migration of contaminants from the SPL pile to the soil and the groundwater. In addition, WDOE recognizes that containment can become an acceptable solution to "portions of the sites that contain large volumes of materials with relatively low levels of hazardous substances where treatment is impracticable." Treatment of SPL has been realized to be impracticable, not only due to excessive costs or time of treatment, but also due to the lack of applicable incineration technology that appropriately destroys SPL material without facing major problems due to material agglomeration due to the high salt content (personal communications - Institute of Gas Research, Reynolds Metals Company, von Roll, Inc., and ALCOA 1992). Even with the advent of the new Reynolds process, commercial capacity of thermal treatment remains extremely limited.

Therefore, although containment is an acceptable solution to SPL, this alternative as a whole does not result in a "permanent" solution to the groundwater plume, does not assure groundwater restoration, does not detoxify, minimize, or destroy any of the wastes present on site, and may not be acceptable to the public. According to WDOE ranking of cleanup technologies, SPL containment receives a rank of 6, soil containment receives a rank of 6, and the plume control measure receives a rank of 7.

5.3.3 Alternative 3: Excavation and Off-Site Disposal

This alternative considers the SPL material only. SPL material would be excavated and disposed off-site in a RCRA landfill facility without destruction or detoxification. Thus, this alternative for SPL material falls under the fifth preference according to WDOE criteria for cleanup technologies.

This alternative relies on containment of the contaminated soils (sixth preference), and institutional controls for the groundwater plume (seventh preference).

5.3.4 Alternative 4: Infiltration Control and Pump-and-Treat

This alternative considers the groundwater plume and both source materials (SPL and contaminated soils). This alternative for groundwater plume restoration falls under the third preference according to WDOE cleanup criteria where the contaminants are separated from the groundwater, the residues detoxified, and the groundwater used to enhance aquifer restoration. Thus, this alternative provides for a permanent solution to the groundwater plume. With the implementation of this alternative, all WDOE criteria for groundwater restoration would be met including the use of treatment methods to reduce the level of contamination to the maximum extent possible, groundwater control through groundwater pumping, adequate groundwater monitoring, and the provision of an alternative water supply.

This alternative considers extending the SPL containment to include currently uncovered SPL material. It also considers eliminating infiltration sources of water that may allow the migration of contaminants from the SPL or the contaminated soil to the groundwater. As such, this alternative falls under the sixth preference for SPL material and contaminated soils.

This alternative is associated with continued plume monitoring, continued provision of alternative water supply to the community, and continued implementation of other institutional controls. As such, this alternative has resulted in protection of human health and the environment (lack of impact of groundwater plume on the Little Spokane River).

Containment of SPL material does not constitute destruction or detoxification of the material, but does represent an acceptable level of control that has been demonstrated since 1978 by the application of an asphalt cap over the SPL pile. The asphalt cap resulted in prevention of further migration of contaminants from the SPL pile to the soil and the groundwater. In addition, WDOE recognizes that containment can become an acceptable solution to "portions of the sites that contain large volumes of materials with relatively low levels of hazardous substances where treatment is impracticable." Treatment of SPL has been realized to be impracticable, not only due to excessive costs or time of treatment, but also due to the lack of applicable incineration technology that appropriately destroys SPL material without facing major problems due to material agglomeration due to the high salt content (personal communications - Institute of Gas Research, Reynolds Metals Company, von Roll, Inc., and ALCOA 1992). Even with the advent of the new Reynolds process, commercial capacity of thermal treatment remains extremely limited. Therefore, this alternative provides for good source control and for aquifer restoration.

5.3.5 Alternative 5: Excavation, Off-Site Disposal, Pump-and-Treat

This alternative considers both sources of contaminants (SPL and contaminated soils) and the groundwater plume.

Off-site transport of the SPL receives a rank of 5, whereas capping of the contaminated soil receives a rank of 6. Groundwater plume remediation receives a rank of 3. The implementation of this alternative may result in a short-term exposure problems from excavation dusts, heavy equipment noise, increased temporary migration potential, and other health hazards.

5.3.6 Comparison of the Remediation Alternatives

Comparison of the five cleanup alternatives utilizing WDOE criteria and technology preference guidance is provided in Table 5-4. According to the table, Alternatives 5 and 4 receive the highest rankings (first and second ranks, respectively) followed by Alternative 3 (third rank) and Alternatives 2 and 1.

TABLE 5-4
COMPARISON OF CLEANUP ALTERNATIVES ACCORDING TO WDOE PREFERENCE

Alternative	WDOE Preference*	Deficiency	Rank**
Alternative 1: no-additional action	7, 7, 7	does not protect human health and the environment not a permanent solution restoration time is too long	5 (21)
Alternative 2: infiltration control	6, 6, 7	not a permanent solution for soil & SPL	4 (20)
Alternative 3: excavation , off-site disposal	5, 6, 7	not a permanent solution for soil plume restoration time is too long potential short-term exposure	3 (18)
Alternative 4: infiltration control and pump-and-treat	6, 6, 3	not a permanent solution for SPL & soil	2 (15)
Alternative 5: excavation, off-site disposal, pump-and-treat	5, 6, 3	potential short-term exposure not a permanent solution for soil	1 (14)

* WDOE preference list includes seven options ranked from highest to lowest. The first value is related to the SPL, the second value is related to the contaminated soil and the third value is related to the plume.
** Rank is based on the sum of WDOE preference. The lowest sum was assigned the highest ranking (Rank 1), the second lowest sum was assigned the second highest ranking and so on. Values between brackets indicate the sum of WDOE preference.

5.4 COMPARISON OF CLEANUP ALTERNATIVES

This section presents a summary of the five cleanup alternatives and compares the relative advantages and disadvantages of each in relation to achieving remediation objectives at KACC-Mead. The performance, implementability, and cost of each alternative are summarized in Tables 5-5 to 5-7, respectively. Table 5-8 provides an overall comparison of the five alternatives based on the criteria provided in Tables 5-5 to 5-7.

5.4.1 Alternative 1: No-Additional Action

The no-additional action alternative relies on the controls that have been implemented since 1978 and on the natural attenuation of the plume. The previously instituted controls have resulted in eliminating further leaching of SPL contaminants into the soil and further migration to the groundwater. New sources of potable water were provided to the impacted community. Contaminants reaching the Little Spokane River had no impact on aquatic life in the river.

The natural mechanisms influencing the groundwater plume have resulted in continued decreases in total and free cyanide concentrations. Overall, the instituted controls and natural mechanisms resulted in lower contaminant concentrations (groundwater) or lower contaminant mobilization (SPL and soil). However, complete remediation of the plume with natural attenuation processes would not be achieved in a reasonable amount of time. Thus, the performance of this alternative is considered average.

The no-additional action alternative would include groundwater monitoring to track cyanide and fluoride migration and changes in plume extent. While monitoring does not accelerate plume attenuation, the results could help identify a plan of action as required to remove any threat the plume may pose at any future date.

Maintenance of the monitoring wells would involve standard practices which have been implemented at KACC-Mead for many years. Therefore, the implementability of this alternative is considered very good.

Because an alternate source of drinking water was supplied to the affected community and because there was no documented effect of the plume on the Little Spokane River, the effect of this alternative on the environment and public health is considered small, especially in the short-term.

TABLE 5-5
PERFORMANCE EVALUATION OF REMEDIATION ALTERNATIVES

Alternative	Description of Alternative	Long Term Effectiveness	Short Term Effectiveness	Reduction of Toxicity, Mobility and Volume	Rank
1 no-additional action	monitor continue with institutional controls	natural attenuation not effective in limiting migration	poor, long restoration time frame	none	poor for plume control
2 Infiltration Control	monitor, asphalt capping, leak monitoring and pipe repair continue with institutional controls	prevents cyanide migration from SPL and soils not effective for controlling the plume	restoration time frame dependent on successful identification of major pipe leaks	limits mobility of soil and SPL contaminants.	poor for plume control good for contaminated soil very good for SPL containment
3 Excavation, Off-Site Disposal	excavate SPL, transport for off-site disposal in a RCRA landfill backfill, cap exposed areas continue with institutional controls	removes SPL material not effective for controlling the plume	substantial safety concerns related to transportation	removal of major source	poor for plume control good for contaminated soil very good for SPL
4 Infiltration Control, Pump-and-Treat	monitor, cap, test for leaks, conduct pipe repairs pump at 200 gpm treat and inject on-site continue with institutional controls	prevents contaminant migration from SPL and soils captures dissolved contaminants removes contaminants from water	combination of pump and treat and infiltration controls is highly reliable	treats contaminants in groundwater	very good for plume good for contaminated soil good for SPL
5 Excavation, Off-Site Disposal, Pump-and-Treat	Similar to Alternative 3 and 4 continue with institutional controls	Similar to Alternative 3 and 4	Similar to Alternative 3 and 4	Similar to Alternative 3 and 4	very good for plume good for contaminated soil very good for SPL

TABLE 5-6
IMPLEMENTABILITY EVALUATION OF REMEDIATION ALTERNATIVES

Alternative	Description of Alternative	Ease of Construction	Operation & Maintenance	Time to Achieve end point	Permitting	Rank
1 No-Additional Action	monitor continue with institutional controls	no construction required	Small occasional maintenance of monitoring wells	> 30 years	not required	very good
2 Infiltration Control	monitor, asphalt capping, leak monitoring and pipe repair continue with institutional controls	standard construction methods for capping and pipe repair or replacement	maintenance of SPL and soil cap	< 5 years	required for a RCRA cap	very good
3 Excavation, Off-Site Disposal	excavate SPL, transport for off-site disposal in a RCRA landfill continue with institutional controls	no construction required	maintenance of soil cap	> 30 years *off site disposal must be completed prior to LDRs	required for transportation and disposal	good
4 Infiltration Control, Pump-and-Treat	monitor, cap, test for leaks, conduct pipe repairs pump at 200 gpm treat and inject on-site continue with institutional controls	standard construction methods	mechanical maintenance for wells, pumps, and treatment components	2 to 10 years	required for remediation of groundwater	very good
5 Excavation, Off-Site Disposal, Pump-and-Treat	Similar to Alternative 3 and 4 continue with institutional controls	Similar to Alternative 3 standard construction methods for GWTP	mechanical maintenance for wells, pumps, and treatment components	2 to 10 years	required for off-site transportation and disposal	very good for soil and plume good for SPL

TABLE 5-7
SUMMARY OF COSTS FOR REMEDIATION ALTERNATIVES

Alternative	Component Cost	Present Worth
Alternative 1 No-Additional Action	Capital Cost = $0.00 O&M = $120,000 for 30 years	PW = $1,131,230
Alternative 2 Infiltration Control	CC1 = $187,779; O&M1 = $200,633; Yr = 1-30 CC2 = $746,176; O&M2 = $125,633; Yr = 1-30 CC3 = $642,534; O&M3 = $125,663; Yr = 1-30	PW1 = $2,079,984 PW2 = $1,930,504 PW3 = $1,826,862
Alternative 3 Excavation, Off-Site Disposal	Capital Cost = $1,712,719 O&M = $29,275,230 Yr = 1 O&M = $171,382 Yr = 2-30	PW = $32,432,171
Alternative 4 Infiltration Control, Pump-and-Treat	CC1 = $1,664,383; O&M1 = $440,463; Yr = 1-10 = $200,663; Yr = 11-30 CC2 = $2,222,780; O&M2 = $365,463; Yr = 1-10 = $125,633; Yr = 11-30 CC3 = $2,119,138; O&M3 = $365,463; Yr = 1-10 = $125,633; Yr = 11-30	PW1 = $4,477,190 PW2 = $4,328,568 PW3 = $4,224,926
Alternative 5 Excavation, Off-Site Disposal, Pump-and-Treat	Capital Cost = $3,189,323 O&M = $29,515,060; Yr = 1 O&M = $411,212; Yr = 2-10 O&M = $171,382; Yr = 11-30	PW = $35,382,426

TABLE 5-8
OVERALL SUMMARY OF CLEANUP ALTERNATIVES

Alternative	Performance	Implementability	Total Time	Cost (Present Worth)
1 No-Additional Action	poor for plume control	very good	> 30 years	PW = $1,131,230
2 Infiltration Control	poor for plume control good for soil good for SPL containment	very good	< 5 years	PW1 = $2,079,984 PW2 = $1,930,504 PW3 = 1,826,862
3 Excavation, Off-Site Disposal	poor for plume control good for contaminated soil very good for SPL	good	> 30 years for plume	PW = $32,432,171
4 Infiltration Control, Pump-and-Treat	very good for plume good for contaminated soil very good for SPL containment	very good	2 to 10 years	PW1 = $4,477,190 PW2 = $4,328,568 PW3 = $4,224,926
5 Excavation, Off-Site Disposal, Pump-and-Treat	very good for plume good for contaminated soil very good for SPL	very good for plume good for SPL	2 to 10 years	PW = $35,382,426

The present worth of Alternative 1 is estimated at $ 1,131,23 for a 30 year monitoring program.

5.4.2 Alternative 2: Infiltration Control

This alternative requires the extension of the asphalt caps from areas of high cyanide concentration to areas of low cyanide concentration (portions of the rubble pile). The use of asphalt caps as a means to eliminate infiltration has been proven to be effective since the first asphalt cap was installed in 1978. Caps not only prevent infiltration and contaminant migration, but they also minimize dust formation and increase the aesthetics of the site. Because an asphalt cap over the SPL pile has eliminated infiltration, the performance of this alternative is considered very good.

Pipe leak testing and pipe replacement or sliplining are alternatives to locate and eliminate the sources of infiltration from underground pipes. Sewage, stormwater, and water pipes carry liquids across the site typically upgradient from the area of contaminated soil. Several pipes were identified as potential candidates for pipe testing and repair. These pipes are located within 600 ft of the SPL pile (CH2MHill, 1988). Pipe leak monitoring was conducted in 1982 at KACC-Mead and proved to be successful. Therefore, the performance of pipe monitoring is considered good.

Capping portions of the site with asphalt and conducting leak testing and pipe repair were conducted at KACC-Mead during the past 14 years. Therefore, implementability of this alternative is considered very good based on this experience.

Neither site capping nor pipe leak control results in a permanent solution to the contamination at KACC-Mead. This alternative results in better contaminant containment, but no remediation. In addition, this alternative does not directly address the groundwater contaminants. The impact of this alternative on the public health and the environment is small.

The present worth of additional capping and pipe monitoring is estimated at $1,372,107. Pipe replacement is estimated at a present worth of $558,397. Pipe sliplining is estimated at a present worth of $454,755.

5.4.3 Alternative 3: Excavation and Off-Site Disposal

Excavation and off-site disposal is an alternative that addresses the major source of cyanide contamination, namely, the SPL material. This alternative requires the excavation of the SPL pile for off-site disposal. Additional material included for removal and disposal along with the SPL pile includes SPL in Area 2 and SPL beneath the rubble pile. For the purpose of this analysis, a total volume of 160,000 yd^3 was assumed.

Removal of SPL material from the site effectively removes the primary contaminant source. Off-site disposal in a RCRA-permitted facility insures proper handling and disposal in a secure environment. No cyanide or fluoride destruction or volume reduction is achieved by implementing this cleanup alternative. In general, the performance of this alternative regarding elimination of the SPL as a source of cyanide and fluoride at the KACC-Mead site is very good.

This alternative does not address the contaminated soils nor the groundwater plume. Removal of the SPL material effectively removes a major source of contaminants, but does not result in complete site cleanup, nor does it assure prevention of further contaminant migration to the groundwater from the contaminated soil. However, this alternative is associated with site restoration and capping after excavation. Thus, infiltration control during and after excavation is completed will result in preventing contaminant migration from contaminated soil. Thus, the performance of this alternative regarding contaminated soil is good. This alternative does not address the groundwater plume. Therefore, the performance of this alternative regarding plume control is poor.

There is no major construction associated with this alternative. Implementation of this alternative must be completed prior to the effective date of the LDR's. Implementability of this alternative is expected to be relatively good.

Because this alternative is concerned only with the removal of the SPL material, the effect of this alternative on the environment and public health is considered small. However, in the short-term, the effect of this alternative on the adjacent environment may be negative. Dust, noise, and increased migration potential of exposed areas during implementation may have a negative effect on the surrounding areas. No additional benefit, over proper containment and pollutant migration prevention, is achieved by implementing this alternative.

The present worth of this alternative using the ChemWaste landfill facility is estimated at $32,432,171.

5.4.4 Alternative 4: Infiltration Control and Pump-and-Treat

Alternative 4 addresses the SPL, the contaminated soil, and the groundwater plume. Infiltration control is similar to that discussed in Alternative 2. In addition, this alternative is composed of the use of three extraction wells approximately 800 ft downgradient of the SPL, the use of groundwater treatment system, and two injection wells installed downgradient of the SPL pile. A combined extraction rate of 200 gpm was deemed sufficient to capture the plume. Five groundwater treatment system options are discussed in Appendix E. All treatment options are feasible and will remove the majority of the cyanide. However, the alkaline hydrolysis process was chosen for the destruction of cyanide and precipitation was chosen for fluoride removal. The performance of this alternative as a means of remediation of the contaminant plume is considered very good. The performance of this alternative regarding the SPL material and contaminated soil is good.

Implementation of this alternative results in accelerated plume remediation. Installation of the caps and conducting leak testing and pipe repairs was performed previously at KACC-Mead with good success. Implementation of infiltration control measures is considered very good. Installation and maintenance of the monitoring wells is considered standard practice. Groundwater treatment equipment is commonly manufactured equipment with well known vendors. Operation and maintenance of the groundwater treatment plant should be standard practice. Therefore, the implementability of this alternative is considered very good.

The effect of this alternative on the public health and the environment is very good in the long-term with little impact in the short-term.

This alternative may be operated for a minimum of two years to a maximum of 10 years. The present worth of implementing this alternative based on a 10-year schedule is estimated at $4,477,190 for capping, leak testing, and pump-and-treat, at $4,328,568 for capping, pipe replacement, and pump-and-treat, and at $4,224,926 for capping, pipe sliplining, and pump-and-treat. These values include monitoring cost of $120,000 per year for only 10 years.

5.4.5 Alternative 5: Excavation, Off-Site Disposal, Pump-and-Treat

This alternative combines Alternative 3, and Alternative 4. The SPL material identified under Alternative 3 would be excavated and transported for off-site disposal. Simultaneously (as much as possible) groundwater extraction would take place followed by on-site treatment with a dedicated treatment plant (Alternative 4). The treated groundwater would be reinjected into the aquifer.

This alternative is comprehensive as it addresses the sources of contaminants and the groundwater plume. Although SPL would be disposed in an off-site landfill without treatment, the material would be secured in a RCRA permitted landfill which is subject to the stringent RCRA regulations and design and safety specifications. The disposed SPL would be contained in the landfill with other compatible material. Liners and capping are a part of the safeguards used in the landfill to prevent migration of contaminants of-site. In addition, leak detection and monitoring is implemented in all RCRA landfills to provide early detection of potential transport off-site so that actions would be taken prior to jeopardizing the public health and the environment. This alternative provides comprehensive waste control at KACC-Mead because the SPL material is removed off-site and groundwater recovery and treatment would be implemented. Therefore, the performance of this alternative regarding SPL is considered very good.

The pump-and-treat system associated with this alternative is the same as that described in Alternative 4. Pump-and-treat allows for plume capture and groundwater and soil cleanup, in conjunction with SPL excavation and disposal. The performance of this alternative regarding contaminated soil and groundwater remediation is considered very good.

This alternative provides good protection to the public health and the environment. The effect this alternative has on the public health and the environment is slightly negative on the short-term based on increased noise and dust release. The long-term effect is considered very good based on removal of pollutant sources and remediation of groundwater.

The time required to implement this alternative would be from a minimum of 2 years to a maximum that may exceed 10 years. The schedule depends largely on project management and the ease of implementing both SPL material removal and the groundwater remediation system.

The cost associated with this alternative based on a present worth is estimated at $35,382,426.

5.4.6 Summary

Alternative 1 assume that the plume would not require remediation and that natural phenomena would result in groundwater restoration with time. It is unlikely restoration of the aquifer would occur in a reasonable period of time. Alternative 1 is not acceptable.

Alternative 2 requires successful implementation of infiltration controls to reduce groundwater concentrations to the cleanup levels. Infiltration control has been demonstrated to be highly effective at the KACC-Mead site. This option is retained for further consideration.

Alternative 3 requires SPL removal and off-site disposal. This alternative does not address the plume or the contaminated soil. Implementation of this alternative may be good but would be very expensive. In addition, there is no regulatory requirement for removal of SPL material for off-site disposal. Therefore, this option is not retained.

Both Alternatives 4 and 5 provide similar levels of protection to human health and the environment. Alternative 5 has the additional benefit of removing a potential source of contamination. However, it is unlikely that Alternative 5 will result in additional groundwater quality improvements over Alternative 4. The incremental cost of removing the SPL material is substantial and disproportionate to the incremental degree of protection it provides. For this reason, Alternative 4 is selected as the preferred alternative.

6.0 PROPOSED CLEANUP ALTERNATIVE

6.1 INTRODUCTION

The proposed cleanup alternative for KACC-Mead is Alternative 4. This alternative ranked better than the other alternatives when all concerns were evaluated as identified in Section 5.2. Based on WDOE criteria (Section 5.3), Alternative 4 ranked number two with a total of 15 points. This ranking was based only on the summation of the technology preferences as identified by WDOE. Under the same criteria, Alternative 5 ranked first with 14 points. Considering the implementability and cost of each alternative, Alternative 4 ranks better than Alternative 5; especially when considering the deficiencies associated with Alternative 5, such as the short-term exposure during excavation and transport and that removal of SPL is unlikely to completely eliminate the source of cyanide and fluoride recharge to the aquifer.

The selected alternative involves pump-and-treat with infiltration control. It is envisioned that the implementation of these technologies for site restoration will be based on a phased approach such that implementation of the second phase would be dictated by the outcome of the implementation of the previous phase.

6.2 PROCESS DESCRIPTION

The phased approach calls for implementing source control technologies first to prevent further migration of contaminants to the groundwater (Phase I). Source control technologies include capping uncovered areas of SPL and conducting pipe testing and leak controls. These technologies result in greater assurance that migration of cyanide and fluoride from the SPL and contaminated soils is prevented. Infiltration control from leaking pipes can be conducted in several methods. The first method includes leak testing and pipe repair as required. The second method calls for pipe replacement, while the third method calls for pipe sliplining. Implementation of infiltration control technologies with continued monitoring for thirty years would result in the following costs given in present worth:

- infiltration control utilizing leak testing on a yearly basis: $2,079,984;
- infiltration control utilizing pipe replacement: $1,930,504; and

- infiltration control utilizing leak testing and pipe sliplining: $1,826,862.

The difference in the present worth cost among the three alternatives is relatively small. However, there is more capital cost associated with pipe replacement and pipe sliplining than for leak testing and pipe repairs. On the other hand, leak testing cost does not include additional costs associated with pipe repairs. However, leak testing on a yearly basis may be better than the other two methods because pipe replacement or sliplining does not guarantee that future leakage would not occur.

The second phase (Phase II) of site remediation is related to the groundwater plume. This phase would not be implemented until the full impact of implementing infiltration control methods have been evaluated (10 years). In addition, evaluation of cyanide concentration and migration velocity and direction would be continued.

If cleanup levels are not achieved within the Phase I time frame and modeling results indicate that it is not technically feasible to achieve these limits, then a more aggressive plume remediation would be applied by implementing the pump-and-treat method (Phase II).

Phase II proposes the use of three groundwater extraction wells perpendicular to the plume flow direction within the location of the highest contamination. One of the existing monitoring wells (well TH-8) is suggested to be used as an extraction well. The other wells would be installed on either side of this well at a sufficient distance to intercept the plume. The combined pumping flow rate at these wells would be at approximately 200 gpm. At the location of the wells and at this pumping rate, it is anticipated that the plume would be intercepted in its entirety. This conclusion was based on preliminary modeling using the Quickflow™ model (Appendix H).

The three extraction pumps would be hard piped to a groundwater treatment plant (GWTP) constructed on site. The tentative location of the groundwater treatment plant is to the east of the SPL pile in the vicinity of the sewage treatment plant. The pipes would be installed beneath the surface to prevent freezing during the winter months. The injection wells laterals would be connected to a header feeding from the GWTP utilizing a single pump with another stand-by pump.

This phase of site remediation includes the construction of a GWTP on site. The GWTP would be designed at a capacity of 200 gpm. In Appendix E, five groundwater treatment systems are discussed. These systems were evaluated thoroughly in Chapter 5 based on effectiveness, implementability, cost, performance, contaminants removed, levels of treatment achieved, and residue production and disposal issues. The preferred alternative was identified as filtration with alkaline hydrolysis. This GWT option is preferred because the treatment system: 1) is among the least expensive systems evaluated, 2) has less unit processes associated with it, 3) does not result in the production of residues, and 4) removes cyanide to low residual concentrations. The process flow diagram for the treatment process is schematically illustrated in Figure 5-5. The first step in the treatment process would be to remove filterable solids that may result in causing abrasion in the subsequent equipment. The filtered effluent is then heated in a heat exchange unit, then pumped at high pressure through an alkaline hydrolysis vessel. Destruction of cyanide occurs at high temperature and pressure giving residuals such as CO_2 and NH_3.

The process diagram of Figure 5-5 does not include fluoride removal which would be removed in a separate precipitation step after the alkaline hydrolysis process. Figure 5-6 identifies a schematic of the fluoride precipitation step. This process includes a coagulation, flocculation and settling steps. Calcium chloride and polymers (as required) are added to enhance the removal of fluoride as calcium fluoride (CaF_2). Overflow from the settling tank would be filtered to remove the fine flocs before discharge. The sludge produced in this process should not contain cyanides. If this is not considered feasible, then the sludge would be disposed of in a RCRA landfill.

Bench-scale tests would be conducted to verify and optimize the alkaline hydrolysis and the fluoride precipitation processes. Once optimized, pilot-scale testing of the alkaline hydrolysis process may be conducted based on the manufacturer's recommendations. Pilot-scale testing for fluoride precipitation would not be required because the unit processes involved in this removal step are well established.

The pump and treat system would include reinjection of the treated water. Part of the design of Phase II would include an evaluation of the feasibility of reinjection of the water below the SPL pile to promote in-situ soil flushing and accelerate the remediation time frame.

Groundwater monitoring would continue at the current pace; i.e., monthly sampling from several wells. Monitoring includes determination of total cyanide, free cyanide, and fluoride concentrations. In addition, monitoring includes determining groundwater elevation in the extraction wells, underneath the injection wells and in their vicinity. Monitoring results would indicate the progress of contaminant removal from the plume. Pumping rates can be adjusted if found to be excessive, resulting in a large decrease in the water table elevation.

6.3 IMPLEMENTATION

Implementation of the proposed phased cleanup alternative requires approval of WDOE. Deed restrictions would be added to prohibit certain uses of the property (i.e., excavation, construction, or well drilling within the SPL areas) in order to minimize environmental and health risks (such as human exposure to SPL material). These restrictions would be imposed on KACC-Mead as the property owner or, in the event of a future sale or lease, would be imposed on the purchaser or lessee.

After approval of this proposed cleanup alternative, a series of bench-scale and pilot-scale (if necessary) studies and design studies would be completed to provide the basis of the detailed design. Bench-scale studies would include desorption isotherms, soil column studies, and coagulation, flocculation and precipitation studies on the groundwater. Alkaline hydrolysis at the bench-scale would be required to verify effectiveness of the process. Pilot-scale studies would include groundwater pumping and alkaline hydrolysis treatment of the groundwater.

The design studies would include geotechnical investigations to develop the criteria for a cap and grading plan as well as groundwater modeling to determine placement and pumping rates for the groundwater extraction system. In addition, a detailed survey of existing water and steam lines in the vicinity of the SPL would be completed to develop a leak testing and replacement program. Table 6-1 summarizes the principal tasks which must be completed to develop a design for each Phase of the program.

No significant technical obstacles are identified which would limit the construction of asphalt caps or the conduction of pipe leak controls. Similarly, there are no significant technical issues that would hinder the implementation of the groundwater recovery and treatment alternative. Both the groundwater extraction and injection system and the GWTP consist of commercially available equipment.

The GWTP is suggested to be located in close proximity of the existing on-site sewage treatment plant in order to allow the same operator(s) to perform the daily required duties. No special skills are required to operate the GWTP. Routine check-ups and maintenance of the equipment would be required. Verification of quality of the GWTP effluent would be conducted

TABLE 6-1

SUMMARY OF REMEDIAL DESIGN ACTIVITIES

PHASE I

- CAPPING & GRADING PLAN
  - ✓ Geotechnical Investigations
  - ✓ Topographic Survey
  - ✓ Preliminary Design
  - ✓ Final Design

- PIPE MONITORING & REPLACEMENT
  - ✓ Survey of Steam, Condensate & Water Lines
  - ✓ Leak Testing
  - ✓ Preliminary Replacement Schedule
  - ✓ Final Design

PHASE II

- GROUND WATER EXTRACTION AND REINJECTION SYSTEM
  - ✓ Pump Test
  - ✓ Flow Model
  - ✓ Preliminary Design
  - ✓ Final Design

- GROUND WATER TREATMENT SYSTEM
  - ✓ Bench Scale Testing
  - ✓ Pilot Scale Testing
  - ✓ Preliminary Design
  - ✓ Final Design

on grab and composite samples. Verification sampling would be conducted once every few days during the first two months of operation which would be reduced to once every week throughout the first year and to once per month for the duration of the project. Other monitoring requirements include, groundwater contaminant concentrations, groundwater elevation, and pumping and injection rates.

6.4 IMPLEMENTATION SCHEDULE

Implementation of this proposed cleanup alternative would proceed in several phases (Figure 6-1). Installation of the asphalt caps and the conduction of pipe leak testing could be completed within two years of initiating design activities. Evaluation of the impact of Phase I implementation on site conditions would be conducted by continued monitoring for up to ten years. If necessary, implementation of Phase II would proceed on year 12.

Phase II testing and implementation would proceed if Phase I fails to achieve the cleanup goals. Testing and optimization of Phase II would require up to one year to complete. Detailed design, equipment procurement, installation, and testing would require another year. Implementation of Phase II may extend for 10 years during which monitoring and remediation progress would be evaluated continuously. After achieving groundwater cleanup goals, the operation of the extraction and treatment systems would be deactivated.

By the end of 10 years of Phase II work, if groundwater cleanup objectives were still not achieved, then the cause(s) would be investigated. If the cause is related to contaminant migration from the contaminated soils, then re-evaluation of the remediation program would be required. However, it is anticipated that cleanup objectives would be achieved during the early phases of this alternative.

6.5 COST

Costs in present worth are estimated as follows for each phase of remediation if implemented concurrently:

Phase I:	Infiltration Control	\$1,826,862 to 2,079,984
Phase II:	Pump-and-Treat	\$2,398,064

These costs exclude costs for bench and pilot-scale testing which may cost up to 20 percent of the actual implementation costs.

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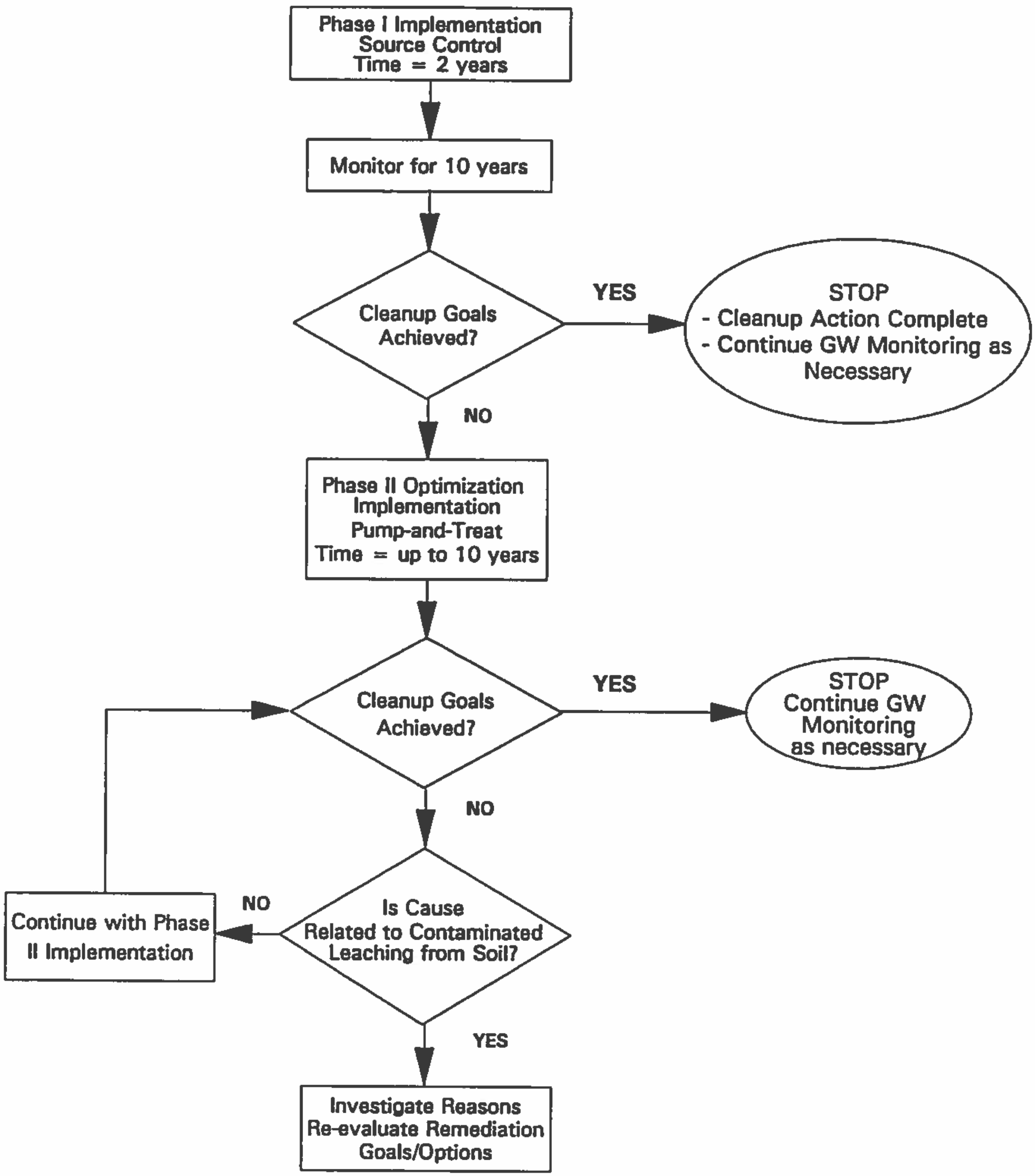

IMPLEMENTATION FLOW CHART FOR THE PROPOSED CLEANUP ALTERNATIVE AT KACC-MEAD SITE

FIGURE 6-1

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