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DIST.	LTR	ENC
BARTHEL, J.M.		
BENGEL, P.R.		
BENSON, C.A.		
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FITZ, R.C.		
GUINN, L.A.		
HUGHES, F.P.		
McANALLY, J.L.		
POWER, A.P.		
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TYSON, A.M.		
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WHEELER, M.		
C. Cowdery	✓	✓
S. Martin	✓	✓
F. Hughes	✓	
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Fawt	✓	
RMRS RECORDS (2)	X	X
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RMRS Rocky Mountain Remediation Services, L.L.C.
. . . protecting the environment
...nmental Technology Site
...80402-0464
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November 20, 1997

Thomas C. Greengard
Kaiser-Hill Company
Rocky Flats Environmental Technology Site
P.O. Box 464
Golden, Colorado 80402

SUBMITTAL OF THE ANALYSIS OF OU 1 881 HILLSIDE FRENCH DRAIN DECOMMISSIONING ALTERNATIVES AND THE ANALYSIS OF OU 1 881 HILLSIDE DECISION CRITERIA OPTIONS FOR THE CESSATION OF OPERATION OF COLLECTION WELL 001 (CW001) - ALP-012-97

Action: Review white papers and return comments to RMRS.

Attached are two white papers, *the Analysis of Operable Unit (OU) 1 881 Hillside French Drain Decommissioning Alternatives and the Analysis of OU 1 881 Hillside Decision Criteria Options for the Cessation of Operation of Collection Well 001 (CW001)*. As requested, the collection well operating cost of $250,000 from the OU 1 Feasibility Study presented at the meeting was researched. This cost is based on a pro-rated share of the Combined Water Treatment Facility (CWTF) cost for a previous year. A more realistic estimate of the annual operating costs was recently estimated by the CWTF manager to be $20,000 for collection and $8,000 for treatment. This equated to a total annual cost of $28,000.

Please return your comments to me by December 5, 1997. If you have any questions, please contact me at extension 4385.

Annette Primrose

Annette Primrose
Acting Manager
Environmental Projects Group

CDC/aw

Attachment:
As Stated

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A-OU01-001353

Analysis of OU 1 881 Hillside French Drain Decommissioning Alternatives

November 21, 1997

1.0 INTRODUCTION

The objective of this evaluation is to analyze different options for decommissioning the French Drain at the 881 Hillside. The French Drain is part of an Interim Measure/Interim Remedial Action to address groundwater as part of the remediation of Operable Unit 1 (OU 1).

The French Drain was constructed between November 1991 and April 1992. The French Drain is 1,435 feet long and has a single sump at its lowest elevation. The French Drain was constructed by excavating a "V " shaped trench two feet into competent bedrock. Due to contours in the bedrock, a number of low points exist along the length of the French Drain. A polyvinyl chloride liner was placed on the downstream wall of the drain. A drain pipe and gravel was placed in the bottom of the drain and then covered with structural fill. Groundwater collected by the French Drain is pumped through a pipe near the top of the drain to the Building 891 Consolidated Water Treatment Facility (CWTF). After treatment the water is discharged to the South Interceptor Ditch (SID).

Decommissioning of the French Drain is part of the final remedy for closure of this operable unit. On October 29, 1997, a meeting was conducted between the Department of Energy, the Colorado Department of Public Health and Environment, the Environmental Protection Agency, Kaiser-Hill, and Rocky Mountain Remediation Services. As an outcome of that meeting, it was decided that an evaluation would prepared focusing on passive draining techniques for the French Drain and emphasizing the capability to restore the French Drain to an operational state.

Ten different alternatives were analyzed for decommissioning of the French Drain. Alternatives were evaluated based on their advantages, disadvantages and cost. The emphasis of the evaluation was placed on passitivity, durability, length of operation, cost, reversibility, erosional impacts, and impacts to slope stability.

2.0 DESCRIPTION OF FRENCH DRAIN DECOMMISSIONING ALTERNATIVES

The alternatives are grouped by whether they utilize mechanical means of continued operation (non-passive) or through gravity flow (passive) and whether the trench integrity is lost (destructive) or retained (non-destructive).

<u>Non-Passive/Non-Destructive</u>

1) **Bypass Treatment System -** Under this alternative no physical modifications would be made to the French Drain or the CWTF. Water would be collected and pumped to bypass portions of the treatment system and then discharged through the effluent line. Although a cost savings would be realized by eliminating some or all of treatment, because of the current configuration of the treatment system, operations would be hampered since the water would have still pass through portions of the system and the influent and effluent tanks would have to be utilized. It is possible that some treatment of the water could occur if the water had to be forced through the ion exchange system in order to utilize the effluent tanks as a discharge point. This alternative provides a short-term solution since it is viable only as long as the treatment system is in use.

2) **Pump to Effluent Line -** This alternative consists of installing a connecting line between the Building 891 CWTF influent and effluent lines. This line would be installed in the utility trench west of the French Drain. Valves added to the influent line and the connecting line would allow water to be redirected to either the effluent line or the Building 891 CWTF, if needed.

3) **Pump to South Interceptor Ditch** - This alternative consists of installing an underground line from the top of the French Drain to the SID. This line would be trenched across the top of the French Drain so as to cause minimal impact to the integrity of the drain and to protect against freezing. Additionally, the line would be valved so that water could be pumped to the treatment system should the need arise. Modifications to the SID, such as laying down rip rap and/or making a spill way, would probably be necessary to reduce soil erosion and to maintain the integrity of the SID. An additional alternative would be to pump the water directly to Woman Creek.

<u>Passive/Non- Destructive</u>

4) **Gravity Flow to the South Interceptor Ditch** - This alternative consists of installing an underground line from the top of the French Drain sump to the SID. Installation of the line would require breaching the French Drain; however, resealing the south French Drain wall by replacing the geomembrane around pipe would result in minimal impact to the integrity of the French Drain. The line would be valved so that water could be pumped to the treatment system should the need arise. Modifications to the SID such as laying down rip rap and/or making a spill way would be necessary to reduce soil erosion and to maintain the integrity of the SID. An additional alternative would be to install a gravity flow line directly to Woman Creek. Another variation of this alternative would be to construct a ditch instead of using underground piping to discharge to a surface water system.

5) **Gravity Flow To Colluvium (Leach Field)** - A gravity flow system similar to the system described under Alternative 4 would be constructed; however, instead of discharging to surface water, the water would discharge to a leach field constructed in the colluvium. The colluvium actually extends beneath the SID and Woman Creek ; however, the colluvium is not very thick and the water could daylight as a seep. Wetlands creation could potentially be avoided through the construction of a clay cap over the leach field.

6) **Breach Drain With Trenches Containing Perforated Pipe** - This alternative consists of breaching the French Drain across approximately five locations and laying perforated pipe from the French Drain to topsoil on the south side. This alternative offers the advantage over using trenches alone since the breach in the French Drain could be sealed with a geomembrane around the pipe to minimize the impact to integrity of the drain. Valving or by grouting the pipe could restore the French Drain to operation. The perforated pipe would allow water to be introduced into the aquifer over a wider area.

7) **Breach Trench At Sump And Create Wetlands Area Between SID and French Drain -** A gravity flow system similar to the system in Alternatives 4 and 5 could be constructed. Water from the pipe would discharge to an artificially created wetland rather than flow directly to the SID. This alternative could provide some natural water remediation through

biological degradation and settling of colloidal radionuclides; although concentrations in the water are already below discharge requirements. It could possibly provide a wetlands credit under the Clean Water Act for the Department of Energy. As site closure proceeds, the volumetric flow rate to a wetlands area could be reduced due to the elimination of leaks in sewer and water lines.

8) **Breach Trench at Sump And Construct A Passive Weir Treatment System -** A gravity flow system similar to the system in Alternatives 4, 5, and 7 could be constructed that would discharge to a multiple weir system. This system would have the advantage of providing some water treatment capabilities and preventing soil erosion. A series of concrete weirs could be constructed between a French Drain outlet and the SID. Because of the lack of elevation between these points, the weir system is proposed to run a 100 extra feet parallel to the SID. An alternative to a passive weir system is a passive air stripper to remove volatile organic compounds (VOCs) ; however, there is not a sufficient grade between the discharge of the French Drain and the eventual outfall in the SID or Woman Creek.

9) **Breach Drain With Angled Boreholes -** Three or four boreholes with slotted screen would be placed at approximately five locations along the length of the French Drain. The holes would be targeted at just above or below the soil/bedrock contact. To reactivate the drain, the holes would be sealed by filling them with grout. A variation of this alternative would be to fill the holes with a sand slurry and cap the top with grout. Restoration of the French Drain under this variation would take significantly more work and so this variation was not pursued farther.

Passive/Destructive

10) **Breach Drain With Trenches -** Approximately four trenches would be cut into the drain at low points. Gravel would be poured into the trenches or existing gravel from the French Drain would be pulled down into the trench as it is being excavated. Due to the geology of the hillside, water passing through these trenches would not infiltrate very deep and would daylight as a seep a short distance down the hillside. Power and control lines for the pump in the French drain sump are likely to be disrupted in this process. Restoring the drain under this alternative would be very difficult.

3.0 ANALYSIS OF ALTERNATIVES

The advantages and disadvantages of the ten alternatives were analyzed and the results are summarized in Table 3-1. All of the advantages were evaluated in terms of permanence and the ability to maintain the integrity of the French Drain; however, it should be noted that regardless of the alternative, erosion, slumping, and other natural forces will, with time, impact any of the alternatives and the viability of re-utilizing the French Drain. Cost estimates for each alternative presented in Table 3-2 are rough order-of magnitude. For alternatives requiring maintenance, it was assumed that maintenance was continued for ten years.

Alternatives 1-3 (Non- Passive/Non- Destructive) require continued operation of the pump in the French Drain. These alternatives are considered short-term actions and would require a follow on action to complete the decommission the French Drain. As a result, these alternatives are

Table 3-1: Comparison of French Drain Decommissioning Alternatives

Decommissioning Alternative	Advantages	Disadvantages
Non- Passive/Non- Destructive		
1) Bypass Treatment System	• No capital cost • No impacts to environment • Water can be treated if need be • French Drain remains completely intact • No stability issues	• Short-term solution • Continued operating costs • Treatment system operations would be hampered
2) Pump to Effluent Line	• Easy to restore flow to treatment system • Low initial cost • French Drain remains completely intact • No stability issues	• Continued operating Cost • Pump would have to be maintained indefinitely • Short-term solution
3) Pump to South Interceptor Ditch	• Easy to restore flow to treatment system • Low initial cost • Minimal impact to French Drain. • No stability issues	• Continued operating cost • Pump would have to be maintained indefinitely • Short-term solution • Spillway or soil erosion protection would be needed
Passive/Non - Destructive		
4) Gravity Flow to the South Interceptor Ditch	• Low maintenance requirements • Long-term solution • French Drain could be easily restored	• Spillway or soil erosion protection would be needed • French Drain would have to be breached • Freeze protection might be necessary • Shifting of the trench could cause drainage problems

Table 3-1: Comparison of French Drain Decommissioning Alternatives

Decommissioning Alternative	Advantages	Disadvantages
5) Gravity Flow To Colluvium (Leach Field)	• Low maintenance requirements • Long-term solution • French Drain could be easily restored	• Potential slope stability problems • French Drain would have to be breached • Leach field functioning would be hampered by clay and shallow depth of topsoil and colluvium • Shifting of the trench could cause drainage problems
6) Breach Drain With Trenches Containing Perforated Pipe	• Water discharge is spread out more • Potentially less erosion protection measures • French Drain could be restored to operation • Long-term solution • Low maintenance	• Potential slope stability problems • Additional cost of sealing around pipe • Potential drainage and erosion problems • French Drain would have to be breached • Possible disruption of pump control and power lines in the French Drain
7) Breach Trench At Sump And Create Wetlands Area	• French Drain could be restored to operation • Long-term solution • Low maintenance • Wetlands credit • Reduction of contaminants through natural processes	• Additional cost of wetlands construction • French Drain would have to be breached • Saturated soil could cause shifting of the trench
8) Breach Trench at Sump And Construct A Passive Weir Treatment System	• French Drain could be restored to operation • Long-term solution • Low maintenance • Some contaminants would be removed	• Additional cost of constructing weir • French Drain would have to be breached • Shifting of the trench could cause drainage problems

Table 3-1: Comparison of French Drain Decommissioning Alternatives

Decommissioning Alternative	Advantages	Disadvantages
9) Breach Drain With Angled Boreholes	• French Drain could be restored to operation • Long-term solution • Low maintenance • Minimal disturbance to hillside	• Some ponding could occur within the drain • Potential drainage and erosion problems • Potential slope stability problems
Passive/Destructive		
10)Breach Drain With Trenches	• Drain is fully decommissioned	• Possible disruption of utilities in drain • Difficult to restore drain to operations • Hillside stability could be disturbed • Water discharge would not be spread along length of drain • Potential drainage and erosion problems

Table 3-2: Cost Estimates for OU 1 881 Hillside French Drain Alternatives

Alternatives	Cost
Non- Passive/Non- Destructive	
1) No Action/Bypass Treatment System *	**$48,000**
2) Pump to Effluent Line *	**$89,000**
3) Pump to South Interceptor Ditch *	**$70,000**
Passive/Non - Destructive	
4) Gravity Flow to the South Interceptor Ditch	**$78,000**
5) Gravity Flow To Colluvium (Leach Field)	**$81,000**
6) Breach Drain With Trenches Containing Perforated Pipe	**$103,000**
7) Breach Trench At Sump And Create Wetlands Area	**$77,000**
8) Breach Trench at Sump And Construct A Passive Weir Treatment System	**$84,000**
9) Breach Drain With Angled Drill Holes	**$150,000**
Passive/Destructive	
10) Breach Drain With Trenches	**$76,000**

* These alternatives are for a project life of 10 years after which additional costs would be incurred to completely decommission the French Drain. These additional costs would significantly increase the total cost of these alternatives.

more expensive over the long-term than the other alternatives presented. The cost estimates for Alternatives 1-3 presented in Table 3-2 are for only ten years of operation and do not include any follow on decommissioning activities. Also, Alternative 1 gives the appearance of being simpler to implement than it would be in reality since it would tie up portions of the treatment system.

The Passive/Non-Destructive Alternatives (Alternatives 4 through 9) better meet the objective of draining the French Drain while allowing the reversal of the decommissioning process. The geometry of the French Drain relative to the SID and Woman Creek plays a crucial role in the evaluation of these alternatives. The French Drain is at the base of the 881 Hillside resulting in a very small difference in elevation between the base of the French Drain and the SID. The French Drain was cut deep into this hillside so that it penetrated the bed rock by about two feet. Because of these conditions, the bottom of the western portion of the French Drain (about 1,045 feet) from the western end to the sump is between one and eighteen feet lower than the bottom of the SID. As a result, water in the western section will preferentially flow towards the sump rather than through breaches in the drain. The slope is such that it would not be feasible to allow water to back up in the drain to force it towards other outlets. In the eastern third of the drain there is sufficient elevation to allow flow to the SID or Woman Creek; however, there are greater distances between the drain and the SID and this is a smaller portion of the total flow.

Flow from the sump to the SID as described in Alternative 4 is possible because there is a drop off in the SID which yields enough of an elevation difference to adequately induce flow. Gravity flow would take the water away from the drain resulting in better slope stability. Additionally, it would discharge to area that already has rip rap so that erosional impacts would be minimal.

The underlying geology in the French Drain area would make the leach field, described in Alternative 5, ineffective. The leach field would be placed in the upper layer of colluvium which is about ten feet thick. The presence of claystone and siltstone beneath the more permeable colluvium might cause the water to mound and daylight rather than infiltrate into lower strata. A possible outcome of a leach field would be a large seep that would likely cause erosion and undermine the stability of the slope around the center of the French Drain.

Breaching the drain with trenches with perforated pipe (Alternative 6), angled boreholes (Alternative 9), or trenches alone (Alternative 10) would be ineffective since most of flow would come out of the trench closest to the sump while the other trenches would be fairly dry. Like Alternative 5, these alternatives might create a seep in an area that could destabilize the French Drain and the hillside and cause erosion and possibly ponding..

Creating a wetlands (Alternative 7) would have some benefits. Although contaminant levels are not of concern, some remediation of organic compounds and radionuclides would occur if they were present. The DOE could also get some wetlands credit under the Clean Water Act; however, the wetlands would require excavation into the base of the hillside, instabilities could arise resulting in slumping and potential impacts to the integrity of the French Drain.

A passive treatment system based on a series of weirs (Alternative 8) suffers from the same lack of elevation as many of the other alternatives. Because there is little elevation difference, only a few weirs could be used between the sump and the nearest feasible point in the SID. To alleviate this problem the weirs could be set parallel to the SID for about 100 more feet. This allows more weirs and as a result greater area of interface between the water and the ambient air. Although not present above levels of concern, this alternative would strip the water of some

VOCs. It would also contain the water and as a result reduce erosion and the potential for slumping along the base of the hill.

4.0 RECOMMENDATIONS

The recommended method for decommissioning the French Drain is run a simple pipeline from the French Drain Sump to the SID (Alternative 4 - Gravity Flow to SID). This option has the following advantages:

- Simple design,
- Easily implementable and reversible,
- Cost effective,
- Low-maintenance,
- Drains the French Drain at its lowest elevation,
- Minimal erosional impacts,
- Minimal impact to slope stability,
- Passive system, and
- Long-term solution.

A second recommended design is Alternative 8, the passive weir system. It would also get the water away from the hillside without inducing slumping.

Analysis of
Operable Unit 1, 881 Hillside
Decision Criteria Options for
Cessation of Operation of the Collection Well

November 1997

TABLE OF CONTENTS

FIGURES

1.0 Introduction

The Operable Unit (OU) 1 Corrective Action Decision/Record of Decision (CAD/ROD) is being amended to reflect findings from the health and safety sampling conducted in May of 1997 (RMRS 1997). Part of the CAD/ROD amendment will address the continued operation (i.e., collection, pumping and treatment) of the existing Collection Well (CW001) at Individual Hazardous Substance Site (IHSS) 119.1. CW001, immediately downgradient of the most contaminated wells within the IHSS (i.e., 0974 and 4387), acts as a sump for the collection of contaminated groundwater within the IHSS. The contaminated groundwater is subsequently pumped and treated at the Building 891 water treatment system. Approximately 40,000 gallons have been collected, pumped, and treated since in installation June 1994.

The purpose of this white paper is to present decision criteria options for the cessation of operation of CW001 for possible inclusion in the OU 1 CAD/ROD amendment. The options evaluated include:

- demonstration of achievement of the intent of the Rocky Flats Cleanup Agreement (RFCA) (i.e., surface water protection) using conservative fate and transport modeling;
- an assessment of concentration-based criteria using concentration data from CW001, and;
- assessment of timeframe-based criteria based on trend analysis of concentration data from CW001.

Each of these options is discussed in the following sections.

2.0 Surface Water Protection Decision Criteria Option

2.1 Background

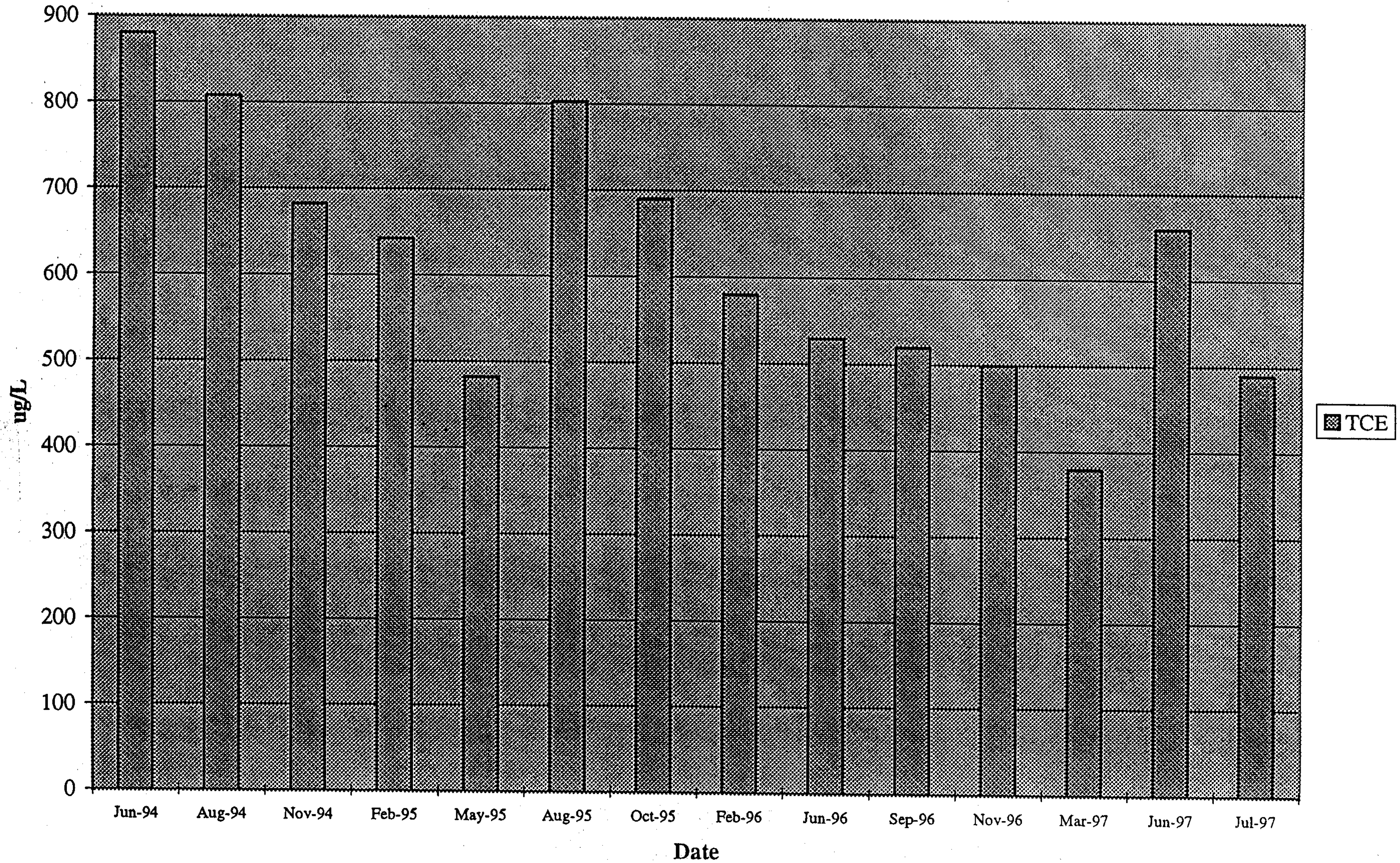
The Action Levels and Standards Framework (ALF) in Attachment 5 of RFCA (DOE 1996) was developed by consensus among the DOE, EPA, and CDPHE with stakeholder input. As stated in ALF, the strategy for groundwater is intended to prevent contamination of surface water by applying maximum contaminant levels (MCLs) as groundwater action levels. Groundwater action levels are based on a two tier approach, Tier I action levels (100 times the maximum contaminant levels [MCLs]) identify sources for accelerated cleanups, and Tier II are action levels which are considered protective of surface water (i.e., MCLs). Under RFCA, if Tier I action levels are exceeded, an evaluation to assess the potential impact the contaminated groundwater poses to surface water is performed. If, based on the evaluation, it is determined that surface water is threatened, a remedial action or management action is pursued. If, based on the evaluation, it is demonstrated that the groundwater plume does not present a risk to surface water (regardless of contaminant concentration), a remedial action or management action is not necessary. However, under the latter circumstance, monitoring is required and is accomplished per RFCA by the Integrated Monitoring Program. At present, the following wells monitor downgradient water quality specific to OU 1: 6486, 5587, 5387, 4887, 4787, 38591, 35691, 11092, 10992, 10792, 10692, 10592, and 0487. Additionally, it is proposed that CW001 be incorporated into the monitoring network.

Groundwater at IHSS 119.1 has historically exceeded the Tier I action levels for trichloroethene (500 µg/L) and, although a decreasing concentration trend is noted, the present concentrations of trichloroethene at CW001 remain near the action level (Figure1).

2.2 Evaluation

As discussed in Section 2.1, if Tier I action levels are exceeded an evaluation to assess the potential impact the contaminated groundwater poses to surface water is performed. Specific to OU 1, if it can demonstrated that the contaminated groundwater does not impact Woman Creek using conservative fate

Figure 1. Time series plot of trichloroethene concentrations at CW001.



and transport modeling, in turn it is demonstrated the intent of RFCA (i.e., surface water protection) has been met and operation of CW001 can cease.

Fate and transport modeling of IHSS 119.1 was performed in support of the Corrective Measures Study/Feasibility Study (CMS/FS) for OU 1 (DOE 1995). The intent of the model was to simulate subsurface solute transport and predict concentrations at two points of demonstration: a) downgradient of the French Drain half-way between the water table and the colluvium-bedrock interface, and b) immediately upgradient of Woman Creek in the alluvium. A detailed discussion of the model, assumptions, and resulting predictions is provided in Groundwater Modeling Results, Appendix B of the CMS/FS (DOE 1995). Of the multiple simulations presented, the remediation alternative predictions represent an evaluation of the impact of the contaminated groundwater at IHSS 119.1 to surface water at Woman Creek. This simulation was selected as representative because it reflects the findings from the recent investigation (i.e., no residual source exists at IHSS 119.1) (RMRS 1997). An overview of select assumptions used in the model are as follows:

- The primary groundwater release mechanism is assumed to be dissolution of residual DNAPL assisted by infiltration. The source was located at the interface between bedrock and colluvium material. The source was assumed to be a residual 24 liters prior to remediation with an additional 30 liters already dissolved in the groundwater. The 24 liter source was assumed to be remediated in 1998.

- The French Drain and CW001 are removed; Transport simulations begin in 1996 and continue through 2028. The steady-state flow is assumed to rapidly re-establish after removal of the French Drain and CW001.

- Transverse (perpendicular) dispersion (spreading) is not simulated. Therefore, the modeled dispersion in the plane of the model will be greater than the actual dispersion. Consequently, the model is conservative and will overestimate dispersion because it does not account for spreading of contaminants in transverse to the model plane.

- The transport of contaminants in groundwater is controlled by groundwater direction and flowrate. Other processes that affect contaminant fate and transport are hydrodynamic, dispersion, degradation, and adsorption. Hydrodynamic dispersion is simulated using dispersivity, groundwater velocity, and molecular diffusion.

- Recharge to groundwater is assumed to occur from interflow and bedrock flow from the Rocky Flats Alluvium and is significantly affected by the low permeability of the colluvium and alluvium at the site. Recharge is decreased during arid conditions and high rain rainfall events because of the lowered infiltration capacity and permeability of the soil. Similarly it is increased during spring and fall when the soil has greater infiltration capacity.

- Groundwater discharge is assumed to occur due to the low permeablity and moisture content of the soil and the low-flow conditions caused by the arid climate at the site. It occurs as evapotranspiration and flow into Woman Creek (Fedors et al 1993a and 1993b). Flow into Woman Creek is indicated by calculated hydraulic gradients of the site and the theory that the groundwater follows topographic features.

The model predictions indicate that after the French Drain and CW001 are removed, concentrations begin to recover and increase due to a continuing groundwater source. Due to the longer travel distance and, as a result, the longer time required for transport to Woman Creek, the magnitude of the predicted increase (maximum) in concentration of trichloroethene at Woman Creek is approximately 35 µg/L (Figure 2). The modeled concentration is within an order of magnitude of the Tier II action level (5 µg/L).

2.3 Recommendation: Surface Water Protection Decision Criteria Option

It was concluded in the CMS/FS and the supporting document, *Summary and Interpretation of Contaminant Hydrogeological Conditions at IHSS 119.1, OU 1, 881 Hillside* (Dames & Moore 1995), that, given the conservatism of the source term estimate and the lack of lateral dispersion in the model, the predicted concentrations are overestimated. More specifically, it was concluded that the source at the site is immobile; the plume is being passively remediated; and the conservatism in the model is at least one order of magnitude. The modeling conducted in support of the CMS/FS demonstrates that the contaminated groundwater at IHSS 119.1 does not impact Woman Creek. In addition, the recent investigation found that the assumed 24 liter source was not present. This evaluation supports the conclusion that the intent of RFCA has been met and operation of CW001 can cease without impacting surface water above action levels.

3.0 Concentration-based Decision Criteria Option

3.1 Background

Normally, the decision to terminate treatment or monitoring is based on demonstrating attainment of a target cleanup level. However, target cleanup levels with respect to OU 1 and specifically CW001 were not incorporated into the original OU 1 CAD/ROD. The absence of a target cleanup level was logical because the planned remedy, by implementation, would have removed CW001. Because the remedy requires amendment (i.e, no source removal action will take place) (RMRS 1997), the selection of a default target cleanup level for CW001 and an approach to demonstrating that cleanup level is attained is a possible decision criteria option to support cessation of operation.

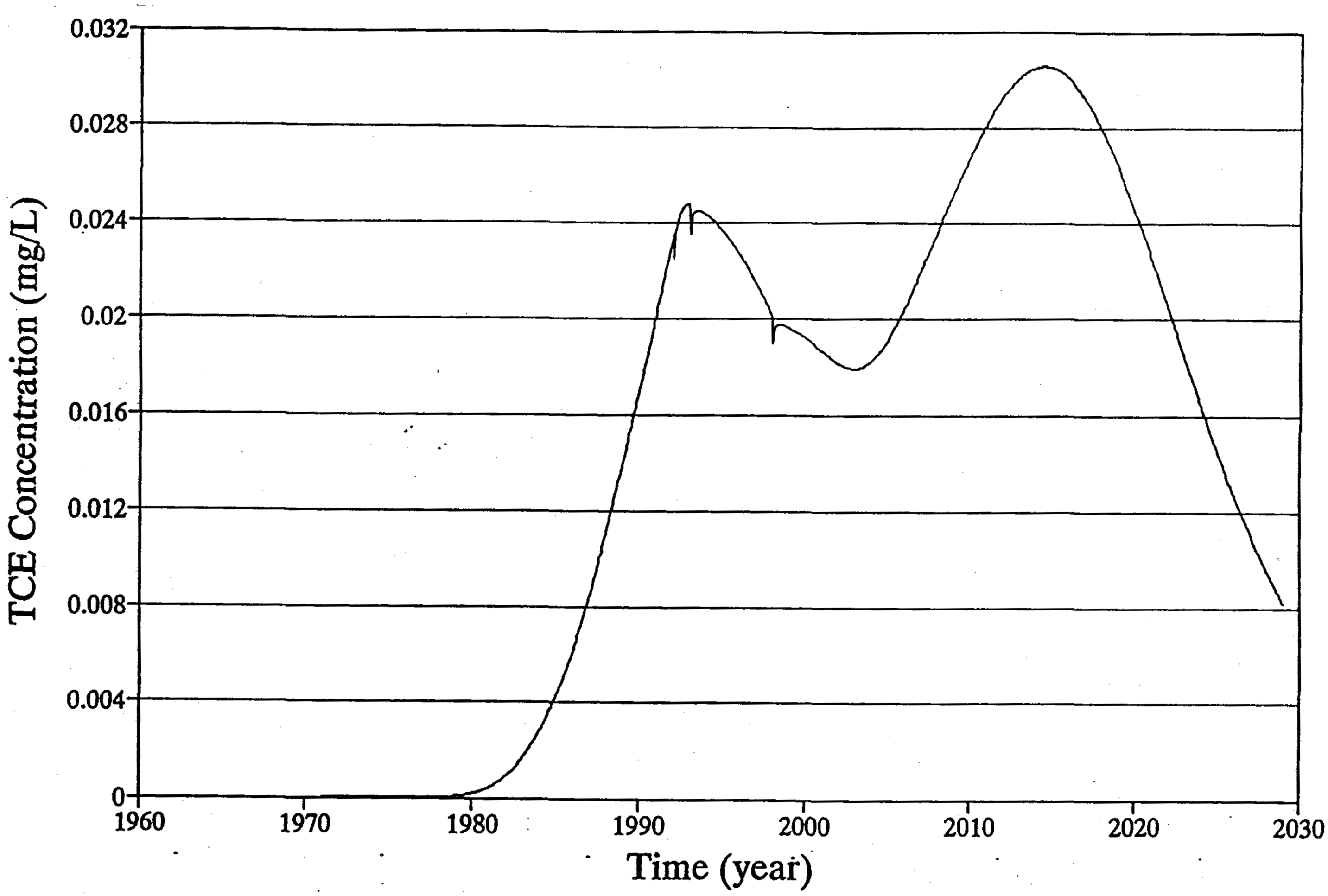
Water quality of the groundwater removed from CW001 has been assessed since June 1994. The sampling and analysis program was conducted on a monthly basis from June 1994 until October 1995. Quarterly monitoring has been performed since that time. As noted in Section 2.1 only trichloroethene exceeds the Tier I action level of 500 µg/l. As a result, the trichloroethene concentrations are considered a good indicator chemical for developing a concentration-based decision criteria.

3.2 Evaluation

The default target cleanup level for CW001 is proposed at 500 µg/L for trichloroethene, the Tier I groundwater action level. Of the contaminants monitored, trichloroethene has the highest concentration in groundwater at IHSS 119.1. Rationale for this selection is supported by the fate and transport modeling, as discussed in Section 2.0, which demonstrates under conservative assumptions that surface water is not significantly impacted by contaminated groundwater at IHSS 119.1. It is assumed that when the trichloroethene target cleanup level is attained, the other contaminants of concern will also be depleted.

In general two factors are considered in developing the approach to demonstrate attainment of the cleanup level. The initial evaluation of includes an assessment of whether or not steady state has been reached in the groundwater system. This evaluation, and ultimate decision, is primarily based on a combination of interpretation of data plots and professional judgment. If steady state conditions have been reached, sampling to assess attainment can be initiated. The recommended technique to demonstrate attainment of the cleanup level is assessing attainment of the mean using yearly averages. By using yearly averages to assess attainment, the effect of seasonal variation in the concentrations is minimized (EPA 1992).

Figure 2. Modeled trichloroethene concentrations immediately upgradient of Woman Creek (Dames & Moore 1995).



3.2.1 Assessment of Steady State Conditions

The notion of steady state is characterized by the following components (EPA 1992):

1. After treatment (in the case of CW001, treatment is considered passive collection in the sump followed by pumping), the water levels, water flow, and the corresponding variability associated with these parameters (e.g. seasonal patterns), should be essentially the same as for those from comparable periods of time prior to the remediation effort.

2. The pollutant levels should have statistical characteristics (e.g., a mean and standard deviation) which will be similar to those of future periods.

With respect to item 1, steady state is assumed because operation of the collection well does not impact water flow or water level. The collection well is a sump from which water is removed. The removal does not place stress on the system. With respect to item 2, the achievement of steady state conditions can be easily assessed by plotting the concentration data obtained and interpreting the plots. Interpretation of the plots is focused on identifying evidence of stability or instability in the system (EPA 1992).

For purposes of this assessment two types of concentration plots were generated. Figure 3 illustrates the average concentration observed in CW001 from June 1994 to October 1995 versus concentrations observed from January 1996 to present. Additionally, the target cleanup level is shown for comparative purposes as well as a linear regression of the January 1996 to present data set. The concentrations of trichloroethene observed from January 1996 are below the prior average (i.e., the average from June 1994 to October 1995) which indicates that the concentrations of trichloroethene have been declining. Additionally, the concentrations of trichloroethene observed from January 1996 do not show a significant downward trend which is an indicator of stability (i.e., steady state conditions) in the system.

Figure 4 illustrates the concentrations observed in CW001 from June 1994 to October 1995 versus concentrations observed from January 1996 to present, adjusting for seasonal effects. Additionally, the target cleanup level is shown for comparative purposes. In addition to demonstrating that the concentration of trichloroethene ha declined with time, the information presented in Figure 4 also illustrates the similarities in seasonal variations. This observation substantiates the conclusion that steady state has been, or is very near being, adequately achieved.

3.2.2 Assessment of Attainment

As indicated in Section 3.2 after steady state conditions have been demonstrated, assessment of attainment of the target cleanup level is appropriate. Consistent with EPA guidance, the recommended technique to demonstrate attainment of the cleanup level is to evaluate mean contaminant concentration using yearly averages. By using yearly averages to assess attainment, the effect of seasonal variation in the concentrations is minimized (EPA 1992).

The overall process involves the following steps (EPA 1992) and is documented in Appendix A:

1. Calculate the yearly averages for the m years of data collected so far (page A-1)
2. Calculate the mean x_m and variance of the yearly averages (page A-2)
3. Calculate the t statistic and d for use in the likelihood ratio calculation (pages A-3, A-4)
4. Calculate the likelihood ratio (page A-5)
5. Decide whether the groundwater attains the cleanup standard (pages A-6, A-7)

Figure 5 illustrates the yearly averages for the calculated using the concentration data from June of 1994 through March 1997. As illustrated in Figure 5, the yearly average concentrations fall below the target cleanup level; thus, it can be intuitively concluded that the cleanup level has been attained at this time. Appendix A presents the calculations as detailed above.

3.3 Recommendation: Concentration-base Decision Criteria Option

Although the calculations as presented in Appendix A demonstrate that attainment of the target cleanup level has not been achieved at this time, consensus on the process by which continued attainment is assessed is critical if a concentration-based decision criteria is incorporated into the CAD/ROD amendment. Appendix A presents the calculations, using the existing concentration data from CW001. The goal of this process is to provide an estimate of the likelihood ratio, an expression which accounts for variability in observed concentration about the mean coupled with the variability of concentration about the cleanup level, for use in deciding if the groundwater attains the cleanup level. To apply these criteria, assessment of attainment would continue to be evaluated annually. Under this option, operation of the CW001 would not cease at this time. The primary disadvantage to this approach is the lack of a calculable timeframe for continued operation or monitoring.

4.0 Timeframe-based Decision Criteria Option

4.1 Background

Another means of deciding when to terminate operation of CW001 is to use linear regression analysis to predict the time when the mean concentration will fall below the target cleanup level. As discussed in Sections 3.1 and 3.2, the indicator contaminant for the evaluation is trichloroethene with default target cleanup level of 500 μg/L.

4.2 Evaluation

Using the water quality data for CW001 groundwater and relying on select statistical analyses from Section 3.0, a simple linear regression model was used to predict the timeframe that the concentration of trichloroethene at CW001 will fall below the 500 μg/L target cleanup level. As shown on Figure 5, a downward trend in the yearly average concentrations has been observed over the period of operation. However, as noted in Section 3.2.1 and illustrated in Figure 4, the downward trend in concentration since January 1996 is not significant. This indicates that the trichloroethene concentrations in CW001 are nearing steady state and additional, appreciable decline in contaminant concentrations may not be realized, regardless of the timeframe CW001 continues to operate.

Figure 6 illustrates the linear regression and prediction of concentrations based on the trichloroethene concentrations observed since January 1996. This timeframe was selected to limit the evaluation to the "tail" of the distribution, assuming near steady state conditions. As shown, the concentrations are predicted to fall below the 500 μg/L target cleanup level over the next two years.

4.3 Recommendation: Timeframe-based Decision Criteria

If it is assumed that the linear regression model accurately represents the system, a decline in trichloroethene concentrations below the target cleanup level will be realized over the next two years. Based on the model, operation of the collection well should cease in 1999.

Figure 3. Comparison of the calculated prior average trichloroethene concentration with concentrations from January 1996 to present for CW001.

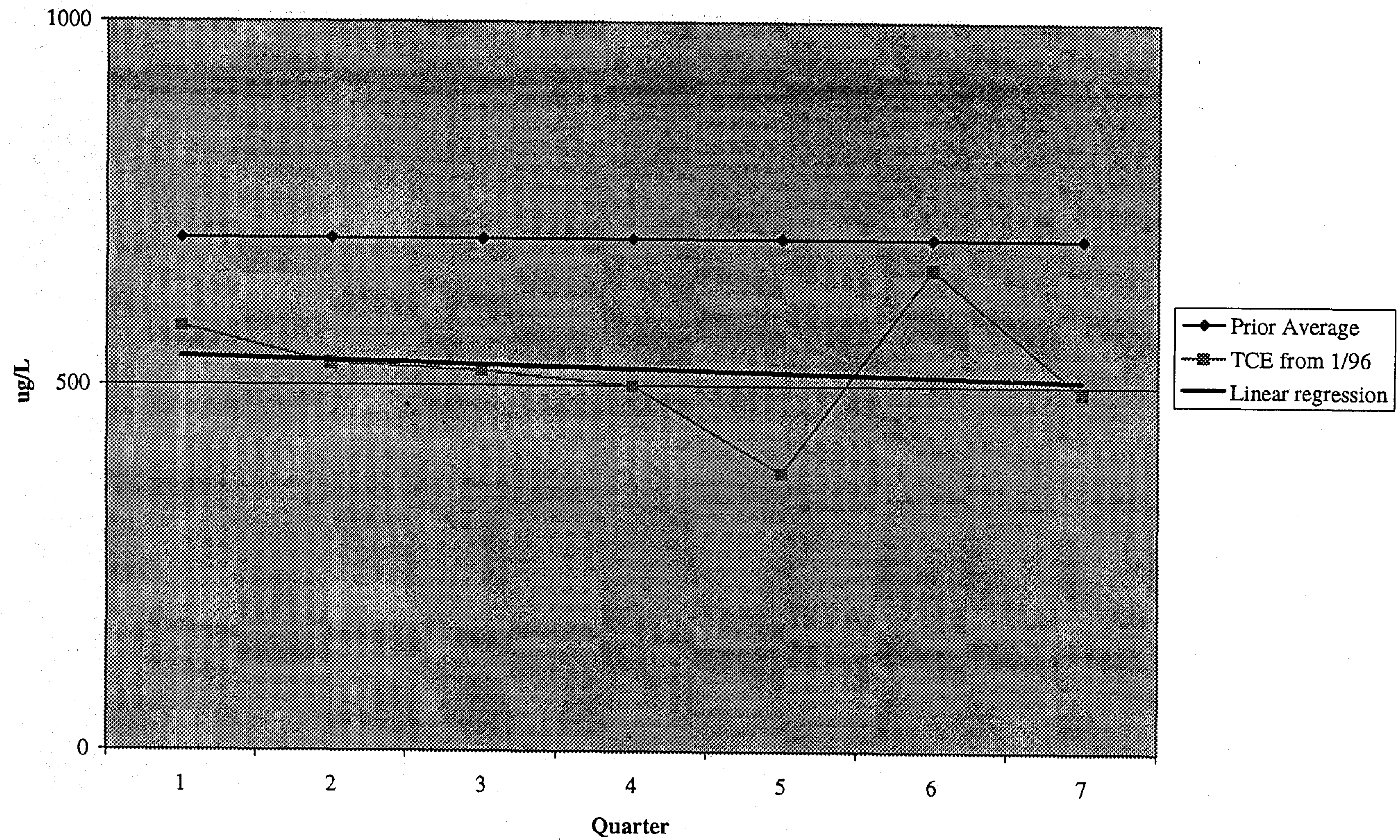


Figure 4. Comparison of the trichloroethene concentrations from June 1994 to October 1995 with concentrations from January 1996 to present.

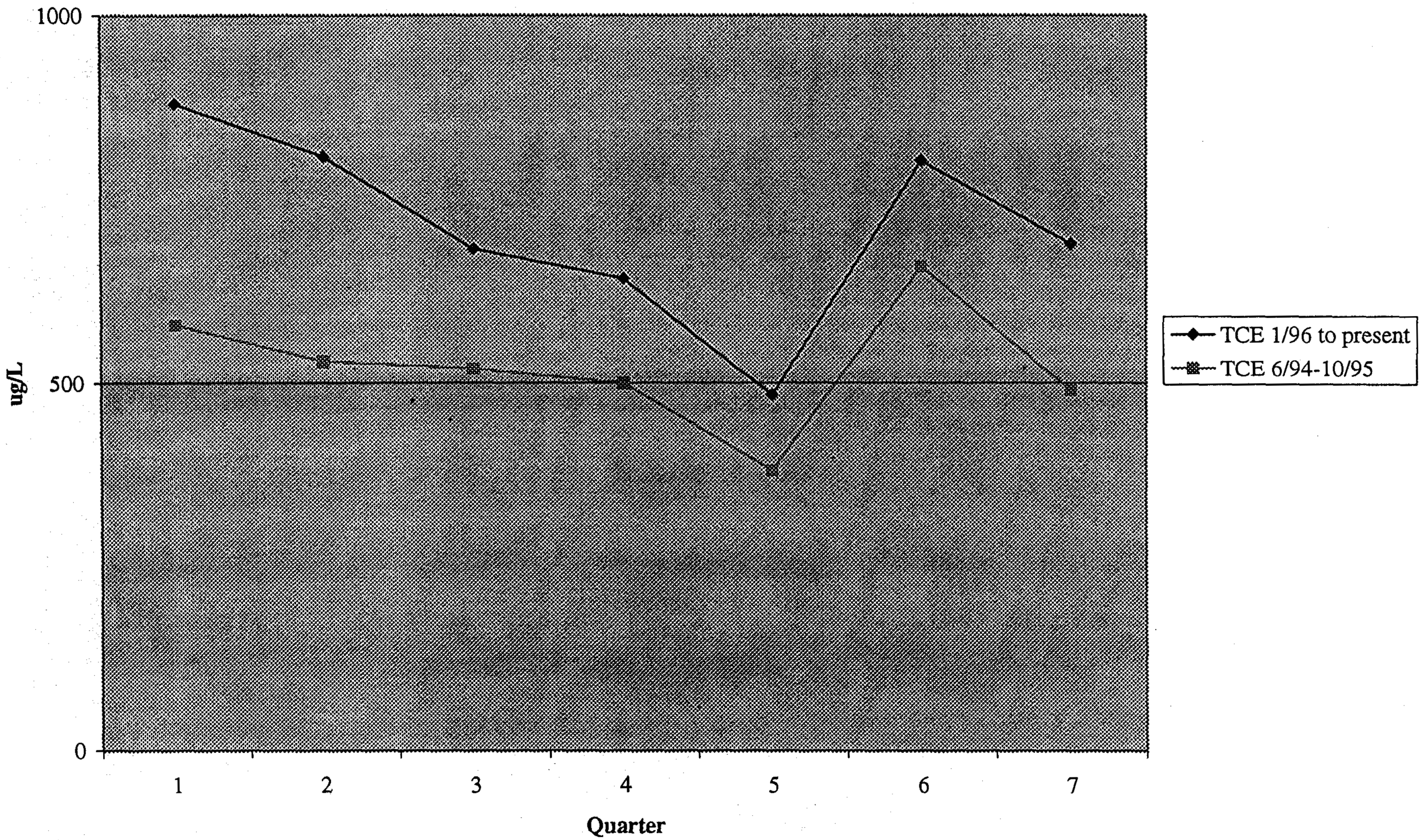


Figure 5. Yearly average trichloroethene concentration for CW001.

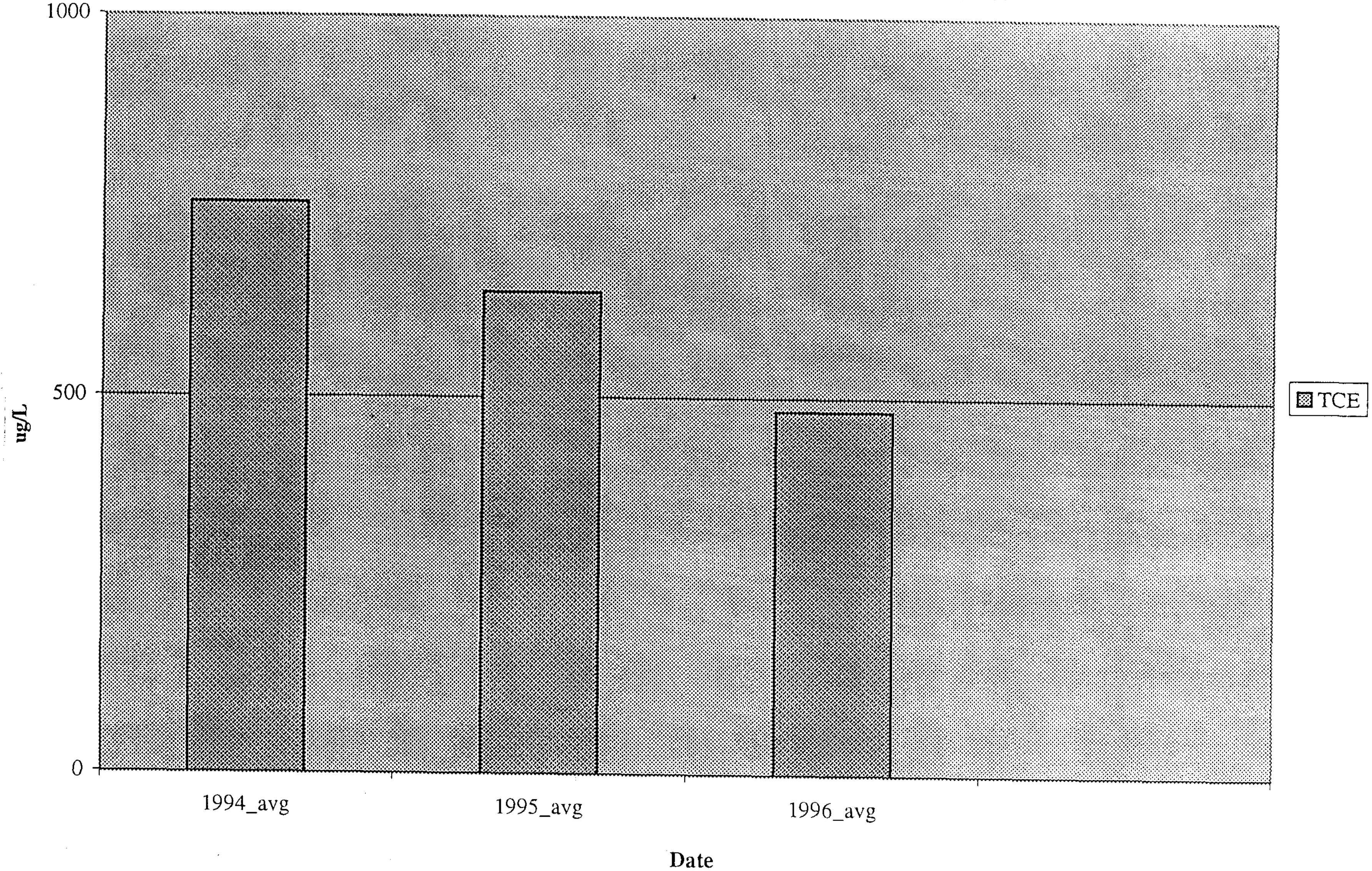
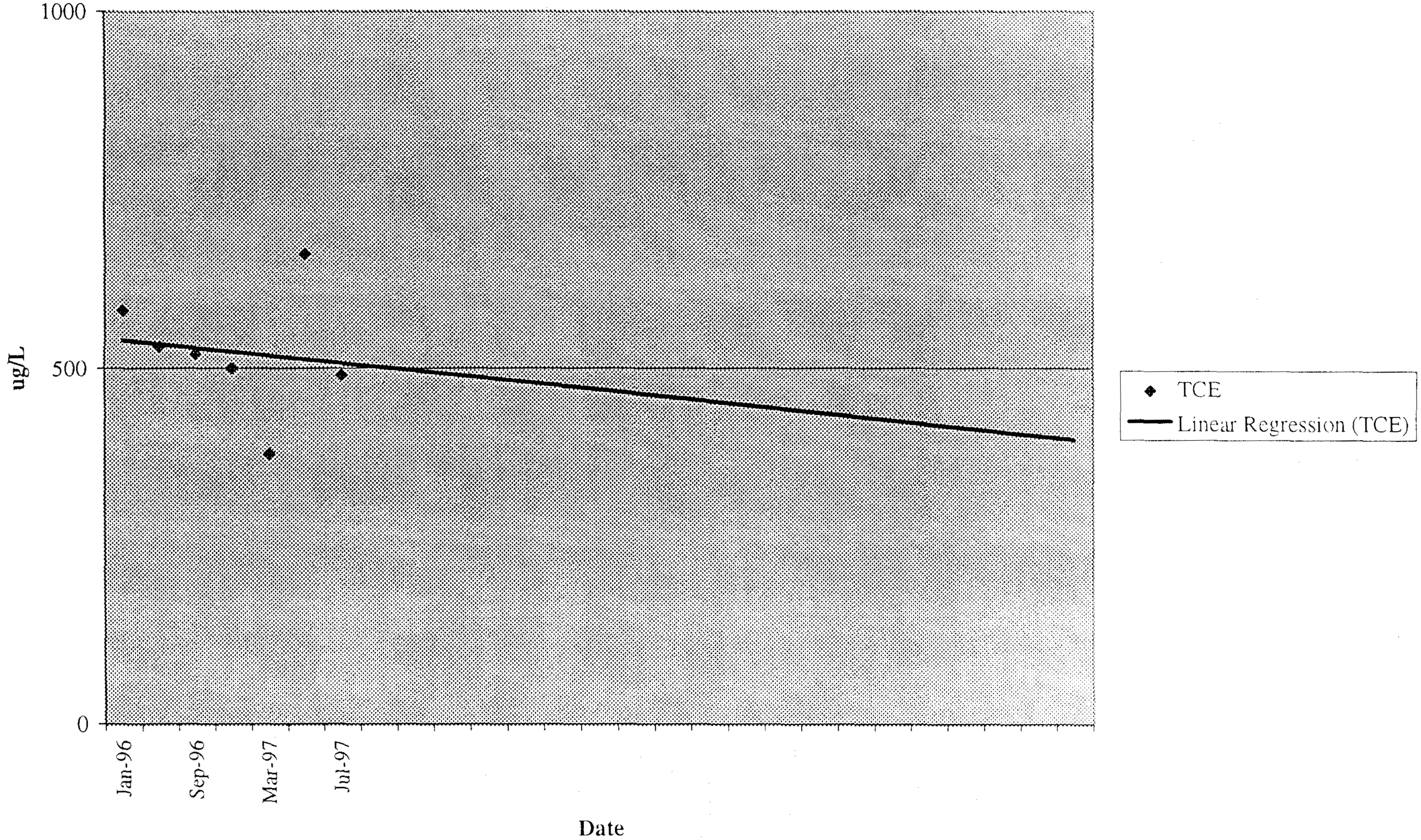


Figure 6. Linear regression and predicted concentrations.



5.0 Summary

The purpose of this white paper is to present decision criteria options for the cessation of operation of CW001 for possible inclusion in the OU 1 CAD/ROD amendment. The options evaluated include:

- demonstration of achievement of the intent of the RFCA (i.e., surface water protection) using conservative fate and transport modeling;
- an assessment of concentration-based criteria using concentration data from CW001, and;
- assessment of timeframe-based criteria based on trend analysis of concentration data from CW001.

Each of the options is considered a feasible approach to include in the CAD/ROD amendment. With the first option, demonstration of achievement of the intent of RFCA, the technical basis supports ceasing operations at CW001 immediately. Cessation of operations at CW001 can not be justified based on the concentration-based criteria. Annual assessments would be continued until attainment was achieved. The third option predicts a two year continued operation timeframe to demonstrate consistent measurements well below the target cleanup level.

6.0 References

Dames & Moore 1995. *Summary and Interpretation of Contaminant Hydrogeological Conditions at IHSS 119.1, OU1, 881 Hillside*, August 2.

DOE 1995. *Final Corrective Measures Study/Feasibility Study Rocky Flats Environmental Technology Site, 881 Hillside Area, OU1*, February.

DOE 1996. *Rocky Flats Environmental Cleanup Agreement.*

EPA 1992. *Methods for Evaluating the Attainment of Cleanup Standards, Volume 2: Groundwater*, EPA 230-R-92-014, July.

RMRS 1997. *Final Post-Corrective Action Decision/Record of Decision Investigation Report for the 881 Hillside Area, IHSS 119.2*, RF/RMRS-97-054.UN, Revision 0, September 2.

Appendix A - Calculations

Assessment of ~~Attainment~~ Concentration-based Decision Criteria

year_avg

Jun-94	880	753.5	1994_avg	754
Aug-94	808		1995_avg	639
Nov-94	683		1996_avg	483
Feb-95	643			
May-95	483	639		
Aug-95	803			
Oct-95	690			
Feb-96	580			
Jun-96	530	483		
Sep-96	520			
Nov-96	500			
Mar-97	380			
Jun-97	660			
Jul-97	490			

Step 1: Calculate yearly averages

A-1

Calculations by: SML 11.20.97

Check by: Craig Cordy 11/21/97

Assessment of Attainment

Concentration-based Decision Criteria

Column1	
Mean	625.3333
Standard Error	78.52883
Median	639
Mode	#N/A
Standard Deviation	136.0159
Sample Variance	18500.33
Kurtosis	#DIV/0!
Skewness	-0.44759
Range	271
Minimum	483
Maximum	754
Sum	1876
Count	3
Confidence Level(95.0%)	337.8825

Step 2:
Calculate mean and variance of yearly average

checked by Gary Curtis 11/21/97

Assessment of Attainment
Concentration - based Decision Criteria

Step 3

$$t = \frac{\bar{x} - \frac{C_s + \mu}{2}}{\sqrt{\frac{s_{\bar{x}}^2}{m}}}$$

where:

$\bar{x}$ = mean of yearly averages (625)

C_s = target cleanup level

μ = upper 95% confidence level value (963)

$s_{\bar{x}}^2$ = sample variance (18500

m = number of years 3

$$t = \frac{625 - \frac{500 + 963}{2}}{\sqrt{\frac{18500}{3}}}$$

$$= -1.36$$

Calculations by: SMC 11.20.97

Checked by: Craig Cady 11/21/9

Assessment of Attainment
Concentration-based Decision Criteria

Step 3 (continued)

$$d = \delta$$

$$\delta = \frac{\mu - C_s}{\sqrt{\frac{s_{\bar{x}}^2}{m}}}$$

where:

μ = upper 95% confidence level value

C_s = target cleanup level

$s_{\bar{x}}^2$ = sample variance

m = number of years

$$\delta = \frac{963 - 500}{\sqrt{\frac{18500}{3}}}$$

$$= 5.896$$

Calculations by: SMC 11-20-97

Checked by: Craig [illegible] 11/21/97

Assessment of Attainment
Concentration - based Decision Criteria

Step 4 - Calculate the likelihood ratio (LR)

$$LR = \exp\left(\delta \frac{m-2}{m} t \sqrt{\frac{m}{m-1+t^2}}\right)$$

where:

δ = estimate from step 3

m = number of years

t = estimate of t statistic from step 3

$$LR = \exp\left[5.896(0.33)(-1.36)(0.0828)\right]$$

$$= 0.00961$$

Calculations by: SMA 11-20-97

A-5

Checked by: Craig [signature] 11/21/97

Assessment of Attainment
Concentration-based Decision Criteria

Step 5 - Decide whether groundwater attains the cleanup level

Decision logic per EPA, 1992

Box 9.10
Deciding if the Tested Ground Water Attains the Cleanup Standard

Calculate:

$$A = \frac{\beta}{(1-\alpha)} \quad \text{and} \quad B = \frac{(1-\beta)}{\alpha} \qquad (9.12)$$

If LR ≤ A, conclude that the ground water in the wells does not attain the cleanup standard.

If LR > B, conclude that the average ground water concentration in the well (or group of wells) is less than the cleanup standard. Perform a trend test using the regression techniques described in Chapter 6 to determine if there is a statistically significant increasing trend in the yearly averages over the sampling period (also see Section 9.7).

If there is not a statistically significant increasing trend, conclude that the ground water attains the cleanup standard (and possibly initiate a follow-up monitoring program). If a significant trend does exist, conclude that the ground water in the wells does not attain the cleanup standard and resume sampling or reconsider treatment effectiveness.

If A < LR ≤ B then collect an additional years worth of data before performing the hypothesis test again.

where:

LR = likelihood ratio from Step 4

$\alpha = 0.1 \therefore A = 0.111$ (EPA, 1992)

$\beta = 0.1 \therefore B = 9.0$

Calculations by: SMC 11.20.97
Checked by: CPC 11/21/97

Assessment of Attainment
Concentration-based Decision Criteria

Conclusion:

$LR \leq A$

~~-5.18~~ 0.0967 < 0.111 ∴ the groundwater does not attain cleanup level

$A < LR < B$

0.111 < ~~-5.18~~ 0.0967 < 9.0 ∴ additional data collection is needed before performing the hypothesis test again (i.e., continued collection / monitoring)

Calculations by: SMW 11.20.97
Checked by: CJC 11/21/97