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USNRC

May 24, 2001

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OFFICE OF SECRETARY
RULEMAKINGS AND
ADJUDICATIONS STAFF

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

ATOMIC SAFETY AND LICENSING BOARD

Before Administrative Judges:
Thomas S. Moore, Presiding Officer
Thomas D. Murphy, Special Assistant

In the Matter of	)	
	)	
HYDRO RESOURCES, INC.	)	Docket No. 40-8968-ML
P.O. Box 15910	)	ASLBP No. 95-706-01-ML
Albuquerque, NM 87174	)	
	)	

INTERVENORS' REPLY TO THE RESPONSES OF HYDRO RESOURCES INC.'S AND NRC STAFF'S RESTORATION ACTION PLAN PRESENTATIONS OF JANUARY 22, 2001 AND INFORMATION GENERATED SUBSEQUENT TO THOSE PRESENTATIONS

INTRODUCTION

Pursuant to the Presiding Officer's Order of April 26, 2001, Intervenors' Eastern Navajo Diné Against Uranium Mining ("ENDAUM") and Southwest Research Information Center ("SRIC") hereby reply to Hydro Resources, Inc.'s ("HRI") and the Nuclear Regulatory Commission ("NRC") Staff's Restoration Action Plan ("RAP") presentations of January 21, 2001 and to information generated subsequent to those presentations, including HRI's March 16, 2001 response to Staff's February 16, 2001

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Request for Additional Information.[1] This reply is supported by the testimony of Ms. April Lafferty and Dr. Richard J. Abitz.[2]

The NRC Staff incorrectly asserts that the RAP satisfies the NRC's requirements for a decommissioning plan in 10 C.F.R. § 40, Appendix A, Criterion 9. See NRC Staff letter of April 16, 2001. Ex. 3. Even as supplemented by HRI's January presentation and the RAI response, the RAP still fails to provide reasonable assurance that Section 8 will be reclaimed adequately after mining activities are completed.

HRI and the Staff fail to demonstrate the adequacy of HRI's methodology for calculating the amount of water that must be processed during groundwater restoration as

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[1] Hereinafter, the Reply of Hydro Resources, Inc. To Intervenors's Reponse to HRI's Cost Estimates for Decommissioning and Restoration Action Plan (January 22, 2001) will be referred to as "HRI's January presentation." The Affidavits of Mr. Mark S. Pelizza and Mr. Richard A. Van Horn Responding to the Affidavits of Steven Ingle and Richard Abitz will be referenced as "Pelizza at __" and "Van Horn at __." The NRC Staff's Response to Intervenors' Financial Assurance Brief (January 22, 2001) will be referred to as "NRC Staff's January 2001 presentation." The Affidavit of Mr. William H. Ford in support of the NRC Staff's January presentation will be referenced as "Ford at __." The HRI response to the Staff's Request for Additional Information ("RAI") will be referred to as "HRI's March 2001 RAI response."

[2] Ms. Lafferty is a qualified expert in ISL mining regulation and hydrogeology. Her professional experience includes employment with the State of Wyoming and the government of Australia as a regulator of in-situ leach mining, including decommissioning funding. A full description of Ms. Lafferty's qualifications is contained in her testimony. See Written Testimony of Ms. April Lafferty in Support of Intervenors' Reply to HRI's And NRC Staff's January 22, 2001, Responses To Intervenors's Presentation on HRI's Restoration Action Plan And Cost Estimates, attached hereto as Exhibit 1. Ms. Lafferty's testimony will be referenced as "Lafferty at __." Dr. Abitz's resume and expert qualifications were submitted in the Intervenors's Response to HRI's Cost Estimates and Restoration Action Plan (December 21, 2000). See Written Testimony of Dr. Richard J. Abitz in Support of Intervenors' Reply to HRI's and NRC Staff's January 22, 2001 Responses to Intervenors's Presentation on HRI's Restoration Action Plan And Cost Estimates, attached hereto as Exhibit 2. Dr. Abitz's testimony will be referenced as "Abitz at __." The Written Testimony of Dr. Richard J. Abitz in Support of Intervenors' Response to Hydro Resources Inc.'s Cost Estimates and Restoration Action Plan of November 21, 2000 (December 19, 2000) will be referenced as "Abitz December 2000 testimony at __."

well as the time needed to complete the restoration effort. As discussed below and in the attached expert declarations, HRI's asserted methodology is illogical and internally inconsistent with other HRI assertions. Moreover, both HRI and Staff inappropriately rely on data from the pilot scale in-situ project conducted by the Mobil Corporation near Crownpoint between 1979 and 1986 as a likely indicator of HRI's ability to restore the groundwater at Section 8 after mining.

While HRI strenuously argues that Church Rock Section 8 is unique and cannot be compared to the Department of Energy's ("DOE") Fernald site, or in-situ leach ("ISL") mines in Wyoming, HRI makes comparisons to its mining sites in Texas, specifically the Longoria and Benavides ISL mines. Intervenors' reply testimony shows that HRI's attacks on comparability of the Fernald uranium groundwater remediation and the Wyoming ISL mines are not supported. Further, HRI's experience with its Texas ISL restoration is an inappropriate basis for comparison.

Despite the well-founded and technically sound opinions of Intervenors' experts, HRI and the Staff repeatedly rely on License Condition ("LC") 9.5, which allows whatever amount of surety is in place to be updated annually. Reliance on an "update," however, is an inappropriate and inadequate method of coping with fundamental defects in a decommissioning funding plan.

As a result of the continuing inadequacies of HRI's RAP, the surety amount proposed by HRI remains inadequate to ensure funds are available to clean up Section 8 as required by Criterion 9. Therefore the Presiding Officer should invalidate the Staff's April 16, 2001, approval of the RAP and revoke HRI's license as to Section 8.

ARGUMENT

I. THE RAP APPROVED BY THE NRC STAFF IS TECHNICALLY AND FINANCIALLY INADEQUATE.

A. HRI's Groundwater Restoration Plan Continues to Underestimate the Amount of Water Needed to Restore a Contaminated Section 8 Aquifer.

1. Description of Pore Volumes and Flare Factors.

Staff and HRI continue to cling to an inadequate groundwater restoration plan that underestimates the amount of water and time needed to adequately restore the aquifer to either primary (i.e. baseline) or secondary (i.e. drinking water) restoration standards. Chief among Intervenors' concerns is the appropriate calculation of the amount of water needed to restore the aquifer.

As described at some length in the Intervenors' December 2000 presentation, the terms to be understood in discussing this issue include "pore volume" and "flare factors." An "initial pore volume" describes the quantity of free water in the pores of a given volume of rock.[3] Calculating the size of that pore volume is crucial to making an accurate assessment of the water that must be flushed through the contaminated fluid for restoration (generally the water is flushed through multiple times).

The initial pore volume does not take into account the fact that contamination

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[3] Initial Pore volume = (area) x (ore zone thickness) x (porosity) x (gallons per cubic foot of rock)

spreads both laterally and vertically in the aquifer beyond the initial calculation. This spreading, or dispersion increases the volume of water that is contaminated and therefore must be treated in a given pore volume. This spreading is accounted for by correcting the initial pore volume. The initial pore volume is corrected by multiplying the initial pore volume by the horizontal flare factor ("HFF"; also called a horizontal or lateral dispersion factor) and the vertical flare factor ("VFF"; also called a vertical dispersion factor). These factors are important because they are crucial in making an accounting of the total volume of water needing restoration. Groundwater restoration is the most significant factor in determining the decommissioning cost estimate. In HRI's RAP, the groundwater restoration cost accounts for 75 percent of the total estimated cost of decommissioning, decontaminating and restoring the Section 8 site, before contingency charges are added. RAP Attachment A-1, Financial Assurance Plan Summary.

2. HRI's calculations of HFF and VFF have no technical basis.

HRI and Staff calculate a corrected pore volume for Section 8 that is based on an HFF and VFF purportedly derived, at least in part, from the Mobil Section 9 Pilot Restoration Project conducted near Crownpoint between 1979 and 1986. Pelizza at 8-9, Ford at 12. In fact these calculations have no technical basis. Further, because the LC 9.5 fixes the number of pore volumes that must be flushed through the aquifer at nine, it is critical that each pore volume be calculated correctly in order to achieve full restoration of the aquifer (LC 9.5 does not specify initial or corrected pore volumes). Thus, the application of the appropriate HFF and VFF to the initial pore volume to create the corrected pore volume is a crucial step in accounting for the amount of water needed to restore the aquifer.

As described in detail in Ms. Lafferty's testimony, the flare factors chosen by HRI were not derived from any site-specific data or geologic analysis conducted either by Mobil for its Section 9 project or by HRI for its Section 8 project. See Lafferty at 10, 11-12. In its January presentation HRI provides two explanations for its selection of an HFF of 1.5 and a VFF of 1.3. The first explanation is "operating experience at other restoration demonstrations and commercial operations." Pelizza at 5. The second explanation is the HFF and VFF values were used to calculate corrected pore volumes processed at the Mobil Section 9 project. Pelizza at 6. However, Ms. Lafferty sets forth in detail that there is no evidence in the Mobil Section 9 documentation in the record of this proceeding that HRI's proposed HFF and VFF values were based on site-specific analysis. Lafferty at 10, 11-12. Rather, these values are found only in HRI's summary compilation of the Mobil Section 9 project. (Pelizza, Att. C at 4) (See also, Hearing Record ACN 9304130415, Hearing Notebook 6.2).

Moreover, Ms. Lafferty points out that HRI could have provided an HFF with at least a minimal basis if it had calculated an HFF solely on the basis of the geometry of the Section 8 site within the perimeter monitoring well ring, which, according to Mr.

Pelizza, is the "limit to acceptable flair [sic]" (Pelizza at 5, n. 7).[4] Lafferty at 10, 12-13, 16. Using the limited information available from maps in both the FEIS and RAP, Ms. Lafferty calculated that area and found that it is 1.87 times larger than the production area. Thus, if HRI had used this site-specific value for its HFF value, its total restoration water budget would have increased from 1.33 billion gallons to approximately 1.67 billion gallons — or, approximately 340 million gallons, which represents an additional 13 months of restoration activities and a significantly higher cost. Id. at 16.

The nine pore volumes are set by license condition and at the present time, regardless of the what the corrected pore volume turns out to be, HRI must set its surety based on flushing nine pore volumes through the contaminated aquifer. As Ms. Lafferty points out, while the nine pore volumes are fixed by license condition, they were not sufficient to achieve restoration to baseline levels for more than half of the regulated constituents at Mobil Section 9. Id. at 10, 16-17. She concludes that Mr. Pelizza and Mr. Ford are wrong to have insisted that the number of pore volumes needed to flush the aquifer during restoration would have been lowered if HRI had used a higher HFF. Id. at 13. Ms. Lafferty therefore concurs with the previous testimony of Mr. Ingle that

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[4] The "perimeter monitoring well ring" referred to here is simply the collection of monitor wells that surround the production area well fields in a more or less circular configuration. Fig. 3.11 in the FEIS depicts the ring of monitor wells that surround the production area for the Church Rock Section 8 and Section 17 mine sites. Perimeter monitor wells are installed around uranium ISL well fields to provide current water quality data and detect the spread of mining-related contaminants outward from the production area. Hence, using perimeter monitor wells as the limit of acceptable flare is inappropriate. If contaminants have hit the monitors at the outer edges of the well field, an excursion of contaminants has occurred such that mining should cease until the spread of contaminants is brought under control.

demonstrated that a site-specific and technically derived flare factor is the only appropriate way to make an accurate estimation of the total volume of water that will need to be restored. Without such an accurate assessment of the total of volume of water to be restored, the NRC Staff should not have approved this RAP and neither should the Presiding Officer.

As Ms. Lafferty notes in her testimony:

> In light of these deficiencies in the technical bases for cost estimates in HRI's RAP, and the Staff's acceptance of the RAP and its inherent limitations (see, NRC Acceptance Letter at 1), Mr. Ingle was correct to use an analogous real-world example, the PRI Highland Project, to assess HRI's RAP. He was entirely correct not to have lowered the number of pore volumes needed to flush the Section 8 aquifer to compensate for suggesting that a higher HFF was justified. His review was appropriately conservative in light of the potential for use of the aquifer at the Section 8 site as an underground source of drinking water. And his critique was reasonable from a regulatory perspective in light of the fact that HRI's performance-based license envisions no direct NRC oversight of the Section 8 operation and requires only an annual surety review.

Id. at 11.

B. The Mobil Section 9 Experience Demonstrates That the Approved Rap Will Not Adequately Decommission the Site or Restore the Groundwater to Applicable Standards.

Both NRC Staff and HRI rely heavily on Mobil Section 9 data as an indication that the RAP will adequately restore the groundwater at Section 8. Pelizza at 6-8. Ford at 8-9, 11-12. This is an unsupportable position.

Contrary to the opinions of HRI and Staff, Mobil Section 9 data demonstrate that the current approved plan for restoration would not restore the groundwater and would, in fact, violate NRC requirements and place the validity of the Final Environmental Impact Statement ("FEIS") and HRI's Consolidated Operations Plan, Revision 2.0 ("COP") in doubt. Despite clear evidence that groundwater restoration was not achieved at Mobil, the NRC Staff fails to meet its "continuing responsibility to assure that all regulatory requirements are met by an applicant and continue to be met." In the Matter of Southern California Edison Company, et al. (Virgil C. Summer Nuclear Station), ALAB-680 16 NRC 127, 143 (1982), citing South Carolina Electric and Gas Co., (Virgil C. Summer Nuclear Station), ALAB-642, 13 NRC 881, 895-96 (1981).

1. Mobil Section 9 data indicate that the current RAP will not restore the groundwater.

The Mobil Section 9 project failed to restore the groundwater that it contaminated through ISL mining. The Mobil Section 9 data relied upon by both Staff and HRI demonstrate that after more than sixteen pore volumes, fully one quarter (26%) of the parameters at Mobil Section 9 did not meet the secondary groundwater restoration goals at Church Rock Section 8. Ford at 8. Further, less than half (42%) of the monitored water quality parameters were returned to baseline. Among those constituents that remained above baseline were uranium, calcium, chloride, molybdenum, selenium, sodium, and zinc. Id. In short, Mobil was unsuccessful in restoring Mobil Section 9 after flushing sixteen pore volumes, either to the applicable standards set for it or the higher standards applicable to Section 8. See Lafferty at 10, 17-21, Table 1.

2. The NRC Staff may not lawfully rely on the Mobil data.

The FEIS explicitly states that restoration efforts must be conducted in an effort to achieve baseline conditions and only "[I]n the event water quality parameters cannot be returned to average pre-mining baseline levels through reasonable restoration efforts, the secondary goal would be to return water quality to the maximum concentrations specified in EPA regulations in 40 CFR Part 141 and §143.3, secondary and primary drinking water regulations." FEIS, Section 2.1.3.1 at 2-20. Additionally, Section 10.4.1 of HRI's COP outlines the groundwater restoration criteria as follows:

> HRI plans that groundwater restoration criteria be established on a parameter-by-parameter basis, with the primary goal of restoration to return all parameters to average pre-mining baseline conditions. To the extent that water quality parameters cannot be returned to the identical average pre-mining baseline levels, the secondary goal will be to return the water quality to the maximum concentration limits as specified in EPA secondary, and primary drinking water regulations (10 CFR part 141 and §143.3).

COP at 163-164.

Despite these clear statements that restoration must attempt to reach primary (i.e., baseline) standards, the NRC Staff has based the size of the required decommissioning fund for Section 8 on a restoration effort that failed to meet significant percentages of its primary or secondary standards: the Mobil Section 9 pilot study. As Mr. Ford's own testimony illustrates, the Mobil data demonstrate that nine pore volumes of flow flushing the aquifer during restoration (as currently calculated with an HFF of 1.5) -- or even more than sixteen pore volumes flushing the aquifer -- would not provide a sufficiently protective surety and would not clean up the contaminated groundwater even to secondary groundwater restoration standards. The Staff's approval of the RAP in the face of this information is in gross violation of the Staff's "continuing responsibility to assure that all regulatory requirements are met by an applicant and continue to be met." In the Matter of Southern California Edison Company, 16 NRC at 143. By approving a RAP that will almost assuredly fail to meet background standards or more than a quarter of secondary restoration goals after more than sixteen pore volumes of flushing, the NRC Staff contradicts the FEIS and the COP, placing the validity of those earlier documents in doubt and violates the Atomic Energy Act and its implementing regulations that prohibit the issuance of a license that is "inimical to ... the health and safety of the public." See Atomic Energy Act, 42 U.S.C. § 2099 and 10 C.F.R. § 40.32(d).[5]

[5] The NRC is effectively building a situation where restoration to baseline must be abandoned as futile, just as it was abandoned at URI's Texas mines. See Abitz at 21-23; Lafferty at 18-21. The Staff may not allow HRI to forego an effort to comply with baseline standards. Lafferty at 20-21. Dr. Abitz demonstrates in his testimony that those baseline standards are likely to be lower than HRI and Staff presume. Abitz at 5-7, Ford at 18. Pelizza at 25. The baseline for uranium at Church Rock Section 8 has not yet been established. But, as Dr. Abitz illustrates, most uranium concentrations measured in the Section 8 ore bodies show levels nearly an order of magnitude below HRI's proposed uranium restoration standard of 0.44 mg/l and some results are near or below EPA's uranium drinking water standard of 0.03 mg/l. See Abitz at 6-7, Table I. At the very least, it is premature for HRI or NRC Staff to conclude that drinking water limitations for Section 8 have been demonstrated. See Ford at 8, 18; Lafferty 21-22. Additionally, the United States Tenth Circuit Court of Appeals established that HRI has no valid underground injection control ("UIC") permit, nor does it have a valid aquifer exemption under the Safe Drinking Water Act ("SDWA") for Section 8 of the Crownpoint Project. See Intervenors' Motion to Supplement the Record (January 27, 2000). Thus, HRI may have to restore the uranium contaminated groundwater to EPA's drinking water standard of 0.03 mg/l rather than the secondary groundwater restoration standard of 0.44 mg/l. Either way, until a firm baseline for uranium at Section 8 is established, in its reliance on the Mobil Section 9 data the RAP is inadequate as it essentially gives up any attempt to reach baseline or the EPA drinking water standard.

C. Dr. Abitz's Comparison of Fernald with Section 8 is Appropriate.

HRI and Staff assert that Dr. Abitz makes an inapt comparison of ongoing restoration at DOE's Fernald site to the restoration as planned in the RAP. Ford at 9, 16-19. Pelizza at 23-28. As demonstrated in Dr. Abitz's testimony, their criticisms are misguided. For example, Mr. Pelizza is incorrect when he asserts that the geochemistry at the Fernald site and Section 8 cannot be appropriately compared. Pelizza at 23-24. The basic physical and chemical processes responsible for mobilizing uranium will occur anywhere in the right scenario. Abitz at 3-4. The two aquifers will be comparable when discussing groundwater remediation as it pertains to oxidized uranium contamination that has been mobilized in the aquifer beneath Fernald and that will be mobilized if mining commences in the Section 8 portion of the Westwater aquifer. Id. at 4.

Mr. Ford is incorrect when he asserts that Dr. Abitz does not provide sufficient detail to support a comparison of groundwater treatment at the Fernald site and Section 8. Ford at 16-20. To the contrary, Dr. Abitz presents the basic information needed to compare the sites, including the aqueous form of uranium contamination in the aquifer, labor costs associated with the groundwater treatment, and restoration goals. Abitz at 13. In any event, the very details that Mr. Ford would have had Dr. Abitz examine -- management efficiencies, pumping efficiencies and contractor administration costs -- were never provided by HRI, and therefore a comparison on that basis was simply not possible. Id.

D. The Approved RAP Relies on Illogical Efficiency Calculations.

In his initial testimony, Dr. Abitz criticized HRI for failing to account for operating efficiency in its cost estimate as HRI assumed a 100 percent efficiency in processing the groundwater, which is unrealistic and therefore leads to an inaccurate estimate of the time and cost required for restoration. Abitz December 2000 testimony at 12.

In response to Dr. Abitz, Mr. Pelizza states that there is not enough operating data to specify what the efficiency will be and cites no experience with operating efficiency from the URI operations at the South Texas sites. Pelizza at 27. This defense is not credible, given that Mr. Van Horn was able to provide other detailed information regarding HRI's Texas operations. Contrary to Mr. Pelizza's assertion, omitting the margin of inefficiency in a uranium restoration operation is not a small matter that can be cured sometime later in a "surety update." Id.

E. NRC Staff Misrepresents the Wyoming Restoration Experience.

In Intervenors' initial presentation, Dr. Abitz discussed the fact that actual ISL operating experience in Wyoming shows that restoration at commercial ISL mines "has taken much longer than originally projected" — 10 years and counting at one operating ISL mine — and has not yet achieved "restoration to premining standards" at any of the commercial sites. Abitz December 2000 Testimony at 9-10. NRC Staff's response that Bison Basin was "successfully" restored is a long stretch at best. Ford at 15-16. Lafferty at 22-23. As Ms. Lafferty explains in her testimony and as is clear from the documents attached to that testimony, there is more to the story.

The initial mine operator went into default and walked away from restoration of the contaminated in-situ leach uranium mine. Id., Att. B-3. As is the case with virtually all government agencies, the Wyoming Department of Environmental Quality ("WDEQ") had limited funds to address the contamination at Bison Basin. Id. Additionally, the WDEQ had significant concerns regarding the possibilities of the site being appropriately restored, both prior to and during the time the state took over the restoration of the site. Id. The WDEQ concerns even went so far as to include suspecting that the data for the site were inaccurate. Id. Specifically, one of the primary concerns identified by the WDEQ was that the concentrations of five constituents exceeded the target restoration values set for these constituents. Id. at 23. The restoration was ultimately considered a "success" because a significantly less stringent class of use standard was used to restore the aquifer than was originally required. Id. Ms. Lafferty notes that this fact, coupled with the short stability period of the partially remediated aquifer, restriction on use of restoration technology, and clearly documented concerns associated with the sampling protocols raise significant doubts about the "successful restoration" of the Bison Basin Uranium Mine. Therefore, Ms. Lafferty concurs with Mr. Ingle and Dr. Staub in their assertions that no commercial wellfield has been restored by the mine operator at any uranium ISL facility in Wyoming. Id.

As Ms. Lafferty states, "it is clear that to identify Bison Basin as an example of successful restoration is questionable at best. If anything, the Bison Basin Decommissioning Project demonstrates the need to have an adequate surety to restore the aquifer should the mine operator default on their obligations." Id.

F. HRI Misrepresents the South Texas Restoration Experience.

In support of their attack on Intervenors' December criticisms of the RAP, HRI submits letters that purport to show that its parent company, Uranium Resources, Inc. ("URI") successfully restored its Benavides and Longoria sites in South Texas. HRI asserts that this "fact" somehow supports its RAP.[6] In fact, URI only partially restored those sites to standards far above the original baseline values and far above the standards that are likely to be applicable to Church Rock Section 8. Further, the example of partial restoration work at those sites does not support the approval of this RAP. It is true that URI received letters from the Texas regulatory agencies stating that URI was released from further restoration of the Longoria and Benavides sites, but once again, a more complete picture, this time provided by Dr. Abitz, paints a very different picture from that presented by HRI.

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[6] Also, HRI states: "Where both Ingle and Abitz share their opinions that the RAP underestimates the time, labor, and costs required for ISL site groundwater restoration, Mr. Van Horn and Mr. Pelizza present the actual time, labor requirements, and costs of the groundwater restoration they have successfully implemented at URI's ISL operations in south Texas." HRI January presentation at 7 and Ex. 1.

URI's success at achieving a release from further restoration at its south Texas sites is not due to an impeccable job of groundwater remediation. Rather, as Dr. Abitz points out, the releases are due to a significant relaxation of restoration standards for key constituents, especially uranium. See Abitz at 20-21, Table III.

Achieving the restoration goals at the Texas sites was accomplished by obtaining regulatory approval to increase the restoration standards over the original baseline levels for bicarbonate, calcium, sulfate, and uranium. The increases in allowable levels of uranium in the water approached two orders of magnitude. The final restoration levels certified by the Texas regulatory agencies achieved the revised standards, but significantly exceeded the original levels set for restoration. If the original standards had remained in effect, Dr. Abitz concludes that restoration would have undoubtedly taken longer and cost more money. Id. at 21.

The Texas regulatory agencies cited several rationales for approving the increased uranium levels. Among the rationales cited are: (1) no federal drinking water limits exist for uranium; (2) raising the uranium value as requested will not render the aquifer unsuitable for any purpose for which it was reasonably suited prior to mining; (3) the Texas authorities' belief that 2.0 mg/l was a common drinking water standard; and (4) because companies appear to have no problems in achieving that level. See Abitz, Att. B, Tables 1 and 2, and Att. C-9 to C-11.

The opinions of the Texas regulatory authority are dangerously out of date. A federal drinking water limit does exist for uranium and it is 0.03 mg/l, not the 2.0 mg/l cited as a common drinking water standard by Texas authorities. As Dr. Abitz notes, when making these determinations the Texas regulators did not have the benefit of the results of recent health studies that demonstrate that long-term ingestion of uranium at even low levels in drinking water is associated with subclinical kidney damage. Id. at 23.

If anything, the issue of the suitability of the aquifer to its previous uses supports Dr. Abitz's point that the Section 8 aquifer is a potential drinking water source. As noted previously, HRI does not have a valid aquifer exemption for Section 8. Accordingly, HRI's restoration target for uranium may be the EPA standard for drinking water. Therefore, total restoration costs associated with URI's poor job of restoring the poorer quality water at the south Texas sites cannot be used as an indication that HRI can restore the higher quality aquifer in New Mexico to baseline or drinking water standards.

II. HRI'S RAP FAILS TO COMPLY WITH NRC STANDARDS FOR DECOMMISSIONING PLANS.

A. Both the Staff and HRI Improperly Rely on LC 9.5.

Both the Staff and HRI assert that LC 9.5 is a mechanism that can be used to rectify any underestimation of the amount of money needed for full decommissioning of Section 8 or the amount of water necessary to be processed for groundwater restoration. See, e.g., HRI's January presentation at 9-10, NRC Staff's January presentation at 5-9. These arguments misconstrue the purpose and function of surety updates. Surety updates are intended to provide for regular, incremental adjustments in the surety to account for inflation and unexpected contingencies. They are not intended to serve as correctives where decommissioning funding estimates are seriously underestimated in the first place. To allow that use of a surety update would completely upend the purpose of requiring licensees to set aside decommissioning funds up front. A licensee that has not set aside sufficient decommissioning funds at the outset may not have the necessary funds later, when the bills come due. The shortfall may result from bankruptcy, going out of business, or merely a lack of assets or cash. As demonstrated by Intervenors' testimony, HRI underestimates the significant financial resources needed to provide sufficient insurance that the groundwater will be restored and the site effectively decommissioned. To allow the use of the surety update to correct such a massive underestimate would violate Criterion 9.

Moreover, post-licensing reliance on the surety update to correct fundamental flaws in the decommissioning funding plan would violate Intervenors' right to a hearing on the decommissioning plan. In CLI-00-08, the Commission held that significant decisions regarding HRI's financial assurance plan for decommissioning the Crownpoint Project cannot be left for post-hearing resolution or a second round of hearings closer to the time of operation. 51 NRC 239, 240.

The Commission has made it clear that demonstration of an adequate surety during the licensing hearing is a requirement of the regulations and necessary to ensure that enough funding will be available in the event HRI is unable to decommission the site and restore the contaminated groundwater. Criterion 9 states in pertinent part:

> Regardless of whether reclamation is phased through the life of the operation, an appropriate portion of surety liability must be retained until final compliance with the reclamation plan is determined. This will yield a surety that is at least sufficient at all times to cover the costs of decommissioning and reclamation of the areas that are expected to be disturbed before the next license renewal.

10 C.F.R. § 40, Appendix A, Criterion 9 (emphasis added). The crucial wording here is "sufficient at all times." This standard cannot be met if, in the middle of its operating term, a financially strapped HRI is unable to "update" its surety by millions of dollars as a result of its initial miscalculation of decommissioning costs. As Ms. Lafferty points out:

> [S]hould HRI fail financially before the demonstration plot is fully restored (and that event could take place as much as two years after initial injection), or before the company completes restoration of the extensive commercial wellfields envisioned in its Consolidated Operations Plan (COP, Fig. 1-4.8 at 22), an adequate surety amount must be in place for the U.S. Government to pay a contractor to finish the work left by the operator. As discussed later in my testimony in regards to the Bison Basin Mine experience in Wyoming, the scenario of an operator defaulting and abandoning the mining site is not speculation, but has a basis in fact.

Lafferty at 8-9.

CONCLUSION

For the foregoing reasons, the surety amount proposed by HRI remains inadequate to ensure funds are available to clean up Section 8 should HRI declare bankruptcy or cease to exist, regardless of the existence of License Condition 9.5. The Presiding Officer should revoke HRI's license as to Section 8 as HRI has not submitted an appropriately supported restoration plan and cost estimate as required by the Atomic Energy Act and NRC regulations.

Respectfully submitted,

Geoffrey H. Fettus
Heather L. Green
Douglas Meiklejohn
NM ENVIRONMENTAL LAW CENTER
1405 Luisa Street, Suite 5
Santa Fe NM 87505
(505) 989-9022

Diane Curran
HARMON, CURRAN, SPIELBERG &
EISENBERG, LLP
1726 M Street, N.W., Suite 600
Washington DC 20036
(202) 328-6874

May 24, 2001

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

ATOMIC SAFETY AND LICENSING BOARD

Before Administrative Judges:
Thomas S. Moore, Presiding Officer
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In the Matter of	)	
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HYDRO RESOURCES, INC.	)	Docket No. 40-8968-ML
P.O. Box 15910	)	ASLBP No. 95-706-01-ML
Rio Rancho, NM 87174	)	
	)	

CERTIFICATE OF SERVICE

I hereby certify that on May 24, 2001, I caused to be served copies of the foregoing:

INTERVENORS' REPLY TO THE RESPONSES OF HYDRO RESOURCES INC.'S AND NRC STAFF'S RESTORATION ACTION PLAN PRESENTATIONS OF JANUARY 21, 2001 AND INFORMATION GENERATED SUBSEQUENT TO THOSE PRESENTATIONS

upon the following persons by U.S. mail, first class, and in accordance with the requirements of 10 C.F.R. § 2.712. Service was also made via e-mail to the parties marked below by an asterisk. The envelopes were addressed as follows:

Administrative Judge
Thomas S. Moore,* Presiding Officer
Atomic Safety and Licensing Board
Mail Stop T-3 F23
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001

Administrative Judge
Thomas D. Murphy, Special Assistant
Atomic Safety and Licensing Board
Mail Stop T-3 F23
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001

Office of the Secretary
U.S. Nuclear Regulatory Commission*
Washington, D.C. 20555-0001
Attn: Rulemakings and Adjudications
Staff

Adjudicatory File
Atomic Safety and Licensing Board
U.S. Nuclear Regulatory Commission*
Washington, D.C. 20555-0001

Atomic Safety and Licensing Board
Panel
U.S. Nuclear Regulatory Commission*
Washington, D.C. 20555-0001

John T. Hull, Esq.
Mitzi Young, Esq.
Office of the General Counsel*
U.S. Nuclear Regulatory Commission
Mail Stop - O-15 D21
Washington, D.C. 20555-0001

Anthony J. Thompson, Esq.
Anthony J. Thompson, P.C.*
1225 19th Street, N.W., Suite 200
Washington, D.C. 20036

David Lashway, Esq.
SHAW PITTMAN*
2300 "N" Street, N.W.
Washington, D.C. 20037-1128

Diane Curran, Esq.
HARMON, CURRAN, SPIELBERG &
EISENBERG, LLP*
1726 M Street, N.W., Suite 600
Washington DC 20036

Chris Shuey
SRIC*
P.O. Box 4524
Albuquerque, NM 87106

Kathleen Tsosie*
ENDAUM
P.O. Box 150
Crownpoint, NM 87313

Edward M. Dobson
DNA-People's Legal Services, Inc.
P.O. Box 310458
Mexican Hat, Utah 84531

Levon Henry, Attorney General
Steven J. Bloxham, Esq.
Navajo Nation Department of Justice
P.O. Drawer 2010
Window Rock, AZ 86515

Jep Hill, Esq.
Jep Hill & Associates
P.O. Box 30254
Austin, TX 78755

Dated at Santa Fe, New Mexico,
May 24, 2001

Geoffrey H. Fettus

May 23, 2001

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

ATOMIC SAFETY AND LICENSING BOARD

Before Administrative Judges:
Thomas S. Moore, Presiding Officer
Thomas D. Murphy, Special Assistant

In the Matter of	)	
	)	
HYDRO RESOURCES, INC.	)	Docket No. 40-8968-ML
P.O. Box 15910	)	ASLBP No. 95-706-01-ML
Albuquerque, NM 87174	)	
	)	

WRITTEN TESTIMONY OF APRIL LAFFERTY IN SUPPORT OF INTERVENORS' REPLY TO HRI'S AND NRC STAFF'S JANUARY 22, 2001, RESPONSES TO INTERVENORS' PRESENTATION ON HRI'S RESTORATION ACTION PLAN AND COST ESTIMATES

On behalf of Eastern Navajo Diné Against Uranium Mining ("ENDAUM") and Southwest Research Information Center ("SRIC"), April Lafferty submits the following testimony regarding the Nuclear Regulatory Commission ("NRC") Staff's and Hydro Resources Inc.'s ("HRI") responses to Intervenors' response to HRI's Restoration Action Plan ("RAP") and cost estimates of November 21, 2000.

1. I am competent to give this testimony, and the factual statements herein are true and correct to the best of my knowledge, information and belief. The opinions expressed herein are based on my best professional judgment and extensive expertise and experience in groundwater hydrology and groundwater restoration of pilot-scale and commercial uranium *in situ* leach

EXHIBIT
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("ISL") mining operations and regulatory review and oversight of uranium ISL mines.

2. I am giving this testimony on behalf of ENDAUM and SRIC to respond to the NRC Staff's and HRI's responses to the Intervenors' response on HRI's RAP for the Church Rock Section 8 site of the proposed Crownpoint Uranium Project ("CUP"), as well as information generated subsequent to those responses, including HRI's March 16, 2001, response to NRC Staff's Request for Additional Information ("RAI") (February 16, 2001).

3. I am an expert in groundwater protection and restoration aspects of uranium ISL mining. My qualifications to give this testimony are contained in my résumé, which is attached as **Attachment A** to this written testimony.[1] My relevant education, training and experience are summarized in my résumé. As stated therein, I hold a Masters Degree in Geology from the University of Cincinnati, and a Bachelors Degree in Geology from Bloomsburg University. Since 1998, I have been a staff hydrogeologist for American Geosciences, Inc. (AGI), where I have reviewed the hydrogeologic aspects of an environmental impact statement for an in-situ leach uranium mine for the Australian Commonwealth Government. While in Australia, I provided technical expertise on the proposed monitoring program, hydrogeologic issues associated with the mining method, and characterization of the aquifer, and developed a technical report on the key issues. From 1995 to 1998, I held positions at the Wyoming Department of Environmental Quality, Land Quality Division ("WDEQ/LQD"). While in Wyoming, I was one of the hydrogeologists who, among other duties, was responsible for ensuring regulatory compliance at in-situ leach uranium mines as well as coal, sand and gravel mines. I was

[1] Attachments will hereinafter be designated as "Att. __."

responsible for inspections and other permitting tasks and assisted in writing regulations and shaping regulatory standards for uranium mines. I also prepared several reports for and letters to mine operators, the public, and federal agencies, including the Nuclear Regulatory Commission. As a technical expert for the State of Wyoming and the government of Australia who has evaluated and resolved groundwater restoration issues at uranium mines, I am familiar with the variety of solid and liquid uranium species that occur in the environment and the chemical and physical properties that affect the mobilization of uranium and its radioactive progeny. I am familiar with all aspects of uranium ISL mining techniques, including lixiviant formulation, construction and operation of injection and extraction wells, ion-exchange processes used to recover uranium from the pregnant lixiviant, and groundwater sweep, reverse osmosis and reductant treatment processes used to restore the mined groundwater zones. I am also familiar with the content and breadth of uranium ISL financial assurance plans, having evaluated several of the plans submitted to WDEQ by commercial ISL operators in the state. I am knowledgeable in restoration and financial assurance requirements of the State of Wyoming and of the NRC, including NRC's financial assurance regulations, codified at 10 CFR 40, Appendix A, Criterion 9.

4. In preparing this testimony I reviewed the following documents:

U.S. Nuclear Regulatory Commission. Letter from Daniel M. Gillen, NRC, to Mark S. Pelizza, HRI, re: Acceptance of Restoration Action Plan for Hydro Resources In-Situ Uranium Mining Project, License SUA-1580 (April 16, 2001) ("NRC Acceptance Letter").

Hydro Resources, Inc. Letter from Mark S. Pelizza, HRI, to Philip Ting, NRC, transmitting response to NRC's Request for Additional Information Concerning Restoration Costs for Hydro Resources In-Situ Uranium Mining Project (March 16, 2001) ("HRI RAI Response"), and attached blue-sheet revisions to Restoration Action Plan.

U.S. Nuclear Regulatory Commission. Letter from Philip Ting, NRC, to Mark S. Pelizza, HRI, re: Request for Additional Information Concerning Restoration Costs for Hydro Resources In-Situ Uranium Mining Project (February 16, 2001) ("NRC February RAI").

Reply of Hydro Resources, Inc. ("HRI") to Intervenors' Response to HRI's Cost Estimates for Decommissioning and Restoration Action Plan (January 22, 2001), including Exhibit 2, Affidavit of Mark S. Pelizza Responding to Affidavits of Steven Ingle and Richard Abitz (January 18, 2001) ("Pelizza January Affidavit"), and Attachments 1 through 6 attached thereto, and Exhibit 3, Affidavit of Richard A. Van Horn Responding to Affidavits of Steven Ingle and Richard Abitz (January 19, 2001) ("Van Horn Affidavit").

NRC Staff's Response to Intervenors' Financial Assurance Brief (January 22, 2001) ("Staff's January Response"), and Staff Exhibit 1, Affidavit of William H. Ford (January 22, 2001) ("Ford January Affidavit").

Intervenors' Response to Hydro Resources Inc.'s Cost Estimates and Restoration Action Plan of November 21, 2000 (December 21, 2000) ("Intervenors' December 2000 Response"), including Written Testimony of Steven C. Ingle (December 19, 2000) ("Ingle Testimony"), and Dr. Richard J. Abitz (December 19, 2000) ("Abitz December 2000 Testimony"), attached thereto as Exhibits 1 and 2, respectively.

Hydro Resources, Inc., Church Rock Section 8/Crownpoint Process Plant Restoration Action Plan ("RAP"). License No. SUA-1580 (November 17, 2000).

Letter from Ms. Georgia A. Cash, District I Supervisor, Wyoming Department of Environmental Quality, Land Quality Division, to Mr. John Cash, Rio Algom Mining Corporation (July 14, 2000), concerning: TFN 3 5/232, Flare Factor Justification, Third Round Review, Rio Algom Mining Corp., Permit No. 633 ("Cash, 2000").

Wyoming Department of Environmental Quality. Memorandum to File, TFN 3 5/232 (Rio Algom Mining Corp., Permit No. 633), from Paula Cutillo (July 13, 2000), re: Flare Factor Justification, Third Round Review ("Cutillo Memorandum, July 13, 2000").

Excerpts from Rio Algom Mining Corp., Annual Report, Permit to Mine #633, Smith Ranch Facility (June 18, 2000) ("RAMC, 2000").

Letter from William Paul Goranson, Rio Algom Mining Corp., to Ms. Paula Cutillo, Wyoming Department of Environmental Quality, Land Quality Division (May 10, 2000), concerning: Response to 2nd Round Comments on Projected Groundwater Restoration Costs, TFN 3 5*232, Permit No. 633, Smith Ranch Facility ("Goranson, 2000").

Excerpts from Draft Evaluation and Simulation of Wellfield Restoration at the RAMC Smith Ranch Facility, prepared for Rio Algom Mining Corporation by Lewis Water Consultants, (October 29, 1999) ("RAMC, 1999").

ENDAUM's and SRIC's Brief on Review of Partial Initial Decision LBP-99-13, Financial Assurance for Decommissioning (August 13, 1999).

Affidavit of William H. Ford (May 11, 1999), Attached as Staff Exhibit 1 to "NRC Staff Response to Questions Posed in April 21 Order" ("Ford May 1999 Affidavit").

Wyoming Department of Environmental Quality. Memorandum to File, TFN 3 5/232 (Rio Algom Mining Corp., Permit No. 633) from Paula Cutillo (February 12, 1999), re: Flare Factor Justification, First Round Technical Review ("Cutillo Memorandum, February 12, 1999").

ENDAUM's and SRIC's Amended Written Presentation on Groundwater Protection (January 18, 1999).

Letter from Ms. Georgia A. Cash, District I Supervisor, Wyoming Department of Environmental Quality, Land Quality Division, to Mr. William Paul Goranson, Rio Algom Mining Corporation (December 9 1998), concerning: Bond Increase for Permit No. 633, Rio Algom Mining Corp. (RAMC), Smith Ranch Facility ("Cash, 1998").

Memorandum from Paula Cutillo, District I Groundwater Hydrologist, to Richard A. Chancellor, Administrator, Wyoming Department of Environmental Quality, Land Quality Division (November 20, 1998), concerning: Request to Revise Bond Amount, Rio Algom Mining Corp., Permit No. 633, Inspection File ("Cutillo, 1998").

U.S. Nuclear Regulatory Commission Source Materials License SUA-1508, Hydro Resources, Inc., Crownpoint Uranium Project (January 5, 1998). Hearing Record ACN 980116066.

U.S. Nuclear Regulatory Commission. Draft Standard Review Plan for In Situ Leach Uranium Extraction License Applications, NUREG-1569 (October 1997) ("Draft Standard Review Plan").

Crownpoint Uranium Project Consolidated Operations Plan, Revision 2.0 ("COP Rev. 2.0"). Hydro Resources, Inc., Albuquerque, New Mexico (August 15, 1997). Hearing Record ACN 9708210179.

Final Environmental Impact Statement to Construct and Operate the Crownpoint Uranium Solution Mining Project, Crownpoint, New Mexico, NUREG-1508, BLM NM-010-93-02, BIA EIS-92-001 ("FEIS"); Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission, in cooperation with U.S. Bureau of Land Management and U.S. Bureau of Indian Affairs (February 1997). Hearing Record ACN 9703200270.

HRI, Inc., Section 9 Pilot Summary Report (March 12, 1993), Attachment 1 to Pelizza January 22, 2001, Affidavit ("HRI Section 9 Summary Report"). Hearing Record ACN 9304130415.

Letter from J.F. Cullen, Mobil Alternative Energy, Inc., to G. Konwinski, USNRC Region IV (November 14, 1986) ("Mobil Oil, 1986"). Hearing Record ACN 8702060301.

Aquifer Restoration at the Bison Basin In Situ Uranium Mine, prepared by Mark Moxley, District Engineer, Wyoming Department of Environmental Quality, Land Quality Division, Lander, Wyoming, and Glenn J. Catchpole, Manager Regulatory Affairs, Uranerz U.S.A., Inc., Capser, Wyoming. Chapter 13 in: *In Situ All Mineral Symposium* (May 22-24, 1989), Casper, Wyoming ("Moxley and Catchpole, 1989").

Final Restoration Document for the Bison Basin Decommissioning Project, prepared by Steve Johnson, Hydrologist, Wyoming Department of Environmental Quality, Land Quality Division (date not known, but received by District II of LQD on May 5, 1989) ("Johnson, 1989").

U.S. Nuclear Regulatory Commission. Letter from Edward F. Hawkins, NRC, to Jim Analla, BIA, transmitting "Draft Finding of No Significant Impact" and "Environmental Assessment by the Uranium Recovery Field Office in Consideration of the Release of Source Material License SUA-1479 for Mobil Oil Corporation Crownpoint, Section 9, In Situ Pilot Test Project, McKinley County, New Mexico, Docket No. 40-8911" (February 4, 1988) ("NRC EA on Mobil License Termination").

Excerpts from Final Report on Phase I (Aquifer Restoration) of Bison Basin Decommissioning Project, submitted to State of Wyoming, Department of Environmental Quality, Land Quality Division, by Altair Resources, Inc. (1988), attached as Attachment A to Ford January 22, 2001, Affidavit ("Altair Resources, 1988").

Letter from G.A. Cresswell, Mobil Oil Corporation, to Gerald W. Stewart, Uranium Licensing Section, Radiation Protection Bureau, New Mexico Environmental Improvement Division (November 10, 1980), concerning: Crownpoint Section 9 Pilot In Situ Uranium Mine Monthly Reported Data – October 1980 ("Mobil Oil, 1980"). Hearing Record HCN 9807100224.

5. In this testimony, I address the NRC Staff's and HRI's responses to the Intervenors's comments on HRI's RAP in the following areas: (1) the need for an adequate surety prior to construction and operation of the proposed HRI Section 8 ISL mine; (2) underestimation of restoration costs; (3) comparability and clarification of restoration experience at Wyoming ISL sites; (4) likelihood of achieving restoration to primary (i.e., baseline) and secondary (i.e.,

drinking water) standards; and (5) importance of including the costs of mechanical integrity testing in the total restoration cost estimates.

6. In my capacity as a hydrogeologist with American Geosciences, Inc. (AGI), I reviewed and evaluated numerous documents related to various technical issues associated with a license for the proposed HRI Section 8 uranium ISL mine located in McKinley County, New Mexico. The purpose of my review was to evaluate data presented within HRI's Section 8 Restoration Action Plan ("RAP"), review and assess Mr. Steven Ingle's December 2000 critique of the HRI RAP on behalf of the Intervenors, and review and comment on HRI's and the NRC Staff's responses to the Intervenors' December 21, 2000, response. This testimony represents my findings and conclusions with respect to adequacy of the HRI RAP to derive a surety estimate that ensures that sufficient funds are available to remediate environmental impacts should the mine operator default after initiation of mining operations in Section 8.

A. HRI's Restoration Action Plan, as amended, is not an adequate basis for establishing a surety amount to cover the costs of decommissioning, decontamination and restoration, and should not have been accepted or approved by the NRC Staff.

7. In his testimony for the Intervenors, Mr. Ingle asserted that HRI's RAP failed to satisfy the NRC's financial assurance criterion and the agency's financial assurance guidelines because of "three main areas of technical deficiencies" in the Plan: (1) underestimation of the volume of restoration water that will be treated at Section 8; (2) "unsubstantiated assumptions and outright errors" about plant operating efficiencies; and (3) failure to include cost components that are typically covered by surety plans for ISL mines in Wyoming. Ingle Testimony, ¶¶ 6-9. In response, Mr. William Ford of the NRC Staff defended the adequacy of HRI's RAP on

essentially three grounds: First, that License Condition 9.5, which provides for annual surety reviews, will allow NRC to adjust the surety level up or down in response to changes in operating conditions, engineering plans, inflation and other factors. Ford January Affidavit, ¶ 3 and n.4. Second, the surety proposed by HRI is "[f]or an ISL facility that is not yet operational, . . .[and] for well fields which have yet to be designed and constructed." Id., ¶ 3. And third, HRI has committed to conducting a restoration demonstration project "within two years of the date on which mining begins" for a well field operated for three months under "commercial activity conditions." Id., ¶¶ 3-5. The clear message of Mr. Ford's testimony is that the RAP is sufficiently detailed and accurate as a basis for HRI's initial surety.

8. For the reasons that follow, I disagree with Mr. Ford's conclusion. First, the annual surety review mandated in License Condition 9.5 will likely occur *after lixiviant has been injected* into the ore-bearing zones at Section 8. As discussed briefly in Dr. Richard Abitz's reply affidavit (¶¶ 8-10) and in his previous testimony in this proceeding,[2] the Section 8 water quality could support a drinking water use; therefore, its protection, even during the demonstration period, must be a primary objective of the surety process. Second, should HRI fail financially before the demonstration plot is fully restored (and it could be as much as two years after initial injection), or before the company completes restoration of the extensive commercial well fields envisioned in its Consolidated Operations Plan (COP Rev. 2.0, Fig. 1-4.8 at 22), an adequate surety amount must be in place for the U.S. Government to pay a contractor to finish the work left by the operator. As discussed later in my testimony in regard to the Bison Basin Mine

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[2] See, e.g., Abitz January 1999 Testimony at 13-15.

experience in Wyoming, the scenario of an operator defaulting and abandoning the mining site is not speculation, but has a basis in fact. And third, as a former uranium ISL mine regulator, I fully agree with Mr. Ingle's insistence that a reasonable but conservative approach to estimating restoration costs must be taken *before ISL operations begin* to ensure that there are adequate funds available to restore the site should the uncertainties of the uranium market and the company's financial conditions cause a default by the operator.

9. For these reasons, Mr. Ford's comfort level with HRI's RAP is not an acceptable substitute for an accurate and comprehensive financial assurance plan. As I set forth in my testimony below, I do not believe that the RAP has adequately or accurately estimated HRI's restoration costs for the Section 8 mine. As such, it is my professional opinion that the NRC Staff erred by accepting and approving the HRI RAP on April 16, 2001. NRC Acceptance Letter at 1-2.

B. HRI underestimates the costs required to restore groundwater because HRI has underestimated the volume of restoration water that will have to be processed to achieve both primary and secondary groundwater restoration standards.

10. Based on my review of Mr. Ingle's testimony, the responses of HRI and the NRC Staff and their experts, Mr. Mark Pelizza and Mr. William H. Ford, respectively, and various other documents relevant to this case (see ¶ 4 above), I concur with Mr. Ingle that HRI's RAP significantly underestimates the costs required to restore the groundwater at the Section 8 site because HRI has underestimated the volume of restoration water that will have to be processed to achieve both primary (i.e., baseline) and secondary (i.e., drinking-water) restoration standards. I am led to this conclusion by several factors, many of which were identified by Mr. Ingle in his

December testimony and further illuminated in the January affidavits of Mr. Pelizza and Mr Ford. I elaborate on these factors in the paragraphs that follow; summarized, they are as follows:

10a. Neither HRI nor the NRC Staff provide a *site-specific, technical* basis for using a horizontal flare factor ("HFF"; also called a horizontal dispersion factor, "HDF") of 1.5 and a vertical flare factor[3] ("VFF"; also called a vertical dispersion factor, "VDF") of 1.3 to account for the horizontal spread of mining fluid outward from the production area during restoration activities. As discussed by Mr. Ingle (December Testimony, ¶¶ 12-18), the effect of using an arbitrarily low HFF that is not based on site-specific analysis (i.e., mine-area geometry, field investigations, and/or computer modeling) is to keep the *total volume of restoration water to be processed lower* than what it would be if a larger HFF were chosen by HRI.

10b. By license condition, HRI *must* conduct initial restoration through nine pore volumes. SUA-1508, License Condition 9.5. HRI cannot unilaterally lower the number of pore volumes used to flush the aquifer to compensate for a higher flare factor. While flushing with nine pore volumes is now the regulatory mandate for HRI, it may *not be sufficient* to restore groundwater quality to baseline at Section 8, just as it was not sufficient to restore the groundwater to baseline levels at the Mobil Section 9 pilot project.

10c. Both HRI and the NRC Staff inappropriately rely on the results of the Mobil Section 9 pilot ISL project as a basis for predicting the likelihood of successful restoration at the proposed Church Rock Section 8 mine. The Mobil Section 9 project conducted leach mining for

[3] I agree with the pore volume and flare factor definitions, in a basic sense, of Mr. Ford (January Affidavit, ¶ 5), Mr. Pelizza (January Affidavit, ¶¶ D1-D7 and ¶E2), and Mr. Ingle (December Testimony, ¶ 11) and will not reiterate definitions of these terms.

an 11-month period in 1979 and 1980 using nine injection wells and four production wells on a five-acre site located about 20 miles north of the proposed Section 8 site. In contrast, HRI proposes commercial-scale ISL mining on about 200 acres using about 440 injection and production wells. Mobil undertook restoration beginning in October 1980, and continued restoration efforts for more than six years thereafter. As the NRC Staff now acknowledges, the Mobil restoration effort was able to return contaminant levels to their baseline values for less than half of the constituents measured.

11. In light of these deficiencies in the technical bases for the cost estimates in HRI's RAP, and the Staff's acceptance of the RAP and its inherent limitations (see, NRC Acceptance Letter at 1), Mr. Ingle was correct to use an analogous real-world example, the Power Resources Inc. ("PRI") Highland Uranium Project in Wyoming, to assess HRI's RAP. He was entirely correct not to have lowered the number of pore volumes needed to restore the Section 8 aquifer to compensate for suggesting that a higher HFF was justified. His review was appropriately conservative in light of the potential for use of the aquifer at the Section 8 site as an underground source of drinking water. And his critique was reasonable from a regulatory perspective in light of the fact that HRI's performance-based license envisions no direct NRC oversight of the Section 8 operation and requires only an annual surety review.

B.1. No technical basis for horizontal and vertical dispersion factors

12. In the RAP (¶ E.2.a at 3), HRI stated that it "uses" an HFF value of 1.5 and a VFF value of 1.3, but did not say how it determined these values. In his January affidavit (¶ D.1 at 5), Mr. Pelizza states that these values "have been calculated by URI engineers based on operating experience at other restoration demonstrations and commercial operations." Yet, he provides

absolutely no calculations, models or other scientific data that support the use of the 1.5 horizontal flare factor at the Section 8 site or the Mobil Section 9 site. He also notes that an HFF of 1.5 and a VFF of 1.3 were used to calculate the adjusted pore volume for the Mobil Section 9 pilot project. Id. at 6. Similarly, Mr. Ford also notes that an HFF of 1.5 and a VFF of 1.3 were used for the Mobil Section 9 restoration analysis. Ford January Affidavit, ¶ 16. However, I can find no reference in any of the Mobil documents I reviewed that Mobil generated either of these values from site-specific data or from groundwater modeling, such as WDEQ did in the PRI Highland example discussed by Mr. Ingle. In fact, the only mention of an HFF of 1.5 for the Mobil project is found in Attachment C of HRI's 1993 Section 9 Pilot Project Summary Report — a document compiled *by HRI* "from several sources within Mobil's files . . ." (Section 9 Summary Report at 1; Pelizza January Affidavit at 6). Dr. Abitz also examined HRI's bases for these flare factors and concluded that HRI "could have picked virtually any combination of horizontal and vertical flare factors to match Mobil's actual total [restoration] volume" (Abitz May 23 Affidavit, ¶ 26).

13. Horizontal and vertical dispersion of fluid outside of an ISL production area is not a trivial matter. Flare is caused by water moving in a radial path or loop from an injection well to a production well. As such, a certain amount of flare always occurs during *in situ* mining. The distance or flare that impacted groundwater migrates beyond the injection and production wells can increase if injection rates exceed production rates because of an imbalance in the well field. Mr. Pelizza claims in his January testimony (¶ D.1, n.7) that the "limit on acceptable flair" [sic] is "the horizontal monitor wells" that surround the production area. (See, FEIS Fig. 3.11 at 3-37 for a map of the Section 8 site showing the perimeter monitor well ring and "mine-zone

perimeter," which encompasses the production area where leach solutions will be injected and mine fluids pumped.) In my professional opinion, accepting horizontal flare out to the monitor well ring is ill-advised. Not only would the efficiency of the mining operation be reduced, but the flare factor itself would also need to be increased to include the volume of the aquifer out to the monitoring well ring. This increase in aquifer area that is impacted by flare will obviously increase the amount of groundwater that must be subsequently restored. An increased volume of groundwater that must be restored will also raise the amount of surety that must be posted to restore the aquifer should HRI default on its restoration obligations.

14. Mr. Pelizza (January Affidavit, ¶ D.3) incorrectly states that if the flare factor were increased, the number of pore volumes required to restore the mine should be decreased. This scenario may be true only if the total gallons of impacted groundwater to be restored were known. However, in the case of HRI's Section 8 site, the volume to be treated is definitely not known, only estimated. The only way to estimate the total volume of groundwater to be restored is to use site-specific or operational data. In his December testimony (¶ 12), Mr. Ingle explained that the Wyoming Department of Environmental Quality developed a model to estimate horizontal flare using geologic, hydrologic and well-field data specific to PRI's Highland Uranium Project. He provided a copy of a WDEQ memorandum and technical report that formed the basis for increasing PRI's Highland flare factor from 1.4 to 3.0. Ingle Testimony, Attachment B at 1. I was the lead author of that report.

15. Mr. Ingle applied the final HFF for the Highland Project of 2.94 to the Section 8 restoration volume estimate contained in HRI's RAP for two principal reasons: First, he could find no technical basis for HRI's selection of an HFF of 1.5, and second, he believed, based on

his review of relevant documents in the HRI case, that the PRI site in Wyoming and Section 8 in New Mexico were sufficiently analogous to allow for a valid comparison. Ingle Testimony at 11-14. In essence, he used a real world example of a site with similar site conditions to the Section 8 site to demonstrate the substantial effect that increasing the horizontal flare has on the estimate of the total restoration water volume. Id. ¶ 18 at 12-13. It is my professional opinion that such a conservative estimate of the volume of groundwater to be restored must be established before the mine operator initiates mining to ensure that sufficient surety is available to address a default. In this manner, the NRC would have a reasonable basis to ensure that adequate funds would be available for restoration.

16. Mr. Pelizza states, "Mr. Ingle's representation that the PRI pore volume example represents universal Wyoming DEQ policy is not consistent with recent actions that the agency has taken with other operators." Pelizza January Affidavit, ¶ D.8. Mr. Pelizza goes on to explain that WDEQ allowed Rio Algom Mining Corporation ("RAMC") to use a flare factor of 1.7 to calculate the restoration water volume at its Smith Ranch Mine. Unfortunately, Mr. Pelizza's characterization of Mr. Ingle's testimony is wrong. Mr. Ingle did not represent that the flare factor and pore volume model applied to the PRI Highland project is "universal WDEQ policy," but simply a method "[t]o test the accuracy of pore volume estimates at Wyoming ISL mines" that the WDEQ staff applied to the Highland Project during a surety review. Ingle Testimony at 9.

17. Mr. Pelizza's recitation of the story behind the Rio Algom HFF left out critical information and facts. In fact, Mr. Pelizza appears to use only those parts of Wyoming DEQ/LQD documents that favor his argument. Further examination of internal WDEQ memos

and letters to RAMC, which I provided in **Attachment B** appended hereto, clearly supports Mr. Ingle's position that the Wyoming DEQ/LQD requires site-specific flare and pore volume calculations. For instance, in reviewing the basis for RAMC's original proposed flare factor of 1.32, a WDEQ hydrologist commented as follows:

> "[I]f a flare factor of 2.94 is applied to the Q-Sand data, then only 2.6 affected pore volumes would be needed to remove 23 million gallons . . .*This method of justification cannot be used to prove that either flare factor is correct.* For this reason, the LQD is requesting that RAMC provide a *technical justification* for using a flare factor of 1.32, which demonstrates an understanding of what is occurring beneath a commercial wellfield (e.g., field investigations or groundwater modeling to support the estimates of horizontal flare)."

Cutillo Memorandum, February 13, 1999 at 4 (emphasis added) (**Att. B-1**).

18. The 1.7 flare factor cited by Mr. Pelizza was agreed to by the LQD staff with several qualifications and reservations. These concerns included the fact that RAMC used data from a pilot area and had not included Radium-226 in the modeling used to estimate the flare factor. Further, the LQD staff opined that the "time and cost to restore a commercial wellfield may be more than predicted due to the complex interaction of radionuclides. This may be verified with validation of the model." Cutillo Memorandum, July 13, 2000, Comment 1.7 (**Att. B-2**).

19. In comment 1.9 of the same document, LQD staff questioned the validity of the model used by RAMC in that it was based on a pilot restoration. For this reason, the agency staff requested that the accuracy of the model be determined against the restoration of Wellfield 1 at the Smith Ranch Mine. The LQD also recommended that validation of the model address the effectiveness of the flare factor and pore volume estimations, and the impact of Radium-226 on restoration (because Radium-226 was not included in the model). Id., Comment 1.9.

B.2. No use of Church Rock Section 8-specific data

20. HRI could have, but did not, calculate an HFF using data specific to the Section 8 site. Unlike the WDEQ staff in the case of PRI, the NRC Staff chose not to require HRI to develop flare factors that have a basis in the hydrogeologic properties or geometric dimensions of Section 8. In my view, at a very minimum, HRI could have calculated an HFF solely on the basis of the geometry of the Section 8 site within the perimeter monitoring well ring, which, as I noted above in ¶ 13, is the "limit to acceptable flair [sic]" (Pelizza January Affidavit, n.7 at 5).[4] Using maps in both the FEIS and RAP, I calculated the area inside the monitoring well ring as 6.4 million square feet, or about *1.87 times* larger than the production area (which, according to data in RAP Table 1, is 3.4 million square feet). Hence, if HRI had substituted this *site-specific* value for the HRI value of 1.5 into the calculation of its total volume of restoration water that appears in RAP Table 1, while keeping all other values, including the VFF value of 1.3, constant, its total restoration water budget would have increased from 1.33 billion gallons to approximately 1.67 billion gallons — an increase of approximately 340 million gallons, which, based on the figures in HRI's Groundwater Restoration Budget spreadsheet in Attachment E-2-1 of the RAP, represents an *additional 13 months* of restoration activities.

B.3. Reliance on License Condition 9.5

21. In lieu of developing a technical basis for an HFF specific to the Church Rock site, HRI and the NRC Staff fall back on SUA-1508 License Condition 9.5, which requires that

[4] As I stated in ¶ 13, I do not agree that allowing flare to the perimeter monitor well ring is acceptable. However, I am using this approach to illustrate what HRI could have done to provide a site-specific basis for an HFF that would be consistent with Mr. Pelizza's views about the extent of acceptable flare.

the initial surety estimate for restoration of the initial well fields at Section 8 be based on treating nine pore volumes of groundwater to restore the aquifer to primary and/or secondary standards. The nine pore volume figure is derived, at least in part, from the Mobil experience (FEIS at 4-40).

22. HRI used the nine pore volume license condition to determine restoration costs of the proposed Section 8 mine, even though the volume of groundwater to be restored is likely to be much greater than the amount estimated by HRI. The primary reason that I strongly believe that the proposed surety is insufficient to cover the cost of restoration at the HRI Section 8 mine is that restoration activities at Mobil Section 9 clearly demonstrated that nine pore volumes were insufficient to restore groundwater to either primary or secondary restoration standards. (See, e.g., FEIS Table 4.10 at 4-34 and Table 4.13 at 4-38; HRI Section 9 Summary Report, Attachment C; Mobil Oil, 1986.) Yet, NRC Staff identifies Mobil Section 9 as the site most analogous to the Section 8 Site and, therefore, conditions at Mobil Section 9 are considered to be indicative of the mining and restoration conditions that will be encountered at HRI's Section 8 site. Ford January Affidavit, ¶¶ 8-10. Accordingly, I will use the restoration history of Mobil Section 9 to demonstrate that HRI's RAP significantly underestimates the cost required to restore the Section 8 site.

C. HRI's and NRC Staff's reliance on the unsuccessful restoration at the Mobil Section 9 Pilot Project contributes to the underestimation of restoration costs for Church Rock Section 8.

23. Mr. Pelizza (January Affidavit, ¶ D.2) states that the methods used to calculate pore volume in the RAP are "consistent with the methods used for the Mobil Pilot in New Mexico." In essence, Mr. Pelizza is saying is that as long as the methods used were applied

consistently in previous documents and at other sites, the pore volume calculation itself must be valid. This approach has no merit. Using a non-site-specific horizontal flare factor and a number of pore volumes that is based on previously flawed data derived from the Mobil Section 9 experience cannot be justified in a regulatory context. In my view, the Mobil Section 9 data demonstrate that nine pore volumes of flow during restoration would not be sufficiently protective to calculate a proposed surety for the mine operations.

24. As outlined in Tables 4.9 and 4.10 of the FEIS and in Mr. Ford's May 11, 1999, affidavit (¶ 8), after 9.7 and 16.7 pore volumes, concentrations of several parameters remained above baseline values in the groundwater beneath the Mobil site. These water quality data are summarized in Table 1 below. If baseline values reported in Appendix B of NRC's 1988 Environmental Assessment for Mobil License Termination are used, eight of the 25 parameters, or approximately 32%, were not restored to baseline after flushing of the aquifer with 16.7 pore volumes. If the baseline values from Table 4.13 of the FEIS (with arsenic corrected per Mr. Ford's, May 11, 1999 Testimony, (¶10, footnote 2)) are used, 15 of the 25 parameters, or approximately 60%, were not restored to baseline after 16.7 pore volumes. Even if molybdenum were not considered a problem contaminant for the reasons set forth in HRI's 1993 Section 9 Pilot Summary Report at 6, 16.7 pore volumes of restoration effort were not adequate to restore much of the groundwater to baseline conditions.

25. As discussed by Mr. Ford (January Affidavit, ¶ 8, and May 11, 1999, Affidavit, ¶¶ 5-6), "after nine to ten pore volumes of restoration effort at the Mobil 9 site, 42% of the monitored water quality parameters were returned to baseline, and approximately 74% of these parameters met the secondary restoration goals described in LC 10.21 of HRI's License." Mr.

Table 1
Baseline Values and Concentrations of Parameters after 9.7 and 16.7 Pore Volumes at Mobil Section 9 Pilot ISL Project (1980-1986)

Parameter	Concentration after 9.7 PV[1]	Concentration after 16.7 PV[2]	Baseline[3] Mean + 3σ	Baseline[4] FEIS, Tbl. 4.13
Arsenic	0.079	0.032	0.025	0.004
Barium	0.2*	0.22*	0.7	0.1
Bicarbonate	122	225		228
Boron	0.1	0.22*	0.5	0.1
Cadmium	<0.005	<0.007	0.036	0.006
Calcium	38	46		5.8
Chloride	150	101	99.8	20.3
Chromium	<0.005	0.011*	0.074	0.007
Copper, dissolved	<0.005	0.012	0.029	0.01
Fluoride	<0.3	<0.5	0.93	0.39
Iron, dissolved	<0.02	0.37	5.5	0.67
Lead, dissolved	<0.02	<0.006	0.063	0.003
Manganese, dissolved	0.051*	0.096*	0.456	0.05
Mercury, total	<0.0001	<0.0001	0.00194	0.00024
Molybdenum, dissolved	9.7	4.8	0.661	0.172
Nickel, dissolved	<0.002	<0.02	0.11	0.02
Nitrate (as N)	0.07	<0.05	0.69	0.09
Comb. Ra-226 & 228	46.7*	37.4*	<89.4	<14.1
Selenium, dissolved	0.095	0.032	<0.01	0.01
Silver, dissolved	<0.005	<0.006	<0.01	<0.01
Sodium	156	141		114
Sulfate (as SO4)	43*	85*	138	38
TDS (at 180 C)	587*	517*	589	357
Uranium (as U)	0.54	0.28	0.062	0.01
Zinc	0.02	0.03		0.01

[1] Values after 9.7 pore volumes from HRI 1993 Section 9 Pilot Summary Report

[2] Values after 16.7 pore volumes from HRI 1993 Section 9 Pilot Summary Report

[3] Baseline mean plus 3σ (standard deviations) and values from NRC 1988 Environmental Assessment

[4] Baseline values from FEIS Table 4.13. (As corrected per Ford, May 11, 1999 testimony)

* Indicates values for parameters that were not below baseline, according to FEIS Table 4.13

Ford goes on to state (at ¶ 8) that this "successful" restoration was "...the basis of the nine pore volume restoration requirement stated in HRI's license." In other words, the NRC Staff considers an acceptable restoration to be one where *more than 50 percent of the water quality parameters were not returned to baseline* and 25 percent of the parameters are not even returned to less stringent secondary restoration goals. Obviously, the basis for restoration of the aquifer using nine pore volumes significantly underestimates the effort that would likely be required to restore the aquifer to even a secondary restoration goal.

26. The statements by Mr. Ford, as well as information discussed above, clearly demonstrate that the Mobil Section 9 site was not restored to baseline or even to the secondary restoration standard. Based on this testimony it is apparent that the NRC staff has already decided that restoration operations at Churchrock Section 8 by HRI will not be able to restore the groundwater to baseline conditions. In his May 11, 1999, affidavit, Mr. Ford states that, "(b)ased on Mobil Section 9 pilot data...in the 9-10 pore volume range as a cut-off to judge successful restoration, it is unlikely that groundwater restoration activities at the Church Rock site will achieve baseline concentrations for all parameters."

27. Mr. Ford states (January Affidavit, ¶ 4), "As an additional check on how much surety should be required, HRI committed to completing a ground water restoration demonstration". As outlined in COP Rev. 2.0 (at 165-167), "Restoration will continue until the groundwater is restored to levels consistent with baseline." The COP (at 163-164) also outlines the groundwater restoration criteria as follows:

> HRI plans that groundwater restoration criteria be established on a parameter-by-parameter basis, with the primary goal of restoration to return all parameters to average pre-mining baseline conditions. To the extent that water quality

> parameters cannot be returned to the identical average pre-mining baseline levels, the secondary goal will be to return the water quality to the maximum concentration limits as specified in EPA primary and secondary drinking water regulations (10 CFR part 141 and §143.3).

The FEIS (at 2-20) explicitly states that restoration efforts must be conducted in an effort to achieve baseline conditions and only "in the event water quality parameters cannot be returned to average pre-mining baseline levels *through reasonable restoration efforts*, the secondary goal would be to return water quality to the maximum concentrations specified in EPA regulations in 40 CFR Part 141 and §143.3, secondary and primary drinking water standards" (emphasis added).

28. NRC's own guidance for uranium ISL mines cautions against relying on secondary standards: "Applications should state that secondary standards will not be applied so long as restoration continues to result in significant improvement in groundwater quality." Draft Standard Review Plan at 6-4. This statement clearly infers that restoration to baseline conditions should be attempted, at the very least, before lowering the restoration goals to secondary restoration standards.

29. Contrary to Mr. Ford's conclusions, NRC erred when it required, by license condition, a surety estimate based on only nine pore volumes, and assumed that this estimate was conservative. Treating nine pore volumes in an attempt to achieve restoration of the aquifer will not return groundwater within the aquifer to baseline water quality. Therefore, as HRI plans to attempt restoration to baseline water quality, the surety estimate must be increased to include more pore volumes so that the NRC can make a reasonable restoration attempt to achieve baseline should HRI default on its restoration obligations. Leaving the surety at a level sufficient

to fund only nine pore volumes of restoration would be tantamount to the NRC not requiring a reasonable attempt to achieve the primary restoration standards.

D. Bison Basin is a poor example of commercial-scale restoration because the State of Wyoming had to assume responsibility for restoring the site after the operator walked away from its restoration obligation

30. Mr. Ford uses the Bison Basin Project as an example of what he believes is a successful restoration of a commercial well field in Wyoming (Ford January Affidavit, ¶¶ 20-21, January 22, 2001). He uses this example to refute the testimonies of both Dr. Staub (January 11, 1999 at 12), and Mr. Ingle (December Testimony, ¶ 45) that no commercial ISL well field has been restored in Wyoming. The fact is that the Bison Basin commercial well field was restored by the State of Wyoming, *not* by the mine operator. Johnston, 1989, at 5 (attached hereto as **Att. B-3**). The mine operator walked away from the site and the State of Wyoming was forced to use money from a letter of credit to conduct restoration activities.

31. A condition for payment of this letter of credit, to which the State of Wyoming agreed, served to restrict the restoration "to the requirements permitted in the reclamation plan..." Id. The State of Wyoming used best practicable technology, according to the restoration plan in the permit, as required by the letter of credit payment agreement. The State of Wyoming qualified the limited "successful reclamation" of the site and issued recommendations to minimize the possibility of a limited restoration occurring in the future.

32. For Mr. Ford to claim that Bison Basin was successfully restored significantly distorts the facts for the following reasons:

- The DEQ had limited funds available to restore the mine and the method of restoration was limited by the letter of credit to the technology outlined in the permit.

- After restoration was completed, the concentrations of five constituents exceeded the target restoration values set for these constituents.

- The WDEQ also found that the Bison Basin aquifer was not stable or in equilibrium at the end of the stability period and that six months was not a sufficient monitoring period to determine the time required for the aquifer to become stable (i.e., the concentrations of analyzed parameters continued to increase throughout the monitoring period.). Johnston, 1989, at 27-30 (see, **Att. B-3**). The DEQ ultimately recommended that the aquifer would need to be monitored for a period of 12 to 18 months to determine when the aquifer had finally become stable.

- The quality of the sample data was suspect and may not have actually been representative of groundwater conditions.

Based on the facts underlying Wyoming's restoration of Bison Basin, it is questionable at best to identify this ISL project as an example of "successful restoration." If anything, the Bison Basin Decommissioning Project should demonstrate the need to have an adequate, *initial* surety to restore the aquifer should the mine operator default on their obligations. Mr. Ingle and Dr. Staub were correct in their assertions that no commercial wellfield has been restored by the mine operator at any uranium ISL facility in Wyoming.

E. Costs for mechanical integrity testing should be included in the RAP

33. In his December 2000 testimony, Mr. Ingle (¶ 43) asserted that HRI did not include in the RAP costs associated with mechanical integrity testing of each injection well. These costs are necessary because the integrity of any injection well casing is integral to ensuring that restoration fluids are delivered to the aquifer being restored and not to other intervals where they could degrade the water quality of those aquifers. Mr. Ford (January Affidavit, ¶ 18) states

that "...during groundwater restoration, injection wells would be injecting clean water. A casing failure at this time might decrease the efficiency of the restoration effort by a small amount, but is unlikely to degrade the water quality of overlying aquifers." This testimony obfuscates the issue.

34. Mechanical integrity testing is the primary method to determine and ensure that mining fluids are being injected into only the permitted aquifer. Mechanical integrity testing of all injection wells is required initially, after work on the well that could damage the well casing, and after every five years of use to ensure that the well integrity is maintained and the mine operator is injecting into the exempted aquifer permitted for injection. Determination of the water quality of all overlying intervals or aquifers is not required to the same degree as is required for groundwater in the ore zone. For instance, the number of wells sampled for baseline is less in overlying and underlying aquifers than in the aquifer being mined. Typically, the same level of characterization is not required (barring any excursions) as these overlying and underlying aquifers should not be impacted by mining operations. Consequently, whether the water used to restore the aquifer is of better or poorer quality than that in the aquifer or interval being affected by a break in the well casing often is not known.

35. Mr. Pelizza states that costs for mechanical integrity testing are not included in the RAP because the wells would be tested by site staff during routine operations. Pelizza January Affidavit at 23. However, RAPs should be inclusive enough to ensure that the regulating authority will have adequate funds to restore the site should the mine operator default on its obligations. A regulating authority is obligated to assume a reasonable worst-case cost scenario should a bond or surety be forfeited and it be necessary for the agency to restore the site.

Therefore, the NRC must assume that records and equipment will not be available to document the condition of the site and that the agency would have to incur additional cost to hire a contractor to conduct mechanical integrity testing. In any case, NRC will have to conduct mechanical integrity testing of the wells at some point during restoration due to work on the wells, because time has elapsed between installation and restoration, or because of the unknown condition of the well. Therefore, sufficient surety must be established to address this cost. In my experience, Mr. Ingle's estimate of $100 per well is reasonable (Ingle Testimony, ¶ 43). If all 215 injection wells were tested at least once during the restoration period, an additional $21,500 would need to be included in the surety estimate.

36. This concludes my testimony.

AFFIRMATION

I declare on this 23 day of May, 2001, at Tuscaloosa Alabama, under penalty of perjury that the foregoing is true and correct to the best of my knowledge, and the opinions expressed herein are based on my best professional judgment.

April Lafferty

Sworn and subscribed before me, the undersigned, a Notary Public in and for the State of Alabama, on this 23rd day of May, 2001, at Tuscaloosa Alabama.

My Commission expires on 4-2-02.

Michele Moore (Harris)
Notary Public

APRIL LAFFERTY

EDUCATION

M.S., Geology, University of Cincinnati, 1992
B.S., Geology, Bloomsburg University, 1989

PROFESSIONAL EXPERIENCE

Hydrogeologist **1998-present**
American Geosciences, Inc., Murrysville, PA
- Reviewed hydrogeologic aspects of uranium mine Environmental Impact Statement for Australian Commonwealth Government. Provided technical expertise on the proposed monitoring program, hydrogeologic issues associated with the mining method, and characterization of the aquifer. Developed report of key issues and recommendations.
- Reviewed technical reports on the geology and hydrogeology of a solvent impacted site to determine if contaminants were migrating offsite and impacting a town's water supply. Prepared report of findings to aid expert witness testimony.

Electronic Systems Manager/CHIA Coordinator **1997-1998**
Wyoming Department of Environmental Quality, Land Quality Division, Cheyenne, WY
- Hydrogeologist responsible for ensuring regulatory compliance at in-situ uranium mines. Responsible for inspections and other permitting tasks. Assisted in writing regulations and shaping regulatory standards for uranium mines.
- Hydrogeologist responsible for preparing and writing cumulative hydrologic impact assessments (CHIAs) to meet federal coal mining permitting requirements. CHIA preparation involved collection, review and analysis of available ground water and surface water quality and quantity data for each mine and synthesis of that data into an impact assessment report for all mines in a drainage basin.

Hydrogeologist **1995-1997**
Wyoming Department of Environmental Quality, Land Quality Division, Cheyenne, WY
- Hydrogeologist responsible for ensuring regulatory compliance at coal, sand and gravel, and uranium mines. Responsible for inspections and other permitting tasks.
- Prepared reports for and letters to mine operators, the public, and the Nuclear Regulatory Commission.
- Assisted in writing regulations and shaping regulatory standards for the mining industry.

Associate Geologist **1994-1995**
Foster Wheeler Environmental Co., Denver CO
- Field Operations Leader in charge of a multi-phase radiological characterization at a military installation. Responsible for designing, implementing, and managing the following field programs: soil sampling, air sampling, bioassay sampling, surveying, and radiological analysis. Also responsible for data management and cost analysis. Managed a staff of four geologists.
- Field Operations Leader for a geotechnical investigation to identify potential landfill liner material at a Superfund site. Responsible for oversight of field activities and personnel, budget tracking, field investigation reports, database development and management, and the final report.
- Field Operations Leader in charge of a geophysical investigation of ordinance disposal pits on a federal military reservation. Responsible for field program design, supervision, and management. Coordinated all activities with several agencies of the federal government.

Attachment
A

Geologist **1993-1994**

American Geosciences, Inc., Murrysville, PA

_ Performed aquifer tests, collected water quality and soil samples, analyzed site conditions, and prepared reports.

_ Conducted UST assessments and closures at public and private sites. Responsible for acquiring all necessary permits, supervising tank removals, soil and ground water sampling, communicating with client and regulatory officials, interpreting data, determining remedial solutions, and preparing the final site closure reports.

_ Performed numerous Phase I environmental liability assessments and subsequent Phase II investigations for lawyers and banks for property transfer in several states.

THE STATE OF WYOMING

JIM GERINGER
GOVERNOR

Department of Environmental Quality

Herschler Building • 122 West 25th Street • Cheyenne, Wyoming 82002

ADMINISTRATION	ABANDONED MINES	AIR QUALITY	INDUSTRIAL SITING	LAND QUALITY	SOLID & HAZARDOUS WASTE	WATER QUALITY
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FAX 777-7682	FAX 634-0799	FAX 777-5616	FAX 777-6937	FAX 634-0799	FAX 777-5973	FAX 777-5973

March 1, 1999

Ms. Pamela French
Rio Algom Mining Corporation
Smith Ranch Facility
P.O. Box 1390
Glenrock, Wyoming 82637

RE: TFN 3 5/232, Flare Factor Justification, Rio Algom Mining Corp. (RAMC), Permit No. 633

Dear Ms. French:

The Land Quality Division (LQD) has received RAMC's response to Comment 6.11 and Attachment 1 of the 1997-98 Annual Report Review. This information has been assigned Temporary Filing Number 3 5/232. Please find enclosed the LQD's first round review of this information.

The LQD does not believe that this information adequately demonstrates an understanding of the extent that mining fluids travel beyond the in-situ pattern boundaries. Additional information has been requested to support the technical justification for RAMC's flare factors.

Please respond to review comments in timely manner. If you have any questions, please contact Paula Cutillo of the District I office at (307) 777-7066.

Sincerely,

Georgia A. Cash
District I Supervisor
Land Quality Division

Enclosure

GAC/pc

cc: Paul Goranson (OK City)
Marvin Freeman (OK City)

Attachment
B-1

MEMORANDUM

TO FILE: TFN 3 5/232, Rio Algom Mining Corp., Permit No. 633

FROM: Paula Cutillo, District I Groundwater Hydrologist PC

DATE: February 12, 1999

SUBJECT: Flare Factor Justification, First Round Technical Review

INTRODUCTION

The Land Quality Division believes that the groundwater restoration costs used to calculate the reclamation bond for Permit No. 633 are underestimated. Rio Algom Mining Corp. (RAMC) was asked by the Land Quality Division (LQD) to provide justification for the flare factors used to calculate affected pore volume and groundwater restoration costs (LQD letter dated February 27, 1998). No justification was provided prior to the 1997-98 Annual Report Review.

The LQD informed RAMC that an analysis of their flare factors and estimated restoration costs was being done by the Division in Comment 6.11 of the 1997-98 Annual Report Review (LQD letter dated August 20, 1998). The LQD pore volume analysis was submitted as Attachment 1 to the Annual Report Review on September 9, 1998.

RAMC responded to Comment 6.11 and Attachment 1 with 1997-98 Annual Report Review Responses dated November 8, 1998, and met with LQD on November 17, 1998 to discuss these responses. The LQD has assigned this information Temporary Filing Number (TFN 3 5/232).

REVIEW

RAMC's response includes comments on the LQD pore volume analysis. The LQD has briefly responded to RAMC's concerns regarding the analysis. Please note that the LQD pore volume analysis was performed for two general reasons. The analysis was used to recalculate RAMC's bond to insure that the bond amount will adequately cover the cost to the State for performing groundwater restoration. Additionally, the analysis was performed to initiate a discussion concerning the technical basis for RAMC's flare factors. As the bond is in the process of being increased and RAMC has provided a discussion on their flare factor, further explanation of the LQD pore volume analysis has been limited in this review.

RAMC's response also justifies their flare factor based on data from the Q-Sand Pilot restoration. The LQD does not believe that this information adequately demonstrates that RAMC has based their flare factors on an understanding of the extent that injection and mining fluids travel beyond the pattern boundaries. This understanding is important in regard to mining efficiency and the cost of groundwater restoration. The following comments request additional information in regard to this concern.

<u>LQD Pore Volume Analysis</u>

1. RAMC states in Response 6.11:

> *"There is no basis or justification indicated [for] this flare factor other than it is a larger number and another ISL operation has apparently agreed to this amount."* (RAMC letter dated November 8, 1998)

In the November 17, 1998 meeting, it was clarified that the LQD's pore volume analysis was based on the pore volume analysis completed by LQD for the Highland Ranch Uranium Project. The technical justification for the LQD's method of determining pore volume is detailed in this study. Ms. Pamela French of RAMC confirmed during the meeting that RAMC received a copy of this study from the LQD. Mr. Paul Goranson of RAMC stated that he did not see study.

2. In Response 6.11, RAMC states that LQD's conclusion that RAMC's horizontal flare factor results in less than 10 ft. of horizontal flare beyond the pattern boundaries is incorrect because the 1.1 (110%) flare factor is applied to the entire wellfield and not to a single pattern of 100ft x 100ft.

   a. The LQD used one pattern to illustrate the extent of horizontal flare because RAMC's groundwater restoration costs are based on the volume of affected groundwater for *one pattern*.

      Table 2 on Page 6-51 in Volume I of Permit No. 633 calculates the affected pore volume for one pattern and then multiplies this number by 218 patterns to determine the 'Effected Pore Volume' of a 'Nominal Mining Unit'. Restoration costs *per pattern* are then calculated from the cost of restoring this mine unit.

      The per pattern restoration cost is multiplied by the number of patterns in each Annual Report (Section 7, Page 49, 1997-98 Annual Report). The LQD, therefore, believes that RAMC is using the volume of flare associated with one 100 ft. x 100 ft. pattern to determine the cost of groundwater restoration.

   b. The LQD agrees that the affected pore volume will increase with the size of the wellfield. The ratio of the area of affected groundwater to the pattern or wellfield area, however, remains the same. For example, assuming 10% horizontal flare and 20% vertical flare:

Pattern area =	10,000 ft^2	Wellfield area (218 patterns) =	2,180,000 ft^2
Affected pattern area =	13,200 ft^2	Affected wellfield area =	2,877,000 ft^2

      The ration of pattern or wellfield area to affected area is 1.32 in both cases.

The LQD maintains that a horizontal flare of approximately 7.5 ft. beyond the pattern boundary is an unrealistic basis for estimating the cost of groundwater restoration.

3. RAMC outlines several reasons why LQD's proposed flare factors are unreasonable and unfair. Several of these reasons have been discussed in prior correspondence and meetings, but are briefly addressed here:

- One justification provided by RAMC for a flare factor of 1.32 is that they have not yet had an excursion, while operations with higher flare factors have had excursions. The LQD believes that excursions are related to the operator's ability to maintain a balanced wellfield, not estimate flare.

- RAMC has noted that because a flare factor of 1.44 has been accepted by LQD for Cogema and Power Resources Inc. (PRI), the LQD is being unreasonable and inconsistent by requiring RAMC to use a higher number.

  Cogema is in District III and appears to be very close to restoring one of their wellfields. Their flare factor of 1.44 will be evaluated based upon the accuracy of their predicted vs. actual time and costs for restoration.

  The Highland Uranium Project operated by PRI is in District I and is located near RAMC. This operation used a flare factor of 1.44 until the LQD completed the above referenced pore volume analysis for the mine. Their current flare factor of 2.94 is a direct result of PRI's additional work with LQD and represents a negotiated increase from 1.44 to 2.94. PRI has been bonded at higher flare factor than RAMC for three years and is performing restoration.

  In addition to using a flare factor of 1.32, RAMC was neither performing restoration nor had they provided a technical justification for their flare factor. The LQD initiated the same process for RAMC that was required for PRI several years ago. RAMC was notified on several occasions over a period of two years of LQD's intent to address the flare factor issue (LQD letter dated December 9, 1998).

  LQD did not intend to treat, and does not believe that RAMC is being treated unfairly or inconsistently.

- RAMC has commented on the specific results of the LQD's pore volume analysis. Since RAMC has submitted these responses, the LQD has revised it's pore volume analysis (LQD letter dated December 11, 1998). The LQD will not, therefore, restate or address these responses.

<u>Q-Sand Pilot Restoration</u>
RAMC has presented data from the Q-Sand Pilot restoration to justify their horizontal flare factor. The Q-Sand Pilot consisted of five patterns which were in production for three years. Restoration of the Q-Sand Pilot was achieved through groundwater sweep.

4. RAMC states that all restoration targets were met within seven pore volumes. The case study submitted by RAMC as supporting information states that the restoration target values were approved by the Wyoming Department of Environmental Quality in 1984. Please clarify if the restoration target values were the baseline values or Water Quality Division Class of Use standards.

5. The data presented by RAMC shows that the Q-Sand was considered restored after approximately 23 million gallons of groundwater were removed from the pattern area. When a flare factor of 1.1 is used, this volume represents seven affected pore volumes.

RAMC has proposed a flare factor of 1.32 for calculating the affected pore volume for the commercial wellfields. Groundwater restoration will involve removing six affected pore volumes. (One pore volume will be treated with chemical reductant and re-injected at 95% and two pore volumes will be treated with reverse osmosis and re-injected at 75%.) RAMC believes that a slightly larger flare factor will account for the reduction in the number of pore volumes removed during restoration of the Q-Sand and the number removed during commercial restoration.

a. As noted by RAMC, if a flare factor of 2.94 is applied to the Q-Sand data, then only 2.6 affected pore volumes would be needed to remove 23 million gallons (see attachment). This method of justification cannot be used to prove that either flare factor is correct. For this reason, the LQD is requesting that RAMC provide a technical justification for using a flare factor of 1.32, which demonstrates an understanding of what is occurring beneath a commercial wellfield (e.g., field investigations or groundwater modeling to support the estimates of horizontal flare).

b. Additionally, it has been shown by RAMC and LQD that wellfield scale, pattern geometry, and hydrogeology affect the volume and extent of affected groundwater. The LQD believes restoration of RAMC's commercial wellfields will be significantly different from the Q-Sand pilot restoration due to differences in scale, pattern geometry, and hydrogeology. These factors, in addition to the fact that RAMC has not yet restored a commercial wellfield using reductant and reverse osmosis, should be considered when discussing actual flare and the duration of restoration.

6. It is stated in response to Comment 6.11, that

> *"In theory, assuming that the affected pore volume estimate is correct, one pore volume sweep will remove all of the impacted water from the pattern in-situ. The basis for having more than one pore volume sweep in the estimates is to account for the heterogeneous nature of the aquifer and more specifically the ore zone. It also accounts for the dilution from waters outside of the patterns."* (RAMC letter dated November 8, 1998)

RAMC proposes to remove six affected pore volumes during groundwater restoration. Please discuss why six pore volumes, as opposed to one or three for example, will account for the heterogeneous nature of the aquifer and for dilution.

Attachment

cc: Paul Goranson (OK City)
Marvin Freeman (OK City)

Rio Algom Mining Corp., Permit No. 633
TFN 3 5/232, Flare Factor Justification
February 12, 1999
Attachment

Q-Sand Pilot Restoration

	5 patterns	5 patterns	5 patterns
Average screened interval	30	30	30
Porosity	0.27	0.27	0.27
Horizontal flare	10%	10%	194%
Vertical flare	0%	20%	0%
Wellfield or pattern area	50,000 sq. ft.	50,000 sq. ft.	50,000 sq. ft.
Wellfield or pattern volume	1,500,000 cu. ft.	1,500,000 cu. ft.	1,500,000 cu. ft.
Wellfield or pattern pore volume	405,000 cu. ft.	405,000 cu. ft.	405,000 cu. ft.
Effected pore volume	445,500 cu. ft.	534,600 cu. ft.	1,190,700 cu. ft.
Effected pore area	14,850 sq. ft.	17,820 sq. ft.	39,690 sq. ft.
Effected wellfield or pattern area	55,000 sq. ft.	66,000 sq. ft.	147,000 sq. ft.
Overall flare factor	1.1	1.32	2.94
Effected pore volume	3,332,786 gal	3,999,343 gal	8,907,627 gal
Groundwater removed to reach targets	23,329,499 gal	23,329,499 gal	23,329,499 gal
# of pore volumes to restore Q-Sand	7.0	5.8	2.6

MEMORANDUM

TO FILE: TFN 3 5/232, Rio Algom Mining Corp., Permit No. 633

FROM: Paula Cutillo, District I Groundwater Hydrologist PC

DATE: July 13, 2000

SUBJECT: Flare Factor Justification, Third Round Review

INTRODUCTION

Rio Algom Mining Corp. (RAMC) submitted responses to the Land Quality Division (LQD) second round review in a letter dated May 10, 2000. The LQD and RAMC met in Cheyenne on May 11, 2000 to discuss these responses.

The following review requests that the flare factor study and Permit No. 633 be revised. Reviewers are Paula Cutillo and Roberta Hoy of the LQD. Reviewers' initials follow each comment.

COMMENTS

1.1 **Response conditionally acceptable.** RAMC has provided a printout of the raw Q-Sand restoration data which shows chloride, uranium, calcium, bicarbonate and sulfate concentrations and volume of groundwater removed over time. Please incorporate this information in the study.**(PC)**

1.2 Response acceptable. RAMC has clarified that the decrease in the number of peripheral injection wells during restoration of the Q-Sand is irrelevant in regard to the determination of the affected pore volume.**(PC)**

1.3 **Response conditionally acceptable.** RAMC has clarified that the pumping rate for the Q-Sand (33gpm) was much less than that proposed for the commercial wellfields. The study prediction using this rate is very close to that the actual restoration time (1.1 years vs. 1.5 years). Please include the Q-Sand pumping rate in the study.**(PC)**

1.4 Response acceptable. RAMC has stated that the restoration target values for the Q-Sand were a combination of Class of Use standards and baseline values. The target concentration used for the MLR model is the final concentration measured at the end of the Q-Sand Pilot restoration.**(PC)**

1.5 **Response conditionally acceptable.** RAMC has stated that the total volume of groundwater extracted during restoration of the Q-Sand Pilot as stated in the study (20,440,000 gals) is incorrect. A total volume of 28,989,035 gals were actually removed. This increases the affected pore volume from 6.39×10^6 gals to 9.06×10^6 gals. RAMC has stated that this does not affect any other result of the study. Please correct the study accordingly.**(PC)**

1.6 **Response conditionally acceptable.** RAMC has clarified that the statement in Subsection 3.1, which states that the MLR model was used to 'compute the pore volume requirements' does not mean that the model was used to determine the number of pore volumes. Rather, the MLR model was used to compute the pore volume flushing curves for the first 3 pore volumes of groundwater sweep required in Phase I of restoration. These calculations were performed using a spreadsheet. Please include the spreadsheet calculations in the study.**(PC)**

1.7 **Response conditionally acceptable.** RAMC has stated that the Q-Sand Pilot restoration and MLR model both indicate that Ra-226 will decline to the target value during the groundwater sweep phase of restoration. Therefore, there was no need to include it in the PHREEQC model. Additionally, the PHREEQC model is not capable of modeling Ra-226.

The LQD is in the process of reviewing one wellfield restoration package (Permit No. 603, TFN 3 4/261). The data for the A-Wellfield at the Highland Uranium Project is not consistent with what was observed at the Q-Sand Pilot or with what is predicted by the MLR model. Ra-226 actually increased within the production area as a result of restoration from a baseline average of 674.5 pCi/l to a post-mining average concentration of 1153 pCi/L. For this reason, it is difficult to accept RAMC's justification for not including Ra-226 in the modeling. The LQD believes that the time and cost to restore a commercial wellfield may be more than predicted due to the complex interaction of radionuclides. This may be verified with validation of the model. Validation of the model is further addressed below. Please include a discussion of Ra-226 in the study.**(PC)**

1.8 Response acceptable. RAMC has discussed the differences in the total volume of groundwater removed noted by the LQD. RAMC states that the differences are due to the inability of the MLR model to account for the injection of RO treated wellfield water.**(PC)**

1.9 Response acceptable. RAMC has stated that the pore volume requirements developed for the Q-Sand Pilot are generally appropriate for all of RAMC's commercial wellfields. RAMC has stated that the MLR model is not sensitive to the scale effect because it is not used to compute flare factors or the size of the affected pore volume.

By validating the MLR model with the results of the Q-Sand Pilot restoration, it is assumed that the restoration of a small pattern area is analogous to the restoration of a commercial wellfield. Although limited in number, the actual restoration of commercial wellfields in the State of Wyoming has not been analogous in time, cost or pore volume requirements, to the restoration of small-scale pilots. The results of the MLR model which are based on the Q-Sand Pilot restoration need to be validated with actual commercial wellfield restoration data. The completion of restoration in Wellfield 1 will provide an opportunity to validate the study predictions. Validation of the model is addressed further below.**(PC)**

1.10 Response acceptable. RAMC has not addressed the question of whether actual commercial wellfield restoration has been driven by conservative constituents such as chloride. However, RAMC has clarified that chloride did not drive the Q-Sand Pilot restoration because the target value of 250 mg/L was the Class I drinking water standard as opposed to the much lower baseline average.

As more commercial wellfields are restored, this data can be used to verify whether restoration will be driven by conservative constituents such as chloride. Validation of the study results is further addressed below.**(PC)**

1.11 Response acceptable. RAMC has clarified that the *net* production rates (production minus injection) are low relative to production and injection rates.**(PC for RH)**

1.12 **Response conditionally acceptable.**

a. RAMC has verified that there is an error in the noted statement in Section 3 on Page 16. The linear relationship shown on Figure 3-16 is valid only for well densities *greater* than 1.5e-04 wells/ft^2. Please correct the study accordingly.

b. The relationship represented in Figure 3-16 was discussed at length during the meeting on May 11, 2000. It was noted that the well densities for Wellfields 3 and 4 fall on the extrapolated portion of the line. During this meeting, RAMC agreed to not use flare factors which correlate to well densities less than 1.5e-04 wells/ft^2. Therefore, RAMC will not use a flare factor less than 1.5. The 1999-2000 Annual Report surety estimate is consistent with this agreement. Please revise the permit to include this commitment.**(PC)**

1.13 **Response conditionally acceptable.** RAMC has clarified that the Wellfield 1 simulation assumes that production and injection rates and overall wellfield balance remain steady throughout the simulation time. RAMC has stated that this assumption is conservative because the radius of influence represents the maximum affected area and the production and injection rates chosen represent historical maximum rates. Please revise the study to state the assumption.**(PC for RH)**

1.14 **Response conditionally acceptable.** RAMC has clarified that the flare factors noted on the figures in Attachment B were calculated by digitizing the particle clouds and using a CAD program to compute the area. Please revise the study to include this information. **(PC)**

1.15 **Response conditionally acceptable.** RAMC has noted that printouts of the computer files would be large and has proposed to provide the MODFLOW/MODPATH computer files on a diskette. Please submit the information in electronic form.**(PC for RH)**

1.16 Response acceptable. RAMC has not discussed restoration costs if a lower Kh/Kv ratio is used. The appropriateness of the 100/1 Kh/Kv ratio may be verified upon completion of restoration in Wellfield 1. Validation of the model is addressed further below.**(PC for RH)**

1.17 Response acceptable. RAMC has stated that they have taken a conservative approach to bonding for the cost to treat 6 pore volumes during restoration even though the geochemical modeling indicates that restoration can be achieved in 4 pore volumes. The LQD agrees that a conservative approach is justified until the model results are validated. Validation of the model is addressed further below.**(PC for RH)**

1.18 **Response conditionally acceptable.** RAMC has clarified that the flare factor noted on Figure C-2 was calculated by digitizing the particle cloud and using a CAD program to compute the area. Please revise the study to include this information.**(PC)**

1.19 Response acceptable. RAMC has explained that Figure 3-16 is a combination of Figures 3-8 and 3-9. Overall flare is reduced by a factor of 1 when the 100/1 Kv/Kh ratio is applied. RAMC has also stated that Figure 3-16 is to be used for RAMC wellfields other than Wellfield 1. Figure 3-16 alone would estimate the flare factor for Wellfield 1 to be 1.4. However, the 3-D modeling indicates the best estimate to be 1.7. RAMC has chosen the 1.7 flare factor for use in the bond as a conservative measure. Figure 3-16 cannot account for small variations in pattern geometry and its accuracy needs to be validated with actual commercial wellfield restoration data. Validation of the model is addressed further below.**(PC)**

1.20 **Response conditionally acceptable.** RAMC has provided the Gelhar and Wilson reference. Please include this reference in the study.**(PC)**

1.21 **Response not acceptable.** RAMC has stated that the results of this study could be applied to future wellfields if aquifer properties, well densities, and net production rates fell within the range of values investigated by the sensitivity analyses. RAMC needs to determine exactly what criteria must be met for the results of the study to be applicable to future wellfields. These criteria need to be included in the permit with the new method for estimating wellfield restoration costs. An alternative for wellfields not meeting the criteria also needs to be provided.**(PC)**

1.22 No response was necessary.**(PC for RH)**

2.1 Response acceptable. RAMC has verified that the new bonding methodology results in a significant increase in the total cost of groundwater restoration. The study itself does not need to be revised in regard to this comment.**(PC)**

2.2 Response acceptable. RAMC has stated to be consistent with the study, the Affected Pore Volume for Wellfield 1 will be revised to 68,920,890 gallons. RAMC has used this value in the 1999-2000 Annual Report surety estimate.**(PC)**

2.3 Response acceptable. RAMC has verified that the average open interval for wells in Wellfield 1 is 18ft. RAMC has stated that 18ft will be used in all future bond calculations. RAMC uses this value for Wellfield 1 in the 1999-2000 Annual Report surety estimate.**(PC)**

2.4 Response acceptable. The 3-D modeling estimated the flare factor for Wellfield 1 to be 1.7. RAMC chose this flare factor to be conservative.**(PC)**

2.5 Response acceptable. RAMC has stated the area was estimated and perimeter injection wells were counted so that Figure 3-16 could be used to determine flare factors for Wellfields 3 and 4. RAMC references the December 13, 1999 submittal for this data.

The December 13, 1999 submittal includes RAMC's calculated area for Wellfields 3 and 4 but does not include the number of peripheral injection wells. However, the 1999-2000 Annual Report surety estimate does include this information.**(PC)**

2.6 Response acceptable. RAMC has agreed to adjust restoration costs for inflation in the 1999-2000 Annual Report reclamation bond. The 1999-2000 Annual Report reclamation bond has been adjusted accordingly.**(PC)**

2.7 Response acceptable. RAMC has stated that they have taken a conservative approach to bonding for the cost to treat 6 pore volumes during restoration even though the geochemical modeling indicates that restoration can be achieved in 4 pore volumes. The LQD agrees that a conservative approach is justified until the model results are validated. Validation of the model is addressed further below.**(PC)**

CONCLUSIONS

- RAMC has proposed a revised method for estimating the cost to restore their commercial wellfields and has provided a technical justification for the new approach.
- The proposed method for estimating groundwater restoration costs needs to be validated with actual commercial wellfield restoration data.

RECOMMENDATIONS

- The LWC study should be revised to address the above comments.
- Permit No. 633 should be revised to:

  1. Include the flare factor study as an addendum or appendix;
  2. Summarize the revised method to be used by RAMC to estimate groundwater restoration costs. The permit should state that the flare factor for any wellfield will not be less than 1.5;
  3. State the calculated area, number of peripheral injection wells, total affected pore volume and flare factor for Wellfields 1, 3, and 4;
  4. State how groundwater restoration costs will be estimated for future wellfields; and
  5. Include a commitment to validate the method used to estimate groundwater restoration costs upon completion of restoration in Wellfield 1. Model validation should address the following:
     - The effectiveness of using Figure 3-16 to estimate flare factor and consequently, affected pore volume;
     - The impact of Ra-226 on restoration;
     - Comparison of flushing curves between a small-scale pilot, a commercial wellfield, and the model;
     - The role of conservative constituents such as chloride in driving restoration; and
     - The appropriateness of a 100:1 Kv/Kh ratio.

cc: Roberta Hoy, LQD

By: Steve Johnson, Hydrologist WDEQ-LQD

I. INTRODUCTION

The purpose of this final restoration document for the Bison Basin Decommissioning Project is to provide a record of, and to determine the success of, groundwater restoration efforts at the abandoned Bison Basin Uranium Mine, Fremont County, Wyoming. This documentation also provides a brief summary of the history of the Bison Basin site which is, otherwise, fairly scattered in the record.

The Bison Basin Uranium Mine is located in southern Fremont County, Wyoming, about 50 miles south of Riverton and 30 miles southwest of Jeffrey City as shown on Figure 1. The uranium ore zones are hosted by the basal sand of the Laney Member of the Green River Formation.

The technical feasibility testing of the Bison Basin site began in June 1977 with a "push pull" test. In 1979 a research and development project was initiated and in 1981 commercial scale mining began. In 1982 mining operations were suspended and in 1986 the mine was abandoned to the DEQ and restoration efforts began.

Baseline water quality was originally classified by WQD as Class III. In 1989, the baseline water quality was reclassified as Class IV water recognizing that pH and concentrations of sulfate, sodium and radium - 226 did not meet Class III criteria.

Attachment
B-3

Best Practicable Technology (BPT), as agreed upon in Permit No. 504, was used to restore the groundwater at this site and restoration was successful.

II. DISCUSSION

A. Site Description - Geog., Geol., & Hydrol.

The permit area is located in the sweetwater River Drainage Basin on the southeast flank of the Wind River Range about four miles north of the Continental Divide. The permit area is characterized by rolling terrain which slopes to the southeast at approximately 150 feet per mile. Elevations range from 7000 to 7200 feet above mean sea level. The permit area is drained by several small ephemeral washes which discharge into either Grassy Lake, a small closed depression, or West Alkali Creek as shown in Figure 2.

The uranium ore zones occur in the basal sands of the Laney Member of the Green River Formation. These units are Lower Eocene in age and are underlain by relatively impervious mudstones and siltstones which act as good aquicludes. The ore zone is located between Horsetrack anticline to the north and the McKay and Daley Lake synclines to the south. The Laney Member sandstone dips to the southeast at 180 feet per mile. Several east-west trending normal faults have been delineated in the vicinity of the mine.

The production zone aquifer within the 40-acre mine area is a relatively persistant sandstone unit, about fifteen thick, consisting of fine to course graned sands. The production zone lies about 375 feet below the land surface, has transmissivity valves which range from 117 to 198 gpd/ft and hydraulic conductivity valves which range from 5.8 to 10.0 gpd/ft^2. No significant vertical leakage was detected during pump tests. The potentiometric surface in the production zone aquifer is about 300 feet above the aquifer and has a southeast hydraulic gradient of .0009 feet/foot.

B. Site History

The technical feasibility of extracting uranium from the ore body at the Bison Basin site was established through two "push-pull" tests involving 4000 gal of a dilute mixture of ammonium carbonate and ammonium bicarbonate as the lixiviant and hydrogen peroxide as the oxident.

A Research and Development project was licensed and carried out in 1979 which involved the mining of a one acre test area by a 25 gpm plant. The lixiviant used was sodium carbonate/bicarbonate and the oxident used was oxygen which was injected down the hole. The test was successful in demonstrating the suitability of the ore body for both mineral extraction and aquifer cleanup using in-situ mining and restoration technology.

In August, 1980 the WY DEQ/LQD issued Permit No. 504 to Ogle Petroleum, Inc. to conduct a commercial scale insitu leach uranium operation at the Bison Basin site. Solution mining began in September 1981 and continued for one year. The lixiviant and oxydent used in the commercial operation was the same as was used in the R&D operation. Monitoring during the operation indicates that, overall, drawdowns were maintained throughout the commercial operation and subsequent stand-by period. Annual production plant bleeds during active mining were 2.8% and 1.3%. Production plant bleed during the standby period was 13.8% for the first year and 100% after that. Four excursions were documented during the commercial operation: two horizontal and one vertical. Correction measures included increasing production plant bleed, over producing the suspect well or wells and reducing injection in the vicinity of the suspect wells. Mining operations were suspended in September 1982 due to the depressed uranium market. Only Mining Unit No. 1 was ever operated. Ogle Petroleum continued to man the mine site 24 hours a day, seven days a week, after mining operations were suspended, and continued to perform all required regulatory monitoring and reporting until 1985.

In 1985 several things became apparent to the DEQ. Petroleum's Bison Basin interests had been transferred several times since 1980 and now these interests rested with Ogle Petroleum California. 2) Ogle Petroleum, Inc. had entered into a joint venture agreement with Western Fuel, Inc. in 1978 which made Western Fuel, Inc. jointly responsible for the Bison Basin Uranium Mine. 3)

None of the Ogle family of corporations intended to accept the responsibilities and obligations of Permit No. 504 for reclamation of the Bison Basin mine site. 4) All operations, including regulatory monitoring and reporting, were going to cease and Ogle Petroleum, Inc. of California was no longer going to serve as the operator of the mine.

As a result of these discoveries the license to mine was transferred into the name of Ogle Petroleum, Inc. of California. Western Fuel, Inc. submitted a letter of credit to the DEQ which was to cover Western Fuel's responsibilities towards reclamation of the Bison Basin Mine site.

Ogle Petroleum, Inc. of California ceased to act as operator of the mine thus, the State became owners of the mine and began bond forfeiture proceedures. The Western Fuel, Inc. letter of credit was drawn upon and a condition for payment was agreed to which restricted the State's restoration efforts at the Bison Basin Site to the requirements already permitted in the reclamation plan of Permit No. 504.

The DEQ awarded the contract for Phase I of the Bison Basin Decommissioning Project on August 1, 1986. Phase I of the project (primarily) involved aquifer restoration and stability monitoring. Active restoration began on October 23, 1986 and was completed on September 22, 1987. The stability of the aquifer was monitored each month for six months beginning in September 1987 and ending in March

1988.

No water quality data was available for the production zone aquifer after mining operations were suspended and before restoration efforts were initiated. Water quality data from excursion monitoring wells indicate that no excursions occurred between October 4, 1982 and the initiation of groundwater restoration efforts. Thus, whatever was in the production zone of the aquifer has apparently remained within the parameter of excursion monitoring wells.

C. Baseline

The original, undisturbed water quality, or baseline, was defined in three stages which correspond to the three stages of operations at the Bison Basin Mine. Baseline was first defined for the production zone aquifer prior to the push-pull test in June 1977. Samples were collected from four wells within the mineralized zone: OP-135, OP-136, OP-140-TC and OP-141-TC. Their locations are shown on Figure 3 and the results of the analysis are listed in Table 14-1 of the Permit Baseline was further defined late in 1978 prior to initiation of the R&D project. Four rounds of samples were collected from eleven wells between mid-August and late-October 1978. Ten of these wells were completed in the production zone and one in the overlying aquifer. Locations of these wells are shown on Figure 3 and the results of the analysis are listed in tables 14-2 and 14-3 of the permit. Finally, prior to the initiation of the commercial operation, four rounds of samples were collected, a minimum of one week apart, in the fall of 1980, from twenty-six wells. Seventeen of these wells were completed in the production zone, eight of which were designated as restoration sampling wells. Also included in the twenty-six were eight overlying aquifer wells and one underlying aquifer well. Table 1 lists the wells which were used to define baseline for all stages of the operation. Before sampling, the water level in the well was measured and then two casing volumes of water were pumped from the well. The samples were filtered through a .45 micron filter and preserved according to the EPA recommendations.

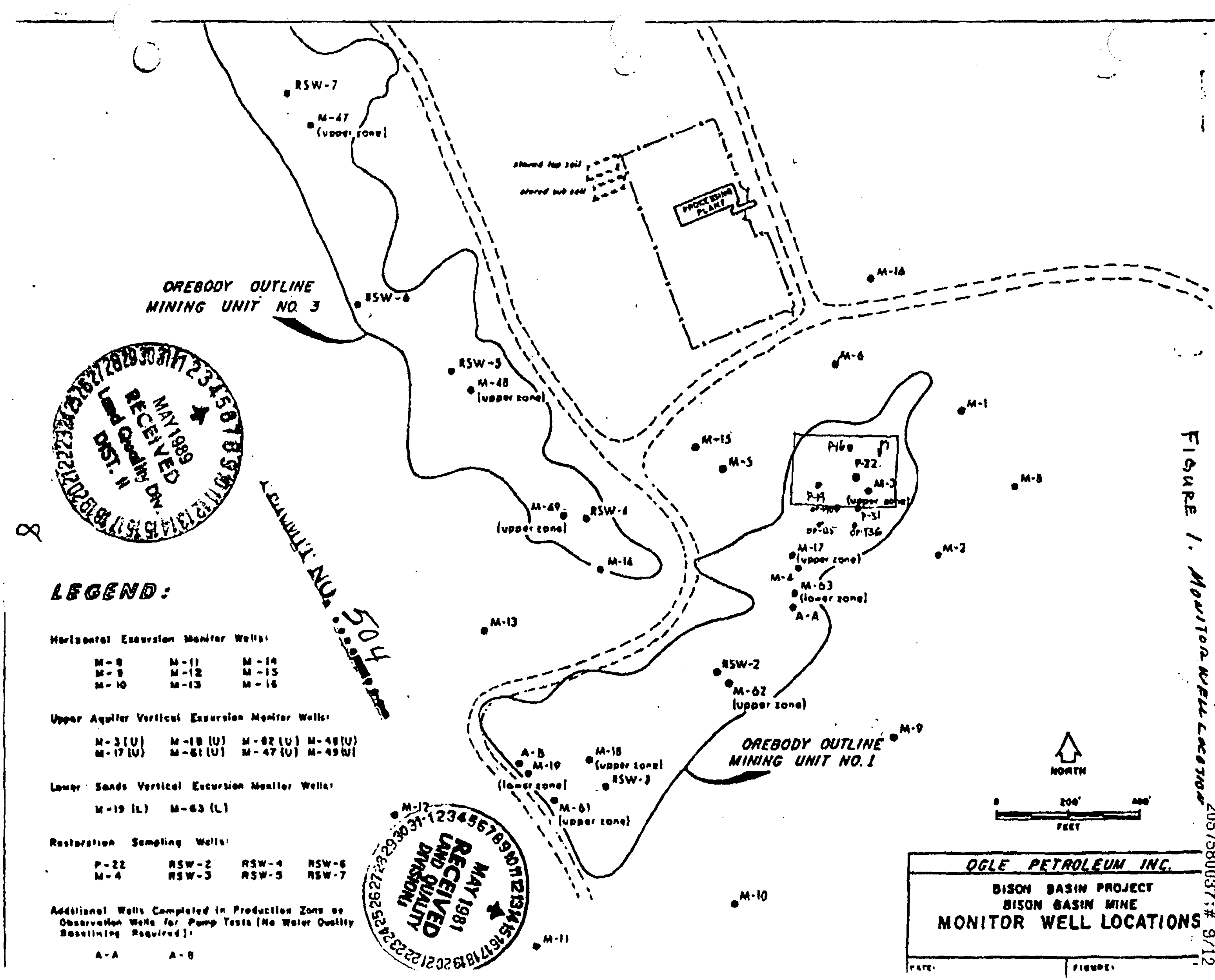


Figure 1. Monitor Well Location
OGLE PETROLEUM INC.
BISON BASIN PROJECT
BISON BASIN MINE
MONITOR WELL LOCATIONS
DATE:
FIGURE:
NORTH
0
200'
400'
FEET
LEGEND:
Horizontal Excursion Monitor Wells:
M-8 M-11 M-14
M-9 M-12 M-15
M-10 M-13 M-16
Upper Aquifer Vertical Excursion Monitor Wells:
M-3 (U) M-18 (U) M-62 (U) M-48 (U)
M-17 (U) M-61 (U) M-47 (U) M-49 (U)
Lower Sands Vertical Excursion Monitor Wells:
M-19 (L) M-63 (L)
Restoration Sampling Wells:
P-22 RSW-2 RSW-4 RSW-6
M-4 RSW-3 RSW-5 RSW-7
Additional Wells Completed in Production Zone as Observation Wells for Pump Tests (No Water Quality Baselining Required):
A-A A-B
OREBODY OUTLINE
MINING UNIT NO. 1
OREBODY OUTLINE
MINING UNIT NO. 3
PROCESSING PLANT
stored top soil
stored sub soil
RSW-7
M-47
(upper zone)
RSW-6
RSW-5
M-48
(upper zone)
M-49
(upper zone)
RSW-4
M-14
M-13
M-16
M-6
M-1
M-15
M-5
M-8
M-2
M-17
(upper zone)
M-4
M-63
(lower zone)
A-A
RSW-2
M-62
(upper zone)
M-9
A-B
M-19
(lower zone)
M-18
(upper zone)
RSW-3
M-61
(upper zone)
M-12
M-10
M-11
P-22
M-3
(upper zone)
P-31
Pile
RECEIVED
MAY 1981
LAND QUALITY DIVISION
RECEIVED
MAY 1989
Land Quality Div.
DIST. II
PERMIT NO. 504
8

TABLE 1 WELLS USED FOR DEFINITION OF BASELINE WATER QUALITY.

DEVELOPMENT STAGE	WELLS	AQUIFER	MINING UNIT
PUSH/PULL TEST	OP-135	ORE BODY	1
	OP-136	ORE BODY	1
	OP-140-TC	ORE BODY	1
	OP-141-TC	ORE BODY	3
RESEARCH AND DEVELOPMENT	303-6-M1	ORE HOST	1
	303-6-M2	ORE HOST	1
	303-6-M4	ORE BODY	1
	303-6-M5	ORE HOST	1
	303-6-M6	ORE HOST	1
	303-6-P7	ORE BODY	1
	303-6-P16	ORE BODY	1
	303-6-P19	ORE BODY	1
	303-6-P22C	ORE BODY	1
	303-6-P31C	ORE BODY	1
	303-6-M3	UPPER AQ	1
COMMERCIAL OPERATION	M3	UPPER AQ	1
	M4	ORE BODY	1
	M8	ORE HOST	1
	M9	ORE HOST	1
	M10	ORE HOST	1
	M11	ORE HOST	1
	M12	ORE HOST	1
	M13	ORE HOST	1,3
	M14	ORE HOST/BODY	1/3
	M15	ORE HOST	1,3
	M16	ORE HOST	1
	M17	UPPER AQ	1
	M18	UPPER AQ	1
	M19	LOWER AQ	1
	M47	UPPER AQ	3
	M48	UPPER AQ	3
	M49	UPPER AQ	3
	M61	UPPER AQ	1
	M62	UPPER AQ	1
	P22	ORE BODY	1
	RSW 2	ORE BODY	1
	RSW 3	ORE BODY	1
	RSW 4	ORE BODY	3
	RSW 5	ORE BODY	3
	RSW 6	ORE BODY	3
	RSW 7	ORE BODY	3

The range of baseline valves obtained at the mine are listed in Table 2. Baseline class of use for the production zone was originally identified by the DEQ/WQD in January 1980 as Class III, with the recognition that pH and radium-226 did not meet the criteria for this class of use. In 1989 the WQD re-examined the basline data and concluded "the (baseline) water quality in the production zone was unsuitable for any use other than industrial due primarily to high pH and the high concentrations of sulfate, sodium and radium-226." The water was reclassified as Class III in Bob Lucht's memo dated February 21, 1989.

Target Restoration Valves, TRV's, listed in Table 2 were based on baseline valves as defined for each parameter for a given mining unit. These baseline valves were defined as the highest valve obtained from the three, or four, rounds of baseline sampling collected from the restoration sampling wells within the specified mining unit. The one exception to this rule is radium-226 which varies drastically from one well to another. In this case the TRV's were defined for each restoration sampling well as the highest radium-226 valve obtained from the three or four rounds of sampling. The TRV's for those parameters which were not present in detectable quantities were defined as the lower detection limit, LDL, for that parameter. That is, the concentrations of those parameters should be reduced to below their respective LDL, with two exceptions: Nitrate and Barium. The TRV's for these two constituants were set at the class of use criteria for domestic water.

TABLE 2

TARGET RESTORATION VALUES
(Units: Mg/l Unless Otherwise Indicated)

PARAMETER	BASELINE RANGE[1]	LIVESTOCK CRITERIA[2]	DOMESTIC CRITERIA[2]	TARGET RESTORATION VALUES[3]
pH (pH Units)	8.05 to 11.4	6.5 to 8.5	6.5 to 8.5	6.5 to Baseline
TDS	1330 to 1812	5000	500	Baseline
Ammonia (as N)	0.07 to 2.5		0.5	Baseline
Nitrate (as N)	0.01 to 0.35	10.0	10.0	10.0
Nitrite (as N)	-0.01	1.0	1.0	1.0
Bicarbonate	0 to 150			500[4] (Total Carbonate)
Carbonate	20 to 48			
Calcium	12 to 62			500[4]
Chloride	9 to 52	2000	250	250
Boron	0.26 to 0.38	5.0	0.75	Baseline
Fluoride	0.66 to 1.2		1.4 to 2.4	Baseline
Magnesium	0 to 8			250[4]
Potassium	4.9 to 16			Baseline
Sodium	320 to 495			Baseline
Sulfate	725 to 1100	3000	250	Baseline
Aluminum	- 0.1	5.0		Baseline
Arsenic	-0.04	0.2	0.05	Baseline
Barium	-0.05		1.0	1.0
Cadmium	-0.02	0.05	0.01	Baseline
Chromium	-0.01	0.05	0.05	Baseline
Copper	-0.01	0.50	1.0	Baseline
Iron	0.01 to 0.13		0.30	Baseline
Lead	-0.05	0.10	0.05	Baseline
Manganese	-0.01		0.05	Baseline
Mercury	-0.001	0.00005	0.002	Baseline
Nickel	-0.05			Baseline
Selenium	-0.02	0.05	0.01	Baseline
Zinc	-0.01	25	5	5
Molybdenum	-0.05			Baseline
Vanadium	- 0.1	0.10		Baseline
Uranium (as U_3O_8)	0.001 to 0.04	5.0[5]	5.0[5]	5.0[5]
Radium 226 (pCi/l)	2.2 to 415.3	5.0[6]	5.0[6]	Baseline Plus [illegible] Error

→ P-16 12.1 ± 0.3
→ A-38 165.4 ± 0.4
→ B-5 70.2 ± 2.1
→ B-50 430.3 ± 1.18

NOTES:

- means not detected at level indicated.

Underlined number means restoration value is higher than expected background concentration.

1. Based on existing data collected from nine wells completed in the mineralized portion of the ore zone aquifer (Well Nos. OP-140-TC, OP-141-TC, OP-135, OP-136, 303-6-P 7, 303-6-P 16, 303-6-P 19, 303-6-P 22C and 303-6-P 330.

2. Based on water quality standards presented in Appendix A of the DEQ Staff Analyses of Comments dated January 14, 1980 (Table 1). Blank space means no criteria established.

3. Baseline is defined for each parameter for a given mining unit as the highest value obtained from the three rounds of baseline sampling (four rounds if significant variation) collected from the restoration sampling wells within the mining unit. Radium 226, because of its extreme variation from one well to the next, is the one exception to the above described definition of baseline. Baseline for radium 226 will be on a well-by-well basis; therefore, radium 226 baseline is defined for each restoration sampling well as the highest radium 226 value obtained from the three rounds of baseline sampling (four rounds if significant variation).

4. Criteria based on U. S. Dept. of Commerce publication entitled "Monitoring Groundwater Quality Monitoring Methodology", National Technical Information Service, PB-256 068L, June, 1976, page 142.

5. All uranium data presented in this application are uranium as U_3O_8. Livestock and domestic criteria given in this Table for uranium and the restoration value of 5.0 mg/l for uranium is on the basis of uranium as U. The conversion factor for converting uranium as U_3O_8 to uranium as U is 0.848.

6. Criteria for combined total of radium 226 and radium 228.

11

The R&D restoration efforts clearly showed that to return the water quality to baseline conditions for all parameters was neither technically practical nor economically reasonable. The restoration requirements, therefore, according to Chapter XXI LQD Rules and Regulations, are to restore the groundwater to a condition of pre-mining use suitability.

Post-it® Fax Note 7671	Date 5/11/01 # of pages ▸
To April Lafferty	From Mark Moxley
Co./Dept.	Co. Package 2 of 3
Phone #	Phone #
Fax #	Fax #

4. BEST PRACTICABLE TECHNOLOGY

A massive groundwater sweep and clean water recycle was used to restore the production zone aquifer. The produced water was treated by reverse osmosis, RO, the permeate reinjected into the aquifer and the effluent discharged into evaporation ponds. Active restoration began in October 1986 and was completed in September 1987. Six pore volumes, or approximately 115 million gallons, of production zone water was treated and reinjected during this time. The bleed/injection split was maintained between 30/70 and 25/75 throughout restoration.

This technology was reasonably applied at the Bison Basin site with only one real problem encountered. The membranes of the RO units became plugged on a regular basis with small colloidal clay particles. This problem was never completely solved but was controlled by cleaning wells, cleaning surg tanks, adding a flocculent to the feed water, and putting new sand in the sand filters.

These restoration efforts do constitute BPT as defined in Permit No. 504 in 1980. The DEQ/LQD was bound to the definition of BPT in this permit by the conditions for payment of the letter of credit from Western Fuels, Inc. When the letter of credit was drawn upon, the DEQ agreed to follow the reclamation plan as written into the 1980 permit even though those restoration efforts may not be considered BPT in light of more current technology.

5. RESTORATION EVALUATION

The groundwater monitoring program during active aquifer restoration and the subsequent six month stability period included 15 excursion monitoring wells and 10 restoration sampling wells. These wells are listed in Table 3 and 4. The excursion monitor wells were sampled twice a month during the circulation of the first three pore volumes and once a month during the circulation of the last three pore volumes. These samples were analyzed for conductivity, chloride and total carbonate and bicarbonate. The well locations are shown on Figure 2.

Some changes had to be made in the list of restoration sampling wells originally agreed to due to problems with some of the wells. Please refer to page 19 of the Final Report for Phase I of the Bison Basin Decommissioning Project (June, 1988) for further explanation. The list of wells in Table 4 are the wells which were finally agreed upon and which were sampled during restoration. These 10 wells were sampled twice a month for conductivity, chloride, and uranium from the time the well field and water treatment plan were placed into operation, October 23, 1986, until April 8, 1987. As of April 8, all three constituants were below their respective TRV's and three more parameters were included in subsequent analysis: total carbonate and bicarbonate, sodium and sulfate. Locations of restoration sampling wells are shown in Figure 1.

TABLE 3. EXCURSION MONITOR WELLS AT THE BISON BASIN SITE.

HORIZONTAL EXCURSION MONITOR WELLS

M-8
M-9
M-10
M-11
M-12
M-13
M-14
M-15
M-16

UPPER AQUIFER VERTICAL EXCURSION MONITOR WELLS

M-3
M-17
M-18
M-61
M-62

LOWER AQUIFER VERTICAL EXCURSION MONITOR WELL

M-19

TABLE 4. Final RESTORATION SAMPLING WELLS AT THE BISON BASIN SITE.

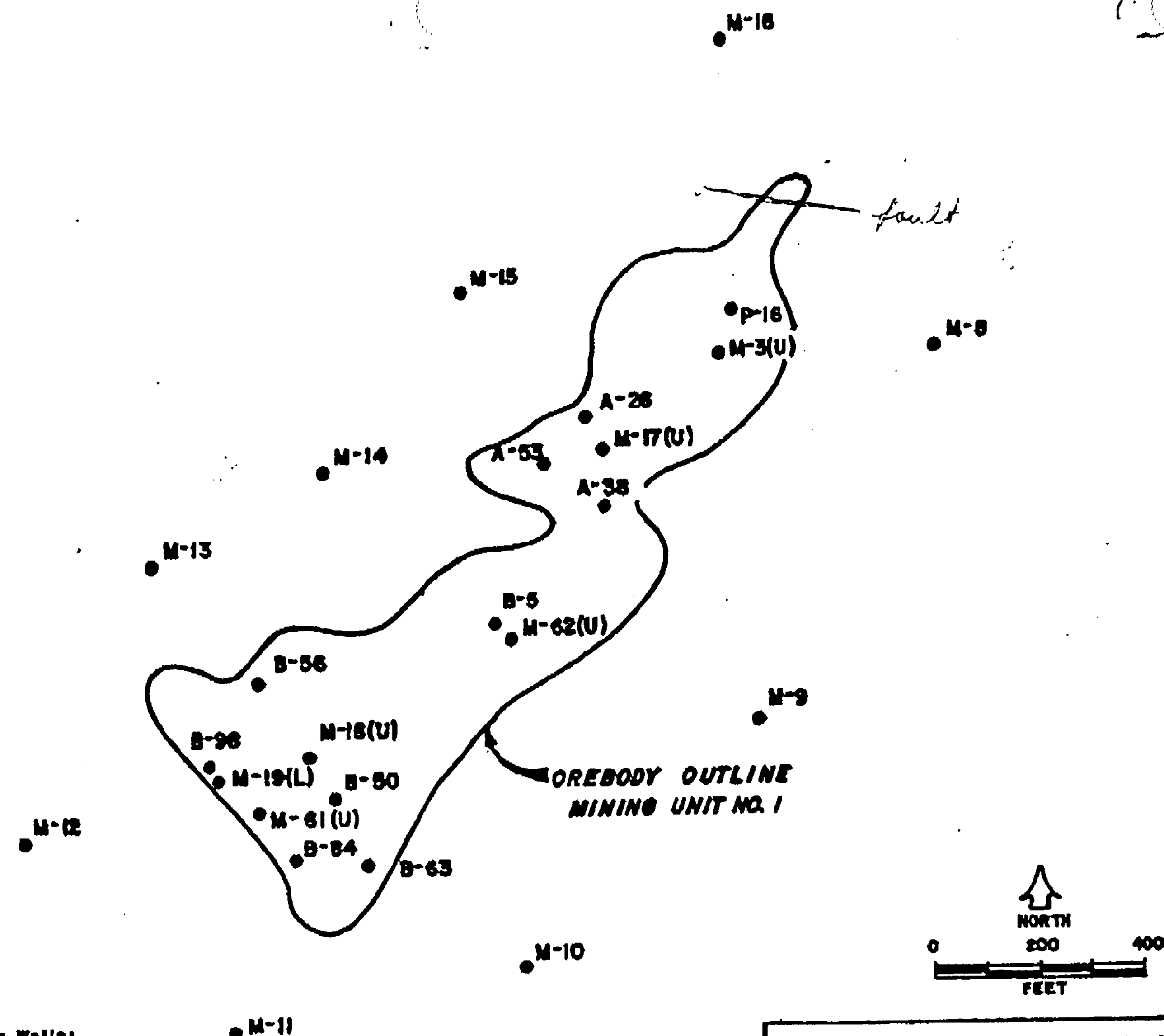
PRIMARY RSW'S

P-16
A-38
B-5
B-50

SECONDARY RSW'S

A-26
A-53
B-56
B-63
B-84
B-98

Figure 2



LEGEND

Horizontal Excursion Monitor Wells:

M-8	M-11	M-14
M-9	M-12	M-15
M-10	M-13	M-16

Upper Aquifer Vertical Excursion Monitor Wells:

M-3 (U) M-18 (U) M-62 (U)
M-17 (U) M-61 (U)

Lower Sands Vertical Excursion Monitor Wells:

M-19 (L)

Primary Restoration Sampling Wells:

P-16 B-5 (RSW-2)
B-50 (RSW-3)

Secondary Restoration Sampling Wells:

A-26	B-63
A-53	B-84
B-56	B-96

-16-

ALTAIR RESOURCES INC.

BISON BASIN DECOMMISSIONING PROJECT
MONITOR WELL LOCATIONS
MINING UNIT NO. 1

Dwg. By: PAH	Scale:	Revised:	Figure: 5.1

During the stability period the four primary restoration sampling wells were sampled monthly and analyzed for the list of parameters in Table 5.

TABLE ~~5.3~~ 5e - RESTORATION PARAMETERS~~, LONG LIST~~

(Units: mg/l unless otherwise noted)

pH (pH units)
TDS
Ammonia (as N)
Nitrate (as N)
Nitrite (as N)
Bicarbonate
Carbonate
Calcium
Chloride
Boron
Fluoride
Magnesium
Potassium
Sodium
Sulfate
Aluminum
Arsenic
Barium

Cadmium
Chromium
Copper
Iron
Lead
Manganese
Mercury
Nickel
Selenium
Zinc

Molybdenum
Vanadium
Uranium (as U_3O_8)
Radium 226 (pCi/l)

Well field averages for each water quality parameter, for each month during the stability period are presented in Table 6. The well field averages for arsenic, boron, flouride, iron and manganese exceeded their respective TRV's at the end of the stability period. All other parameters were at or below their respective TRV's.

The water quality data were averaged over the stability period on a well by well basis and are listed in Table 7 along with the standard deviations. The stability period averages for flouride and Boron exceed their respective TRV's at all wells. The stability period averages for arsenic, manganese and radium-226 exceeded their respective TRV's at two of the four wells. Finally the stability period average for iron exceeded its TRV at one of the four wells.

Table 6

WELL FIELD AVERAGES OF EACH WATER QUALITY PARAMETER FOR EACH STABILITY PERIOD SAMSTABILITY

PARAMETER	TRV	10/87	11/87	12/87	1/88	2/88	3/88	PERIOD	ST. DEV.
TDS	1812	714.5	721.5	755	737	791.8	780.5	750.05	28.70532
SPECIFIC CONDUCTIVITY						1319.166		1319.166	0.000009
SODIUM	495	258	255.25	257.5	257.5	265	268.75	260.3333	4.829740
POTASSIUM	16	3.2	4.075	3.675	3.825	3.26	3.8	3.639166	0.313121
CALCIUM	500	19.075	16.4	18.45	17.175	19.12	19.775	18.3325	1.179013
MAGNESIUM	250	3.25	3.25	3.375	3.25	4.73	3.425	3.546666	0.533632
SULFATE	1100	180.25	159.5	165.5	169.5	184.8	177.75	172.8833	8.863723
CHLORIDE	250	154.5	161	155.5	153.25	158.4	165.75	158.0666	4.286769
TOTAL CARBONATE	500	255.25	265.75	270.5	271.25	282.3	285.75	271.8	10.14355
PH (SITE)	6.5-11.4		7.1175	7.04	7.185	6.9875	7.075	7.081	0.067242
ALUMINIUM	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1		
AMMONIA	2.9	0.1025	0.1125	0.22	0.125	0.083	0.0825	0.120916	0.046828
ARSENIC	-0.04	0.01675	-0.0125	0.01	0.01575	0.0183	0.01725		
BARIUM	1	-0.05	-0.05	-0.05	-0.05	-0.32	-0.05		
BORON	0.38	0.3875	0.35	0.5	0.5	0.537	0.5	0.462416	0.068374
CADMIUM	-0.02	-0.02	-0.02	-0.02	-0.02	-0.0092	-0.02		
CHROMIUM	-0.01	-0.01	-0.01	-0.01	-0.01	-0.016	-0.01		
COPPER	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01		
LOURIDE	1.2	1.475	1.55	1.65	1.5	1.476	1.7075	1.55975	0.089290
IRON	0.13	0.0575	0.0875	0.1	0.05	0.087	0.3175	0.116583	0.091549
LEAD	-0.05	-0.05	-0.05	-0.05	-0.05	-0.032	-0.05		
MANGANESE	-0.01	0.04	0.025	0.0325	0.035	0.024	0.0275	0.030666	0.005713
MERCURY	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001		
MOLYB	0.05	-0.05	-0.05	-0.05	-0.05	-0.028	-0.05		
NICKEL	-0.05	-0.05	-0.05	-0.05	-0.05	-0.017	-0.05		
NITRATE	10	-1	-1	-1	-1	-0.406	-0.01		
NITRITE	1	-1	-1	-1	-1	-0.406	-0.01		
SELENIUM	-0.02	0.001	-0.02	-0.02	-0.02	0.0121	-0.00625		
URANIUM	5	0.297775	0.36625	0.3375	0.32625	0.38017	0.371925	0.346645	0.028969
VANADIUM	-0.1	-0.05	-0.1	-0.1	-0.1	-0.1	-0.1		
ZINC	5	0.005	0.0025	-0.01	-0.005	-0.01	-0.01		
RADIUM	12.4	74.125	62.125	43.85	55.475	67.9	64.775	61.375	9.653982

WELL FIELD AVERAGES OF EACH WATER QUALITY PARAMETER FOR EACH STABILITY PERIOD SAMSTABILITY

PARAMETER	TRV	10/87	11/87	12/87	1/88	2/88	3/88	PERIOD AVG
TDS	1812	714.5	721.5	755	737	791.8	780.5	750.05
SPECIFIC CONDUCTIVITY						1319.166		1319.166
SODIUM	495	258	255.25	257.5	257.5	265	268.75	260.3333
POTASSIUM	16	3.2	4.075	3.675	3.825	3.26	3.8	3.639166
CALCIUM	500	19.075	16.4	18.45	17.175	19.12	19.775	18.3325
MAGNESIUM	250	3.25	3.25	3.375	3.25	4.73	3.425	3.546666
SULFATE	1100	180.25	159.5	165.5	169.5	184.8	177.75	172.8833
CHLORIDE	250	154.5	161	155.5	153.25	158.4	165.75	158.0666
TOTAL CARBONATE	500	255.25	265.75	270.5	271.25	282.3	285.75	271.8
PH (SITE)	6.5-11.4		7.1175	7.04	7.185	6.9875	7.075	7.081 **
ALUMINIUM	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	
AMMONIA	2.9	0.1025	0.1125	0.22	0.125	0.083	0.0825	0.120916
ARSENIC	-0.04	0.01675	-0.0125	0.01	0.01575	0.0183	0.01725	
BARIUM	1	-0.05	-0.05	-0.05	-0.05	-0.32	-0.05	
BORON	0.38	0.3875	0.35	0.5	0.5	0.537	0.5	0.462416 *
CADMIUM	-0.02	-0.02	-0.02	-0.02	-0.02	-0.0092	-0.02	
CHROMIUM	-0.01	-0.01	-0.01	-0.01	-0.01	-0.016	-0.01	
COPPER	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	
FLOURIDE	1.2	1.475	1.55	1.65	1.5	1.476	1.7075	1.55975 *
IRON	0.13	0.0575	0.0875	0.1	0.05	0.087	0.3175	0.116583 *
LEAD	-0.05	-0.05	-0.05	-0.05	-0.05	-0.032	-0.05	
MANGANESE	-0.01	0.04	0.025	0.0325	0.035	0.024	0.0275	0.030666 *
MERCURY	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	
MOLYB	0.05	-0.05	-0.05	-0.05	-0.05	-0.028	-0.05	
NICKEL	-0.05	-0.05	-0.05	-0.05	-0.05	-0.017	-0.05	
NITRATE	10	-1	-1	-1	-1	-0.406	-0.01	
NITRITE	1	-1	-1	-1	-1	-0.406	-0.01	
SELENIUM	-0.02	0.001	-0.02	-0.02	-0.02	0.0121	-0.00625	
URANIUM	5	0.297775	0.36625	0.3375	0.32625	0.38017	0.371925	0.346645
VANADIUM	-0.1	-0.05	-0.1	-0.1	-0.1	-0.1	-0.1	
ZINC	5	0.005	0.0025	-0.01	-0.005	-0.01	-0.01	
RADIUM	12.4	74.125	62.125	43.85	55.475	67.9	64.775	61.375

compute well field average TRV

73.85

AVG 85

TABLE 7

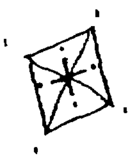
WELL 8-5

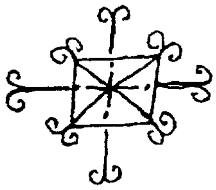
PARAM	HIGHEST	TARGET	10/22/87	11/24/87	12/22/87	1/23/88	2/23/88	3/22/88	average	std. dev.	AVG<TRV Y/N
[redacted]			706	712	754	716	752	744	[redacted]		Y
SP. COND.	2200								ERR	ERR	
[redacted]			255	252	252	246	254	26[redacted]			Y
[redacted]			3.6	4.3	4.3	3.8	4.3	4.3	[redacted]		Y
[redacted]			24.8	23.7	24.7	23.4	22.3	26	[redacted]		Y
[redacted]			4	4.7	5.1	4.5	5.2	4.6	[redacted]		Y
[redacted]			151	139	145	138	141	138	[redacted]		Y
[redacted]			148	157	149	144	148	164	[redacted]		Y
[redacted]			308	315	323	318	330	334	[redacted]		Y
[redacted]				7.29	7.26	7.51	7.1	7.35	[redacted]		Y *
ALUMINUM	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	ERR	
[redacted]			0.09	0.1	0.15	0.11	0.12	0.08	[redacted]		Y
ARSENIC	-0.04	-0.04	-0.04	-0.04	-0.04	-0.04	-0.04	-0.04	-0.04	ERR	
BARIUM	-0.05	1	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	ERR	
[redacted]			0.05	0.5	0.5	0.5	0.5	0.5	[redacted]		
CADMIUM	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	ERR	
CHROMIUM	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	ERR	
COPPER	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	ERR	
FLOURIDE [redacted]			1.5	1.5	1.5	1.4	1.4	1.55	[redacted]		
IRON	0.13	0.13	-0.1	-0.1	-0.1	-0.1	-0.1	0.11	-0.065	0.078262	Y ← last conc < TRV
LEAD	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	ERR	
MANGANESE [redacted]			0.06	0.05	0.05	0.05	0.05	0.[redacted]			
MERCURY	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	ERR	
MOLYB	-0.05	0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	ERR	
NICKEL	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	ERR	
NITRATE	0.39	10	-1	-1	-1	-1	-1	-0.01	-0.835	0.368951	
NITRITE	-0.01	1	-1	-1	-1	-1	-1	-0.01	-0.835	0.368951	
SELENIUM	-0.02	-0.02	-0.001	-0.02	-0.02	-0.02	-0.01	-0.01	-0.0135	0.007158	
URANIUM	0.04	5	0.333	0.378	0.467	0.342	0.3001	[redacted]			Y
VANADIUM	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	ERR	
ZINC	-0.01	5	0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.00666	0.007453	Y
RADIUM	419.3	12.4	99.8	83.9	68.3	75.3	92	72.2	[redacted]		

"Problem" Parameters

1. Boron
2. Flouride
3. Manganese
4. Radium

A parameter is a "problem" if the avg. conc. for the 6 stability period samples exceed the TRV.





how much

Master List
Problem Parameters

1. Arsenic
2. Boron stable
3. Flouride not stable
4. Iron not stable
5. Manganese stable
6. Radium not stable

SENT BY:WDEQ LANDER, WY ; 5-11- 1 ; 2:18PM ; → 2057580037;#12/13

HV685

WELL 8-50

PARAM	HIGHEST	TARGET	10/22/87	11/24/87	12/22/87	1/23/88	2/23/88	3/22/88	average	std. dev.	AVG<TRV
TDS	1812	1810									
SP. COND.	2200		800	732	712	672	704	664	[redacted]		Y
									ERR	ERR	
[redacted]			294	253	254	236	248	238	[redacted]		Y
[redacted]			3.3	4	3	4.7	3.2	3	[redacted]		Y
[redacted]			14.3	9.6	9.8	7.9	9	8.5	[redacted]		Y
[redacted]			4	2.2	2.1	2.1	2.5	2	[redacted]		Y
[redacted]			256	169	161	155	155	147	[redacted]		Y
[redacted]			158	156	151	148	155	160	[redacted]		Y
[redacted]			262	235	242	210	224	212	[redacted]		Y
ALUMINIUM	-0.1	-0.1		6.93	6.81	6.95	6.85	6.9	[redacted]		Y Y
[redacted]			-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	ERR	
ARSENIC	-0.04	-0.04	0.12	0.12	0.31	0.17	0.12	0.09	[redacted]		Y
BARIUM	-0.05	1	0.074	-0.04	0.06	0.08	0.08	0.084	0.056333	0.043763;	← Last conc < TRV
[redacted]			-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	ERR	
CADMIUM	-0.02	-0.02	0.5	0.5	0.5	0.5	0.5	0.5	[redacted]		
CHROMIUM	-0.01	-0.01	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	[redacted]		
COPPER	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	ERR	
[redacted]			-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	ERR	
[redacted]			1.5	1.7	1.9	1.7	1.8	2	[redacted]		
LEAD	-0.05	-0.05	0.1	0.12	0.2	-0.1	0.14	0.22	[redacted]		Y
MANGANESE	-0.01	-0.01	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	ERR	
MERCURY	-0.001	-0.001	0.01	-0.01	0.01	0.01	0.01	-0.01	0.003333	0.009428	Y
MOLYB	-0.05	0.05	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	ERR	
NICKEL	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	ERR	
NITRATE	0.39	10	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	ERR	
NITRITE	-0.01	1	-1	-1	-1	-1	-1	-0.01	-0.835	0.368951	
SELENIUM	-0.02	-0.02	-1	-1	-1	-1	-1	-0.01	-0.835	0.368951	
URANIUM	0.04	5	-0.001	-0.02	-0.02	-0.02	-0.01	-0.01	-0.0135	0.007158	
VANADIUM	-0.1	-0.1	0.306	0.368	0.13	0.316	0.0446	0.3001	[redacted]		Y
ZINC	-0.01	5	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	ERR	
[redacted]			0.01	0.02	-0.01	0.01	-0.01	-0.01	0.001666	0.012133	
			32.9	25.5	21.4	18.1	26.4	23.3	[redacted]		OK

PROBLEM PARAMETERS

1. ARSENIC
2. BORON
3. FLOURIDE
4. RADIUM

WELL A-38

PARAM	HIGHEST	TARGET	10/22/87	11/24/87	12/22/87	1/23/88	2/23/88	3/22/88	average	std. dev.	AVG<TRV
TDS	1812	1812	804	870	902	898	950	95	[redacted]		y
SP. COND.	2200								ERR	ERR	
[redacted]			295	306	307	313	319	325	[redacted]		y
[redacted]			3.6	4.5	4	3.9	3.4	4.	[redacted]		y
[redacted]			15.3	16.9	17.3	17.8	17	18.6	[redacted]		y
[redacted]			3.1	4.5	4.2	4.1	5	4.4	[redacted]		y
[redacted]			205	217	221	226	231	241	[redacted]		y
[redacted]			176	188	184	183	192	17	[redacted]		y
[redacted]			264	290	283	300	308	31	[redacted]		y
[redacted]				7.11	6.85	6.89	6.58	6.7	[redacted]		y*
ALUMINIUM	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	ERR	
[redacted]			0.1	0.12	0.17	0.11	0.09	0.08	[redacted]		y
[redacted]			0.073	0.07	0.06	0.063	0.07	0.065	[redacted]		
BARIUM	-0.05	1	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	ERR	[redacted] — last conc < TRV
BORON	0.38	0.38	0.5	-0.1	0.5	0.5	0.5	0.5	0.4	0.223606	
CADMIUM	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	ERR	
CHROMIUM	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	ERR	
COPPER	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	ERR	
FLOURIDE	[illegible]	[illegible]	1.4	1.3	1.3	1.3	1.35	1.	[redacted]		
IRON	0.13	0.13	0.33	0.43	0.4	0.5	0.58	0.71	[redacted]		y
LEAD	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	ERR	
MANGANESE	-0.01	-0.01	0.03	0.03	0.03	0.04	0.03	0.03	[redacted]		
MERCURY	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	ERR	
MOLYB	-0.05	0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	ERR	
NICKEL	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	ERR	
NITRATE	0.39	10	-1	-1	-1	-1	-1	-0.01	-0.835	0.368951	
NITRITE	-0.01	1	-1	-1	-1	-1	-1	-0.01	-0.835	0.368951	
SELENIUM	-0.02	-0.02	-0.001	-0.02	-0.02	-0.02	-0.01	-0.01	-0.0135	0.007158	
URANIUM	0.04	5	0.514	0.602	0.651	0.526	0.588	0.5745	[redacted]		y
VANADIUM	-0.1	-0.1	0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.06666	0.074535	y ← last conc < TRV
ZINC	-0.01	5	0.01	0.01	-0.01	-0.01	-0.01	-0.01	-0.00333	0.009428	
RADIUM	419.3	[illegible]	134.4	118.9	69.6	106.2	124.9	136	[redacted]		o/<

PROBLEM PARAMETERS

1. ARSENIC
2. BORON
3. FLOURIDE
4. MANGANESE
5. KALIUM

WELL P-16

PARAM	HIGHEST BASE	TARGET VALUE	10/22/87	11/24/87	12/22/87	1/23/88	2/23/88	3/22/88	average	std. dev	AVG < TRV ?
[redacted]			548	572	652	662	748	75[redacted]	[redacted]		Y
[redacted]	2200										
[redacted]			188	210	217	235	239	251	[redacted]		Y
[redacted]			2.3	3.5	3.4	2.9	2.7	3.6	[redacted]		Y
[redacted]			21.9	15.4	22	19.6	25.9	26	[redacted]		Y
[redacted]			1.9	1.6	2.1	2.3	6.6	2.7	[redacted]		Y
[redacted]			109	113	135	159	173	185	[redacted]		Y
[redacted]			136	143	138	138	145	160	[redacted]		Y
[redacted]			187	223	234	257	271	283	[redacted]		Y
[redacted]				7.14	7.24	7.39	7.42	7.35	[redacted]		Y
ALUMINIUM	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	ERR	
[redacted]			0.1	0.11	0.25	0.11	0.09	0.08	[redacted]		Y
ARSENIC	-0.04	-0.04	-0.04	-0.04	-0.04	-0.04	-0.04	-0.04	-0.04	ERR	
BARIUM	-0.05	1	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	ERR	
[redacted]			0.5	0.5	0.5	0.5	0.5	0.5	[redacted]		[redacted] ✓
CADMIUM	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	ERR	
CHROMIUM	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	ERR	
COPPER	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	ERR	
[redacted]			1.5	1.7	1.9	1.6	1.6	1.88	[redacted]		[redacted]
IRON	0.13	0.13	-0.1	-0.1	-0.1	-0.1	-0.1	0.23	-0.045	0.122983	[redacted] ← last conc < TRV
LEAD	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	ERR	
[redacted]			0.06	0.03	0.04	0.04	0.05	0.04	[redacted]		[redacted]
MERCURY	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	ERR	
MOLYB	-0.05	0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	ERR	
NICKEL	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	ERR	
NITRATE	0.39	10	-1	-1	-1	-1	-1	-0.01	-0.835	0.368951	
NITRITE	-0.01	1	-1	-1	-1	-1	-1	-0.01	-0.835	0.368951	
SELENIUM	-0.02	-0.02	0.007	-0.02	-0.02	-0.02	-0.01	0.005	-0.00966	0.011642	Y ← last conc < TRV
[redacted]			0.0381	0.117	0.102	0.121	0.169	0.1929	[redacted]		Y
VANADIUM	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	ERR	
ZINC	-0.01	5	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	ERR	
[redacted]			29.4	20.2	16.1	22.3	28.3	27.6	[redacted]		[redacted]

"PROBLEM" PARAMETERS

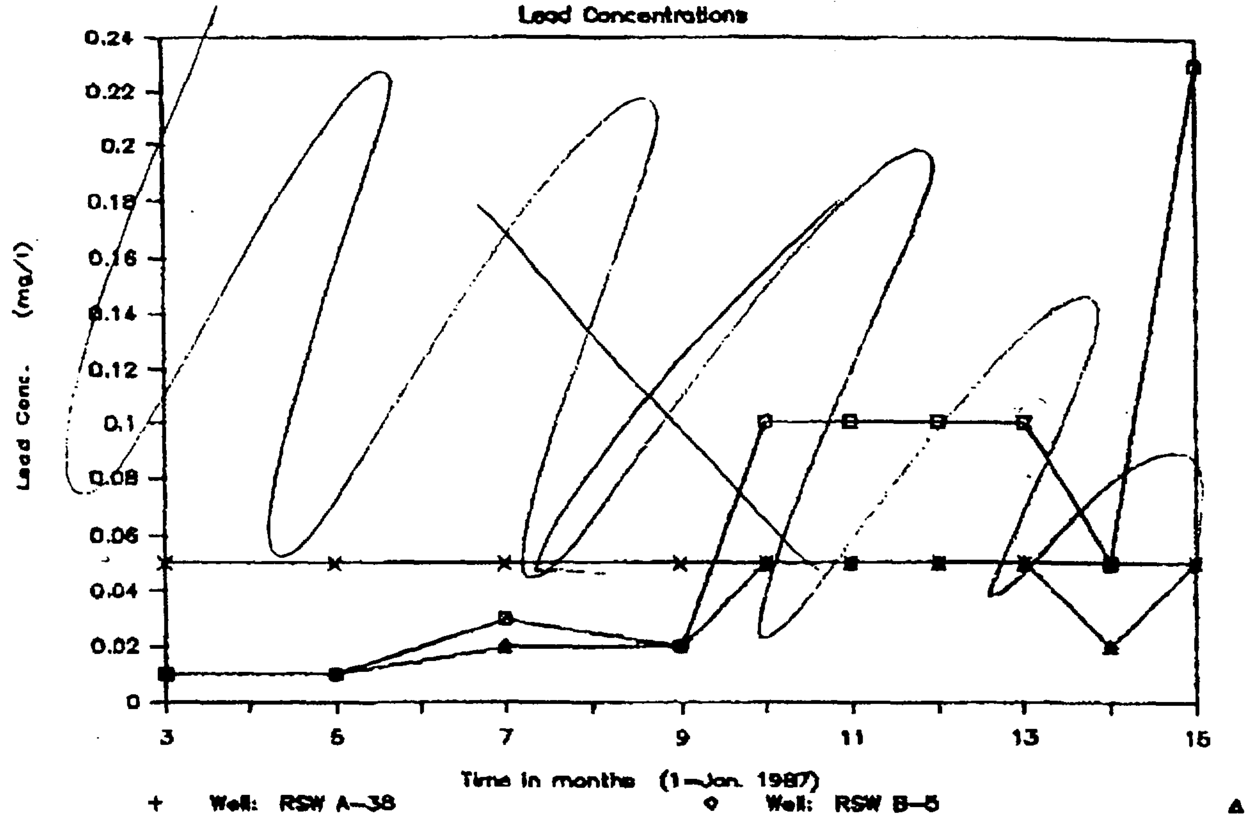
1. BORON
2. FLOURIDE
3. IRON
4. MANGANESE
5. RADIUM

Post-it® Fax Note 7671	Date 5/11	# of pages ▶
To April Lafferty	From Mark Moxley	
Co./Dept.	Co. Package 3 of 3	
Phone #	Phone #	
Fax #	Fax #	

Water quality data for parameters which had averages that exceed their respective TRV's at one time or another were plotted against time in order to identify temporal trends. These graphs are presented as Figures 3-9 and include the parameters: arsenic, boron, flouride, iron, manganese and radium-226. Manganese, boron and arsenic appear to be somewhat stable in all four wells. Radium-226 appears to be stable in all wells except A-38, in which, although concentrations have remained below TRV, the concentrations of the last three samples of the stability period seem to have shown a significant increase with time. Flouride appears to be increasing with time although the trend is not well defined.

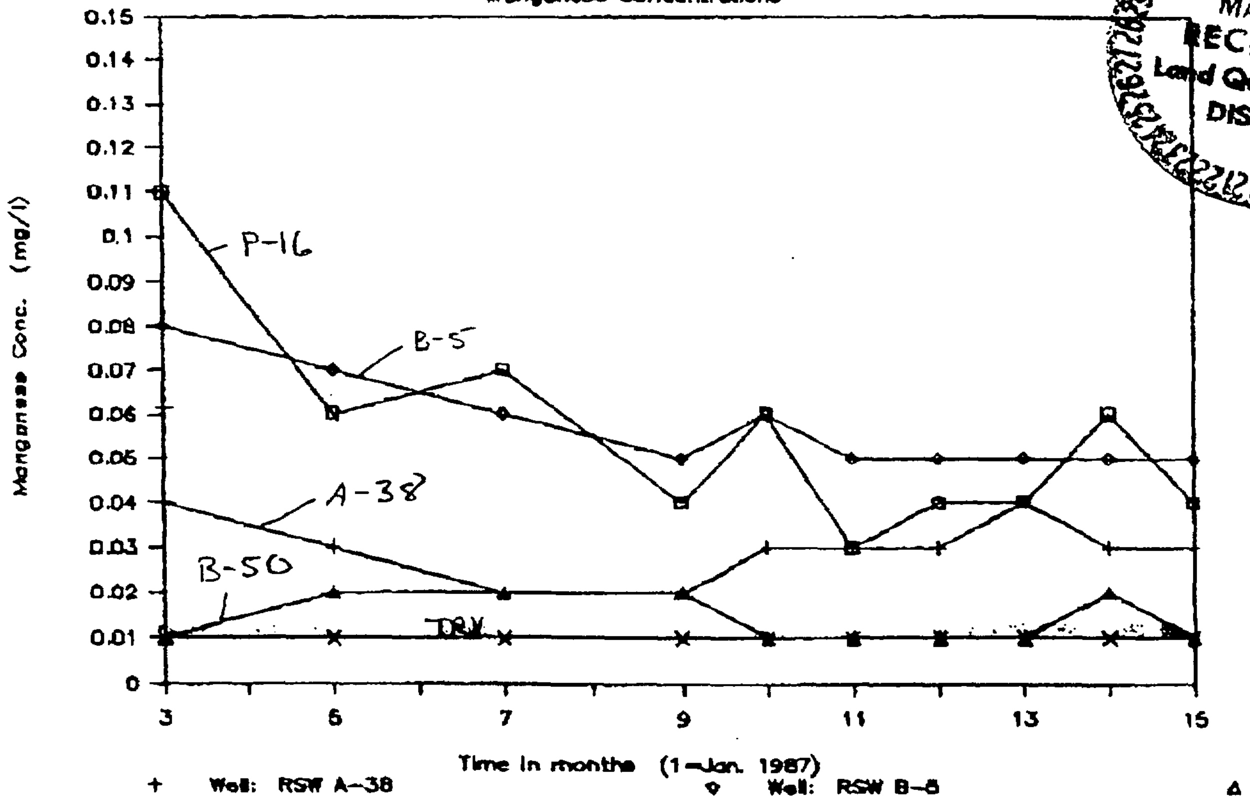
Bison Basin Decommissioning Project

Lead Concentrations



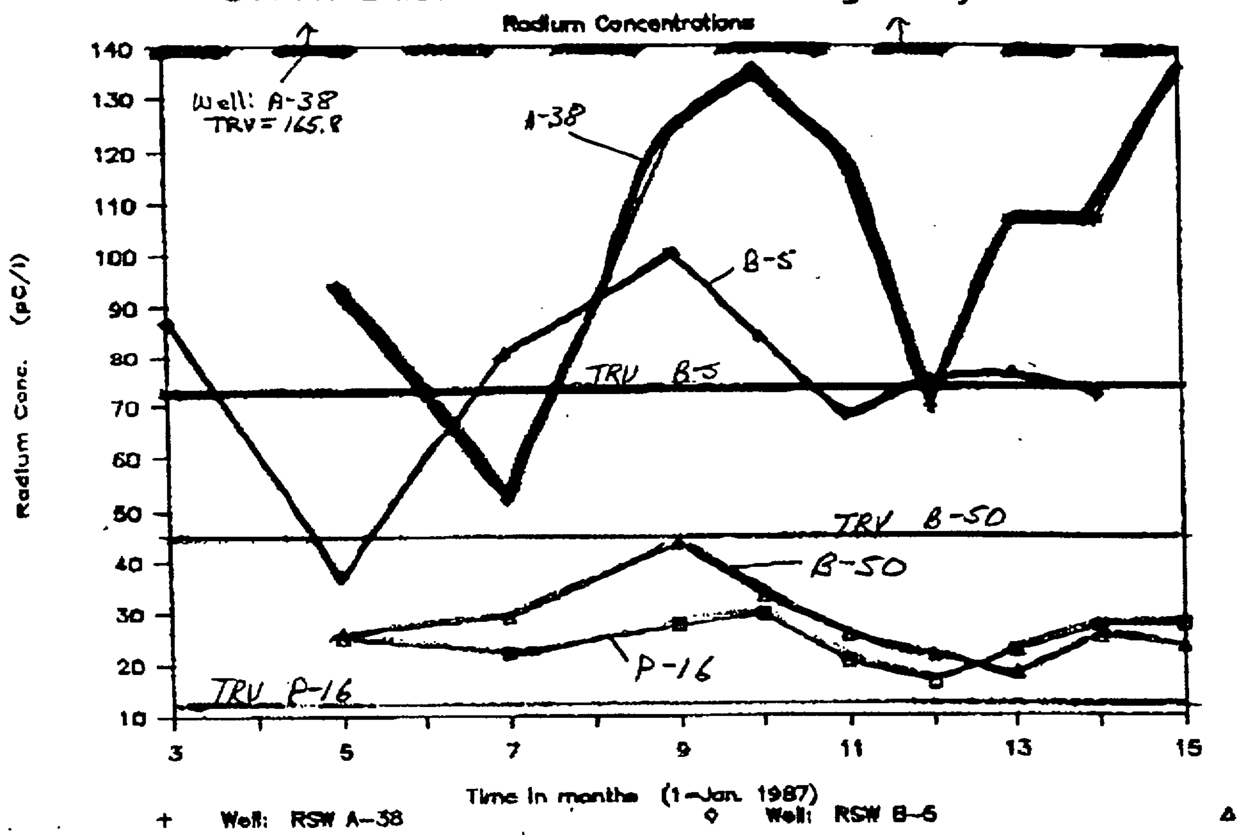
Bison Basin Decommissioning Project

Manganese Concentrations



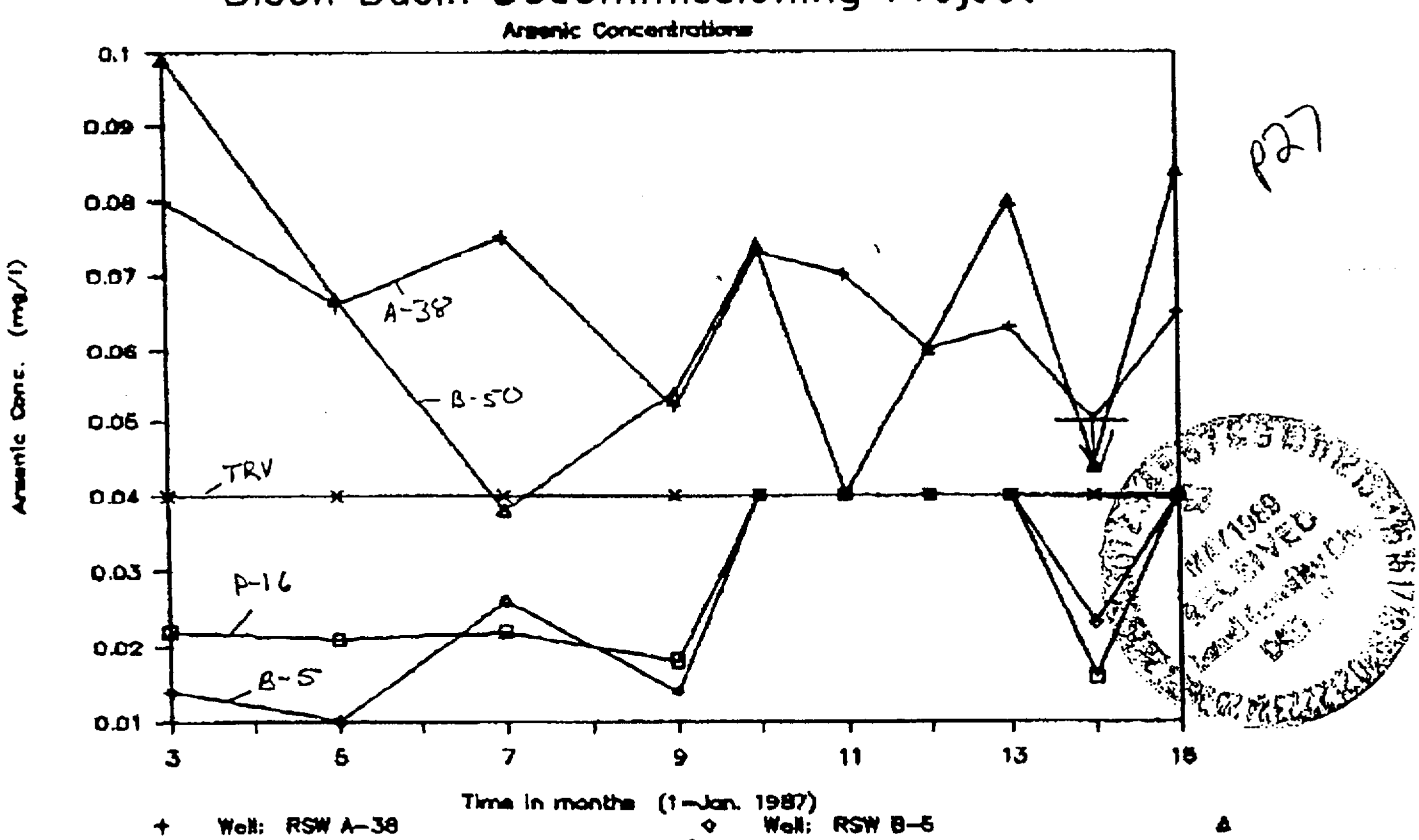
P30

Bison Basin Decommissioning Project

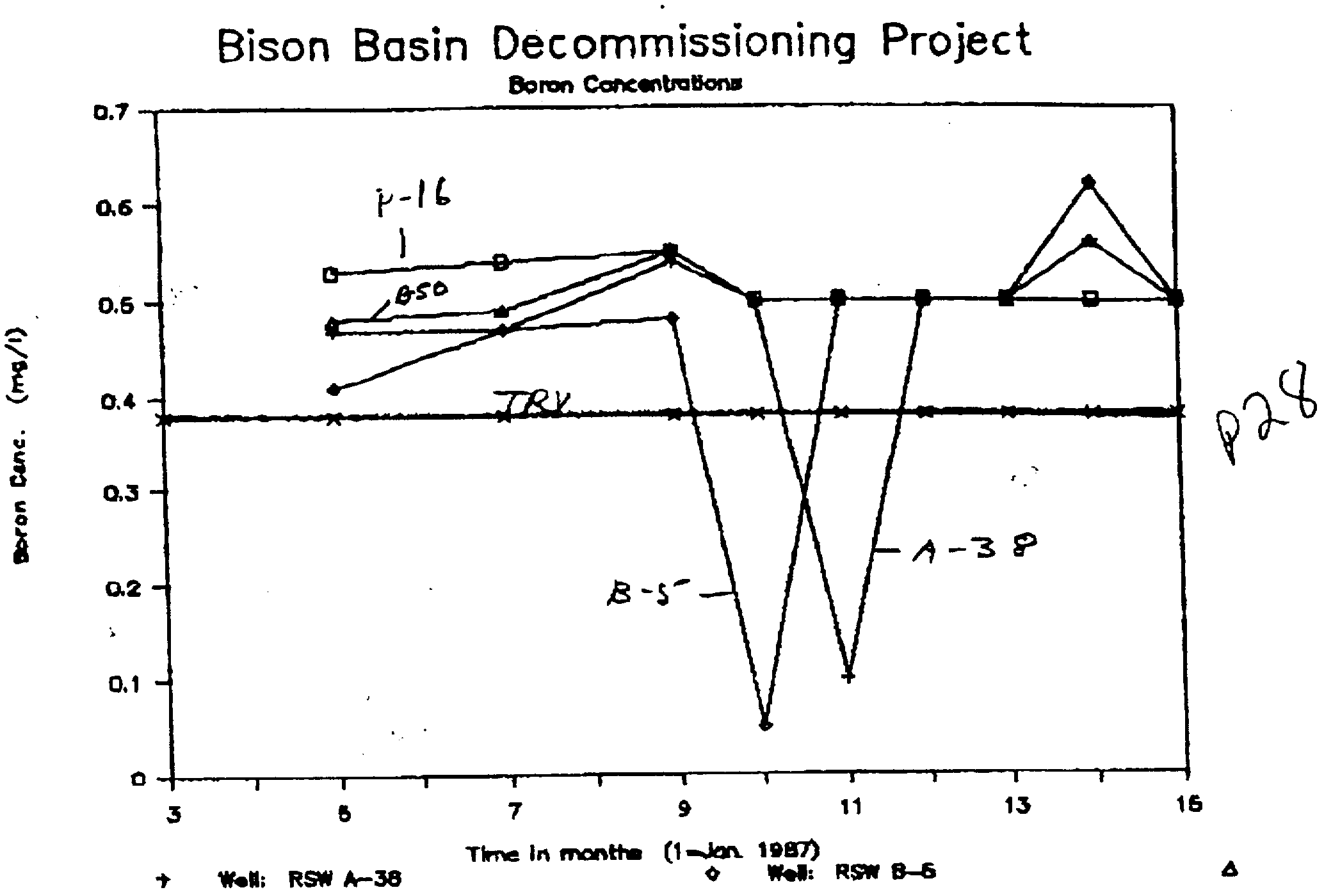


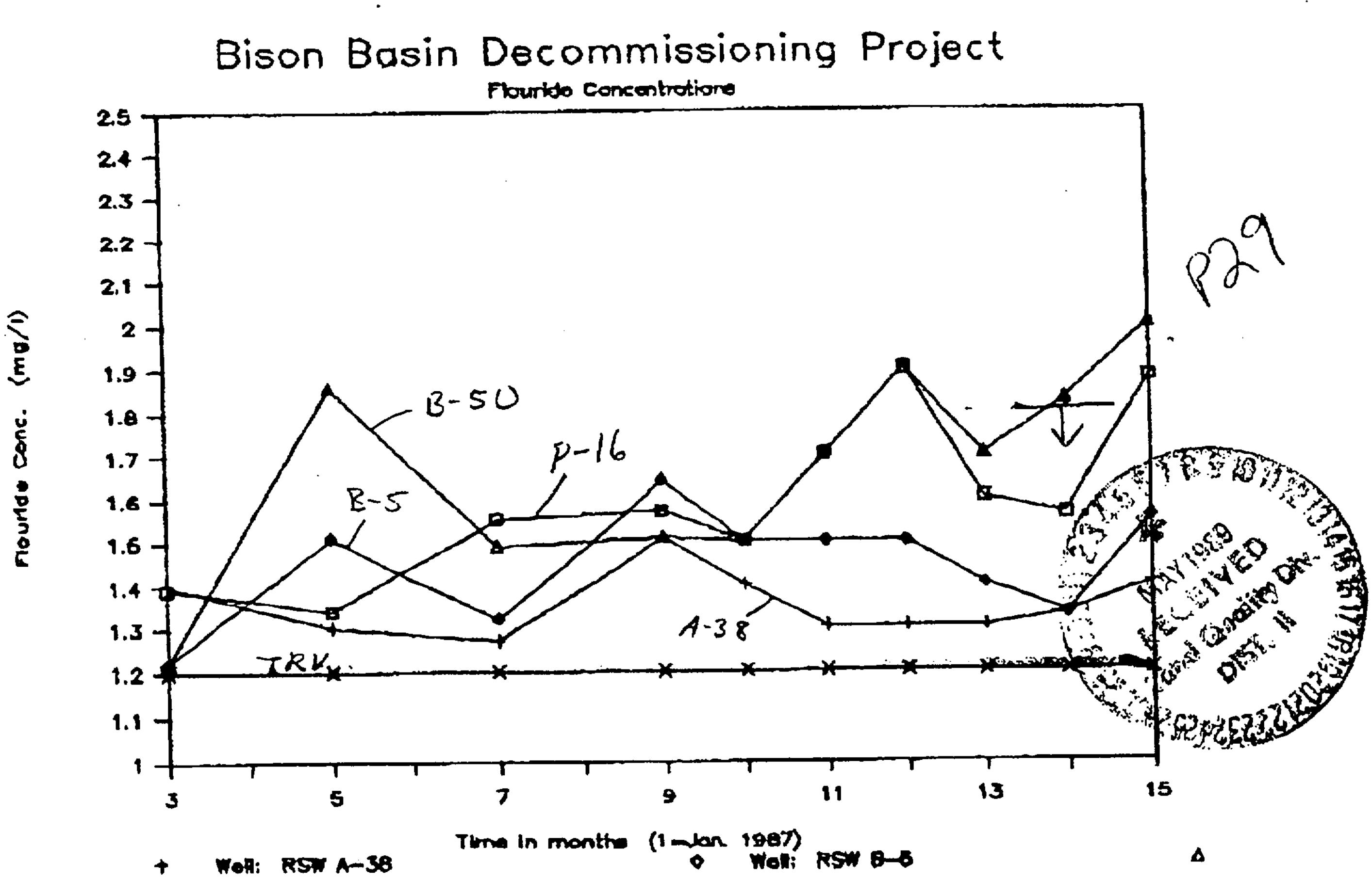
p31

Bison Basin Decommissioning Project

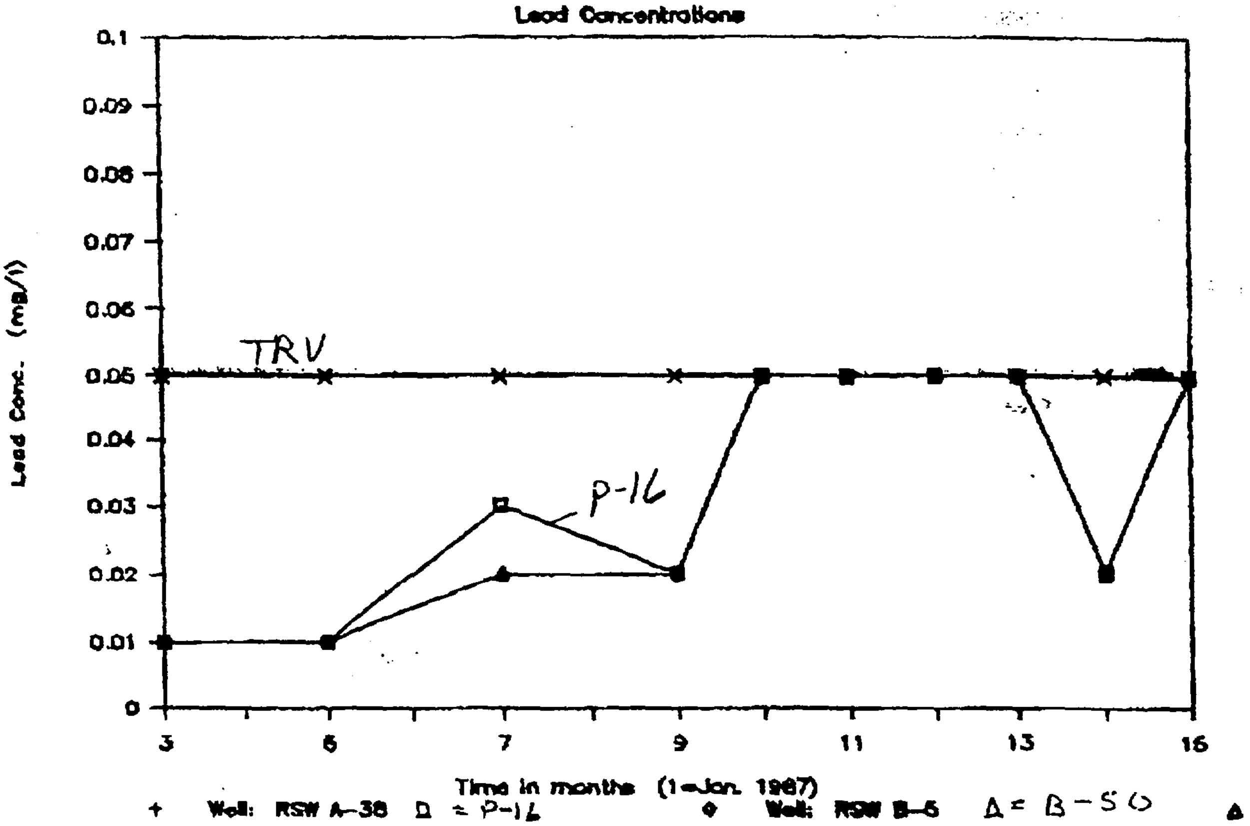


p27

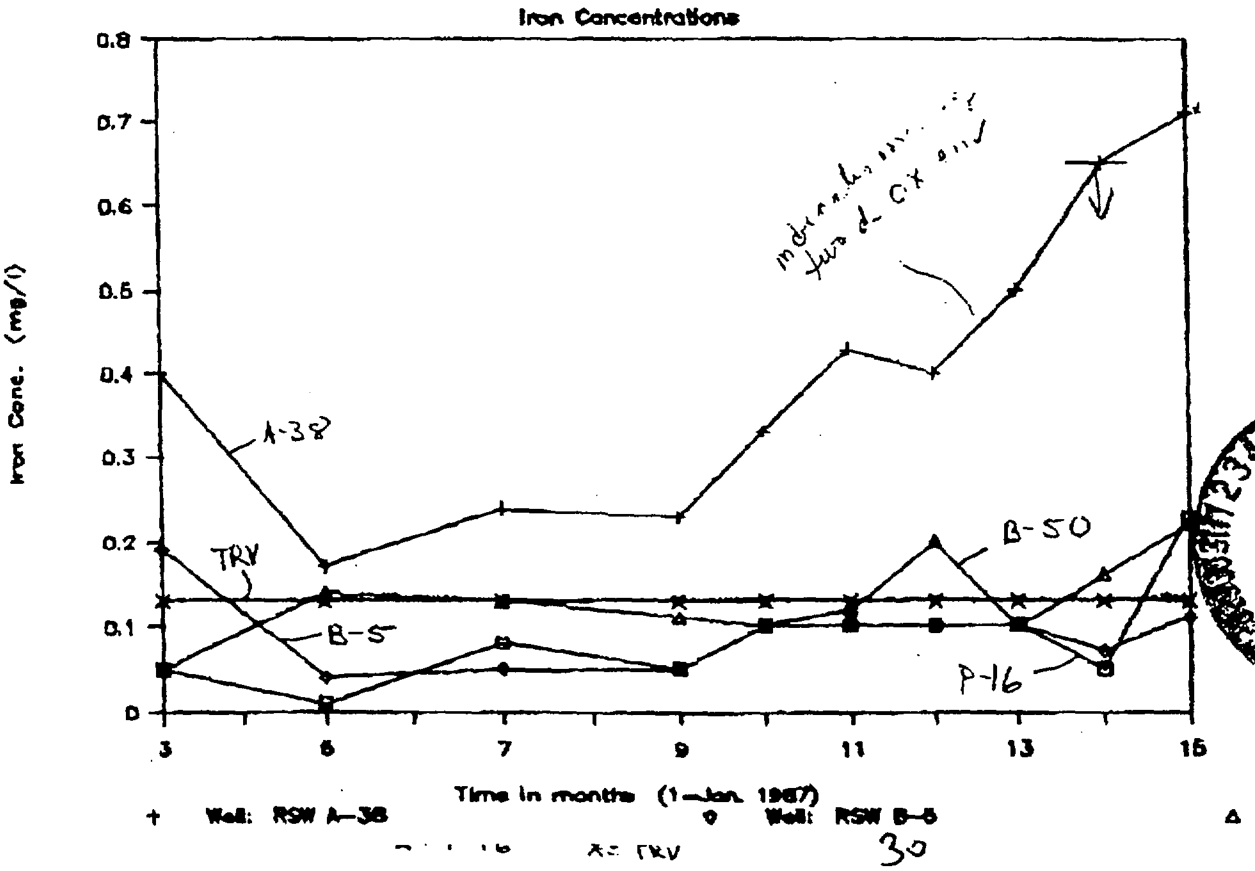

Bison Basin Decommissioning Project
Boron Concentrations
Boron Conc. (mg/l)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
3
5
7
9
11
13
15
Time in months (1=Jan. 1987)
+ Well: RSW A-38
◇ Well: RSW B-5
△
P-16
B50
TRV
A-38
B-5
P28


Bison Basin Decommissioning Project
Flouride Concentrations
Flouride Conc. (mg/l)
2.5
2.4
2.3
2.2
2.1
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
3
5
7
9
11
13
15
Time in months (1=Jan. 1987)
+ Well: RSW A-38
◇ Well: RSW B-5
△
B-50
P-16
B-5
A-38
TRV
P29
RECEIVED
MAY 1989
Land Quality Div.
DIST. II

Bison Basin Decommissioning Project



Bison Basin Decommissioning Project



Iron in well A-38 is clearly rising with time. The upward trends of these parameters may indicate minor aquifer instabilities.

One explanation for these instabilities is the reduction of pH from baseline by one or two pH units throughout the aquifer. The mobility of elements such as iron and manganese are pH sensitive.

QA/QC at the Bison Basin Decommissioning Project was not exemplary. Fortunately QA/QC did not become a burning issue at Bison Basin because, even in view of the apparent error, it has remained clear which parameters are problematic.

Quality control/quality assurance measures include sample splits taken by Altair Resources, the DEQ and the NRC. Comparison of DEQ split samples with the appropriate Altair "regular" sample shows that the results of the analysis differ by more than 10% for one or more of the restoration sampling wells for the parameters listed in Table 8. Of these parameters potassium, magnesium, ammonia and calcium are at least an order of magnitude below their respective TRV's and thus are not a major concern with restoration success. Arsenic, boron, iron and manganese are parameters that we have identified problems with already and the questions raised by the poor QA/QC match do not alter our concerns. Analysis of Ra and U often show inconsistency and so, the poor agreement between splits is not of great concern for these parameters. Further, U and Ra remain safely below their respective TRV's.

The evaluation of statistically different data points or "hotspots," is not valuable or valid at the Bison Basin site because there are only four sampling points. To say that any one of these wells respresents a "hotspot" would mean dismissing one quarter of the available data as meaningless.

VII. GEOCHEMICAL DISCUSSION

It is difficult to quantify the redox state of the aquifer at the Bison Basin site because electron activity (pE or Eh) was not measured. A qualitative estimate of the redox state can be made based on observations of iron and manganese concentrations. Both Fe and Mn concentrations were increased with respect to baseline. These increases are most likely a result of the lower pH of the reinjected RO water. Fe and Mn become more soluable in water that has a lower pH. During the stability period Fe levels began to rise, especially in well A-38 while Mn levels remained fairly stable. This may indicate that the aquifer water is moving towards a more reducing state. As shown on Figure , for the pH range measured during the stability period, a reduction in the redox potential of the aquifer should result in more Fe going into solution and Mn staying about the same. If this is the case then the aquifer water is right in the middle between oxydizing and reducing conditions and moving towards more reducing conditions. In the absence of any other strong evidence we assume this chemical system describes the redox state of the aquifer.

p38

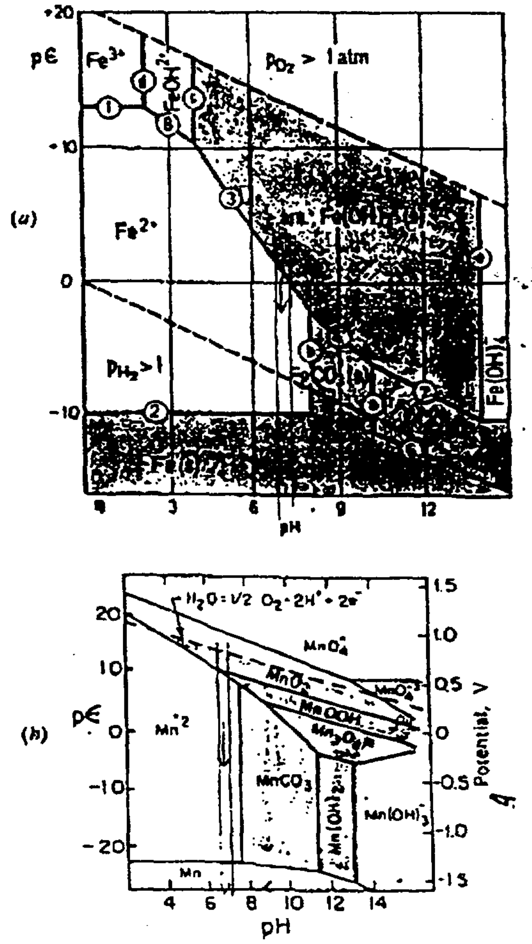


Figure 7.7 pε-pH diagrams for the Fe, CO_2, H_2O, and Mn-CO_2 systems (25°C). (*a*) Solid phases considered: amorphous $Fe(OH)_3$, $FeCO_3$ (siderite), $Fe(OH)_2$, Fe. $C_T = 10^{-3}$ *M*, [Fe] = 10^{-5} *M*. Equilibria and equations needed for construction of diagram are given in Table 7.4. (*b*) Solid phases considered: $Mn(OH)_2$(s) (pyrochroite), $MnCO_3$(s) (rhodochrosite), Mn_3O_4(s) (hausmannite), γ-MnOOH (manganite), γ-MnO_2 (nsutite).

7.5 REDOX CONDITIONS IN NATURAL WATERS

Only a few elements—C, N, O, S, Fe, Mn—are predominant participants in aquatic redox processes. Table 7.5 presents equilibrium constants for several couples pertinent to consideration of redox relationships in natural waters and their sediments. Data are taken principally from the second edition of *Stability Constants of Metal-Ion Complexes*. A subsidiary symbol pε°(W) is convenient for considering redox situations in natural waters. pε°(W) is

The aquifer had not reached equilibrium by the end of the stability period. Fe and Ra levels were rising and the redox state was still adjusting. The six month stability period was not long enough to allow the aquifer to equilibrate. Twelve to eighteen months would have been a better lenghth of time.

The aquifer water is expected to continue to move towards more reducing conditions and the pH is expected to rise as water from outside the well field flows into the contaminated area.

6. DETERMINATION OF SUCCESS

Overall restoration was successful at the Bison Basin Decommissioning Project. The success of these efforts was judged by whether or not best practicable technology has been adequately used and whether or not all parameters are below the class of use criteria. As discussed earlier BPT was properly carried out according to the restoration plan in the permit. No parameters remain above the class of use as defined by WQDf. In this case class of use is Industrial or Class IV.

III. IN SUMMARY, WE CONCLUDED:

1. Concentrations of Fl, B, As, Mn, Fe, and Ra exceeded their respective TRV's.
2. pH was lowered by approximately two pH units.

3. The redox potential of the aquifer was nearly neutral and trending towards reducing conditions.

4. The aquifer was not in equilibrium at the end of the stability period.

5. Six months is not long enough for the stability period.

6. QA/QC was deplorable on this project.

7. The best practicable technology as defined in the 1980 permit has been used to restore the site.

8. None of the parameters were above the Class of Use criteria for Industrial water.

9. Restoration was successful.

IV. We recommend that in the future the DEQ/LQD not be bound to the definition of BPT in the original permit. It must be recognized that technology changes so rapidly in this field that to ignore the valuable information which has come to light in the ten years between the time the mine was originally permitted and the time restoration begins would be remiss.

If is further recommended that QA/QC be reviewed upon receipt of the data and that corrective measures or explanation addressing any discrepencies be developed immediately.

Finally it is recommended that the stability period following active restoration last 12 to 18 months.