Department of Energy
Albuquerque Operations Office
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OCT 24 1996

Mr. Joseph J. Holonich, Chief
Uranium Recovery Branch
Division of Waste Management
Office of Nuclear Material Safety
and Safeguards Mail Stop T7J9
U. S. Nuclear Regulatory Commission
Washington, DC 20555

Dear Mr. Holonich:

This concerns the Department of Energy (DOE) Uranium Mill Tailings Remedial Action Green River, Utah, disposal site ground water compliance strategy. As a follow-up to the discussions on July 25 and August 8, 1996, and the Nuclear Regulatory Commission (NRC) letter dated August 29, 1996, enclosed are the "Analysis and Discussion of the Original Ground Water Protection Strategy" and the "Green River Neutron Probe History."

The site ground water concentration limits established under provisions of the Environmental Protection Agency 40 CFR 192.02(c) standards have been exceeded as noted in the enclosure. However, based on our analysis and DOE's proposed change in the ground water compliance strategy (meeting supplemental standards based on wide spread ambient contamination versus maximum or background concentration limits), implementing corrective action pursuant to 40 CFR 192.04 should not be necessary.

The DOE ceased collecting data from the neutron probes after September 1991. As discussed in the enclosure, well construction and the materials used have resulted in instrument calibration problems. Any data collected would be suspect. If the proposed ground water compliance strategy is applied, the neutron probes will no longer be needed. The DOE is more concerned about the potential problem the probe tubes may pose to the long-term integrity of the radon barrier. We recommend that the probe tubes be decommissioned as soon as the proposed ground water compliance strategy is approved.

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The DOE will proceed to develop the Green River Remedial Action Plan (RAP) Modification No. 2 (Mod 2) which will include Appendix E, the Ground Water Protection Strategy. The revision of Appendix E will be based on the revised network of monitoring wells discussed in DOE's May 22, 1996, letter, and other changes agreed upon by the NRC, state of Utah (state), and DOE. We anticipate sending Rap Mod 2 for NRC and state review and concurrence in the near future.

Your timely response to the need for corrective action and decommissioning of the tubes is appreciated. If there are any questions, have your staff contact me at (505) 845-5758.

Sincerely,

Michael F. Abrams

Michael F. Abrams
Site Manager
Environmental Restoration Division

Enclosures (2)

cc w/enclosures:
L. Morten, DEQ, Utah
S. Wright, TAC

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construction of the disposal cell. These two constituents were high in tailings pore fluids (DOE, 1989), and are among the most mobile constituents in ground water at the site. Thus, the association of these two constituents in ground water is currently considered to provide a fingerprint of processing related contamination.

The concentration limits used in the initial ground water protection strategy (Final DOE Protection Limits, listed in Table 1) were based on background as determined from measurements in ground water samples from 16 monitor wells screened in the unnamed member of the Cedar Mountain Formation, and were located near the disposal cell. In the case of lead, the UMTRA Project MCL (40 CFR §192.02) was greater than background, and was adopted as the concentration limit.

Subsequent measurements have shown that the ground water quality in the vicinity of the disposal cell is variable with time, even within a single well. It was originally thought that the large differences in observed constituent concentrations represented naturally occurring variations of ground water chemistry within the unnamed member of the Cedar Mountain Formation. Thus, an upper limit to background could be estimated by using the highest measured concentration for each constituent to that date. However, later measurements did not always bear this out. Arsenic and nitrate have frequently exceeded the background-based concentration limits (DOE, 1995), (the maximums tabulated in the right-hand portion of Table 1). Maximums were observed in monitor wells 0176 and 0813, but levels in other wells not tabulated here also exceeded maximum levels.

Based on observed contaminant trends, the estimated background concentrations were revised upward and finalized (DOE, 1994). However, it has become apparent that the hydrology of the site is more complex than originally assumed. Therefore, based on new data and evaluation of ground water quality at the site it was conceded that the site conceptual model and the ground water protection strategy had to be revised.

New Site Conceptual Model

Evaluation of previous and existing data supports the position that the observed maximum exceeded levels of the proposed concentration limits is not necessarily indicative of cell failure, but may instead reflect migration of processing-related contamination. The revised site conceptual model is based on the following assertions (see the revised Appendix E of the Remedial Action Plan for details):

- Preexisting processing-related contamination exists in the vicinity of the disposal cell.
- The hydrology of the uppermost aquifer is complex because of pervasive fracturing, shallow horizontal gradients, and variable vertical gradients.

ANALYSIS AND DISCUSSION OF THE ORIGINAL GROUND WATER PROTECTION STRATEGY (MCLs/BACKGROUND), GREEN RIVER SITE, UTAH

Introduction

New data from the Green River Site necessitate a change in the ground water protection strategy in Appendix E of the Remedial Action Plan (DOE, 1989). The new ground water protection strategy, making use of supplemental standards (40 CFR §192.22(a)) based on widespread ambient contamination due to high selenium concentrations, will be described in detail in the forthcoming modification to Appendix E of the Remedial Action Plan. This letter reviews the history of the change in ground water protection strategy, evaluates observed changes in contaminant profiles in ground water monitor wells at the site, and explains why these changes do not warrant corrective action.

Initial Ground Water Protection Strategy

The initial ground water protection strategy for the Green River Site was based on meeting maximum concentration limits (MCLs) or background concentration levels for listed constituents at designated point-of-compliance monitor wells (40 CFR §192.02(c)), Table 1. An additional element of the initial strategy was to monitor the moisture content in the cover and in the disposal cell to address the issues related to the water content of placed tailings and windblown materials. The rationale for moisture content monitoring (i.e., excessive construction water) and subsequent problems in its application have been discussed in the report *Neutron Moisture Monitoring* (DOE, 1992), and the Green River Neutron Probe History.

The initial ground water protection strategy relied heavily on available information on process history, which indicated that processing-related contamination should be confined to the northwest portion of the site, at least 600 feet downgradient from the location of the disposal cell. Preexisting high levels of certain constituents (e.g. nitrate, arsenic, and uranium) in ground water in the area of the current disposal cell were apparently attributed to natural background concentrations.

Preexisting Contamination Near The Disposal Cell

Subsequent evaluations of ground water quality in the area of the disposal cell have determined that levels of nitrate, uranium, and other constituents that existed prior to construction of the disposal cell are associated with preexisting processing-related contamination. The strongest evidence for the presence of preexisting contamination is provided by two former monitor wells (GRN-01-0562 and -0816) that were in the vicinity of the present disposal cell (Figure 1) and showed significantly elevated nitrate and uranium compared to off-site wells (Table 2) prior to

- The disposal cell will be a transient source of water and contaminants as excess water in the tailings slowly drains until equilibrium is established between bulk moisture content and the rate of infiltration through the cover.

- Background ground water in the uppermost aquifer is of poor quality and is not a usable resource due to widespread existence of selenium.

- There is a high level of confidence that selenium in background is not related to uranium processing at the site - new background wells have been identified that do not contain high levels of nitrate or uranium. These constituents are much more mobile than selenium in ground water at the site and serve as a fingerprint of site-related contamination.

Consequences Of The New Site Conceptual Model

An important consequence of the new site conceptual model is that compliance with ground water protection standards will be achieved by applying supplemental standards (40 CFR §192.22(a)) based on the poor-quality ground water naturally present in the uppermost aquifer. Because there is no usable ground water resource to protect, there is no point-of-compliance nor is there any need to monitor for constituents that might be hazardous to human health and the environment. A full discussion may be found in the forthcoming modification to Appendix E of the Remedial Action Plan.

Point-of-compliance wells were installed because the initial ground water protection strategy was to detect leachate from the disposal cell by its chemical signature. However, while significant leachate could be symptomatic of cell failure, it is chemically indistinguishable from transient drainage. (Leachate is moisture that has infiltrated through the cover before passing through the cell, and is distinct from transient drainage, which is due to aquifer loading, compaction of the tailings, and drainage of construction water). Because leachate and transient drainage both arise from moisture that has chemically equilibrated with the contents of the disposal cell, they will be chemically identical. The cell has been engineered so that the quantity of leachate will be negligible over its 1,000-year design life. On the other hand, transient drainage is an inherent part of the design and construction of the cell, and may persist in ever-diminishing quantities for a decade or more.

The principal tailings-derived contaminants that could be present at high concentrations in cell leakage (transient drainage or leachate) are nitrate, sulfate, and uranium. Additionally, these contaminants are also processing-related and already exist in ground water in the vicinity of the disposal cell. Thus, high concentrations of one or more contaminants in ground water from monitor wells in the vicinity of the disposal cell do not provide a useful indication of cell failure, because some seepage is inherent in the design of the cell, and because every contaminant in the cell also exists elsewhere on the site.

Evaluation Of Observed Contaminant Trends

For various reasons, the observed exceeded levels for various constituents are not indicative of cell failure as implied by the initial site conceptual model. Exceeded levels for one constituent do not correlate with exceeded levels for other constituents, as would be expected for cell-derived contamination. Also, it is unlikely that sufficient time had elapsed since the cell construction to allow contaminant migration to the monitor wells. Geochemical and statistical evaluations of the ground water data indicate that ground water in the vicinity of the disposal cell has been affected by uranium processing activities.

The complexities of contaminant concentrations in monitor wells are illustrated in Figures 1-5, showing nitrate, sulfate, TDS, uranium, and selenium in monitor wells 0171–0176, 0179, and 0813. These wells are located around the apron of the disposal cell (Figure 1) and were point-of-compliance wells under the initial ground water protection strategy. Under the strategy being proposed in the forthcoming Appendix E of the Remedial Action Plan, they will be simply monitor wells.

Nitrate distribution patterns (Figure 2) are quite striking, with concentrations in well 0171 increasing from nearly uncontaminated values to over 100 milligrams per liter (mg/L) over the course of two sampling rounds. Monitor well 0171 is now part of a group of four wells that are affected by a high-nitrate source. Sulfate and TDS patterns (Figures 3 and 4 respectively) have recently shown a significant increase in another well (0172) and are now higher than all of the other wells, which are closely clustered. (TDS tracks sulfate because sulfate and its counter-ion sodium are the dominant constituents in ground water at this site). Uranium trends (Figure 5) are somewhat less coherent. Well 0179 consistently exhibits high levels, wells 0173 and 0174 have consistently shown very low levels near the detection limit, and several of the remaining wells showed a simultaneous decline of approximately an order of magnitude in late 1994. Selenium concentrations (Figure 6) have been consistently high in two wells (0176 and 0179) and scattered, but low in the remaining wells.

Interpretation of these trends is ambiguous. Nitrate, sulfate, and uranium are potential indicators of tailings-derived moisture, but they have not changed in concert. Nitrate has increased sharply in well 0171, whereas sulfate has increased primarily in well 0172. At the same time uranium has declined in well 0171 and increased slightly in well 0172. Nitrate and uranium changes are synchronous, occurring in the latter half of 1994, but are inversely related. Thus, there is no single source, either preexisting contamination or tailings seepage, that can uniquely explain these trends. These data do not preclude the possibility of significant seepage from the cell, but are more readily explained by migration of preexisting processing-related contamination through the fractured aquifer beneath the disposal cell. Even if tailings seepage were the source, seepage at this stage is most likely related to transient drainage and thus not representative of cell failure.

Conclusions

The presence of preexisting contamination in the vicinity of the disposal cell complicates assessment of disposal cell performance because hazardous constituents identified in the tailings are also present in ground water downgradient of the disposal cell due to processing activities. In addition, changes in concentration levels unrelated to disposal cell performance may occur at the disposal site as a result of migration of preexisting contamination. The historical monitoring data do provide much information about the likely range in concentration of each contaminant at the former processing site, but because of the small-scale but widely ranging variability in ground water flow rate and contaminant distribution, the predictive power of these data at any single point (e.g., points of compliance) is very weak. For the same reasons, the high concentrations measured in several wells to date are not an indication of cell failure.

These conclusions, in conjunction with the proposed application of supplemental standards based on widespread ambient contamination, should not require corrective action as defined in 40 CFR 192.04.

REFERENCES

DOE (U.S. Department of Energy), 1995. *Water Sampling and Analysis Plan, Green River, Utah, Rev. 1, DOE/AL/62350-86, August 1995, prepared by Jacobs Engineering Group for the U.S. Department of Energy, UMTRA Project Office, Albuquerque Operations Office, Albuquerque, New Mexico.*

DOE (U.S. Department of Energy), 1994. *Long-Term Surveillance Plan for the Green River, Utah, Disposal Site, Rev. 1, DOE/AL/62350-89F, August 1994, prepared by Jacobs Engineering Group for the U.S. Department of Energy, UMTRA Project Office, Albuquerque Operations Office, Albuquerque, New Mexico.*

DOE (U.S. Department of Energy), 1992. *Neutron Moisture Monitoring (NMM) and Moisture Contents in the Green River, Utah, UMTRA Disposal Cell, DOE/AL-050129.0000, June 1992, prepared by the U.S. Department of Energy, UMTRA Project Office, Albuquerque Operations Office, Albuquerque, New Mexico.*

DOE (U.S. Department of Energy), 1989. *Remedial Action Plan and Final Design for Stabilization of the Inactive Uranium Mill Tailings at Green River, Utah, Volume IIA, Appendix E, UMTRA-DOE/AL-050510-GRN0, March, 1991, prepared by the U.S. Department of Energy, UMTRA Project Office, Albuquerque Operations Office, Albuquerque, New Mexico.*

CODE OF FEDERAL REGULATIONS

40 CFR §192, Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings, U.S. Environmental Protection Agency (1995).

Figure 1
Monitor Wells
Green River, Utah, Disposal Site

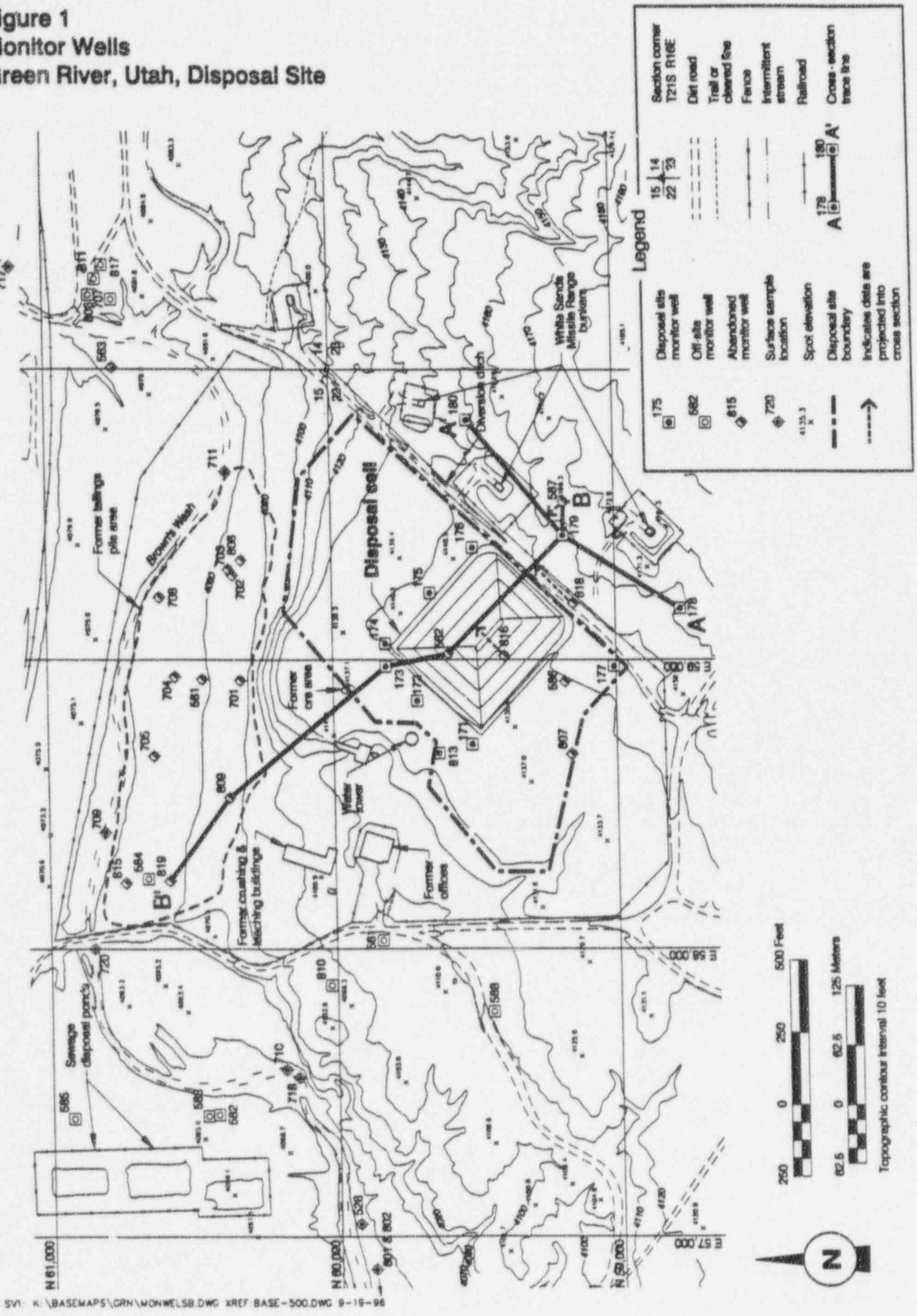

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Table 1. Hazardous constituents and concentration limits proposed for disposal, and their maximum observed values, at the Green River Site

Constituent	Units	UMTRA Project MCLs[a]	Final DOE Protection Limits[b]		Maximum Observed Values[c] Conc.	Well	Date
Arsenic	mg/L	0.05	0.06	(Bkg)	0.19	0813	1/26/95
Cadmium	mg/L	0.01	0.026	(Bkg)	0.012	0813	1/8/90
Chromium	mg/L	0.05	0.07	(Bkg)	0.08[d]	0813	5/10/88
Lead	mg/L	0.05	0.05	(MCL)	none		
Molybdenum	mg/L	0.1	0.22	(Bkg)	0.22	0813	1/7/88
Nickel	mg/L	----	0.09	(Bkg)	none		
Nitrate	mg/L	44	293	(Bkg)	370	0176	1/26/95
Selenium	mg/L	0.01	2.50	(Bkg)	0.44	0176	4/18/91
Uranium	mg/L	0.044	0.229	(Bkg)	0.074	0176	6/8/94
Vanadium	mg/L	----	0.38	(Bkg)	none		
Radium	pCi/L	5	25.5	(Bkg)	not reported		
Net Gross Alpha	pCi/L	15	158	(Bkg)	157.9	0176	1/31/91

[a] 40 CFR §192.02

[b] *Long-Term Surveillance Plan* (DOE, 1994). Final DOE protection limits were based on the maximum observed concentrations in samples taken before, during, and after remediation in monitor wells GRN01-0171 to -0180, -0561, -0562, -0806, -0811, -0813, and -0816.

[c] As listed in the *Water Sampling and Analysis Plan* (DOE, 1995). All of these exceed UMTRA Project MCLs, and arsenic and nitrate exceed the final DOE limits.

[d] The minimal exceedance of the final DOE limits by chromium is most likely due to rounding errors

Table 2. Nitrate and uranium concentrations in the unnamed member of the Cedar Mountain Formation at the Green River Site

Constituent	Background[a] (mg/L)	Disposal site[b] (mg/L)
Nitrate	<0.1 to 4.1	45 - 173
Uranium	<0.003	0.007 - 0.146

[a]Monitor wells GRN-01-0585, -0806, and -0811.

[b]Monitor wells GRN-01-0562 and -0816.

Notes:

1. Data were collected from 1986 to 1988, before the disposal cell was constructed.
2. Concentrations in monitor wells on the disposal site are compared to concentrations in background monitor wells.

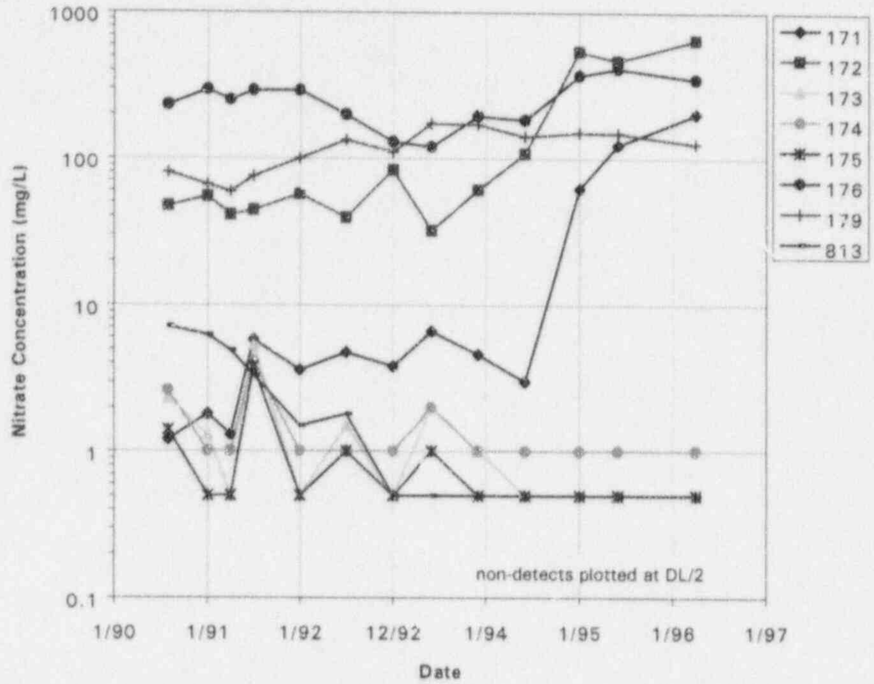

FIGURE 2.
NITRATE AT DISPOSAL SITE MONITOR WELLS, GREEN RIVER, UTAH

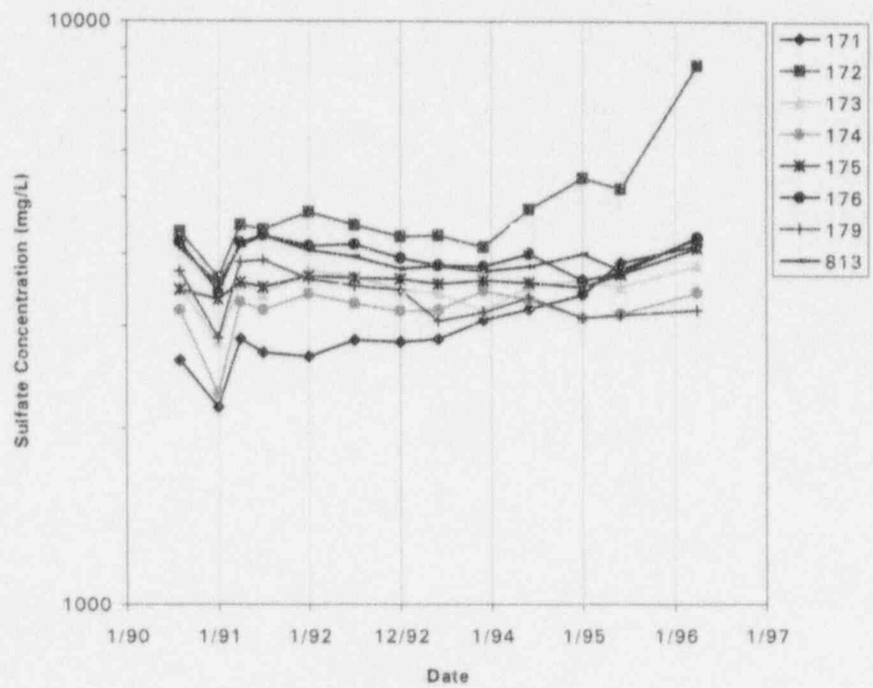

FIGURE 3.
SULFATE AT DISPOSAL SITE MONITOR WELLS, GREEN RIVER, UTAH

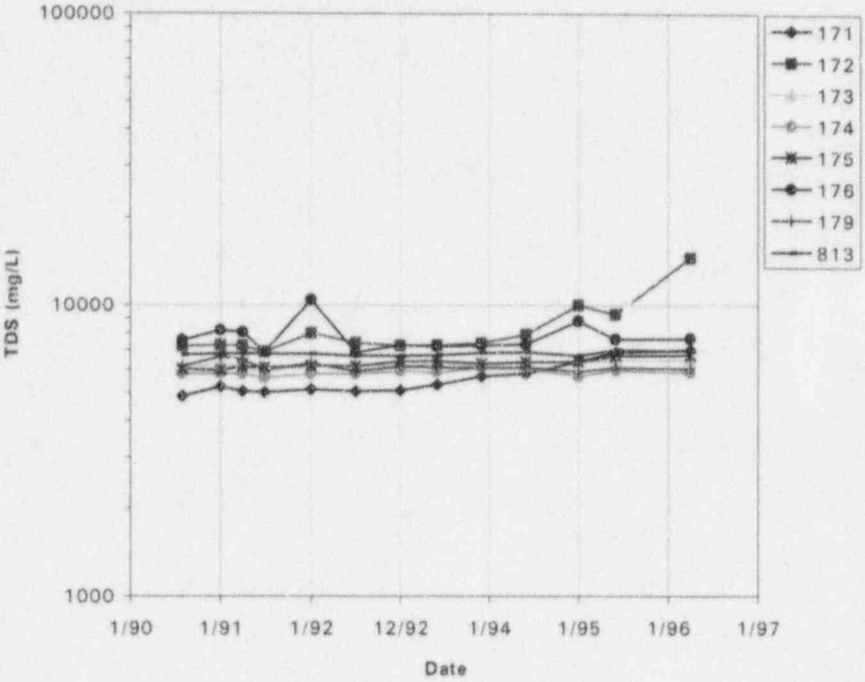

FIGURE 4.
TDS AT DISPOSAL SITE MONITOR WELLS, GREEN RIVER, UTAH

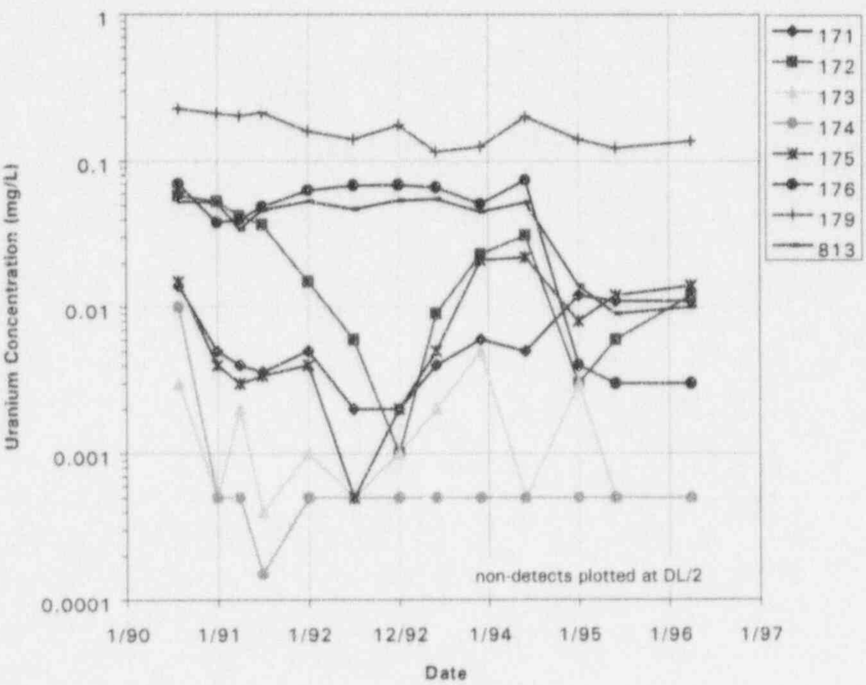

FIGURE 5.
URANIUM AT DISPOSAL SITE MONITOR WELLS, GREEN RIVER, UTAH

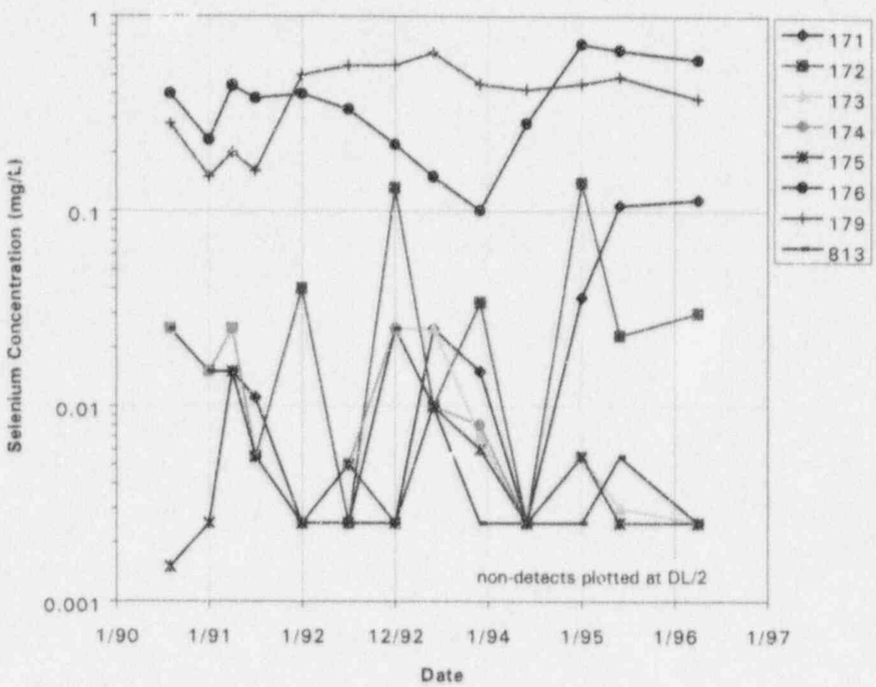

FIGURE 6.
SELENIUM AT DISPOSAL SITE MONITOR WELLS, GREEN RIVER, UTAH

GREEN RIVER NEUTRON PROBE HISTORY

Much of the neutron access tube history may be found in correspondence and documentation in the DOE UMTRA and NRC files. Some of the history is based on the recollection of senior project participants as best collaborated by written documentation.

In 1988 during design and review of the UMTRA Green River disposal cell, the NRC expressed concern about performance of the disposal cell. After several conference calls between DOE and NRC, the DOE responded to NRC's issue 9 by saying "... Early detection of unexpected moisture flux through the cover or leachate generation and movement can also be evaluated by one or more of the following methods: 1. Gypsum blocks, 2. Neutron access tubes, 3. Microlysimeters, Meteorological instrumentation ..."

Conversations between DOE and NRC on the use of neutron access tubes for cell moisture monitoring continued into mid-1989. NRC representatives maintained that neutron moisture monitoring was required as an important part of the overall ground water protection strategy (i.e. travel time and MCLs) for Green River, and if after a few years the monitoring indicated that the cell was operating "properly", the access tubes and the point of compliance wells could be abandoned.

In the Fall of 1989, from September 5th through October 7th, four neutron access tubes were installed in the Green River disposal cell. Problems began almost immediately, when hard drilling in the fill prevented installation of standard 2 inch diameter aluminum neutron moisture tubes and 5 inch diameter steel casing had to be used. Difficulties and delays in obtaining a license for the neutron moisture probe, caused DOE contractors to rent a CPN 501 DR Depth probe for initial moisture readings in the tubes. Proper cross-calibration between the rented neutron probe and the probe finally licensed for this work was never successfully completed.

On July 27, 1990, the DOE submitted a request to NRC for removal of the neutron access tubes. Reasons cited to support removal included proven performance of the radon barrier, loss of cover integrity caused by the neutron access holes, cost of monitoring, questionable accuracy of the neutron probe readings.

On February 7, 1991, the NRC denied the DOE's request to remove the neutron access tubes citing a review by PNL and restating their TER comment that this monitoring was required.

From March through September of 1991, the DOE collected three additional rounds of neutron moisture probe data. Calibration and moisture probe data drift problems persisted.

In November 1991, the DOE initiated a study to evaluate the effectiveness of the neutron moisture monitoring at the Green River site. During the study period, DOE contacted NRC's consultant, Pacific Northwest Laboratory, for their help in evaluating Green River neutron probe data difficulties. In June of 1992 the study report titled

"Neutron Moisture Monitoring (NMM) and Moisture Contents in the Green River, Utah, UMTRA Cell" was published.

On June 25, 1992, the DOE transmitted their completed NMM study report to NRC with a second request to discontinue neutron moisture monitoring at the Green River site. Each of the earlier deficiencies in DOE's justification for NMM closure as outlined in PNL's Evaluation Report was addressed and answered in this DOE submittal.

A DOE special study report, referred to as the "Shiprock Special Study" (dated January 1991), provided a technical basis for modeling the Green River disposal cell with an unsaturated hydraulic conductivity in the "travel time " ground water protection calculations. On September 18, 1992, the NRC transmitted a letter including staff comments that rebutted findings of this special study, indicating that it should not be used as a "scientifically-defensible" basis for supporting technical decisions at other UMTRA sites (such as Green River).

November 13, 1992, the NRC sent a letter to DOE rebutting points included in the DOE's June 25th submittal, and transmitting a second PNL evaluation report (dated November 10, 1992) that pointed out further difficulties with DOE's interpretation of NMM data. As a conclusion, the NRC again did not concur on the DOE's request to remove the Green River neutron access tubes.

After receiving the comments included in NRC and PNL's rebuttal of the DOE's Shiprock Special Study and NMM Study Reports, the DOE directed its contractors to conduct a thorough review. As part of this review, Dr. Lorne Everett, an expert on vadose zone monitoring with the neutron moisture probe, was retained as an expert. Dr. Everett is a national expert on unsaturated flow monitoring and has been used extensively by EPA and PNL as a consultant.

After an intensive investigation of the Shiprock Special Study data, and a review of this study by Dr. Everett, a letter was submitted to DOE by Jacobs Engineering Group on November 18, 1993, stating that the Shiprock Special Study was flawed, and recommending that it be retracted.

With respect to NMM at Green River, Dr. Everett found several significant problems with the work that had been done and with the instrumentation. He pointed out that "well" construction (i.e. neutron access tube construction), equipment performance, and data interpretation problems exist. With respect to construction of the neutron access tubes, he said that the large access hole casing diameter used, reduces the sensitivity of neutron moderation, although the degree of reduced sensitivity cannot be determined because of instrument problems and poor calibration. Other potential construction problems that needed to be resolved include appropriate casing material (i.e. steel vs. aluminum), borehole diameter, casing diameter, casing connections, and surface completion details.

After reviewing the NMM calibration data, Dr. Everett said that it was clear that there is no compatibility between the depths at which water content were measured and the

depths at which the neutron moderation readings were made. A new probe calibration program would be required, similar to those used at permanent DOE facilities.

Review of data indicated that the instrument clearly showed evidence of drift, which may be evidence of a scaling control knob malfunction. Data also indicated that there was a 100%+ error in readings related to temperature effects alone. Older Campbell Pacific neutron probes utilize a trifloride detector which are sensitive to temperature fluctuations. It is not know what type of detector the DOE instrument has, and Dr. Everett recommended that an investigation be conducted to determine if the probe should be replaced with a Helium 3 detector.

To reactivate neutron moisture monitoring at the Green River site, Dr. Everett recommended that the following would be required: 1. Completely re-evaluate the neutron probe instrumentation being used and repair or replace it; 2. Study literature on use of neutron probes in large diameter steel casings, and determine if the existing tubes can be used or have to be replaced; 3. If existing large tubes are found to be technically feasible for use in this case, a special probe centralizer needs to be fabricated and tested to eliminate probe positioning errors; 4. Special calibration standards need to be constructed using existing site tailings materials and samples of existing access tubes to relate neutron counts to actual water content at the site; 5. A long-term transfer standard should be constructed and maintained to facilitate use of different neutron probes when a replacement probe is required; 6. On-site calibration standards should be established using materials (i.e. tailings) from the existing cell; 7. A standard operating procedure (SOP) for use of the neutron probe should be established; 8. Personnel who use the NMM should be H&S and technically trained to use the neutron probe; and 9. A weather station should be constructed and maintained at the disposal cell to help evaluate NMM data.

Since the UMTRA Green River Disposal Cell is a remote un-manned site, and not a permanent manned facility, it was concluded that many of Dr. Everett's recommendations for reactivating neutron moisture monitoring at Green River were not practical. A closer look at the background water quality data was undertaken, and it is now proposed that supplemental standards based on wide spread ambient contamination would be a reasonable ground water protection strategy for the Green River Site.

The neutron access tubes will no longer be needed at the Green River Site if supplemental standards are applied. The DOE proposed to decommission and remove the neutron access tubes because they may eventually cause problems with the long-term integrity of the radon\infiltration barrier. Upon NRC's approval, the decommissioning will be performed in a manner that will effectively ensure the integrity of the cell cover.