

# PROPOSED GROUND WATER PROTECTION STRATEGY FOR THE URANIUM MILL TAILINGS SITE AT GREEN RIVER, UTAH

Final

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FOR THE URANIUM MILL TAILINGS SITE  
AT GREEN RIVER, UTAH**

**Final**

**November 1994**

**Prepared for  
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## LIST OF ACRONYMS AND ABBREVIATIONS

<u>Acronym</u>	<u>Definition</u>
°C	degrees Celsius
cm	centimeter
cm/s	centimeters per second
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
°F	degrees Fahrenheit
ft	foot
gpd	gallons per day
H	hydrogen
km	kilometer
LTSP	long-term surveillance plan
m	meter
MCL	maximum concentration limit
MG	million gallons
mg/L	milligrams per liter
mi	mile
mm	millimeter
N	nitrogen
NEPA	National Environmental Policy Act
NRC	Nuclear Regulatory Commission
O	oxygen
PMP	probable maximum precipitation
Se	selenium
TDS	total dissolved solids
USGS	U.S. Geological Survey

## 1.0 WATER RESOURCES PROTECTION STRATEGY SUMMARY

The U.S. Department of Energy (DOE) proposes the following modification of the water resources protection strategy detailed in the remedial action plan for the Green River, Utah, disposal site (DOE, 1991a). The modification is based on new information, including ground water quality data collected after remedial action was completed and on a revised assessment of disposal cell design features, surface conditions, and site hydrogeology. The modification will result in compliance with the U.S. Environmental Protection Agency's (EPA) proposed ground water protection standards (52 FR 36000 (1987)). A summary of the principal features of the water resources protection strategy for the Green River disposal site follows:

- All tailings and contaminated material at the Green River site have been consolidated into a stable and partially below-grade disposal cell. The disposal cell is covered with a low-permeability radon/infiltration barrier that greatly reduces the radon flux from the cell and the rate of infiltration of surface water through the cell.
- The local climate, hydrogeologic conditions, infiltration and ground water recharge rates, the moisture content of the tailings and contaminated materials, and surface and subsurface drainage patterns were considered in the design of the disposal cell. The design and construction of the disposal cell, in conjunction with the natural conditions at the site, ensures that human health and the environment are protected.
- Hazardous constituents that are reasonably expected to be in, or may be derived from, residual radioactive material stabilized at the disposal site were identified through chemical analyses of pore fluids; they include arsenic, cadmium, chromium, lead, molybdenum, nickel, nitrate, selenium, uranium, vanadium, and radium-226 and -228. In addition, the net gross alpha activity of the pore fluid exceeds the maximum concentration limit (MCL) proposed by the EPA (1987).
- The constituents and their concentration limits listed in the remedial action plan (DOE, 1991a) remain unchanged; however, the term "protection limit" now is used instead of "concentration limit." The concentration limits presented in the completion report (DOE, 1991b) are based on the Title I MCLs or on background levels.
- The previously established point-of-compliance wells are redesignated as disposal site monitor wells. Analysis of water in these wells will continue as a best management practice.
- To achieve compliance with the proposed EPA ground water protection standards, the DOE proposes to use narrative supplemental standards rather than establishing numerical concentration limits for constituents in ground water at a point of compliance. The application of supplemental standards is based on the classification of ground water in the Cedar Mountain Formation (uppermost aquifer) as Class III (limited-use) because it is not a current or potential source of drinking water. The uppermost aquifer may be considered Class III because it meets the following criteria:

- Based on a review of regional and site-specific hydrogeologic and water quality information, widespread, ambient, soluble selenium related to naturally occurring mineralization in the area is present in the ground water. High levels of other contaminants (with respect to state and federal standards) in the ground water, notably sodium and sulfate, also are associated with the naturally occurring mineralization.
- The quality of the water from the uppermost aquifer that has not been affected by milling activities at the Green River site does not meet drinking water standards and does not compare favorably with water typically used as public supply in Utah. Cleanup of this naturally contaminated ground water to drinking water standards in the disposal site area would require extensive and costly treatment processes. Such treatment is not typically used in Utah or in the region; therefore, the naturally contaminated ground water cannot be cleaned up from an engineering practicality perspective for use as a public water supply by reasonably employed treatment methods.
- The Green River disposal cell comes as close as possible to meeting the otherwise applicable standards. The DOE has assessed the performance of the disposal cell at the Green River site in conjunction with the hydrogeologic system and demonstrated that the releases of hazardous and radiological constituents to the ground water and surface water will be minimal; therefore, human health and the environment are protected.
- Natural, stable materials were used in all design components of the Green River disposal cell so that long-term performance is ensured. Furthermore, the DOE demonstrated that the features necessary for compliance with the EPA ground water protection standards do not require active maintenance in order to ensure that they perform as intended for the design life of the disposal cell.
- The DOE will continue to monitor the ground water during the post-disposal period to demonstrate that the initial performance of the disposal cell is in accordance with design requirements. If, through continued ground water monitoring, concentrations of any of the identified hazardous constituents are shown to be increasing in the uppermost aquifer, a risk assessment will be performed to determine the extent and severity of the increasing levels of contamination, and an appropriate action will be implemented to protect human health and mitigate degradation of the environment. Specifics of the monitoring program are detailed in the Green River long-term surveillance plan (LTSP) (DOE, 1992a).
- Demonstration of cleanup and control of existing processing site-related ground water contamination at the Green River disposal site are addressed under a separate DOE program and National Environmental Policy Act (NEPA) process. The remedial action does not preclude or interfere with active ground water restoration, should it be required.

## 2.0 CONCEPTUAL DESIGN FOR WATER RESOURCES PROTECTION

### 2.1 DESIGN CONSIDERATIONS

Climate, hydrogeologic and geochemical conditions, infiltration and ground water recharge, surface and subsurface drainage, and transient drainage are important considerations when assessing whether a ground water resource is protected from potential degradation. These conditions are discussed in the following sections.

#### 2.1.1 Climate

Local climate affects the quantity of surface water available to infiltrate through the stabilized contaminated material. The climate in the vicinity of the Green River site is arid with large ranges in daily temperatures. The mean annual precipitation at Green River for a period of record from 1898 through 1977 was 6 inches (153 millimeters [mm]) (NWS, n.d.). The typical monthly precipitation is 0.3 to 0.5 inch (8 to 13 mm); however, more precipitation occurs during August and September (0.6 to 0.8 inch [15 to 20 mm]). Average annual potential lake evaporation is estimated to be 40 to 43 inches (1000 to 1100 mm) (Kohler et al., 1959). The mean annual temperature at Green River for the period from 1951 to 1980 was 52 degrees Fahrenheit (°F) (11 degrees Celsius [°C]), with a range from 23°F (-5°C) in January to 78°F (26°C) in July (NOAA, 1981).

#### 2.1.2 Hydrogeologic and geochemical conditions

Three hydrostratigraphic units, listed in ascending order, are present at the former Green River site: 1) the basal Buckhorn Member (lower hydrostratigraphic unit); 2) an unnamed member of the Cedar Mountain Formation, which lies between the basal Buckhorn Member of the Cedar Mountain Formation and the overlying Dakota Formation and alluvium (middle hydrostratigraphic unit); and 3) the alluvium beneath the former tailings pile location adjacent to Brown's Wash (upper hydrostratigraphic unit).

The Buckhorn Member of the Cedar Mountain Formation is defined as the lower hydrostratigraphic unit. The ground water in this unit is confined throughout the site by 15 to 25 feet (ft) (4.6 to 7.6 meters [m]) of shales and mudstones. The confining unit in the Cedar Mountain Formation and a strong vertically upward hydraulic gradient isolate ground water in the Buckhorn Member from seepage that might occur from the processing and disposal site areas (DOE, 1994).

Confined and semiconfined ground water is present in the middle hydrostratigraphic unit beneath the Green River site. This unnamed member of the Cedar Mountain Formation consists primarily of sandstone, limestone, siltstone, and shale. Ground water flows to the north-northwest; however, flow velocities have not been reliably established for this unit. Based on field

observations of geologic features and pumping test data, this unit is not laterally extensive and is low-yielding, although the sustained yield is estimated to be greater than 150 gallons per day (gpd). The redox potential in this aquifer varies from moderately oxidizing to very reducing. As interpreted by the U.S. Nuclear Regulatory Commission (NRC), the uppermost aquifer (middle hydrostratigraphic unit) is the entire saturated thickness above the Buckhorn Member between the alluvium and Dakota Sandstone (NRC, 1990).

The upper hydrostratigraphic unit at the site is the Brown's Wash alluvium. Ground water in this unit is unconfined and is locally perched above well-cemented sandstone of the Dakota Formation and is perched above the shale and limestone of the Buckhorn Member where those units are not fractured.

### **2.1.3 Infiltration and ground water recharge**

Given the natural surface conditions in the vicinity of the Green River site, only a small percentage of precipitation is expected to deep-percolate and recharge the underlying ground water in the uppermost aquifer. The U.S. Geological Survey (USGS) estimated that less than 1 percent of average annual precipitation deep-percolates and recharges ground water in the Green River-Moab area. The recharge-to-precipitation ratio is very small but is consistent with ratios estimated for similar climatic zones of Nevada and western Utah (USGS, 1982).

Most of the precipitation that falls on the disposal cell either evaporates or runs off the cell through the rock erosion protection layer and the filter bedding layer. In the arid environment at the Green River site, where the potential annual lake evaporation is over five times the mean annual precipitation, the multi-component cover of the disposal cell is an effective infiltration barrier (DOE, 1991a).

### **2.1.4 Surface and subsurface drainage**

The runoff from the former processing site and the disposal area flows northwest towards Brown's Wash and, thence, into the Green River. Any runoff from the watershed north of the Green River site is intercepted by Brown's Wash before reaching the site area.

Areas surrounding the disposal cell are filled and graded to direct runoff away from the cell and to prevent ponds of surface water from forming at or near the edge of the disposal cell. The disposal cell configuration causes runoff to occur as sheet flow over the slopes.

In a steady-state condition, the seepage rate from the bottom of the disposal cell primarily is a function of the infiltration rate through the radon/infiltration barrier. On the basis of laboratory and field tests of the radon/infiltration barrier material, the saturated conductivity of the barrier is at least  $2 \times 10^{-8}$  centimeters per second (cm/s) (NRC, 1990). Transient drainage conditions resulting from

the seepage of tailings pore fluid and water added during disposal cell construction can occur after completion of a disposal cell. However, the tailings and other contaminated material were placed at a very low level of saturation in the Green River disposal cell. Disregarding differences in test results from separate sampling rounds, the initial moisture condition of the tailings and other contaminated material varied from 15 to 25 percent saturated (DOE, 1992b). Consequently, the potential impact from transient seepage of pore fluid from the disposal cell on the quality of ground water in the uppermost aquifer is expected to be minimal.

## 2.2 DESIGN FEATURES

The principal design features that ensure that the Green River disposal cell is in compliance with the EPA ground water standards are described in the following section. Also included is a discussion of the design life and maintenance requirements of the principal components of the disposal cell.

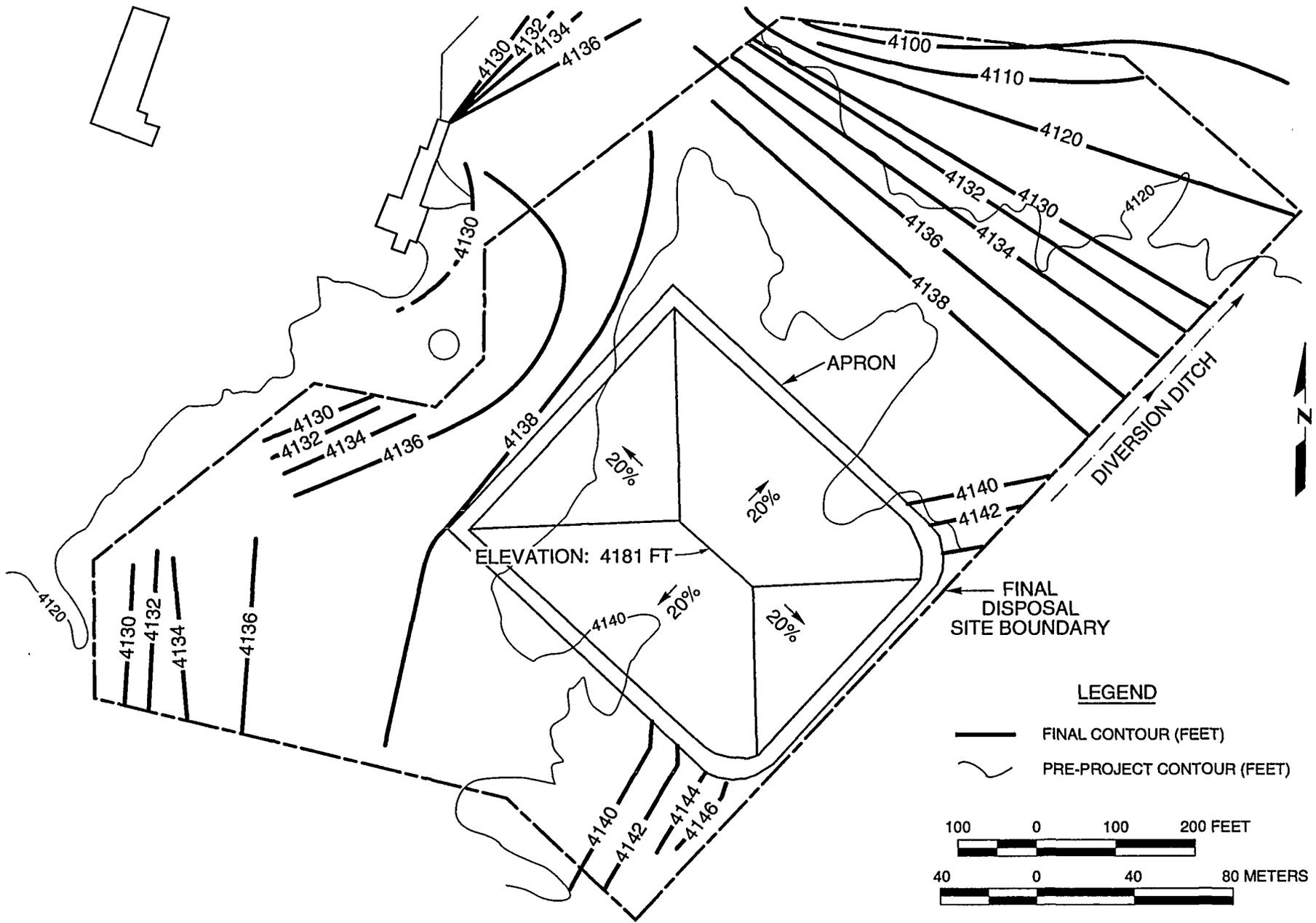
### 2.2.1 Disposal cell geometry

The disposal cell footprint is square, with relatively steep sideslopes (20 percent). The steep slopes minimize planar surfaces through which precipitation can infiltrate; therefore, the volume of surface water that potentially can seep through contaminated material is lessened. The disposal cell configuration, cross section, and cover details are shown on Figures 2.1, 2.2, and 2.3.

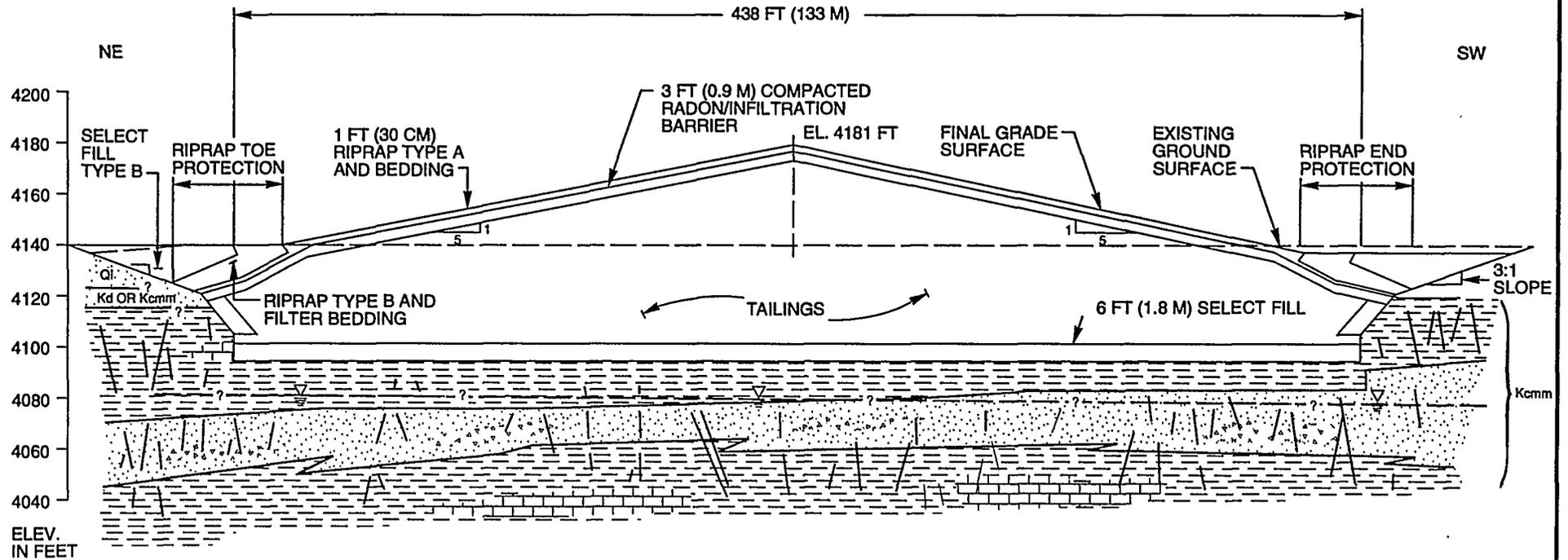
### 2.2.2 Disposal cell components

The disposal cell at the Green River site is designed to stabilize the tailings and contaminated material from the Green River processing site, reduce airborne radon concentrations, and protect ground water resources. The contaminated materials are covered with a multi-layered cover consisting of (in ascending order): 1) radon/infiltration barrier, 2) a filter layer, and 3) an erosion protection barrier. The cover components are:

- Radon/infiltration barrier—The radon/infiltration barrier minimizes the infiltration of water into the contaminated materials, and thereby reduces the subsequent seepage of leachate from the disposal cell; it also inhibits radon emanation. The barrier consists of 3 ft (0.9 m) of silty clay amended with 6 percent by weight sodium bentonite and compacted to 100 percent of standard Proctor density. Based on extensive testing, including both field and laboratory measurements, the saturated conductivity of the radon barrier layer is  $2 \times 10^{-8}$  cm/s or less.
- Filter layer—A highly permeable filter layer directly above the radon/infiltration barrier enhances lateral runoff of precipitation off the disposal cell and thus reduces direct vertical infiltration of water through the tailings and contaminated material. The size range of material used to construct the filter



**FIGURE 2.1**  
**PLAN VIEW OF THE GREEN RIVER DISPOSAL CELL**



REF: DOE, 1991a

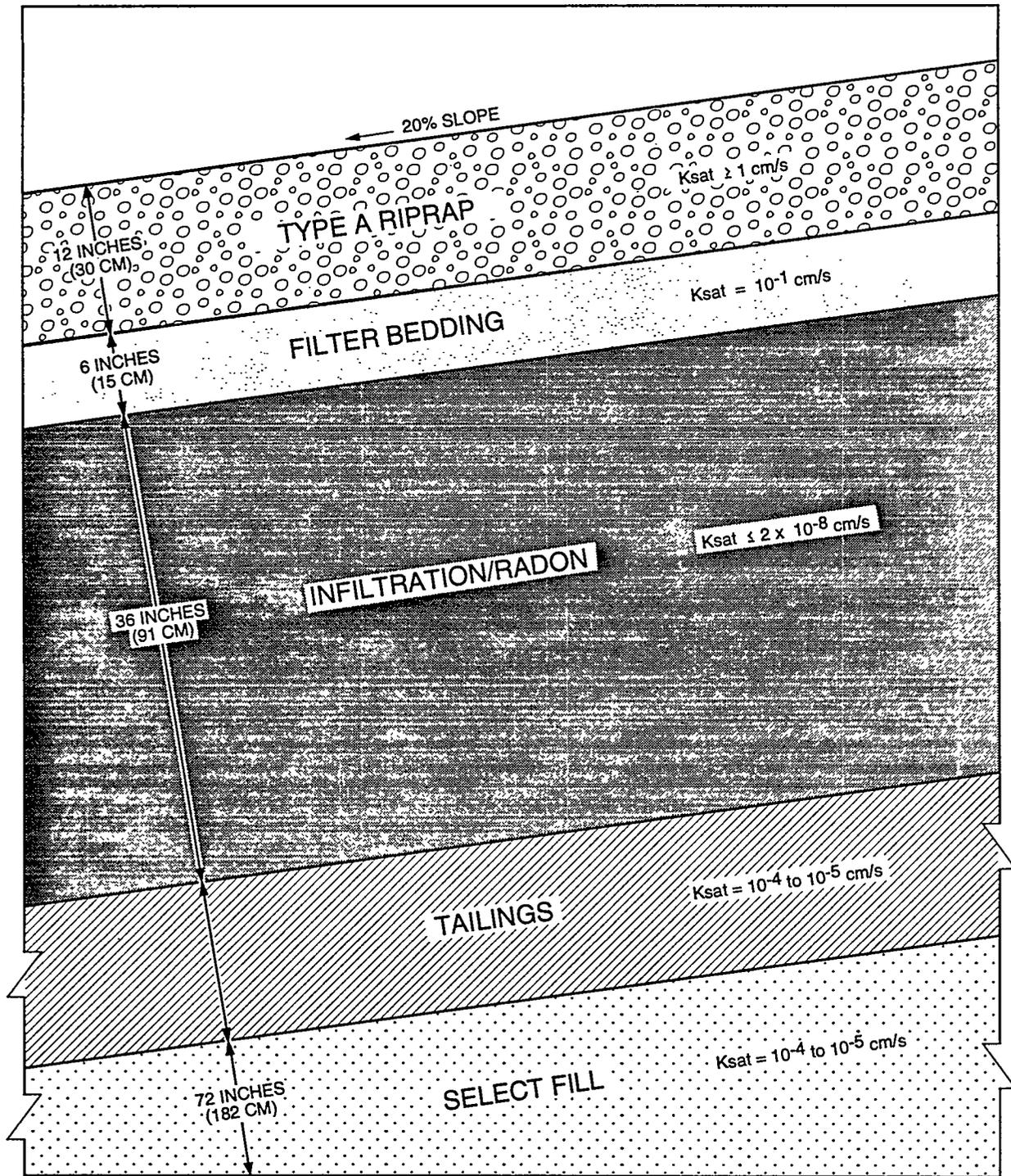
**LEGEND**

FORMATION	MATERIAL	ROCK TYPE
qi	TERRACE SEDIMENTS	SOILS
Kd	DAKOTA SANDSTONE	BEDROCK
Kcmm	CEDAR MOUNTAIN FORMATION - UNNAMED MEMBER (MIDDLE HYDROSTRATIGRAPHIC UNIT)	
		<ul style="list-style-type: none"> <li> SANDSTONE OR SILTSTONE</li> <li> SHALE OR MUDSTONE</li> <li> LIMESTONE</li> <li> CONGLOMERATE</li> </ul>
	FRACTURES	
	POTENTIOMETRIC SURFACE	



NOTE: ELEVATIONS ARE GIVEN IN FEET. TO CONVERT FROM FEET TO METERS, MULTIPLY FEET BY 0.3048.

**FIGURE 2.2**  
**DIAGRAMMATIC CROSS SECTION OF DISPOSAL CELL AND FOUNDATION**  
**GREEN RIVER, UTAH, DISPOSAL SITE**



SCHEMATIC - NOT TO SCALE

**LEGEND**

$K_{sat}$  SATURATED HYDRAULIC CONDUCTIVITY  
 cm/s CENTIMETERS PER SECOND

REF: DOE, 1991a

**FIGURE 2.3  
 DISPOSAL CELL COVER SYSTEM  
 GREEN RIVER, UTAH, DISPOSAL SITE**

layer was calculated to ensure that both the thickness and hydraulic conductivity of the layer will divert runoff laterally off the sideslopes of the disposal cell, yet runoff velocity will not erode the radon/infiltration barrier.

- Erosion protection layer—The rock layer on the top and sideslopes of the disposal cell is designed to prevent erosion due to surface runoff resulting from the probable maximum precipitation (PMP) falling on the disposal cell.

### 2.2.3 Disposal cell longevity

The EPA ground water protection standards require that the disposal cell be designed to stabilize the contaminated material and protect the environment for 1000 years where reasonably achievable, and, in any case, for at least 200 years. In addition, the design features and components of the disposal cell must not require active maintenance to ensure their long-term performance.

Natural, stable materials were used in the Green River disposal cell so that long-term stability of the tailings and contaminated material is assured. The riprap used to cover the disposal cell was selected based on its durability. The long-term integrity of the radon/infiltration barrier is ensured by the overlying filter and riprap layers, which protect it from degradation by wind, water, burrowing animals, and, to a lesser extent, plant roots.

### 3.0 DISPOSAL AND CONTROL OF RESIDUAL RADIOACTIVE MATERIALS AND NONRADIOACTIVE CONTAMINANTS

#### 3.1 GROUND WATER PROTECTION STANDARD

The current ground water protection strategy for the Green River disposal site is to meet MCLs or background concentration levels for the constituents listed in Table 2 of the completion report (DOE, 1991b) at designated monitor wells. As an additional element of the existing strategy, the DOE committed to monitoring the moisture content of contaminated material placed in the disposal cell.

The DOE is proposing to change the existing ground water protection strategy for the Green River disposal site as follows: compliance with the proposed EPA ground water protection standards will be achieved by applying supplemental standards at the Green River disposal site based on the presence of Class III (limited-use) ground water in the uppermost aquifer due to widespread natural ambient contamination (52 FR 36000 (1987)). Ground water in the uppermost aquifer (saturated sandstone, siltstone, limestone, and shale of the middle hydrostratigraphic unit) is not a current source of drinking water because of the presence of widespread, ambient concentrations of naturally occurring selenium, sulfate, and total dissolved solids (TDS) not due to activities involving residual radioactive material from the former processing site that cannot be cleaned up using treatment methods reasonably employed in public water supply systems (52 FR 36000 (1987)).

The current EPA ground water protection strategy consists of three components: 1) a list of designated hazardous constituents; 2) a list of proposed protection standards for the constituents; and 3) a point of compliance. These elements are discussed below.

##### 3.1.1 Hazardous constituents

Testing for the hazardous constituents listed in Table 1, Appendix I of the EPA standards (EPA, 1987) and Appendix IX of 40 CFR Part 264 (1994) was performed by the DOE to characterize the tailings pore fluid. Based on chemical analyses, 12 hazardous constituents (arsenic, cadmium, chromium, lead, molybdenum, net gross alpha, nickel, nitrate, selenium, uranium, vanadium, and radium-226 and -228) are found in the pore fluid and are elevated above Title I MCLs. The concentrations of all other Appendix I and Appendix IX constituents in the pore fluid, including organic contaminants, are below the range of background levels and the MCLs, or are below the laboratory detection limit.

##### 3.1.2 Hazardous constituent protection limits

To achieve compliance with the proposed EPA ground water protection limits at the Green River disposal site, the DOE proposes narrative supplemental standards to supersede the previously proposed numerical concentration limits for constituents in ground water at the point of compliance. To ensure that the

remedial action comes as close as possible to meeting otherwise applicable standards as is reasonable under the circumstances, however, the DOE recommends using indicator constituents for long-term ground water monitoring at the disposal cell. Criteria for selecting constituents for long-term ground water monitoring at the disposal cell were as follows:

- The constituent is clearly present in the tailings, and a large differential exists between tailings pore water concentrations and ground water concentrations in the vicinity of the disposal cell.
- There is both theoretical and empirical evidence of mobility and conservation of the constituent in the geochemical environment around the disposal cell.

Four sampling rounds of tailings pore water from lysimeter 714 were taken during September 1986, March 1987, July 1988, and December 1988. Table 3.1 shows constituents that exceeded the highest concentrations observed in samples from disposal cell vicinity monitor wells on at least two sampling occasions.

**Table 3.1 Pore space and cell area water quality (lysimeter 714 and monitor wells 171, 180, 562, 813, and 816)**

Constituent	Number of sampling rounds	Tailings pore water concentrations			Disposal cell area ground water
		Low	Median (mg/L)	High	Observed range (mg/L)
Aluminum	2	1,840		6,300	<0.05 - 0.90
Ammonium	3	11	13	14	<0.03 - 1.4
Chromium	3	1.1	2.6	4.0	<0.01 - 0.09
Iron	2	267		2,200	<0.01 - 2.5
Magnesium	2	1,090		2,640	1 - 542
Manganese	2	122		360	0.01 - 1.7
Nitrate (NO <sub>3</sub> <sup>-</sup> )	3	2	4,500	6,100	1 - 293
Sulfate	2	16,000		56,200	915 - 4,710
Uranium-234, -238	3	221	650	675	<0.001 - 0.23

mg/L — milligrams per liter.

With the exception of chromium and iron, all of these constituents were determined, using statistical inferential methods, to be present at concentrations above background levels in the upper Cedar Mountain Formation underlying the former tailings pile (DOE, 1994). This demonstrates that the remaining constituents in Table 3.1 are able to migrate into the water table at the Green River site. However, aluminum, ammonium, magnesium, and manganese are

subject to various physicochemical mechanisms, including sorption onto the aquifer matrix, precipitation, and ion exchange. These processes will tend to remove these constituents from solution in ground water and to impede their migration. On the other hand, nitrate, sulfate, and uranium are relatively stable under the existing geochemical conditions in ground water beneath the cell and are transported through the aquifer matrix at roughly the same velocity as water. Therefore, these constituents were selected to monitor the potential for migration of tailings-related contamination into the ground water beneath the cell.

Protection limits for future measurements of nitrate, sulfate, and uranium were established for monitor wells located downgradient or crossgradient of the disposal cell (DOE monitor wells 171 through 176 and 813). Filtered chemical analysis data collected between 1990 and 1994 were used to establish baseline water quality. Because baseline conditions varied a great deal between the monitor wells, protection limits were established well by well.

Protection limits for each well and constituent were determined using a 95/95 normal-based tolerance interval procedure. The 95/95 percent upper tolerance limit represents an estimate of the 95th percentile of well concentration measurements plus a margin of error. The margin allows for estimation errors that are likely to occur when small data sets are used for inference. The procedure provides 95 percent confidence that at least 95 percent of all future measurements will lie below the protection limit, provided contaminant levels do not begin to trend upward in the future. The 95/95 percent upper tolerance limit has been proposed by the EPA (1989) as a method that achieves a reasonable balance between false negative and false positive results.

If the calculated upper tolerance limit was less than the MCL for a constituent, the protection limit was set equal to that MCL. Table 3.2 summarizes the range and mean of the historical data used in computations, the 95/95 percent upper tolerance limit, and the proposed ground water protection limit for each well and constituent.

### **3.1.3 Point of compliance**

A point of compliance is not required when supplemental standards are used in a compliance strategy. As a best management practice, however, the DOE will continue to monitor the ground water by periodically sampling the former point of compliance wells (now termed monitor wells). Details are specified in the LTSP (DOE, 1992a).

## **3.2 SUPPLEMENTAL STANDARDS**

An application for supplemental standards must address the following three elements: 1) the description and applicability of the proposed supplemental standards; 2) a demonstration that the remedial action complies with the supplemental standards; and 3) a demonstration that the remedial action comes

**Table 3.2 Summary of 1990-1994 filtered water quality and proposed protection limits for disposal cell monitor wells, Green River, Utah**

Monitor well	Number of samples	1990 - 1994		95/95 percent tolerance limit	Proposed protection limit
		Range	Mean		
mg/L					
<b>Nitrate (MCL = 44 mg/L)<sup>a</sup></b>					
171	9	1.2 - 6.6	3.7	10	44
172	9	32 - 83	51	97	97
173	9	1.0 - 5.3	1.8	6	44
174	9	1.0 - 4.1	1.6	5	44
175	8	1.0 - 3.8	1.5	5	44
176	9	120 - 293	222	424	424
813	11	1.0 - 9.3	3.5	12	44
<b>Sulfate (no MCL)</b>					
171	10	2180 - 3210	2780	3590	3590
172	10	3640 - 4760	4350	5270	5270
173	10	2820 - 3740	3420	4180	4180
174	10	2300 - 3450	3180	4130	4130
175	9	3470 - 3660	3570	3760	3760
176	10	3440 - 4300	3990	4740	4740
813	12	3540 - 4300	3970	4620	4620
<b>Uranium (MCL = 0.044 mg/L)<sup>b</sup></b>					
171	10	0.002 - 0.014	0.005	0.014	0.044
172	10	0.001 - 0.058	0.028	0.086	0.086
173	10	<0.001 - 0.005	0.002	0.005	0.044
174	10	<0.001 - 0.010	0.002	0.011	0.044
175	9	<0.001 - 0.022	0.008	0.032	0.044
176	10	0.038 - 0.091	0.060	0.108	0.108
813	12	0.034 - 0.060	0.050	0.068	0.068

mg/L — milligrams per liter.

<sup>a</sup>The MCL for nitrate is 10 mg/L as N, which equals 44 mg/L NO<sub>3</sub><sup>-</sup>.

<sup>b</sup>The MCL for uranium is 30 pCi/L, which is equivalent to 0.044 mg/L, assuming secular equilibrium between major isotopes.

as close to meeting the otherwise applicable standards as is reasonable under the circumstances (NRC, 1989).

Because a ground water compliance strategy based on meeting specified concentration limits for hazardous constituents at a point of compliance was initially proposed by the DOE for the Green River site (DOE, 1991a), the justification for changing the initial, but not approved, compliance strategy is incorporated in the discussion of the description and applicability of the supplemental standards. Additionally, a discussion of proposed modifications to disposal site features that were necessary components of the initial ground water compliance strategy is included.

### **3.2.1 Description and applicability of proposed strategy**

The existing ground water protection strategy for the Green River disposal site is to meet MCLs or background concentration levels for the constituents listed in Table 3.1 at designated point of compliance wells (DOE, 1991b). As an additional element of the existing strategy, DOE is committed to monitoring the moisture content of contaminated material placed in the disposal cell.

Based on new information collected since remedial action was completed, the revised ground water protection strategy for the Green River disposal site is to achieve compliance with the proposed EPA ground water protection standards by applying supplemental standards at the Green River disposal site, based on the presence of Class III (limited use) ground water in the uppermost aquifer caused by widespread, ambient contamination (52 FR 36000 (1987)). Ground water in the uppermost aquifer is not a current source of drinking water because of the existence of widespread, ambient concentrations of naturally occurring selenium, sulfate, and TDS not due to activities involving residual radioactive material from the former processing site that cannot be cleaned up using treatment methods reasonably employed in public water supply systems (52 FR 36000 (1987)). Furthermore:

- No ground water sources that require treatment to meet state or federal standards are used for public supply in Utah. Ground water from the uppermost aquifer would require "substantial" treatment, as defined in Utah's Administrative Code R317-6-3 (Utah, 1993a) to be of drinking water quality. Accordingly, the treatment technologies required to upgrade the water quality at the Green River site are not those typically or reasonably employed in the region.
- The ground water not impacted by activities at the former processing site contains concentrations of selenium in excess of the EPA (and state) MCL of 0.01 milligrams per liter (mg/L). In addition, the levels of numerous constituents that impact the aesthetic quality of the water are elevated well above the limits found in both state and federal secondary drinking water standards.

- In accordance with Utah's classification system (R317-6-3, 3.6) (Utah, 1993a), the uppermost aquifer may be presumed a Class III (limited-use) ground water source because the level of TDS is greater than 3000 mg/L, and the concentration of selenium exceeds the state standard of 0.01 mg/L.

### Treatability analysis

The treatability analysis of the ground water from the uppermost aquifer consists of: 1) a discussion of the characteristics of water typically used for municipal supply in Utah, and in the east-central and southeastern region of Utah; 2) the DOE's assessment of background water quality in the vicinity of the disposal site; and 3) an evaluation of the practicability of treating ground water from the uppermost aquifer after considering the differences between items 1 and 2. The proposed EPA ground water standards and the EPA secondary drinking water standards are used as the criteria for determining the technical and economic viability of treating water from the uppermost aquifer. Ground water standards promulgated by the state for metals and inorganic chemicals are identical to the proposed EPA standards, except the state includes copper in its list of metals with MCLs, whereas molybdenum is included in the EPA standards as a regulated metal, but is not on the state's list (Utah, 1993a). In Utah, EPA secondary standards are used as an additional guideline for determining whether an aquifer is a potentially usable drinking water source (Topham, 1993).

The approach to determining whether treating a ground water source is reasonable, including an economic-based test, is taken directly from *Guidelines for Ground-Water Classification Under the EPA Ground-Water Protection Strategy* (EPA, 1986).

To demonstrate that treating a water source is reasonable, the following should be considered:

- Standards and criteria for treatment—The standards are usually MCLs. For constituents without MCLs, however, other criteria can be used to assess treatability, including recommended MCLs or health advisory levels.
- Regional availability of treatment technologies ("reference technologies")—In some areas of the country a treatment method may be used commonly, whereas in another region of the country it may not be used at all. The treatment technologies typically used in EPA Region VIII (Colorado, Montana, North and South Dakota, Wyoming, and Utah) are listed in Table 3.3 and include aeration, carbon adsorption, precipitation, chlorination, flotation, fluoridation, and filtration. As defined in Utah statutes, conventional treatment technologies include flocculation, sedimentation, filtration, and disinfection. Other technologies, such as air stripping, desalination (reverse osmosis), ion exchange, and ozonation are not commonly used in EPA Region VIII. In Utah, technologies such as ion exchange and reverse osmosis

**Table 3.3 Application of treatment technologies in public water supply systems for EPA Region VIII (Colorado, Montana, North Dakota, South Dakota, and Utah)<sup>a</sup>**

Technologies commonly applied in Region VIII	Number of systems identified
Aeration	8
Carbon adsorption	4
Chemical precipitation	35
Chlorination	64
Flotation	70
Fluoridation	23
Granular medium filtration	44
<b>Technologies seldom applied in Region VIII</b>	
Air stripping	0
Desalination (reverse osmosis)	1
Ion-exchange	2
Ozonation	0
<b>Technologies not applied in Region VIII</b>	
Distillation	0
Wet air oxidation	0
Biological treatment	0

<sup>a</sup> Table modified from Table 4-9, *Guidelines for Ground-Water Classification Under the EPA Ground-Water Protection Strategy*, (EPA, 1986).

are classified as specialized treatment methods (R317-6-1, 1.29) (Utah, 1993a).

- **Treatment efficiency**—The treatment (removal) efficiency for a given contaminant or group of contaminants requires an evaluation of interferences and interactions of constituents. Contaminant concentration, physical conditions, solution chemistry, and the presence of competing or interfering ions can all contribute to large variations in the efficiency of treatment methods.

In addition, an economics-based test for determining the practicality of treating ground water can be used by itself or in conjunction with the "reference technology" approach. Specifically, the cost to a community of treating ground water for use as a drinking water supply is compared to the average cost incurred by the community for its current drinking water supply.

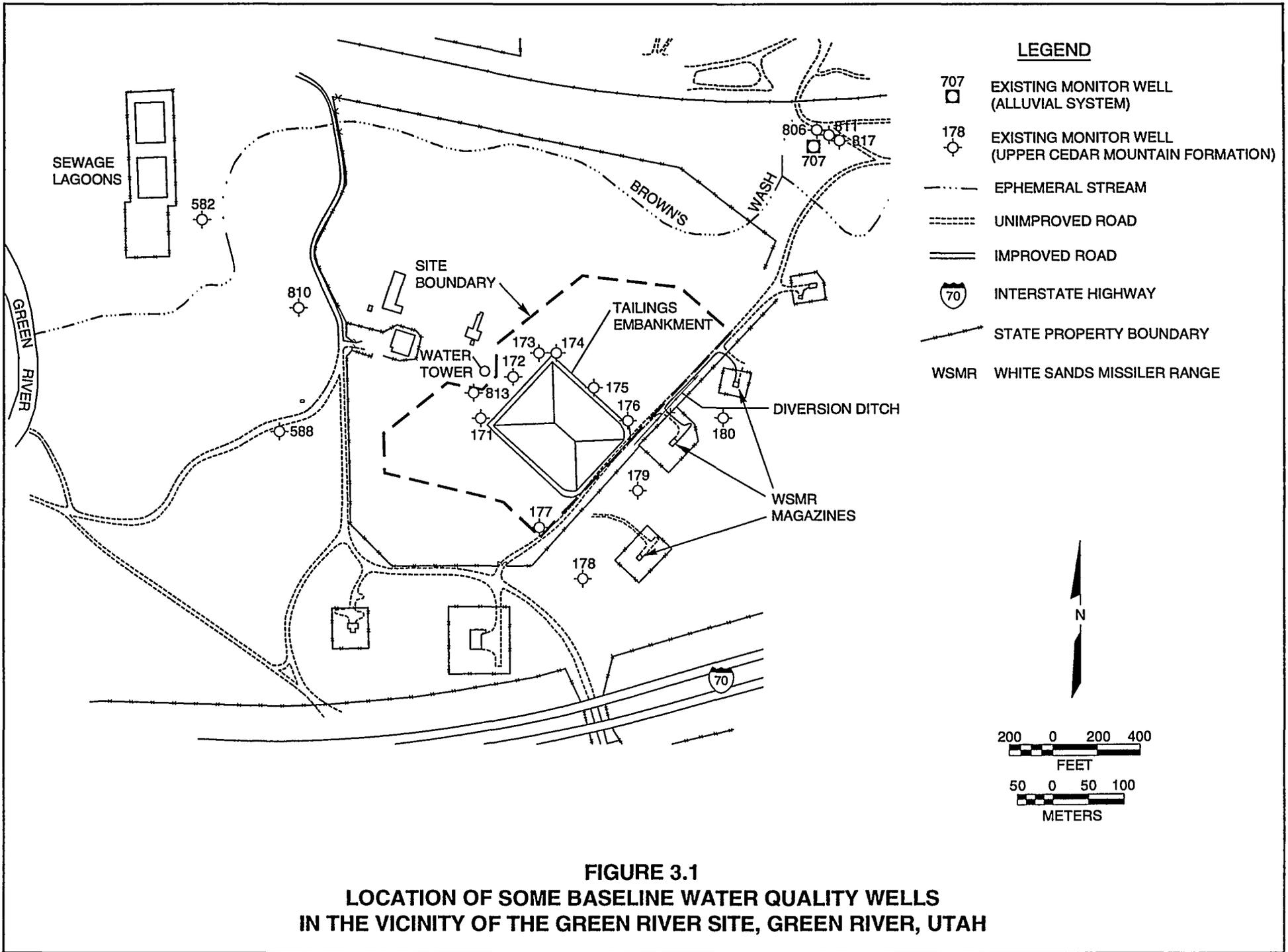
### Characteristics of water used for municipal supply in Utah

The Utah Department of Natural Resources maintains a data base containing information on 1505 discrete drinking water supply systems located throughout the state. Drinking water for 576 public systems in Utah is obtained from springs, while ground water from wells is used to supply another 878 drinking water systems. Surface water is the source of drinking water for the remaining 51 public systems listed in the data base (Topham, 1993). The following information is based on a review of documents provided by the State of Utah Natural Resources—Division of Water Rights, the Utah Division of Drinking Water, and on conversations with personnel from both agencies. Additional information is acquired from EPA guidelines (EPA, 1986).

- Currently, no drinking water source in Utah requires treatment to remove EPA-regulated constituents (Georgeson, 1993).
- The concentration of TDS in ground water supplies is less than 3000 mg/L, and usually less than 1000 mg/L (Topham, 1993).
- There are very few reverse-osmosis and ion-exchange systems in EPA Region VIII used for treating public water supplies. There are no reverse osmosis facilities in Utah used for treating a public water supply. The three ion-exchange plants currently operating in Utah are utilized for reducing TDS in industrial wastewater (Georgeson, 1993).

### Assessment of ground water at the designated site

To determine baseline water quality, water samples were taken from wells designated by the DOE as baseline water quality monitor wells. The NRC gave conditional concurrence to the DOE's selection of baseline monitor wells (DOE, 1992a; 1991a). The baseline water quality at the Green River site has been adequately characterized; the NRC conditionally agrees that the data are representative of baseline water quality (DOE, 1992a; 1991a). The baseline wells include those monitor wells located 1) upgradient of the disposal site (monitor wells 177, 178, 179, 180, and 818); 2) crossgradient and downgradient of the disposal site (monitor wells 171, 172, 173, 174, 175, 176, 561, 562, 807, 810, 812, 813, and 816); 3) upgradient to the processing site (monitor wells 806, 811, and 817); and 4) in the Buckhorn Member (monitor wells 582, 586, 587, 588, and 819). The quality of the water found in crossgradient and downgradient wells is not affected by the presence of the disposal cell, and no baseline wells are close enough to the former processing site area to be impacted by the contaminated, unconfined alluvial aquifer water underlying the former processing site area. Monitor wells within, or adjacent to, the former processing site area are not considered in the analysis of baseline water quality. The locations of some of the baseline water quality monitor wells are shown on Figure 3.1.



Based on water quality data collected at the site on a regular basis for the last 7 years, selenium is present in nearly all baseline wells at levels above the standard. Not only is selenium pervasive in baseline wells completed in the uppermost aquifer throughout the site area, it is also found in concentrations above the MCL in the Buckhorn Member. Ground water in the Buckhorn Member exists under confined conditions in the site area and expresses a vertically upward hydraulic gradient in relation to the overlying hydrostratigraphic units. Therefore, ground water from the Buckhorn Member is a likely source of some of the selenium in the overlying unit. The widespread, high levels of selenium present in the ground water from the uppermost aquifer are attributable to naturally occurring mineralization within the Cedar Mountain Formation. In accordance with EPA treatability criteria, the occurrence of selenium in the ground water meets the definition of widespread, ambient contamination.

Extremely elevated levels of sulfate and TDS are found in the ground water from the uppermost aquifer. As with selenium, the high levels of sulfate and TDS (sodium and sulfate) are present in nearly all baseline wells, and the high levels are reported in all sampling rounds since early 1986. The presence of widespread, ambient levels of secondary contaminants in the ground water also is related to naturally occurring mineralization in the vicinity of the Green River site. The state classifies a ground water containing greater than 3000 mg/L TDS as Class III (limited-use) ground water; the federal limit is 10,000 mg/L.

A summary of the minimum and maximum concentrations of selenium as a function of monitor well location is presented in Table 3.4. Other contaminants found in the ground water from the uppermost aquifer (and the Buckhorn Member) also are shown on Table 3.4.

**Table 3.4 Range of concentrations of contaminants found in ground water at the Green River site**

Constituent	Monitor well location				MCL (mg/L)
	Upgradient of disposal site (mg/L)	Crossgradient and down-gradient of disposal site (mg/L)	Upgradient of processing site (mg/L)	Buckhorn Member (mg/L)	
Selenium	0.002-0.65	0.002-2.5	0.002-0.05	0.002-0.11	0.01
Sulfate	474-3900	481-7950	104-819	393-2120	250 <sup>a</sup>
TDS <sup>b</sup>	2000-6630	1870-13900	1350-6580	1830-3820	1000 <sup>a</sup>

<sup>a</sup>Drinking Water Standard.

<sup>b</sup>Sodium (Na) is the other ion found at high concentrations in the ground water.

### Applicable treatment technologies (reference technologies)

Generally, water treatment systems are designed to operate effectively over a range of conditions. The water distributed through a public system should be of high quality and any hazardous or radiologic contaminants present in the untreated water must be lowered to levels below applicable state and federal MCLs in the treated water. Hence, the maximum observed concentrations of hazardous constituents in the ground water are used when assessing the conceptual design of a treatment system and when addressing the issue of treatability.

In all wells, the levels of selenium found in ground water from the uppermost aquifer are typically elevated above the MCL; however, the maximum observed concentrations of selenium are highly variable, ranging from slightly above the MCL to over two orders of magnitude above the MCL. Thus, determining a characteristic influent to a hypothetical treatment plant is problematic. The following approach to resolve this issue is proposed:

- Because of liability issues and existing institutional controls, no drinking water supply wells will ever be installed within the boundaries of the designated disposal site or installed on property owned by the U.S. Army.
- Although the following wells have been installed for the purpose of assessing baseline ground water conditions, they are located off the site; therefore, the levels of contamination present in ground water drawn from wells 561 and 810 (crossgradient and downgradient, respectively), and 806, 811, and 817 (upgradient) are representative of contaminant concentrations that could be expected in drinking water supply wells completed in the Cedar Mountain Formation.
- Because of the significant upward gradient at the interface of the Cedar Mountain Formation and the Buckhorn Member and the likelihood that contaminants found in Buckhorn water naturally migrate into the uppermost aquifer, or could be drawn there by an extraction well, the concentrations of contaminants found in the Buckhorn Member water also must be considered in treatment plant design.

The required removal efficiencies for selenium are presented in Table 3.5 and are based on lowering selenium concentrations to the MCL. Other assumptions associated with removal efficiencies are referred to in preceding paragraphs.

The treatment processes that most readily remove selenium include chemical precipitation, reverse osmosis, ion exchange, and ozonation (EPA, 1986). In addition, activated alumina adsorption also is used to reduce levels of selenium in water. The latter two processes, ozonation and alumina adsorption, are not currently in use in EPA Region VIII or in Utah ([EPA, 1986], [Georgeson, 1993]); thus, they cannot be considered reasonably employed in public water supply systems.

**Table 3.5 Required removal efficiency of selenium**

Well number	Range of concentrations (mg/L)	Required removal efficiency
561, 810 (crossgradient and downgradient)	0.005-011	Up to 91%
806, 811, and 817 (upgradient)	0.002-0.05	Up to 80%
582, 586, 587, 588, and 819 (Buckhorn Member)	0.002-0.11	Up to 91%

The process and typically achievable removal efficiencies for selenium are as follows: 1) chemical precipitation — 45 to 70 percent; 2) reverse osmosis — up to 99 percent; and 3) ion exchange — up to 98 percent. The variation in removal efficiencies of selenium using chemical precipitation (i.e., conventional treatment) is due to the type of coagulant used in the process, with best results achieved using ferric sulfate and poorer results using lime. In addition, the effectiveness of conventional treatment also is dependent on the oxidation state of selenium. The removal efficiencies cited above apply to selenium +4, because the removal efficiencies for selenium +6 is 10 percent or less using conventional treatment, regardless of the precipitant used (Montgomery, 1985). On the basis of pH and Eh conditions, selenium +4 as  $\text{HSeO}_3^-$  is the predominant species in the Cedar Mountain Formation water; however, chemical precipitation cannot produce the desired effluent water quality.

Based on the reported removal efficiencies, reverse osmosis and ion exchange can achieve acceptable water quality levels for selenium. Although neither reverse osmosis nor ion exchange are used in public water systems in Utah, both processes are in limited use in EPA Region VIII. Thus, the ground water from the Cedar Mountain Formation might not be considered Class III utilizing reference technology criteria alone. An economic-based test is used in conjunction with the reference technology criteria, however, to demonstrate that the ground water cannot be cleaned up using treatment methods reasonably employed in public water supply systems and is, therefore, Class III (limited-use) ground water.

**Economic-based test**

The size of the hypothetical user population of ground water from the uppermost aquifer is based on a calculation of sustained yield of the water-bearing strata. The sustained yield and areal extent of the water-bearing zone are determined from pumping test data and hydrogeologic characterization of the area (DOE, 1994). Based on hydrogeologic data, the estimated maximum sustainable yield of the uppermost aquifer system is 15,000 gpd. The population that could be served by this yield is 100 (150 gpd per person). Using the state average of

3.15 persons per household, the potential user population is equivalent to 32 households.

A population of 100 persons will use about 5.5 million gallons per annum (i.e., 100 persons x 150 gpd per person x 365 days). The annual cost for a typical ground water system to produce this amount of water is about \$41,360 (i.e., 5.5 million gallons x \$7519 per million gallons from Exhibit G of the EPA guidelines [EPA, 1986]). Finally, the estimated system cost apportioned to acquisition and service is approximately \$16,130 (i.e., \$41,360 x 39 percent from Exhibit H [EPA, 1986]). The median household income for Green River is \$21,369. The income estimate is based on data supplied by Governor's Office of Planning and Budget (Utah, 1993b).

Although either ion exchange or reverse osmosis are appropriate processes for cleaning up ground water from the uppermost aquifer, the high level of TDS and the oxidation state of selenium in the water are expected to raise the treatment costs of either process. Given the high level of TDS in the ground water, the operational efficiency of an ion-exchange plant or a reverse-osmosis system is dependent not on the level of trace hazardous constituents in the ground water, but on the high levels of major ions such as sulfate. Additionally, the cost of an anionic exchange system (as required for selenium removal) is about 50 percent higher than a typical cation exchange system (EPA, 1979). Thus, the cost of treating ground water from the uppermost aquifer is expected to be comparatively high because of interfering ions and the chemical characteristics of the trace contaminant.

The estimated annualized costs of treating this ground water source with anionic exchange or reverse osmosis are \$5,442 and \$15,768, respectively. These costs were calculated using Exhibit H (EPA, 1986), inflating the costs to 1994 dollars assuming an annual inflation rate for the period of 5 percent, and prorating the costs for a population of 100. Because anionic exchange clearly is the less expensive system, the cost of using a reverse-osmosis system is not assessed further. The estimated of acquisition and support services for an ion-exchange plant is \$16,130, for a total cost of \$21,572. Total annual cost per household for an ion-exchange system is \$674 (\$21,572 divided by 32 households).

Two threshold values are used to complete the Class III economic-based test: 1) the total system cost and 2) the treatment costs per household. The total system cost is the total annual water system cost per household divided by annual income per household. The treatment cost per household is the percent increase in the water rate and is determined by comparing the current average yearly residential water bill with the predicted yearly household cost for water from a new treatment system.

If the "total system cost" exceeds 0.3 to 0.4 percent and treating the proposed ground water source increases water rates more than 100 percent, the ground water is Class III (limited-use). The range is based on a national survey, wherein

it was determined that the average yearly water bill is 0.3 to 0.4 percent of average annual household income. Based on information obtained from the Green River Water Supervisor (Fluckey, 1993; 1994), the average annual residential water bill in Green River is about \$160. For the residents of Green River, the average annual water bill represents 0.75 percent of total annual household income (Table 3.6). Ground water from the uppermost aquifer is therefore deemed economically untreatable and, accordingly, a Class III (limited-use) resource.

**Table 3.6 Summary of economics-based test**

Proposed system	Total system cost threshold percent	Exceeds percentage of annual household income paid by current water users?	Exceeds EPA proposed range of 0.3-0.4 percent?	Annual treatment cost per household	Percent change in average annual residential water bill	Greater than 100 percent increase to average water bill?
Anionic exchange system	3.1	Yes	Yes	\$674	+321	Yes

When an economic-based test of treatability is applied to conditions in the local community or area, the following information is also relevant:

- No public water systems in Emery County, including the Green River Municipal System, are supplied by wells. Drinking water for all public systems in Emery County is diverted from surface water sources and springs (Utah, 1991).
- The Green River is the source of all drinking water for the town of Green River. As required by federal regulations, the surface water is treated to reduce turbidity caused by suspended solids, eliminate pathogenic organisms, and alleviate taste and odor problems. The Green River treatment plant employs the following processes: sedimentation, alum and low-dose polymer addition, coagulation and flocculation, sedimentation, filtration, and chlorination (Fluckey, 1994).
- Treatment plant wastes generated by the Green River sewage treatment facility are pumped to a holding pond. The wastes are disposed of in a public landfill (Fluckey, 1994).
- Ground water diversion from wells accounts for about 50 percent of the total public water supply in adjacent Grand County. All public supply wells in Grand County, however, are completed in the Navajo Sandstone Formation and water diverted from this formation requires no treatment to meet either state or federal drinking water standards.

- Based on information obtained from town water supervisors and water supply district managers, all drinking water supply wells in southeastern Utah, including those in San Juan County and on the Navajo Indian Reservation, are screened in the Navajo Sandstone Formation. Water diverted from the Navajo Sandstone Formation is ranked as Class II (drinking water quality) or better using the state's classification system (R317-6-3, 3.6) (Utah, 1993a).

### 3.2.2 Compliance of remedial action with supplemental standards

The compliance demonstration consists of an evaluation of land and water use in the vicinity of the site and the potential impacts of ground water use to human health and the environment. Moreover, although the DOE is not proposing numerical concentration limits for hazardous or radiologic constituents at a point of compliance, the DOE will continue to sample wells located downgradient of the disposal cell. Thus, disposal cell design features and predicted cell performance also are relevant to the discussion of compliance of the remedial action with the supplemental standards. A complete discussion of the disposal cell components and their function is presented in Section 3.2.3.

#### Land use

Green River, Utah, is a town of about 900 permanent residents (Utah, 1993b). The economic basis of the community is tourism and agriculture. The principal agricultural activity is melon farming, although corn and hay are other cash crops commonly grown in the area. The former uranium processing site is located outside of the town boundaries; Green River and the unincorporated community of Elgin are the closest population centers.

There are 13 occupied houses and trailers and 4 abandoned residences in the unincorporated community of Elgin. The population of Elgin is estimated to be about 30 persons (Fluckey, 1993). There are two residences located within 1 kilometer (km) of the site. There is very little farming activity among residents of the community of Elgin, although some of the residents raise horses, grow pasture grasses, and have small vegetable gardens. The U.S. Army White Sands Missile Range and Headquarters Control operations uses most of the vacant land south and east of the disposal site. The headquarters military facility is located immediately northwest of the disposal site and includes several large buildings and about 70 mobile home units. None of the mobile homes are occupied at the present time. Six magazines are located immediately south and southeast of the site between the site and Interstate 70. These magazines are abandoned and have not been used for nearly 20 years. Although operations at the missile range and headquarters have been discontinued, it is possible they may be resumed in the future.

### Water use

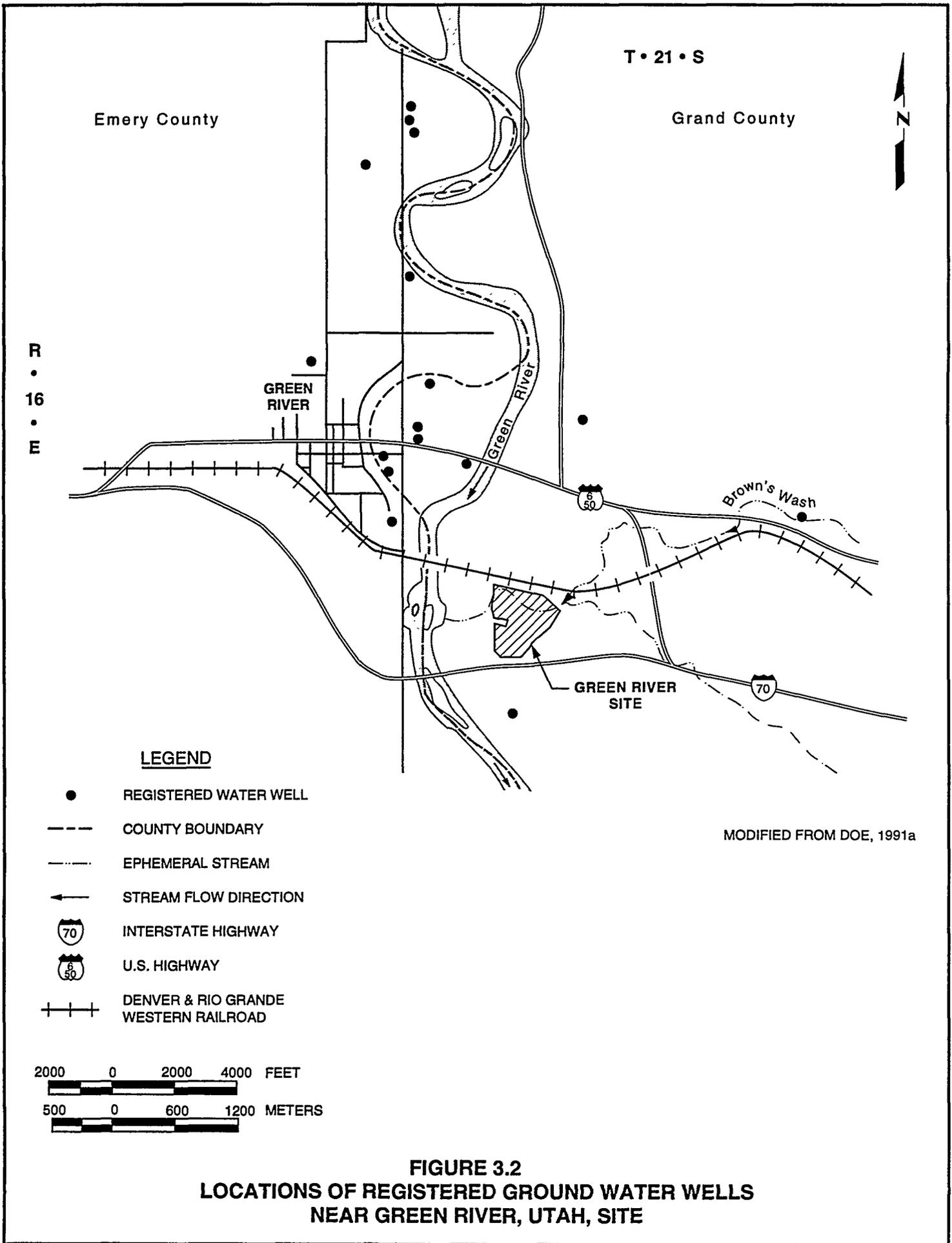
There are no drinking water wells located within a 2-mile (mi) (3-km) radius of the Green River site. The populations of the town of Green River and the community of Elgin are connected to a municipal water supply system. The source of water for the municipal supply system is the Green River. The water intake station and the municipal water treatment facility are approximately 0.75 mi (1.2 km) upstream of the former processing site. The river water used for public supply is conventionally treated using sedimentation, alum addition and flocculation, and filtration. The treatment plant has a maximum capacity of 1.5 million gallons per day.

Though a large number of tourists visit the Green River area in the summer, thereby greatly increasing daily water use, the average daily water use by the permanent population of Green River is about 200,000 gallons. About 5000 gpd are consumed by the permanent residents of the Elgin area. The monthly water rate is \$11.50 for the first 6000 gallons and \$1.25 for every additional 1000 gallons.

There are 10 registered water wells and 1 well owned by the state of Utah identified within a 2-mi (3-km) radius of the former uranium processing site. The locations of these wells are shown on Figure 3.2. Most of the registered wells are located on the western side of the Green River, which acts as a hydrologic barrier to shallow ground water on either side of it. Except for the state-owned well, most of the wells are shallow and are completed in the Green River alluvium. Because of generally poor quality, shallow ground water in the region, and the availability of good-quality surface water from the Green River, none of the wells shown on Figure 3.2 is being used as a drinking water source (Fluckey, 1993). Some of the wells are in limited use as a source of water for stock, lawns, or gardens.

Nearly all the water used for agricultural and domestic gardens in the area is obtained from the Green River Canal. The water in the canal is diverted from the Green River several miles upstream of the town.

Future development of the uppermost aquifer at the Green River site is unlikely for several reasons: All present needs of Green River and Elgin, in terms of both quality and quantity of drinking water, are supplied by the Green River. Nearly all present and projected agricultural needs are, or will be, supplied by the Green River Canal. In order for a ground water source to be considered suitable for development the following criteria would have to be met: 1) the aquifer would have to be relatively shallow (500 feet or less) due to the high cost of pumping ground water from a deep aquifer, and 2) the ground water would have to be acceptable as a drinking water source without treatment. Personnel from the State Division of Drinking Water confirmed that the latter constraint is common in Utah; that is, the residents of most small towns cannot afford the cost of treating contaminated ground water for use as their drinking water supply. According to the Green River Water Supervisor, most of the permanent residents



of Green River and Elgin have limited incomes and could not afford an increase in water rates (Fluckey, 1994).

### 3.2.3 Remedial action approaches meeting the otherwise applicable standards

The disposal cell design at the Green River site is designed to control radioactive materials and hazardous constituents in conformance with ground water protection standards as required in the proposed EPA ground water protection strategy.

To ensure that the remedial action comes as close to meeting the otherwise applicable standard as is reasonable under the circumstances, protection limits are proposed for hazardous constituents in ground water.

The protection limits are based on either the EPA MCLs or on baseline (background) levels. The DOE is reasonably certain that the concentration limits (now protection limits) presented in the LTSP (DOE, 1992a) could be met in monitor wells because of the design features of the disposal cell and favorable climatic conditions, including the following:

- The average annual precipitation in the Green River area is 6 inches (152 mm). Average annual potential lake evaporation is 40 to 43 inches (1000 to 1100 mm), or 5 to 6 times greater than precipitation (USGS, 1982).
- Based on the results of both laboratory and field tests, the saturated conductivity of the radon/infiltration barrier is  $2 \times 10^{-8}$  cm/s or less. Thus, the rate of infiltration through the contaminated material is minimized. The NRC has concurred with DOE in its assessment of the saturated conductivity of this layer (NRC, 1990).
- All contaminated materials were placed drier than their optimum moisture content. Although the specific placement moisture content of the tailings and other contaminated material is disputed, what is not disputed is that all contaminated material layers are placed at a low degree of saturation. Hence, the volume of contaminated pore fluid that can seep into the ground water of the uppermost aquifer, during both transient and steady-state drainage condition, is minimized.
- A buffer layer of select fill was placed on the bottom of the disposal cell. The NRC agrees that the buffer layer does not contribute hazardous or radiologic constituents to any seepage from the disposal cell, and that the buffer acts as a reservoir for storing seepage from tailings and contaminated material layers (NRC, 1990).

### 3.4 CLOSURE PERFORMANCE ASSESSMENT

The DOE demonstrated that the remedial action at the Green River disposal site complies with the proposed EPA ground water protection standards (52 FR 36000 (1987)) by meeting supplemental standards based on the presence of Class III (limited-use) ground water in the uppermost aquifer. The DOE assessed the performance of the designed disposal cell at the Green River site in conjunction with the hydrogeologic system and has shown that the disposal cell acts to minimize and control releases of hazardous constituents to ground water and surface water, and radon emanations to the atmosphere, to the extent necessary to protect human and the environment (52 FR 36000 (1987)).

Natural, stable materials were used in constructing the Green River disposal cell so that long-term performance is ensured. The DOE also demonstrated that the design features necessary for compliance with the ground water protection standards minimize the need for further maintenance of the disposal site.

### 3.5 PERFORMANCE MONITORING

Pursuant to 40 CFR §192.02(b)(1994), the DOE implemented a monitoring program which is adequate to demonstrate that the initial performance of the disposal cell is in accordance with design requirements. The method for performance monitoring of the disposal cell is described in the LTSP (DOE, 1992a). Although point of compliance wells are not required under the supplemental standards compliance strategy, the DOE will continue to monitor ground water in the uppermost aquifer downgradient from the disposal cell as a best management practice.

The moisture content of the contaminated layers of the disposal cell will not be monitored, and the DOE will decommission the neutron probe access tubes in accordance with the requirements of Standard Operating Procedure 16.1.15, "Neutron Probe Access Hole Decommissioning" (JEG, n.d.).

### 3.6 CORRECTIVE ACTION PLAN

In accordance with the proposed EPA ground water standards (52 FR 36000 (1987)), the DOE is required to evaluate corrective actions that could be implemented if, based on performance monitoring, the disposal cell is not performing as intended. The DOE considered reasonable failure scenarios of the disposal cell and site area and can demonstrate that corrective actions could be implemented after detecting a release of contaminants above the proposed levels.

The Green River disposal cell was constructed to perform for the mandated design life of 1000 years. The disposal cell incorporates standard safety factors on all design components and should, therefore, perform for a period of greater than 1000 years with minimal maintenance. The anticipation is that the disposal cell will not fail, because natural materials were used in its construction and the

radon/infiltration barrier is adequately protected from disruption by animals, plants, wind, and water.

If exceedances of the proposed protection limits occur, the DOE will do screening and evaluative monitoring. If the results of monitoring indicate a potential disposal cell failure, a risk assessment will be conducted.

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#### 4.0 LIST OF CONTRIBUTORS

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J. Senger	Site management
A. Holm, J. Gibb, J. Jones	Document review
WordCenter, Inc.	Text processing, editing
J. Bartel	Technical editing

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## 5.0 REFERENCES

- DOE (U.S. Department of Energy), 1994. *Baseline Risk Assessment of Ground Water Contamination at the Uranium Mill Tailings Site Near Green River, Utah*, final, DOE/AL/62350-116, prepared by the U.S. Department of Energy, UMTRA Project Office, Albuquerque Operations Office, Albuquerque, New Mexico.
- DOE (U.S. Department of Energy), 1992a. *Long-Term Surveillance Plan for the Green River, Utah, Disposal Site*, final, DOE/AL/62350-89F, prepared by the U.S. Department of Energy, UMTRA Project Office, Albuquerque Operations Office, Albuquerque, New Mexico.
- DOE (U.S. Department of Energy), 1992b. *Neutron Moisture Monitoring (NMM) and Moisture Contents in the Green River, Utah, UMTRA Disposal Cell*, UMTRA-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), 1991a. *Remedial Action Plan and Site Conceptual Design for Stabilization of the Inactive Uranium Mill Tailings at Green River, Utah*, UMTRA-DOE/AL-050510-GRN0, prepared by the U.S. Department of Energy, UMTRA Project Office, Albuquerque Operations Office, Albuquerque, New Mexico.
- DOE (U.S. Department of Energy), 1991b. *Green River, Utah, Final Completion Report*, MKO/UMT/0690-0529, Vol. 3, Appendix K, December 1991, prepared by MK-Ferguson Co. for the U.S. Department of Energy, UMTRA Project Office, Albuquerque Operations Office, Albuquerque, New Mexico.
- EPA (U.S. Environmental Protection Agency), 1989. *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities -- Interim Final Guidance*, EPA/530-SW-89-026, EPA Office of Solid Waste, Waste Management Division, Washington, D.C.
- EPA (U.S. Environmental Protection Agency), 1987. "Ground-Water Protection Standards," SAR 1166 Document GWSTD1.WP5, Office of Radiation Programs, U.S. Environmental Protection Agency, Washington, D.C.
- EPA (U.S. Environmental Protection Agency), 1986. "Guidelines for Ground-water Classification Under the EPA Ground-water Protection Strategy," final draft, EPA Office of Ground-water Protection, Office of Drinking Water, Washington, D.C.
- EPA (U.S. Environmental Protection Agency), 1979. "Estimating Water Treatment Costs, Volumes 1-3, EPA-600/2-79-162, EPA Office of Ground-water Protection, Office of Drinking Water, Washington, D.C.
- Fluckey, Gary, 1994. Water Supervisor, Green River, Utah, personal communication with J. Crain, Characterization and Remedial Design Department, UMTRA Project Technical Assistance Contractor, UPDCC File Location No. 10.16.3, UMTRA Project Office, Albuquerque Operations Office, Albuquerque, New Mexico.

- Fluckey, Gary, 1993. Water Supervisor, Green River, Utah, personal communication with J. Crain, Characterization and Remedial Design Department, UMTRA Project Technical Assistance Contractor, available at the UMTRA Project Office, Albuquerque Operations Office, Albuquerque, New Mexico.
- Georgeson, Michael, 1993. Utah Division Of Drinking Water, Salt Lake City, Utah, personal communication to James Crain, Characterization and Remedial Design Group, UMTRA Project Technical Assistance Contractor, Albuquerque, New Mexico, dated October 26, 1993.
- JEG (Jacobs Engineering Group Inc.), n.d. *Albuquerque Operations Manual*, standard operating procedures, prepared by Jacobs Engineering Group Inc., Albuquerque, New Mexico, for the U.S. Department of Energy, UMTRA Project Office, Albuquerque Operations Office, Albuquerque, New Mexico.
- Kohler et al. (M.A. Kohler, T.J. Nordenson, and D.R. Baker), 1959. "Evaporation maps of the United States," U.S. Weather Bureau Technical Paper No. 37, p. 13.
- Montgomery (James M. Montgomery, Consulting Engineers, Inc.), 1985. *Water Treatment – Principles and Designs*, John Wiley & Sons, New York, New York.
- NOAA (National Oceanic and Atmospheric Administration), 1981. *Climatography of the United States No. 20, Green River, Utah for the Period 1951 through 1980*, National Climatic Center, Asheville, North Carolina.
- NRC (U.S. Nuclear Regulatory Commission), 1989. *Standard Format and Content for Documentation of Remedial Action Selection at Title I Uranium Mill Tailings Sites*, Staff Technical Position, Division of Low-Level Waste Management and Decommissioning, Office of Nuclear Material Safety and Safeguards, February 24, 1989, Washington, D.C.
- NRC (U.S. Nuclear Regulatory Commission), 1990. *Technical Evaluation Report for the Proposed Remedial Action at the Green River Tailings Site, Green River, Utah*, final, NRC Division of Low-Level Waste Management and Decommissioning, Office of Nuclear Material Safety and Safeguards, Washington, D.C.
- NWS (National Weather Service), n.d. "Normal annual precipitation and normal May-September precipitation, State of Utah, Utah State Engineer's Office and Water and Power Board, Salt Lake City, Utah.
- Topham, Russell, 1993. Utah Division of Drinking Water, Salt Lake City, Utah, personal communication to James Crain, CARD Group, Technical Assistance Contractor, Albuquerque, New Mexico, dated November 1, 1993.
- USGS (U.S. Geological Survey), 1982. "Regional Hydrology of the Green River-Moab Area, Northwestern Paradox Basin, Utah," Open-File Report 82-107, prepared in cooperation with the U.S. Department of Energy.

Utah, 1993a. "Administrative Rules For Ground Water Quality Protection," R317-6, Utah Administrative Code, Utah Department of Environmental Quality, Division of Water Quality, Salt Lake City, Utah.

Utah, 1993b. "1990 Census Brief: Income of Utah," Governor's Office of Planning and Budget, Salt Lake City, Utah.

Utah, 1991. "Water Use Data for Public Water Suppliers and Self-Supplied Industry in Utah, 1988-1989," Water Use Report No. 8 - 1991, Utah Department of Natural Resources, Division of Water Rights, Salt Lake City, Utah.

#### CODE OF FEDERAL REGULATIONS

40 CFR Part 192, *Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings*, U.S. Environmental Protection Agency (1994).

40 CFR Part 264, *Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities*, U.S. Environmental Protection Agency (1994).

#### FEDERAL REGISTER

52 FR 36000, "Standards for Remedial Actions at Inactive Uranium Processing Sites, Proposed Rule," September 24, 1987.