GROUND WATER CLASSIFICATION: "SIGNIFICANT" AND "SPECIAL" SOURCES AND THE INDIVIDUAL AND GROUND WATER PROTECTION REQUIREMENTS OF 40 CFR PART 191 AT YUCCA MOUNTAIN

FINAL REPORT
CNWRA Task Activity 3702-002-305-602

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FIGURE

1.0 INTRODUCTION

The U.S. Nuclear Regulatory Commission (NRC) has requested that the Center for Nuclear Waste Regulatory Analyses (Center) review existing data concerning the Yucca Mountain site to develop a classification of the aquifer system(s) based on the definitions of 40 CFR Part 191, "Environmental Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes". Specifically, the Center has been directed to evaluate whether "Significant Sources of Groundwater" (40 CFR 191.15) and/or "Special Sources of Groundwater" (40 CFR 191.16) exist at or near the Yucca Mountain site.

In preparing this report, the Center has relied on the text of 40 CFR Part 191 as it was promulgated as a Final Rule on September 19, 1985 (50 FR 38066). The Final Rule has been remanded to the U. S. Environmental Protection Agency (EPA) by the 1st Circuit Court of Appeals to remedy certain procedural flaws with the individual and groundwater protection requirements. It is possible that when the Rule is repromulgated, there will be a new indexing scheme for sections of the Rule. However, for the purposes of this report, the reader is directed to the September, 1985 version for citations.

The Center recognizes that this groundwater classification report may require significant changes, depending on the nature and magnitude of revisions to the Rule which are now being considered by the EPA. In particular, the conclusions of this report may need to be changed if EPA alters significantly the definitions of significant and special sources of groundwater.

2.0 BACKGROUND

Pursuant to its authorities and responsibilities under the Atomic Energy Act of 1954, as amended, Reorganization Plan No. 3 of 1970, and the Nuclear Waste Policy Act of 1982, the EPA promulgated generally applicable environmental standards for the management and disposal of spent nuclear fuel and high-level and transuranic radioactive wastes in 1985 (40 CFR Part 191; 50 FR 38066, September 19, 1985). In the Final Rule, EPA added two sections - Individual Protection Requirements (40 CFR 191.15) and Ground Water Protection Requirements (40 CFR 191.16) - that had not been included in the Draft Rule. The purpose of the two new sections was "to provide protection for those individuals in the vicinity of a disposal system" (50 FR at 38072) and "to avoid any significant degradation of the important drinking water resources provided by these Class I ground waters" (50 FR at 38074).

The NRC regulation, 10 CFR Part 60, "Disposal of High-Level Radioactive Wastes in Geologic Repositories", requires that the geologic repository be sited and designed to comply with the generally applicable environmental standards (10 CFR 60.112). Thus, the geologic setting for a licensable repository must meet the individual protection and ground water protection requirements of 40 CFR Part 191.

2.1 Individual Protection Requirements

Section 191.15 states:

Disposal systems for spent nuclear fuel or high-level or transuranic radioactive wastes shall be designed to provide a reasonable expectation that, for 1,000 years after disposal, undisturbed performance of the repository shall not cause the annual dose equivalent to any member of the public in the accessible environment to exceed 25 millirems to the whole body or 75 millirems to any critical organ. All potential pathways (associated with undisturbed performance) from the disposal system to people shall be considered, including the assumption that individuals consume 2 liters per day of drinking water from any significant source of ground water outside the controlled area.(Emphasis added)

The critical portion of the requirement for this analysis has been emphasized, as its evaluation requires consideration of two definitions presented in 40 CFR 191.12:

> (g) "Controlled area" means: (1) a surface location, to be identified by passive institutional controls, that encompasses no more than 100 square kilometers and extends horizontally no more than five kilometers in any direction from the outer boundary of the original location of the radioactive wastes in a disposal system; and (2) the subsurface underlying such a location.
>
> (n) "Significant source of ground water", as used in this Part, means (1) an aquifer that: (i) is saturated with water having less than 10,000 milligrams per liter of total dissolved solids; (ii) is within 2,500 feet of the land surface; (iii) has a transmissivity greater than 200 gallons per day per foot, provided that any formation or part of a formation included within the source of ground water has a hydraulic conductivity greater than 2 gallons per day per square foot; and (iv) is capable of continuously yielding at least 10,000 gallons per day to a pumped or flowing well for a period of at least a year; or (2) an aquifer that provides the primary source of water for a community water system as of the effective date of this Subpart.

2.2 Ground Water Protection Requirements

Section 191.16 states:

> (a) Disposal systems for spent nuclear fuel or high-level or transuranic radioactive wastes shall be designed to provide reasonable expectation that, for 1,000 years after disposal, undisturbed performance of the disposal system shall not cause the radionuclide concentrations averaged over any year in water drawn from any portion of a special source of ground water to exceed:
>
> (1) 5 picocuries per liter of radium-226 and radium-228;
>
> (2) 15 picocuries per liter of alpha-emitting radionuclides (including radium-226 and radium-228 but excluding radon; or

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(3) The combined concentrations of radionuclides that emit either beta or gamma radiation that would produce an annual dose equivalent to the total body or any internal organ greater than 4 millirems per year if an individual consumed 2 liters per day of drinking water from such a source of ground water.

(b) If any of the average annual radionuclide concentrations existing in a special source of ground water before construction of the disposal system already exceed the limits in 191.16(a), the disposal system shall be designed to provide a reasonable expectation that, for 1,000 years after disposal, undisturbed performance of the disposal system shall not increase the existing average annual radionuclide concentration in water withdrawn from that special source of ground water by more than the limits established in 191.16(a). (Emphasis added)

The critical portion of the requirement for this analysis has been emphasized, as its evaluation requires consideration of another definition presented in 40 CFR 191.12:

(o) "Special source of ground water", as used in this Part, means those Class I ground waters identified in accordance with the Agency's Ground-Water Protection Strategy published in August 1984 that: (1) are within the controlled area encompassing a disposal system or are less than five kilometers beyond the controlled area; (2) are supplying drinking water for thousands of persons as of the date that the Department chooses a location within that area for detailed characterization as a potential site for a disposal system (e.g,in accordance with Section 112(b)(1)(B) of the NWPA); and (3) are irreplaceable in that no reasonable alternative source of drinking water is available to that population.

3.0 ANALYSIS

The individual and ground water protection requirements are very narrowly drawn with respect to the types of water that qualify for coverage. This is best seen through a logical analysis of the two key definitions. The analysis that follows uses the notation and definitions due to Copi (1986, especially chapters 8 and 9; see also Quine, 1982, especially Part I):

" . " : Conjunction

" V " : Disjunction

" ≡ " : Logical Equivalence

In addition, parentheses have their common algebraic meaning.

A definition that applies certain conditions can be viewed as a conditional statement under logical equivalence. For example, the definition

> "Controlled area" means: (1) a surface location, to be identified by passive institutional controls, that encompasses no more than 100 square kilometers and extends horizontally no more than five kilometers in any direction from the outer boundary of the original location of the radioactive Wastes in a disposal system; and (2) the subsurface underlying such a location. (40 CFR 191.12(g))

can be rewritten as:

> "There is an area called the "Controlled area" if and only if there is a surface location (and the subsurface underlying such a location), to be identified by passive institutional controls, that encompasses no more than 100 square kilometers and extends horizontally no more than five kilometers in any direction from the outer boundary of the original location of the radioactive Wastes in a disposal system."

When written in this form, which is the "standard form" for a statement of logical equivalence, the nature of the relationship between antecedent(s) and consequent can be seen clearly, even though the antecedent follows the consequent in the English sentence structure. Because logical equivalence is commutative, the order of antecedent and consequent may be adjusted to suit the convenience of the problem (or speaker).

Finally, conjunction, disjunction and logical equivalence are truth-functional statements, and the symbols " . ", " V ", and " = " are truth-functional connectives.

3.1 Logical Structure of "Significant Source of Ground Water"

Let **SgSGW** = "**Significant source of ground water**, as used in this Part"

TDS = "an aquifer that: (i) is saturated with water having less than 10,000 milligrams per liter of **total dissolved solids**"

Depth = "an aquifer that: (ii) is **within 2,500 feet of the land surface**"

T/K = "an aquifer that: (iii) has a **transmissivity** greater than 200 gallons per day per foot, provided that any formation or part of a formation included within the source of ground water has a **hydraulic conductivity** greater than 2 gallons per day per square foot"

Yield = "an aquifer that: (iv) is capable of continuously **yielding at least 10,000 gallons per day** to a pumped or flowing well for a period of at least a year"

CWS = "an aquifer that provides the primary source of water for a **community water system** as of the effective date of this Subpart"

Then the definition can be rewritten in standard form as:

(TDS . Depth . T/K . Yield) V (CWS) = (SgSGW)

Using the standard truth functions applied to material implication, if (**SgSGW**) is true (i.e., there exists a significant source of ground water), then either the multiple conjunction of part (1) of the definition is true or the premise "the aquifer is the primary source of ground water for a community water supply outside the controlled area" is true.

To evaluate the case with respect to the Yucca Mountain site, consider data for the saturated portion of the Topopah Springs member of the Paintbrush Tuff at Well J-13, which lies outside the controlled area (Figure 1), using data from Thordarson (1983).

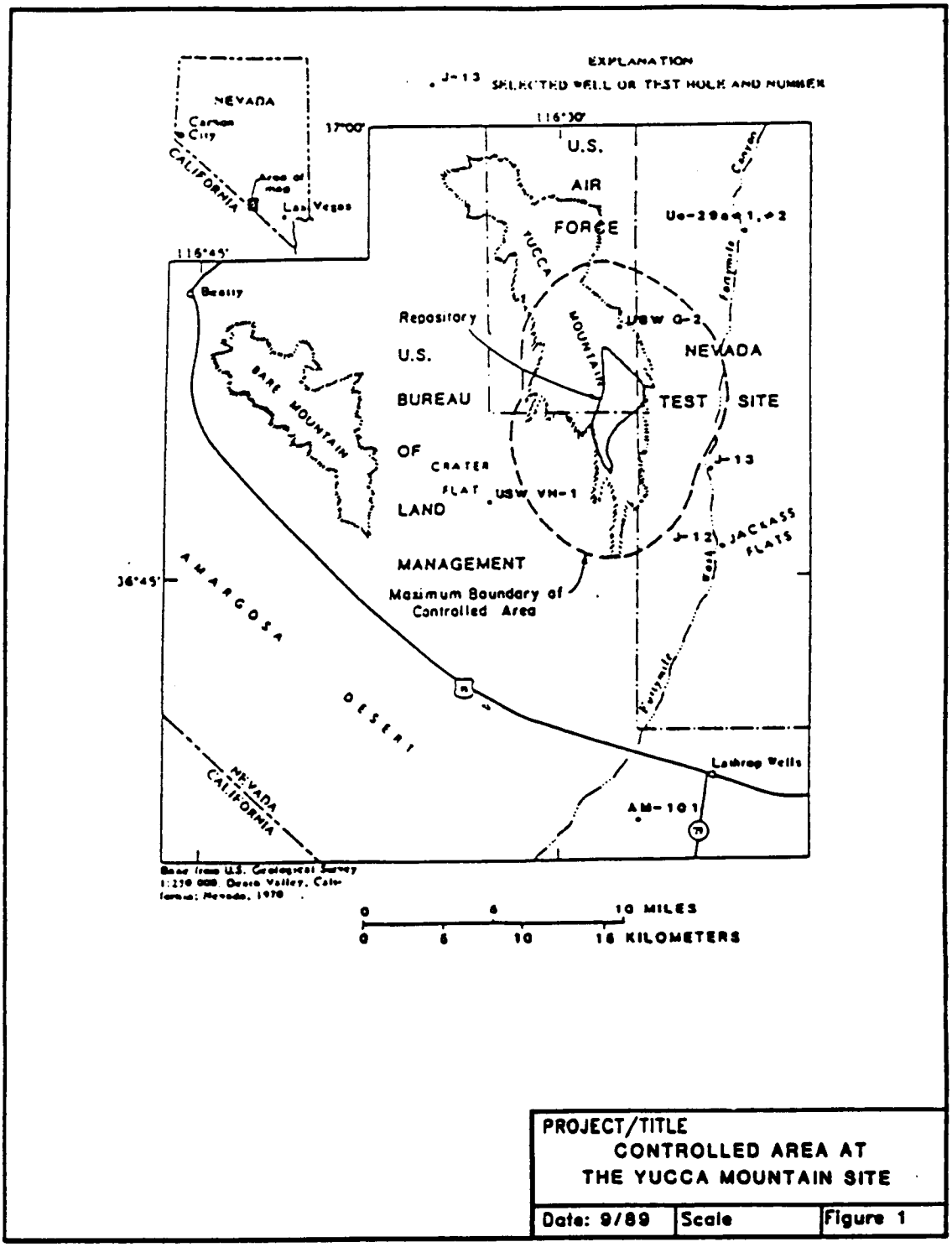
First, the Topopah Springs unit does not provide the primary source of water to a community water supply as of September, 1985, nor is it expected to provide water to a community water supply by whatever date the Final Rule is repromulgated. Thus, part (2) of the definition is not true.

Second, for the multiple conjunction of part (1) of the definition to be true, all four components of the conjunction must be true. These are examined below:

- The water has a TDS significantly less than 10,000 mg/l. Component **TDS** is true.
- The aquifer was penetrated from depths of 207.3 to 449.6 meters below ground surface, with a static water level of 282.2 meters (925.9 feet) below ground surface. Component **Depth** is true.
- A pumping test indicated a transmissivity of 120 meters squared per day (9,664 gpd/ft) and a hydraulic conductivity of 1.0 meter per day (24.54 gpd/sq.ft). Component **T/K** is true.
- The pumping history of the well and the aquifer parameters show that Well J-13 is capable of producing more than 10,000 gallons per day for a period of at least a year. Component **Yield** is true.

Because each component of the antecedent is true, the conjunction (**TDS . Depth . T/K . Yield**) is true, and therefore (**SgSGW**) is true. Thus, there is at least one significant source of ground water outside the controlled area at the Yucca Mountain site. The Topopah Springs unit generally forms the upper part of the saturated zone at and outside the accessible environment boundary along likely groundwater flow paths. It is generally the first saturated zone below the repository level, encountered outside the controlled area and therefore it is the key aquifer with respect to individual protection. (Within the controlled area the Topopah Spring is unsaturated and the water table is first encountered in the Prow Pass Member at wells USW WT#2, USW G-4, and USW H-4. The water table appears first in the Bullfrog Member at USW H-5) Outside the controlled area, it is expected that a family water supply well would be completed in the first unit that yields sufficient water of sufficiently high chemical quality to meet the family or individual needs. Thus, it is necessary for this analysis only to show that at least one "Significant Source of Ground Water" exists.

Figure 1 Controlled Area Near Yucca Mountain Site, Nevada



PROJECT/TITLE CONTROLLED AREA AT THE YUCCA MOUNTAIN SITE		
Date: 9/89	Scale	Figure 1

3.2 Logical Structure of "Special Source of Ground Water"

Let **SpSGW** - "**Special source of ground water**, as used in this Part"

CA - "those Class I ground waters identified in accordance with the Agency's Ground-water Protection Strategy published in August 1984 that: (1) are within the **controlled area** encompassing a disposal system or are less than five kilometers beyond the controlled area"

DW1000 - "those Class I ground waters identified in accordance with the Agency's Ground-water Protection Strategy published in August 1984 that: (2) are supplying **drinking water for thousands** of persons as of the date that the Department chooses a location within that area for detailed characterization as a potential site for a disposal system (e.g., in accordance with Section 112(b)(1)(B) of the NWPA)"

IRREP - "those Class I ground waters identified in accordance with the Agency's Ground-water Protection Strategy published in August 1984 that: (3) are **irreplaceable** in that no reasonable alternative source of drinking water is available to that population"

Then the definition can be rewritten in standard form as:

(CA . DW1000 . IRREP) - (SpSGW)

Note that the analysis used here does not, in the first instance, require that there be a Class I ground water resource (although the definition does). Clearly, if there are no Class I ground waters, then there can be no "Special Source of Ground Water". However, while Class I is a necessary condition, it is not sufficient, as it is a subclass of Class I ground waters that meet the EPA definition (see also NRDC et al. v. EPA, CA 1, 1987, Slip Opinion at 17). Thus, one may assume that the water is Class I and then look to the three conjunctive requirements for that resource. If the definition can be addressed through that analysis, it is not necessary to test the water resources for compliance with the requirements of the Ground-water Protection Strategy. Similarly, the fact that EPA - the responsible agency for ground-water classification - has not classified the water is irrelevant.

Using the standard truth functions applied to logical equivalence, if the consequent (**SpSGW**) is <u>true</u> (i.e., there exists a special source of ground water), then the multiple conjunction of the definition is true. For the conjunction (**CA .DW1000 . IRREP**) to be true, all three antecedent premises must be true. That is, to show that there is <u>not</u> a "special source of ground water", it suffices to show that any one of the three antecedents is false.

Given the existence of a "significant source of ground water" as a surrogate for the assumption of Class I water within five kilometers of the controlled area (see Section 3.1 above) and the obviously arid nature of the area as indicative of ground water as irreplaceable, the only antecedent that is a candidate for analysis is **DW1000**, the requirement that the aquifer is supplying drinking water for thousands of people. The aquifers within five kilometers of the controlled

area do not now supply drinking water to thousands of people. Thus, **DW1000** is false, as is (**CA . DW1000 . IRREP**). Thus, there can be no "Special Source of Ground Water" at the Yucca Mountain site, even if all other aspects of the designation of a Class I ground water under the 1984 Ground-water Protection Strategy were met. Therefore, with respect to this analysis, it is not necessary to determine whether there are Class I ground waters at or near the Yucca Mountain site.

4.0 CONCLUSIONS

Based on the definitions in 40 CFR Part 191 and the available technical data, the Topopah Springs unit of the Paintbrush Tuff qualifies as a "Significant Source of Ground Water", and DOE will be obligated to address the Individual Protection Requirements of 40 CFR 191.15 in its license application. However, no "Special Source of Ground Water" exists at the Yucca Mountain site (nor could one be defined in the future, because of the time-limiting restriction on the water-supply requirement). Therefore, the Ground Water Protection Requirement of 40 CFR 191.16 does not apply to the Yucca Mountain site.

5.0 REFERENCES

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