

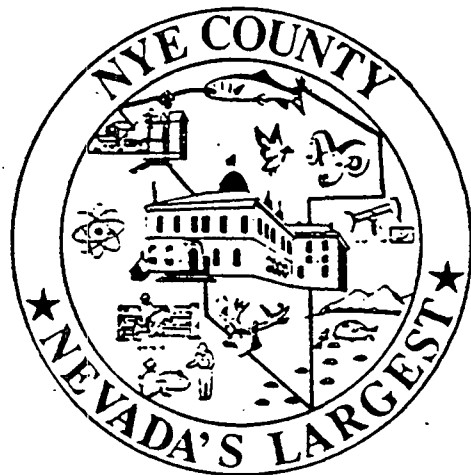
**ORIGINAL INTENT, HISTORICAL BACKGROUND  
AND INTERPRETATION OF GROUND-WATER TRAVEL  
TIME REGULATIONS - PERSPECTIVE OF THE SITUS JURISDICTION**

**NUCLEAR WASTE TECHNICAL REVIEW BOARD  
PANEL ON HYDROGEOLOGY AND GEOCHEMISTRY**

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## **SUMMARY**

- **REGULATORY PERSPECTIVE**
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- **DEFINITIONS**
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## GROUND-WATER TRAVEL TIME PROVISIONS

### ■ DOE SITING GUIDELINES

- ▶ **GEOHYDROLOGY DISQUALIFYING CONDITION.** A SITE SHALL BE DISQUALIFIED IF THE PRE-WASTE EMPLACEMENT GROUND-WATER TRAVEL TIME FROM THE DISTURBED ZONE TO THE ACCESSIBLE ENVIRONMENT IS EXPECTED TO BE LESS THAN 1,000 YEARS ALONG ANY PATHWAY OF LIKELY AND SIGNIFICANT RADIONUCLIDE TRAVEL.

10 CFR 960.4-2-1(d)

- ▶ **FAVORABLE CONDITION.** SITE CONDITIONS SUCH THAT THE PRE-WASTE EMPLACEMENT GROUNDWATER TRAVEL TIME ALONG ANY PATH OF LIKELY RADIONUCLIDE TRAVEL FROM THE DISTURBED ZONE TO THE ACCESSIBLE ENVIRONMENT WOULD BE MORE THAN 10,000 YEARS.

10 CFR 960.4-2-1(b)(1)

### ■ NRC LICENSING CRITERIA

- ▶ **GEOLOGIC SETTING.** THE GEOLOGIC REPOSITORY SHALL BE LOCATED SO THAT PRE-WASTE EMPLACEMENT GROUNDWATER TRAVEL TIME ALONG THE FASTEST PATH OF LIKELY RADIONUCLIDE TRAVEL FROM THE DISTURBED ZONE TO THE ACCESSIBLE ENVIRONMENT SHALL BE AT LEAST 1,000 YEARS OR SUCH OTHER TRAVEL TIME AS MAY BE APPROVED OR SPECIFIED BY THE COMMISSION.

10 CFR 60.113(a)(2)

▶ ON A CASE-BY-CASE BASIS, THE COMMISSION MAY APPROVE OR SPECIFY SOME OTHER RADIONUCLIDE RELEASE RATE, DESIGNED CONTAINMENT PERIOD OR PRE-WASTE EMPLACEMENT GROUNDWATER TRAVEL TIME, PROVIDED THAT THE OVERALL SYSTEM PERFORMANCE OBJECTIVE, AS IT RELATES TO ANTICIPATED PROCESSES AND EVENTS, IS SATISFIED. AMONG THE FACTORS THAT THE COMMISSION MAY TAKE INTO ACCOUNT ARE -

- (1) ANY GENERALLY APPLICABLE ENVIRONMENTAL STANDARDS FOR RADIOACTIVITY ESTABLISHED BY THE ENVIRONMENTAL PROTECTION AGENCY;
- (2) THE AGE AND NATURE OF THE WASTE, AND THE DESIGN OF THE UNDERGROUND FACILITY, PARTICULARLY AS THESE FACTORS BEAR UPON THE TIME DURING WHICH THE THERMAL PULSE IS DOMINATED BY THE DECAY HEAT FROM THE FISSION PRODUCTS;
- (3) THE GEOCHEMICAL CHARACTERISTICS OF THE HOST ROCK, SURROUNDING STRATA AND GROUND WATER; AND
- (4) PARTICULAR SOURCES OF UNCERTAINTY IN PREDICTING THE PERFORMANCE OF THE GEOLOGIC REPOSITORY.

10 CFR 60.113(b)

▶ FAVORABLE CONDITION. PRE-WASTE EMPLACEMENT GROUNDWATER TRAVEL TIME ALONG THE FASTEST PATH OF LIKELY RADIONUCLIDE TRAVEL FROM THE DISTURBED ZONE TO THE ACCESSIBLE ENVIRONMENT THAT SUBSTANTIALLY EXCEEDS 1,000 YEARS.

10 CFR 60.122(b)(7)

## DEFINITIONS

### ■ DOE GUIDELINES - 10 CFR 960.2

- ▶ "ACCESSIBLE ENVIRONMENT" MEANS THE ATMOSPHERE, THE LAND SURFACE, SURFACE WATER, OCEANS, AND THE PORTION OF THE LITHOSPHERE THAT IS OUTSIDE THE CONTROLLED AREA.
- ▶ "DISTURBED ZONE" MEANS THAT PORTION OF THE CONTROLLED AREA, EXCLUDING SHAFTS, WHOSE PHYSICAL OR CHEMICAL PROPERTIES ARE PREDICTED TO CHANGE AS A RESULT OF UNDERGROUND FACILITY CONSTRUCTION OR HEAT GENERATED BY THE EMPLACED RADIOACTIVE WASTE SUCH THAT THE RESULTANT CHANGE OF PROPERTIES COULD HAVE A SIGNIFICANT AFFECT ON THE PERFORMANCE OF THE GEOLOGIC REPOSITORY.
- ▶ "GROUND-WATER" MEANS ALL SUBSURFACE WATER AS DISTINCT FROM SURFACE WATER.
- ▶ "GROUND-WATER FLUX" MEANS THE RATE OF GROUND WATER FLOW PER UNIT AREA OF POROUS OR FRACTURED MEDIA MEASURED PERPENDICULAR TO THE DIRECTION OF FLOW.

- ▶ **"GROUND-WATER TRAVEL TIME" MEANS THE TIME REQUIRED FOR A UNIT VOLUME OF GROUND WATER TO TRAVEL BETWEEN TWO LOCATIONS. THE TRAVEL TIME IS THE LENGTH OF THE FLOW PATH DIVIDED BY THE VELOCITY, WHERE VELOCITY IS THE AVERAGE GROUND-WATER FLUX PASSING THROUGH THE CROSS-SECTIONAL AREA OF THE GEOLOGIC MEDIUM THROUGH WHICH FLOW OCCURS, PERPENDICULAR TO THE FLOW DIRECTION, DIVIDED BY THE EFFECTIVE POROSITY ALONG THE FLOW PATH. IF DISCREET SEGMENTS OF THE FLOW PATH HAVE DIFFERENT HYDROLOGIC PROPERTIES, THE TOTAL TRAVEL TIME WILL BE THE SUM OF THE TRAVEL TIMES FOR EACH DISCREET SEGMENT.**

■ **NRC LICENSING CRITERIA - 10 CFR 60.2**

- ▶ **"ACCESSIBLE ENVIRONMENT" - SAME AS DOE GUIDELINES**
- ▶ **"DISTURBED ZONE" MEANS THAT PORTION OF THE CONTROLLED AREA THE PHYSICAL OR CHEMICAL PROPERTIES OF WHICH HAVE CHANGED AS A RESULT OF UNDERGROUND FACILITY CONSTRUCTION OR AS A RESULT OF HEAT GENERATED BY THE EMPLACED RADIOACTIVE WASTES SUCH THAT THE RESULTANT CHANGE OF PROPERTIES MAY HAVE A SIGNIFICANT EFFECT ON THE PERFORMANCE OF THE GEOLOGIC REPOSITORY.**
- ▶ **"GROUNDWATER" MEANS ALL WATER WHICH OCCURS BELOW THE LAND SURFACE.**

## REGULATORY HISTORY AND BACKGROUND

### DOE GUIDELINES

- ORIGINAL GEOHYDROLOGY DISQUALIFYING CONDITION
  - ▶ 1,000 YEARS . . . UNLESS THE CHARACTERISTICS AND CONDITIONS OF THE GEOLOGIC SETTING, SUCH AS THE CAPACITY FOR RADIONUCLIDE RETARDATION AND GROUND-WATER FLUX, WOULD LIMIT POTENTIAL RADIONUCLIDE RELEASES TO THE ACCESSIBLE ENVIRONMENT TO THE EXTENT THAT THE (SYSTEM GUIDELINE QUALIFYING CONDITION/EPA STANDARDS/PART 60) COULD BE MET.
  
- STRONG CRITICISM
  - ▶ FASTEST GROUND-WATER TRAVEL TIME SHOULD BE SPECIFIED INSTEAD OF AVERAGE.
  
  - ▶ HOW TRAVEL TIME WAS TO BE CALCULATED SHOULD BE EXPLAINED.
  
  - ▶ 1,000 YEARS SHOULD BE INCREASED TO 10,000.
  
  - ▶ "UNLESS" CLAUSE SHOULD BE DELETED. RENDERS STATEMENT OF DISQUALIFYING CONDITION AMBIGUOUS AND ASSUMES NRC 'S LICENSING FUNCTION.
  
- DOE RESPONSE - FINAL GHDQ
  - ▶ DOE CLARIFIED BY USING THE GENERIC "TRAVEL TIME" IN THE DQ AND EXPLAINING HOW IT WOULD BE CALCULATED IN THE DEFINITION OF GROUND-WATER TRAVEL TIME. THIS DEFINITION CONSIDERS FLUX.

▶ **1,000 YEARS CONFORMS TO NRC GROUND-WATER TRAVEL TIME CRITERIA, ADOPTED EARLIER.**

- **ADDITIONALLY, 1,000 YEARS LONG ENOUGH FOR MOST OF THE FISSION PRODUCTS TO DECAY TO "GENERALLY INNOCUOUS LEVELS OF RADIOTOXICITY."**

**49 FR 47732 12/6/84**

▶ **MODIFYING LANGUAGE (UNLESS - -) DELETED AND REPLACED BY "AND SIGNIFICANT."**

- **CITED NRC "OR SUCH OTHER . . ." LANGUAGE.**
- **SOME FLEXIBILITY SHOULD BE PROVIDED, PARTICULARLY WHERE FLUX IS SMALL AND PROCESSES PROMOTING RETARDATION PROVIDE "EXCELLENT ISOLATION CAPABILITIES."**
- **DOE FELT "AND SIGNIFICANT" WAS NECESSARY IN ORDER TO AVOID DISQUALIFYING AN ADEQUATE SITE BEFORE SITE CHARACTERIZATION**

▶ **NRC ACCEPTED CHANGES.**

- **"AND SIGNIFICANT" REDUNDANT AND NOT IN CONFLICT WITH 60 PART 113(a)(2)**
- **NRC EXPECTS THAT THE FASTEST PATH OF LIKELY RADIONUCLIDE TRAVEL WILL BE SIGNIFICANT, UNLESS DOE CAN MAKE THE "CLEAREST AND MOST COMPELLING SHOWING TO THE CONTRARY."**
- **EXPECT DOE TO INTERPRET GUIDELINES IN THE SAME WAY.**

**49 FR 28134 7/10/84**



- **IMPORTANT TO REMEMBER THAT 960.4-2-1 IS A SITE SELECTION GUIDELINE.**
  - ▶ **WRITTEN WHEN SEVERAL SITES WERE UNDER CONSIDERATION.**
  - ▶ **PURPOSE WAS TO SELECT FROM AMONG THEM FOR SITE CHARACTERIZATION, AS WELL AS FINAL SUITABILITY.**

## NRC LICENSING CRITERIA

- **PROPOSED RULE - 1981. TRAVEL TIME "FROM THE FAR FIELD" TO THE ACCESSIBLE ENVIRONMENT AT LEAST 1,000 YEARS.**
- **FINAL RULE - 1983. FASTEST PATHWAY OF LIKELY RADIONUCLIDE TRAVEL. DISTURBED ZONE INSTEAD OF FAR FIELD.**
- **PRE-WASTE EMPLACEMENT BECAUSE MUST BE INDEPENDENT OF OVERALL REPOSITORY PERFORMANCE TO CONTRIBUTE TO THE LEVEL OF CONFIDENCE WHICH COMMISSION MUST HAVE.**
  - ▶ **"IN ADDITION, REQUIREMENTS FOR CONTAINMENT, CONTROLLED RELEASE RATE AND 1,000 YEAR GROUND WATER TRANSIT TIME ARE THREE CRITERIA WHICH ACT INDEPENDENTLY OF THE OVERALL REPOSITORY PERFORMANCE TO PROVIDE CONFIDENCE THAT THE WASTES WILL BE ISOLATED AT LEAST FOR AS LONG AS THEY ARE MOST HAZARDOUS."**

46 FR 35281 7/8/81

- ▶ **RETAINED GWTT REQUIREMENT IN ADOPTING UNSATURATED ZONE PROVISIONS IN 1985.**
  - **BASED ON COMMISSION 'S BELIEF THAT THE GWTT REQUIREMENT "REPRESENTS AN INDEPENDENT MEASURE OF THE OVERALL HYDROGEOLOGIC SYSTEM PERFORMANCE WHICH MAY ENCOMPASS A VARIETY OF HYDROGEOLOGIC PARAMETERS INCLUDING GROUND WATER FLUX."**

- **IMPORTANT TO MAINTAIN A STANDARD OF PERFORMANCE FOR THE GEOLOGIC SETTING THAT IS A MEASURE OF THE QUALITY OF THE NATURAL BARRIERS AND IS INDEPENDENT OF ANY INTERACTION BETWEEN THESE NATURAL BARRIERS AND THE ENGINEERED BARRIERS.**
- **PRE-WASTE EMPLACEMENT GWTT IS SUCH A PERFORMANCE STANDARD. NOT DEPENDENT UPON THE EFFECTS OF WASTE EMPLACEMENT AND IS INTENDED TO PROVIDE ASSURANCE OF ISOLATION BEYOND THE FIRST 1,000 YEARS.**

**50 FR 29644 7/22/85  
NUREG 1046**

- **FLEXIBILITY PROVIDED BY 60.113(b) HAS BEEN IMPORTANT FROM THE OUTSET.**

- ▶ **"SIMILARLY, THE COMMISSION MAY APPROVE OR SPECIFY A RADIONUCLIDE RELEASE RATE OR A PRE-WASTE EMPLACEMENT GROUNDWATER TRAVEL TIME THAT DIFFERS FROM THE NORMAL VALUES, PROVIDED THAT THE EPA STANDARD AS IT RELATES TO THE ANTICIPATED PROCESSES AND EVENTS, IS SATISFIED. APPROPRIATE VALUES WILL BE DETERMINED IN THE COURSE OF THE LICENSING PROCESS, IN A MANNER SENSITIVE TO THE PARTICULAR CASE, USING THE PRINCIPLES SET OUT IN THE PERFORMANCE OBJECTIVES, WITHOUT HAVING TO HAVE RECOURSE TO THE EXEMPTION PROVISIONS OF THE REGULATIONS."**

**48 FR 28197 6/21/83  
NUREG 0804**

- ▶ **FOR ANY PATHWAY LESS THAN 1,000 YEARS DOE WILL BE REQUIRED TO MAKE THE "CLEAREST AND MOST COMPELLING SHOWING" UNDER 60.113(b).**

## SOME IMPORTANT CONSIDERATIONS

- **GROUND WATER INCLUDES BOTH UNSATURATED AND SATURATED ZONES.**
- **GROUND WATER INCLUDES BOTH LIQUID AND VAPOR PHASES.**
  - ▶ **SPECIFICALLY CONSIDERED BY NRC IN ADOPTING UNSATURATED ZONE AMENDMENTS.**
    - **VAPOR TRANSPORT OF CONTAMINANTS IDENTIFIED BY NRC STAFF AS A POTENTIAL CONCERN ASSOCIATED WITH DISPOSAL IN THE UZ ZONE.**
    - **"IN UNSATURATED GEOLOGIC MEDIA WATER IS TRANSPORTED IN BOTH LIQUID AND VAPOR PHASES."**
    - **RELATIVE CONTRIBUTION OF TRANSPORT VIA BOTH PHASES AND THEIR DIRECTION OF MOVEMENT DIRECTLY INFLUENCE CONTAINMENT.**
    - **"VAPOR TRANSPORT, PARTICULARLY WHEN A THERMAL GRADIENT IS IMPOSED, MAY PROVIDE A POSSIBLE MECHANISM FOR RADIONUCLIDE MIGRATION FROM A GEOLOGIC REPOSITORY."**

**49 FR 5935 2/16/84**  
**50 FR 29646 7/22/85**  
**NUREG 1046**
  - ▶ **THIS MAY VERY WELL CONSTITUTE THE FASTEST PATHWAY OF LIKELY RADIONUCLIDE TRAVEL.**
  - ▶ **MAY BE CONSIDERED UNDER 60.113(b).**
  - ▶ **CLEAREST AND MOST COMPELLING SHOWING.**

- **ACCESSIBLE ENVIRONMENT INCLUDES LAND SURFACE.**
- **DISTURBED ZONE EXTENDS WELL BEYOND REPOSITORY BOUNDARY.**
  - ▶ **INCLUDES ENTIRE AREA THERMALLY AFFECTED.**
  - ▶ **SO LONG AS CHANGE OF PROPERTIES MAY HAVE SIGNIFICANT AFFECT ON PERFORMANCE.**
- **DOE 'S CONCURRENCE GUIDELINES INITIALLY DEFINED DZ IN TERMS OF PERMANENT CHANGE.**
  - ▶ **"PERMANENTLY" REMOVED IN RESPONSE TO NRC CONCURRENCE CONDITION.**
  - ▶ **DEFINITION OF DZ IN 10 CFR 60.2 NOT LIMITED TO AREAS THAT HAVE CHANGED "PERMANENTLY."**
  - ▶ **NRC CONCERNED THAT DOE MIGHT NEGLECT TRANSIENT CHANGES THAT COULD HAVE A SIGNIFICANT EFFECT ON REPOSITORY PERFORMANCE.**

**49 FR 28134, 28135 7/10/84**

- **REASONABLE ASSURANCE**
  - ▶ **COULD BE LEAST WELL UNDERSTOOD ASPECT OF LICENSING PROCESS.**
  - ▶ **HAS BEEN THE STANDARD SINCE THE BEGINNING OF ATOMIC ENERGY LICENSING.**
  - ▶ **HAS ITS ROOTS IN THE ATOMIC ENERGY ACT.**
  - ▶ **JUDICIALLY APPROVED.**
  - ▶ **INCORPORATED INTO THE NWPA.**

- ▶ **CRITICIZED FROM BOTH SIDES IN COMMENT ON PART 60.**
- ▶ **WILL CONTROL DETERMINATION AND EFFECT ON LICENSING OF FASTEST PATHWAYS.**
- ▶ **EXPLAINED IN 60.101.**
  - **COMPLETE ASSURANCE IS NOT REQUIRED.**
  - **PROOF OF THE FUTURE PERFORMANCE OF ENGINEERED BARRIER SYSTEMS AND THE GEOLOGIC SETTING OVER TIME PERIODS OF MANY HUNDREDS OR MANY THOUSANDS OF YEARS IS NOT TO BE HAD IN THE ORDINARY SENSE OF THE WORD.**
  - ▶ **MAKE ALLOWANCE FOR THE TIME PERIOD, HAZARDS, AND UNCERTAINTIES INVOLVED.**
- ▶ **NEITHER IMPLIES A LACK OF CONSERVATISM NOR CREATES A STANDARD WHICH IS IMPOSSIBLE TO MEET.**

**48 FR 28204 6/21/83**

- ▶ **TWO PRINCIPAL ELEMENTS.**
  - **PERFORMANCE ASSESSMENT MUST INDICATE THAT THE LIKELIHOOD OF EXCEEDING THE EPA STANDARD IS LOW.**
  - **THE COMMISSION MUST BE SATISFIED THAT THE PERFORMANCE ASSESSMENT IS SUFFICIENTLY CONSERVATIVE, AND ITS LIMITATIONS ARE SUFFICIENTLY WELL UNDERSTOOD, THAT THE ACTUAL PERFORMANCE OF THE REPOSITORY WILL BE WITHIN THE PREDICTED LIMITS.**

**48 FR 28201 6/21/83**

- ▶ **"THE COMMISSION'S TASK IS NOT ONLY A MATHEMATICAL ONE OF MODELING A SYSTEM AND FITTING VALUES FOR PARTICULAR BARRIERS INTO THE MODEL IN ORDER TO ARRIVE AT A 'BOTTOM LINE' OF OVERALL SYSTEM PERFORMANCE. THE COMMISSION IS ALSO CONCERNED THAT ITS FINAL JUDGMENT BE MADE WITH A HIGH DEGREE OF CONFIDENCE."**

**48 FR 28196 6/21/83**

## GENERAL VIEWS AND INTERPRETATIONS

- **GWTT STANDARD MUST BE INDEPENDENT OF REPOSITORY OPERATION.**
- **MEANINGFUL, MEASURABLE TEST OF SUITABILITY/LICENSABILITY.**
  - ▶ **MINIMUM STANDARD.**
  - ▶ **CAN RELY ON MULTIPLE, REDUNDANT BARRIERS SUCH AS EBS, RETARDATION, ETC., TO GET TO PERFORMANCE OBJECTIVES ONCE GWTT IS DEMONSTRATED.**
- **NOTEWORTHY THAT GWTT STANDARD IS LABELED "GEOLOGIC SETTING." THIS SHOULD BE VIEWED PRIMARILY AS A SITING ISSUE, RATHER THAN A PERFORMANCE ISSUE.**
- **GWTT IS NOT A POTENTIALLY ADVERSE CONDITION.**
  - ▶ **IN DOE GUIDELINES ONLY A DISQUALIFYING CONDITION AND A FAVORABLE CONDITION.**
  - ▶ **IN NRC LICENSING CRITERIA ONLY IN GEOLOGIC SETTING AND FAVORABLE CONDITION.**
  - ▶ **IN OTHER WORDS, IF GWTT IS LESS THAN 1,000 YEARS, THAT IS NOT POTENTIALLY ADVERSE, BUT ADVERSE IN FACT; I.E., DISQUALIFYING - UNLESS DOE CAN, UNDER THE CLEAREST AND MOST COMPELLING SHOWING STANDARD, DEMONSTRATE FACTORS WHICH WOULD WARRANT NRC INVOKING "OR SUCH OTHER" LANGUAGE.**



- **"SIGNIFICANT" UNDER EITHER 960.4-2-1(d) OR 60.113(b), SHOULD NOT BE EQUATED MERELY WITH THE EPA STANDARD OR NRC PERFORMANCE OBJECTIVES.**
  - ▶ **COULD HAVE SEVERAL RELATIVELY FAST PATHWAYS, EACH CAPABLE (LIKELY) OF CARRYING LESS THAN STANDARD ALLOWS, BUT WHICH COLLECTIVELY COULD HAVE LARGER IMPACT.**
  - ▶ **"SIGNIFICANT" SHOULD BE INTERPRETED, APPLYING SCIENTIFIC CONSERVATISM, AS SOMETHING LESS THAN STANDARD ALLOWS FOR ANY SINGLE GROUND WATER PATHWAY.**
  
- **DELINEATION OF THE DISTURBED ZONE IS CRITICAL.**
  - ▶ **CLEARLY SHOULD INCLUDE ALL AREA DISTURBED BY THERMAL EFFECTS.**
  - ▶ **MAY EXTEND INTO SATURATED ZONE.**

- **REASONABLE TO EXPECT THAT NRC WILL NOT DENY LICENSE FOR YUCCA MOUNTAIN MERELY BECAUSE THERE MAY BE ONE (OR SOME) GWTT PATHWAYS OF LESS THAN 1,000 YEARS, WHICH CARRY VERY SMALL AMOUNTS OF WATER OR RADIONUCLIDES, IF THE OVERALL SYSTEM PERFORMANCE OBJECTIVE AND THE EPA STANDARD IS CLEARLY MET. BUT THE BURDEN, IF FASTEST IS LESS THAN 1,000 YEARS, TO ARRIVE AT A REASONABLE ASSURANCE, WILL BE "CLEAREST AND MOST COMPELLING SHOWING."**