

Introduction to Thermal-Loading Issues

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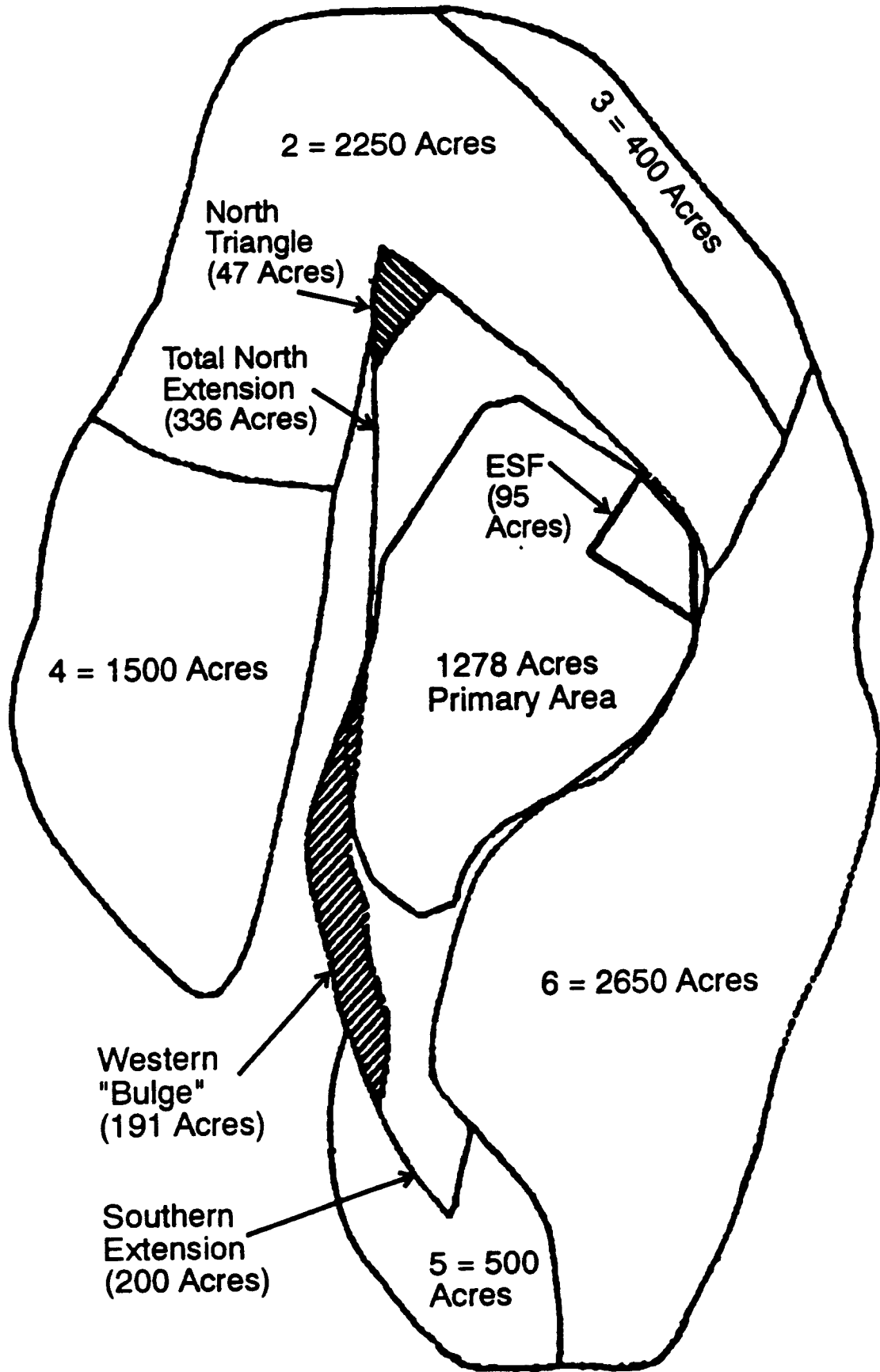
Quotes about Thermal Loading

From the Board's Fifth (June 1992) Report

- **"Because an adequate evaluation of the technical merits and uncertainties of various thermal-loading strategies has not yet been performed, the Board believes that making a commitment to a specific strategy and corresponding waste management system design is premature."**
- **"The primary goal... should be to ensure system safety throughout the life of the repository with a minimum of uncertainty. Sound technical analysis should not be sacrificed to meet what may be unrealistic and unnecessary program schedules."**
- **"It is wise to keep options open until competing strategies are thoroughly evaluated..."**

CONTROLS ON THERMAL LOADING

- **BURNUP HISTORY OF SPENT FUEL**
- **AGE OF FUEL SINCE REMOVAL FROM REACTOR**
- **WASTE COMPOSITION INCLUDING RELATIVE AMOUNTS OF SPENT FUEL AND DEFENSE WASTE**
- **AMOUNT OF SPENT FUEL PER WASTE PACKAGE**
- **NUMBER OF PACKAGES PER ACRE**
- **SPATIAL ARRANGEMENT OF FUEL AGES IN REPOSITORY**



**ASPECTS OF THE WASTE MANAGEMENT SYSTEM AFFECTED BY
THE SELECTION OF A SPECIFIC THERMAL LOADING STRATEGY
(CONTD.)**

- **USE AND DESIGN OF AN ENGINEERED BARRIER SYSTEM AND BACKFILL**
- **FUEL AND CLADDING PERFORMANCE, CANISTER CORROSION**
- **RELEASE AND TRANSPORT OF RADIONUCLIDES TO THE ASSESSIBLE ENVIRONMENT**
- **WASTE MONITORING AND RETRIEVABILITY IN REPOSITORY**
- **COST OF WASTE MANAGEMENT SYSTEM**
- **LICENSABILITY OF REPOSITORY (PREDICTABILITY OF ITS LONG-TERM PERFORMANCE)**

ASPECTS OF THE WASTE MANAGEMENT SYSTEM AFFECTED BY THE SELECTION OF A SPECIFIC THERMAL LOADING STRATEGY

- **WASTE HANDLING, TRANSPORTATION AND STORAGE**
- **WASTE PACKAGE DESIGN INCLUDING CAPACITY**
- **REPOSITORY SIZE AND DESIGN**
 - A. BOREHOLE VS. DRIFT EMPLACEMENT**
 - B. DRIFT DIAMETER AND SEPARATION**
 - C. VENTILATION AND ENGINEERED HEAT CONTROLS AND
EFFECTS (E.G. HEAT PIPES)**

Some Possible Consequences of Different Thermal Loading Choices

	'Low' (sub-boiling i.e. wet)	'Medium' (dry-wet)	'High' (dry-wet)	'Higher' (extended-dry)
Areal Power Density (APD) (kw/Ac)	~15	~30	~60 (57 is DOE SCP base-line)	~120 (114 suggested by LLNL)
Expected boiling/below boiling conditions near waste package over time	esp. below boiling	early boiling → below boiling	boiling for ~300 to 1000 years → below boiling thereafter	above boiling for 1,000 to >10,000 years
Size of disturbed zone	small	large	large	largest
Risk of waste package (WP) failure (via corrosion) & aqueous & gaseous radionuclide (RN) releases	high at all times	high during below-boiling period	high after 300-1000 year (during below-boiling period)	may be low, but unknown; high T's may accelerate WP failure and RN releases.

Some Possible Consequences of Different Thermal Loading Choices (continued)

	'Low' (sub-boiling)	'Medium' (dry-wet)	'High' (dry-wet)	'Higher' (extended- dry)
Risk that refluxion could enhance RN releases to accessible environment	low	high during below- boiling period	high during below-boiling period	highest
Simplicity of concept (simple is better for licensing)	complex	more complex	more complex	may be simplest, but proof is needed
Time & cost to obtain scientific evidence needed for licensing	considerable	more	even more	perhaps less than 'low'

ISSUES AND CONCERNS RELATED TO THE EXTENDED-DRY CONCEPT

- (1) A LARGE HEAT LOAD DOES NOT GUARANTEE THAT COMPLETE FORMATION DRY-OUT WILL BE ACHIEVED.**
- (2) EVEN AT TEMPERATURES WELL ABOVE BOILING, LIQUID WATER MAY BE RETAINED IN THE ROCK BY CAPILLARY AND ADSORPTIVE PROCESSES.**
- (3) LIQUID CONDENSATE MAY FLOW IN FRACTURES EVEN IF MOST OF THE ROCK MASS NEAR THE REPOSITORY DRIES OUT.**
- (4) INCREASED REPOSITORY HEAT LOAD WILL PROBABLY ENHANCE FRACTURE FLOW.**
- (5) DIFFERENTIAL DRYING AND CONDENSATION MAY ENHANCE LIQUID FLOW NEAR SOME WASTE PACKAGES EVEN AS OTHERS ARE DRIED OUT.**
- (6) INCREASED HEAT LOAD ENHANCES THE POTENTIAL MIGRATION AND ESCAPE OF GAS-BORNE RADIONUCLIDES.**

**ISSUES AND CONCERNS
RELATED TO THE EXTENDED DRY CONCEPT
(CONTD.)**

- (7) INCREASED TEMPERATURES MAY REDUCE THE STABILITY OF MINED OPENINGS.**
- (8) INCREASED TEMPERATURES MAY REDUCE THE SORPTIVE ABILITY OF MINERALS IN THE TUFF TOWARDS DISSOLVED RADIONUCLIDES.**
- (9) HIGHER TEMPERATURES MAKE IT MORE DIFFICULT TO MAINTAIN OPERATIONAL SAFETY, AND TO ASSURE WASTE RETRIEVABILITY.**
- (10) HIGHER TEMPERATURES MAY CAUSE DEGRADATION OF FUEL CLADDING AND HLW GLASS DEVITRIFICATION.**
- (11) HIGHER TEMPERATURES MAY LEAD TO THE FORMATION OF A REPOSITORY-SIZED VAPOR-DOMINATED HYDROTHERMAL SYSTEM WITH FRACTURE SEALING BY PRECIPITATED SILICA (ETC). THE RESULTANT PRESSURE BUILDUP MAY LEAD TO EXPLOSIVE CONDITIONS.**

**SOME KEY DATA INPUTS NEEDED FOR THE MODELING
AND PREDICTION OF REPOSITORY PERFORMANCE
UNDER DIFFERENT THERMAL LOADS**

- **SITE CHARACTERIZATION DATA**
- **RESULTS OF HEATER TESTS**
- **INFORMATION ON COUPLED PROCESSES**
- **GEOHERMAL ANALOGS**