U.S. Department of Energy

OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT

Integration of Total System Performance Assessment (TSPA) and Repository Design

Presented to:

Nuclear Waste Technical Review Board

Presented by:

William J. Boyle
Kirk Lachman
Office of Repository Development

February 09, 2005
Las Vegas, Nevada

Overview

- **Historical Perspective**
- **Drip Shield Example**
- **Current Practice**

TSPA/Design History

TSPA Iteration	Summary of Key Results
1988 Site Characterization Plan	• Applied basic methodology for Monte Carlo uncertainty analyses based on scenarios.
TSPA-1991	• Demonstration of TSPA approach. • Models limited to UZ and SZ, and volcanism identified importance of uncertainty in UZ flow paths.
TSPA-1993	• Improved models for UZ, SZ, early models for coupled processes, EBS, biosphere. • Importance of uncertainty in thermal hydrology, UZ flow, corrosion of engineered materials.
TSPA-1995	• Incorporate new science and design, evaluate alternative models. • Importance of robust process models for WP degradation, seepage, UZ and SZ transport.
TSPA-VA	• Supported the 1998 Viability Assessment, models based on best current information. • Ranked importance of uncertainty in each of the major components for 10,000, 100,000, and 1,000,000 years. • Emphasis on seepage, water chemistry, corrosion, and SZ.
1999 License Application Design Selection (LADS)	• TSPA tools used to evaluate relative merits of design alternatives. • Demonstrated that multiple designs were viable for long-term performance.
2000 TSPA for Site Recommendation	• Robust modeling system using fully qualified inputs • Conservative approach to some components. • Regulatory importance of volcanism identified. • Conservative treatments of uncertainty complicated realistic understanding.
2001 Supplemental Science and Performance Analyses (SSPA)	• More realistic treatment of uncertainty. • Incorporation of new information since TSPA-SR. • Confirmed potential suitability. • Confirmed importance of volcanism and EBS performance for 10,000 years. • Insights into EBS and natural system effects on peak dose.
2001 TSPA for the Final Environmental Impact Statement	• Updated SSPA to include new information, revised regulatory boundary.
2002 Sensitivity Analyses (one-on and one-off)	• Insight into barrier performance. • Risk-importance information regarding model components. • Importance of volcanic disruption for 10,000-yr regulatory compliance.
TSPA-LA (in progress)	• Models updated to current information.

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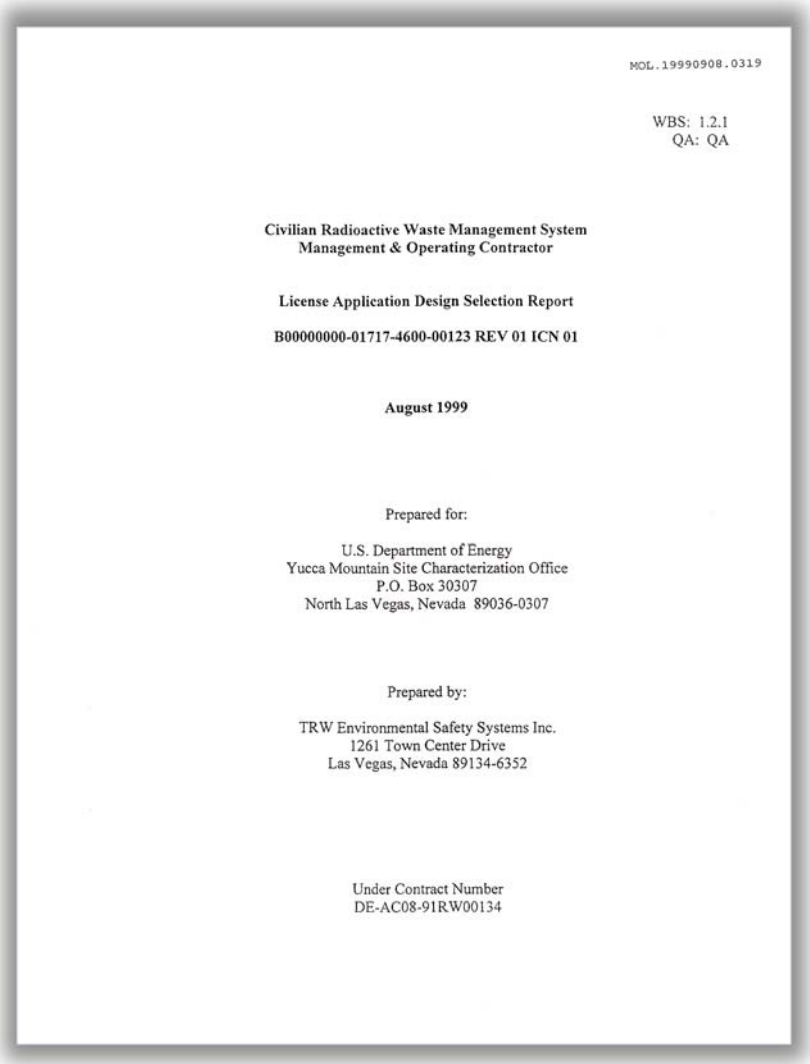
License Application Design Selection Report



MOL.19990908.0319

WBS: 1.2.1
QA: QA

Civilian Radioactive Waste Management System
Management & Operating Contractor

License Application Design Selection Report

B00000000-01717-4600-00123 REV 01 ICN 01

August 1999

Prepared for:

U.S. Department of Energy
Yucca Mountain Site Characterization Office
P.O. Box 30307
North Las Vegas, Nevada 89036-0307

Prepared by:

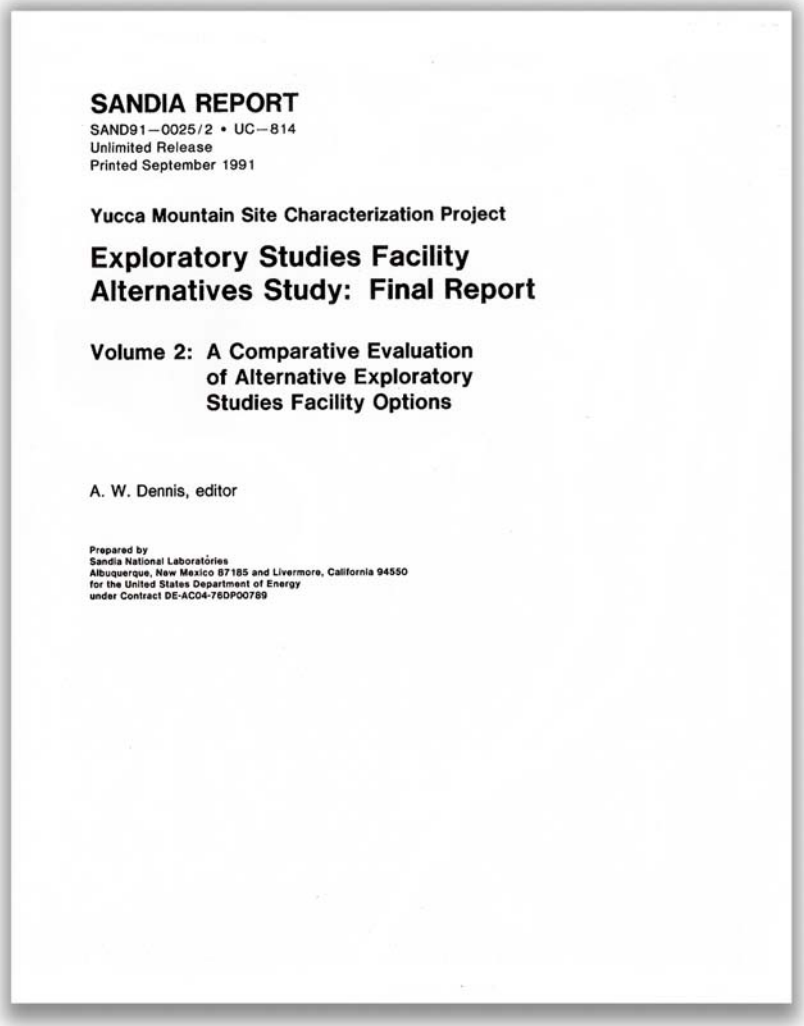
TRW Environmental Safety Systems Inc.
1261 Town Center Drive
Las Vegas, Nevada 89134-6352

Under Contract Number
DE-AC08-91RW00134

Evaluation Criteria

- Meets Regulatory Criteria
- Safety/Licensibility
- Construction/Operation/Maintenance
- Flexibility
- Cost/Schedule

Exploratory Studies Facility Alternatives Study



SANDIA REPORT

SAND91–0025/2 • UC–814
Unlimited Release
Printed September 1991

Yucca Mountain Site Characterization Project

Exploratory Studies Facility Alternatives Study: Final Report

Volume 2: A Comparative Evaluation of Alternative Exploratory Studies Facility Options

A. W. Dennis, editor

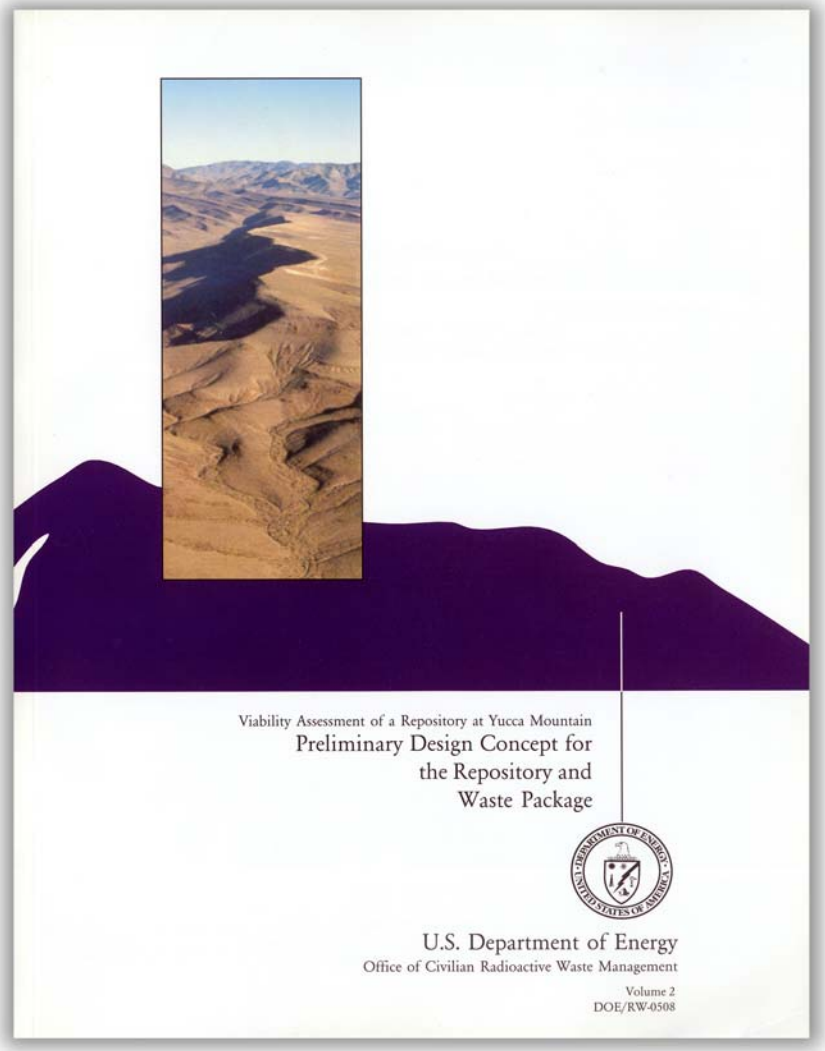
Prepared by
Sandia National Laboratories
Albuquerque, New Mexico 87185 and Livermore, California 94550
for the United States Department of Energy
under Contract DE-AC04-76DP00789

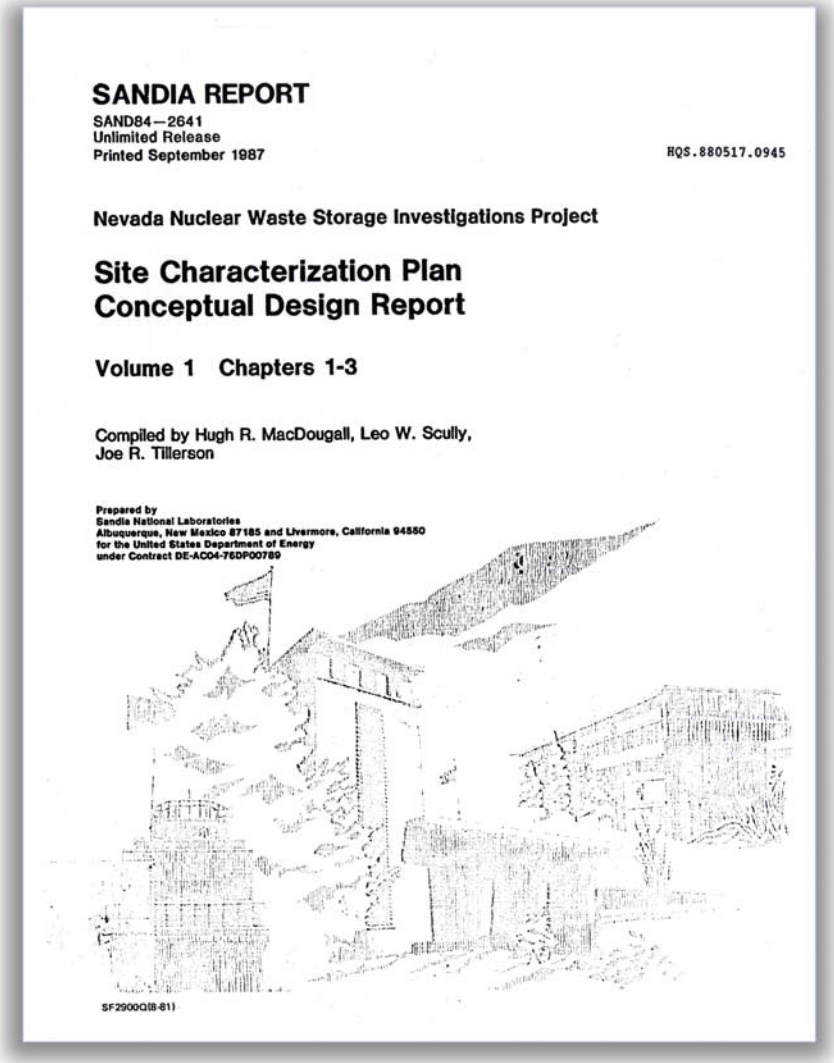
Two sets of seventeen options each were evaluated and ranked

Evaluation Criteria

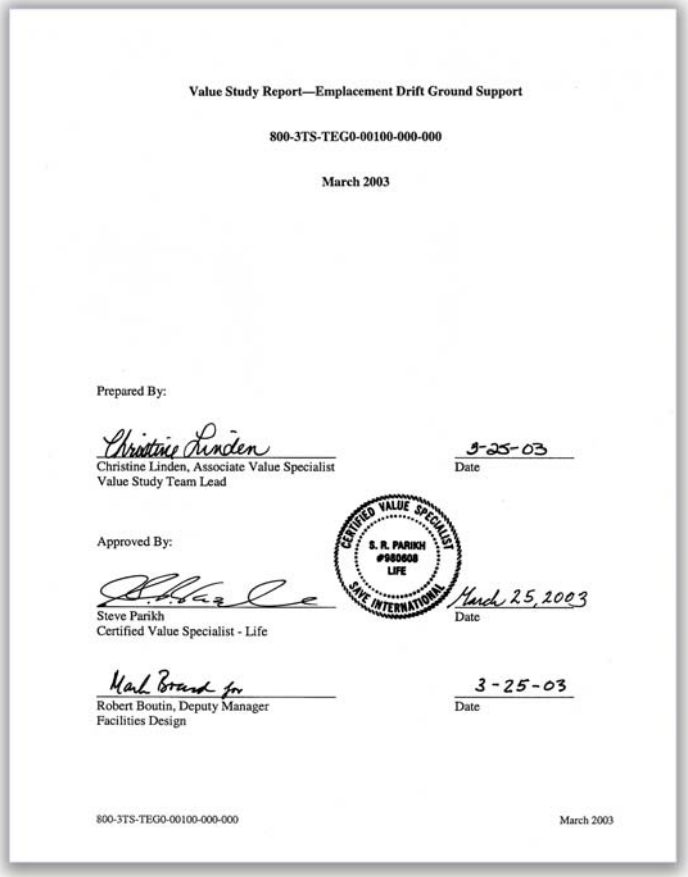
- **Postclosure health impacts**
- **Preclosure radiological releases**
- **Preclosure non-radiological safety**
- **Aesthetic impacts**
- **Impacts on historical properties**
- **Cost impacts**

Viability Assessment (VA) and Site Characterization Plan Conceptual Design Report (SCP CDR)





Value Engineering Studies



Value Study Report—Emplacement Drift Ground Support

800-3TS-TEG0-00100-000-000

March 2003

Prepared By:

Christine Linden, Associate Value Specialist
Value Study Team Lead — Date: 3-25-03

Approved By:

Steve Parikh
Certified Value Specialist - Life — Date: March 25, 2003

CERTIFIED VALUE SPECIALIST S. R. PARIKH #980608 LIFE SAVE INTERNATIONAL

Robert Boutin, Deputy Manager
Facilities Design — Date: 3-25-03

800-3TS-TEG0-00100-000-000 March 2003

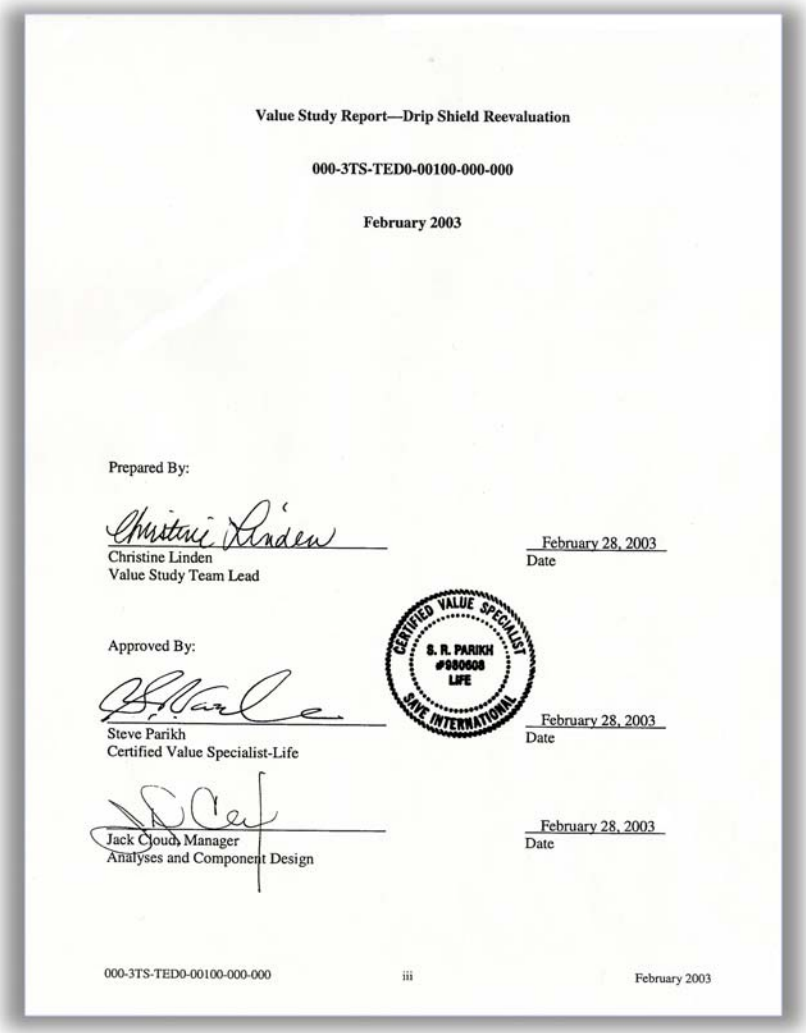
Seven different ground support methods studied by a panel that included non-project experts

Evaluation criteria:

- **Design based**
  - **Ease of operations**
  - **Ease of maintenance**
  - **Service life up to 300 years**
  - **Functioning in varied conditions**
  - **Ease of construction**
- **Science/TSPA based**
  - **Effect on hydrological/chemical environment in drift**
- **Management**
  - **Support 2004 License Application**
- **Environmental Safety and Heath**
  - **Environmental health and safety of workers**

Value Engineering Studies

(Continued)



Value Study Report—Drip Shield Reevaluation

000-3TS-TED0-00100-000-000

February 2003

Prepared By:

Christine Linden
Value Study Team Lead

February 28, 2003
Date

Approved By:

CERTIFIED VALUE SPECIALIST
S. R. PARIKH
#980608
LIFE
SAVE INTERNATIONAL

Steve Parikh
Certified Value Specialist-Life

February 28, 2003
Date

Jack Cloud, Manager
Analyses and Component Design

February 28, 2003
Date

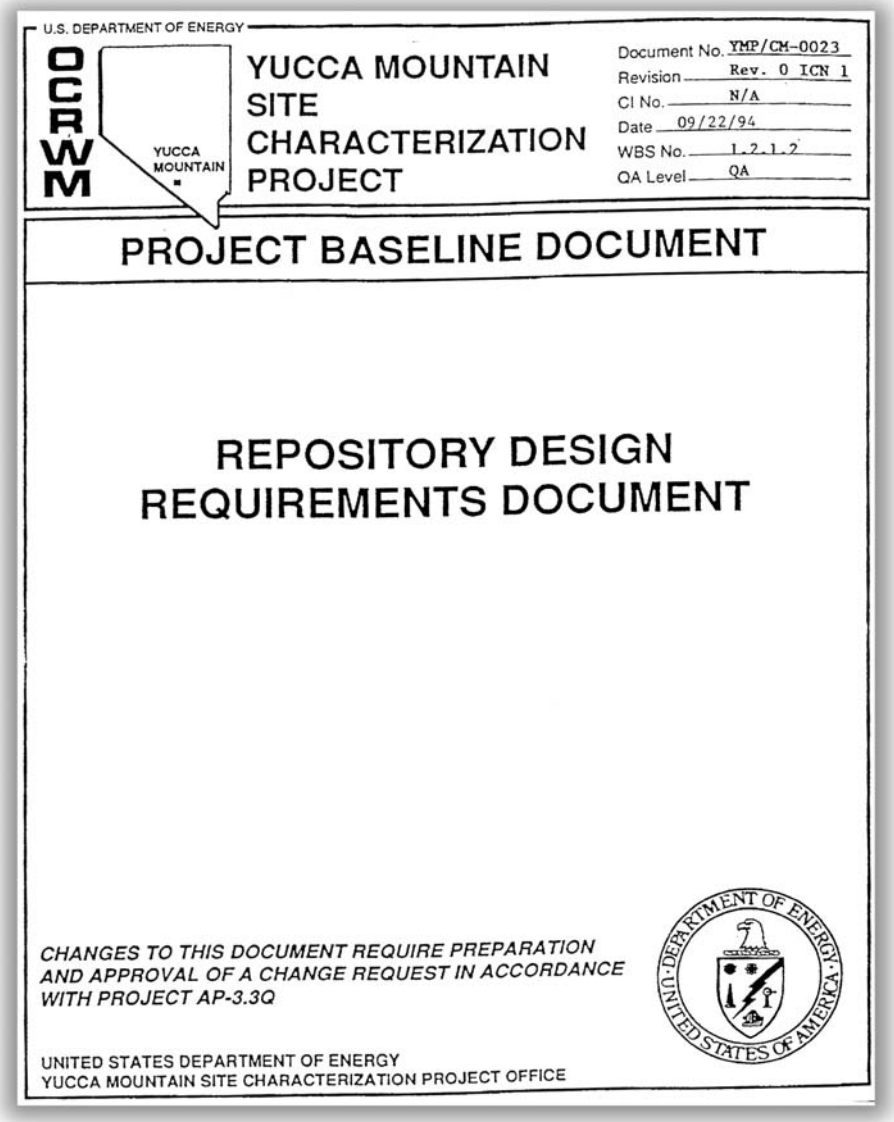
000-3TS-TED0-00100-000-000 iii February 2003

Ten drip shield concepts studied by a panel

Evaluation criteria

- Performance
- Regulatory acceptability
- Compatibility
- Programmatic risk
- Schedule compliance
- Flexibility
- Adaptability to incremental design evolution

Repository Design Requirements



U.S. DEPARTMENT OF ENERGY

OCRWM

YUCCA MOUNTAIN

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

Document No. YMP/CM-0023
Revision Rev. 0 ICN 1
CI No. N/A
Date 09/22/94
WBS No. 1.2.1.2
QA Level QA

PROJECT BASELINE DOCUMENT

REPOSITORY DESIGN REQUIREMENTS DOCUMENT

CHANGES TO THIS DOCUMENT REQUIRE PREPARATION AND APPROVAL OF A CHANGE REQUEST IN ACCORDANCE WITH PROJECT AP-3.3Q

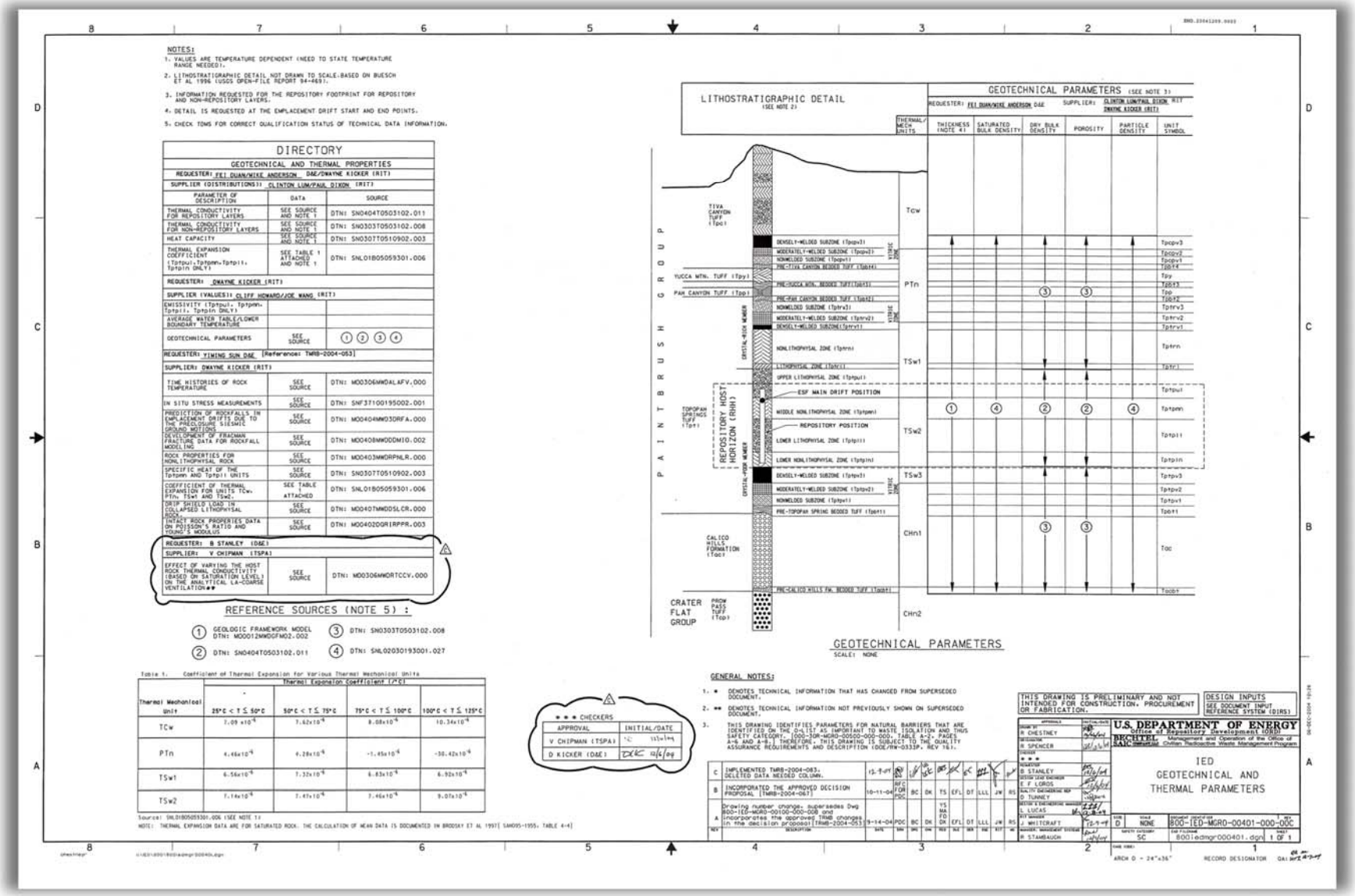
DEPARTMENT OF ENERGY · UNITED STATES OF AMERICA ·

UNITED STATES DEPARTMENT OF ENERGY
YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT OFFICE

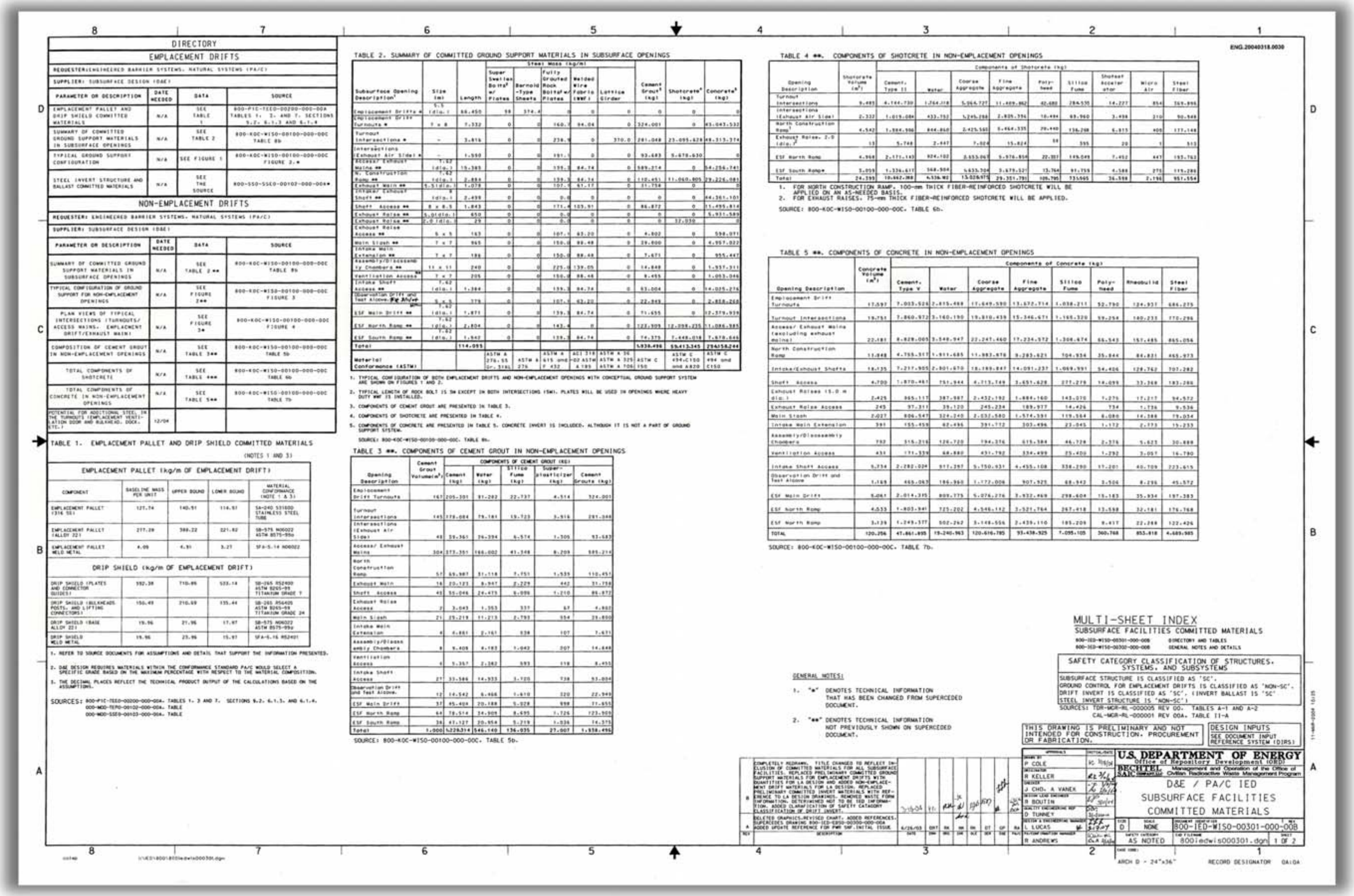
Information Exchange Drawings

- **Concept introduced after the Site Recommendation to control data hand-offs between TSPA and design**
  - **Improved control of data, transparency, and traceability**
  - **Implemented by Administrative Procedure AP-3.24 Q, Drawings**

Information Exchange Drawings

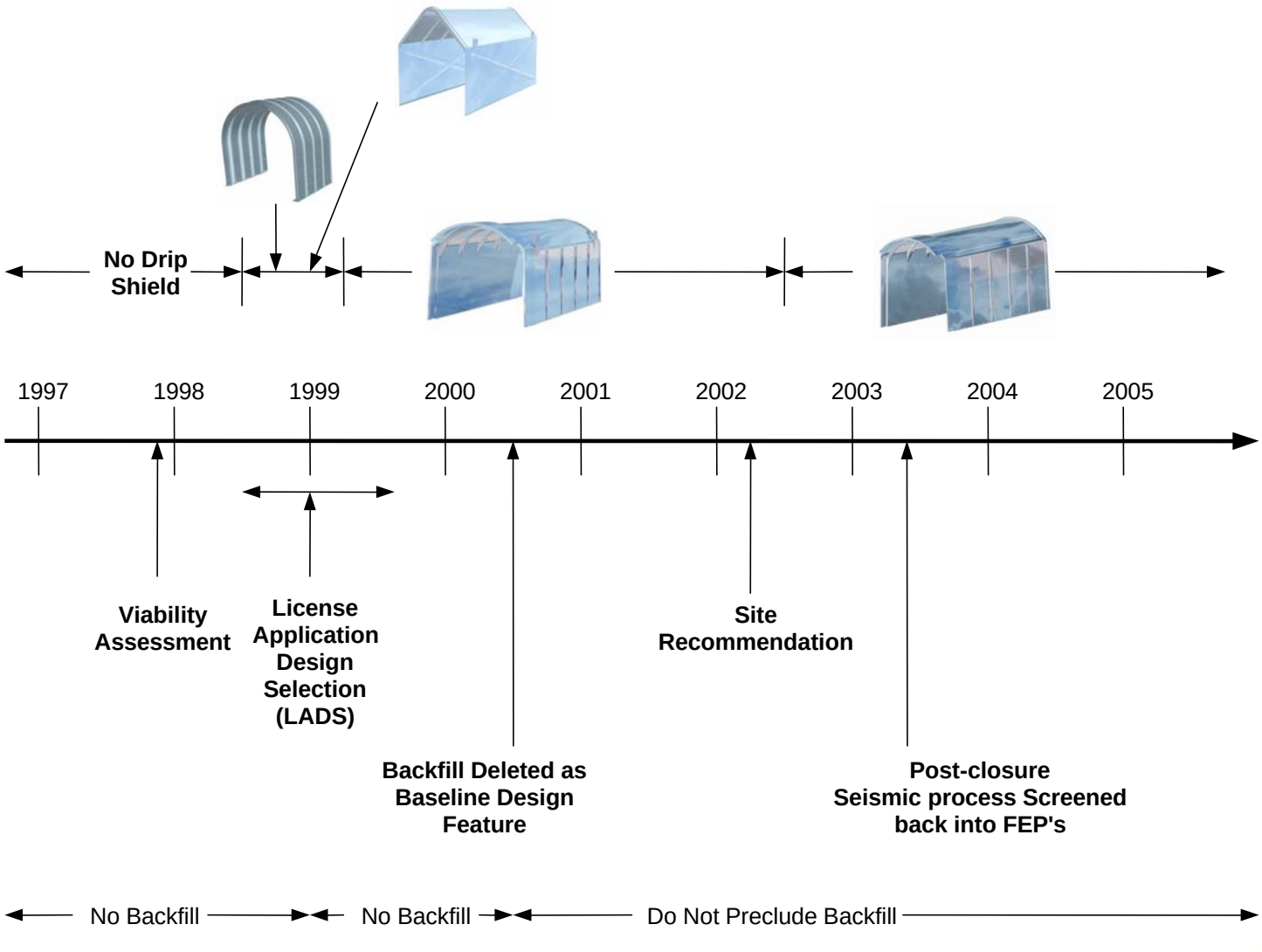


Information Exchange Drawings (continued)



Drip Shield Example

Chronology of Drip Shield Introduction and Development



Drip Shield Historical Background

- **Concept of a drip shield emerged from the multi-layered, multi-material waste package concepts considered in the LADS**
- **Based on long-term performance, Alloy 22 and titanium alloys are favored over stainless steel and carbon steel as drip shield material**
- **Waste package being Alloy 22, titanium alloy chosen for drip shield to avoid common material failure mode guided by defense-in-depth**

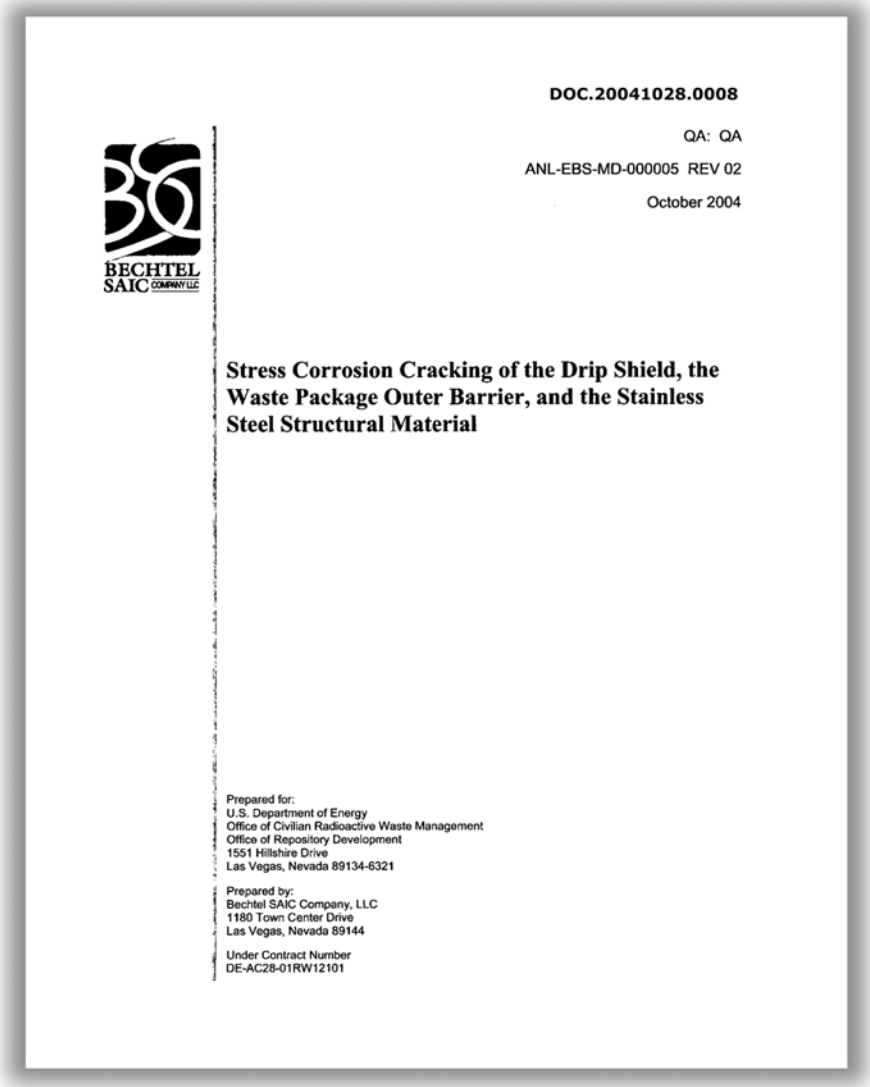
Drip Shield Historical Background
(continued)

- The basic geometry of the drip shield has not changed significantly since 1999. The drip shield design incorporated Alloy 22 base plates, titanium grade 7 (Ti-7) sheets and titanium grade 24 (Ti-24) structural members
- The changes from the Site Recommendation design to the LA design involved the addition of longitudinal stiffeners along the length of the inner surface of the "roof" and increasing the height
- The latter change was to ensure that rocks striking the top of the drip shield would not deform the Ti-7 plates such that the waste package would be contacted

Stress Corrosion Cracking of Drip Shields

- **Ti-Grade 7 may be subject to stress corrosion cracking (SCC)**
- **A SCC model has been developed to estimate the likelihood of the initiation and propagation**
- **The model indicates that rock fall may lead to SCC and may be produced by "juvenile failures"**
- **However, analyses of the interactions of potential seepage on the drip shields with SCC (considering extent of cracking and crack morphology) indicate that the cracks will be tight and/or filled with corrosion products and mineral assemblages to the extent that advective flow through the cracks is extremely unlikely**
- **Stress corrosion cracking of the titanium drip shield has been excluded from the nominal case TSPA**

Stress Corrosion Cracking Analysis and Modeling Report (AMR)



DOC.20041028.0008

QA: QA

ANL-EBS-MD-000005 REV 02

October 2004

BECHTEL SAIC COMPANY LLC

Stress Corrosion Cracking of the Drip Shield, the Waste Package Outer Barrier, and the Stainless Steel Structural Material

Prepared for:
U.S. Department of Energy
Office of Civilian Radioactive Waste Management
Office of Repository Development
1551 Hillshire Drive
Las Vegas, Nevada 89134-6321

Prepared by:
Bechtel SAIC Company, LLC
1180 Town Center Drive
Las Vegas, Nevada 89144

Under Contract Number
DE-AC28-01RW12101

Integration of TSPA and Design by Process Control

Technical Management Review Board

- **The Technical Management Review Board (TMRB) was established by BSC in April 2003 to formalize the integration process**
- **This board supports the Repository Development Manager in technical management, integration, and coordination of development of the repository**
- **Board Composition:**
  - **Design and Engineering Manager**
  - **Post-closure Safety Manager**
  - **License Application Manager**
  - **Chief Science Officer**
  - **Systems Integration Manager**
  - **Repository Development Project Operations Manager**
  - **Repository Operations Manager**
  - **Program Integration Manager**
  - **Total System Performance Assessment Manager**
  - **DOE Observers**

Technical Management Review Board
(Continued)

- **Functions**
  - **Provides planning guidance**
  - **Approves/disapproves new design concepts**
  - **Integrates technical and design concepts across science, TSPA, and design**
  - **Reviews and ensures resolution of technical issues associated with design, TSPA, and licensing activities**

Technical Management Review Board
(Continued)

- **TSPA and Design are under formal configuration control**
  - **This includes all data, models, calculations, and analyses that are either direct inputs or affect the TSPA configuration; TMRB approval is required for any changes**
- **This is a key step to ensure that the input data to the TSPA models and the design analyses and calculations are controlled by the same change control process**

Summary

- **TSPA and design are both managed through a formal change control process**
- **TSPA and design are integrated**
- **Integration is an ongoing process in a controlled environment**