

U.S. Department of Energy  
Office of Civilian Radioactive Waste Management

# **Total System Performance Assessment - Site Recommendation**

Presented to:

**NRC/DOE Technical Exchange on Total System Performance  
Assessment (TSPA) for Yucca Mountain  
San Antonio, Texas**

Presented by:

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CRWMS M&O**

**June 6, 2000**

**YUCCA  
MOUNTAIN  
PROJECT**

TSPA I IRSR REV. 2 ACCEPTANCE CRITERIA	PRESENTATION/ DOCUMENTATION	SELF-ASSESSMENT	PATH FORWARD TO CLOSURE
<b>SUBISSUE 1 - System Description and Demonstration of Multiple Barriers</b>			
<b>Transparency and Traceability of the Analysis</b>			
<b>TSPA Documentation Style, Structure, and Organization</b>			
T1) Documents and reports are complete, clear, and consistent.	All PMRs, TSPA-SR	Largely Resolved	The TSPA-SR is currently being performed. For this acceptance criteria to be closed, the TSPA-SR Technical Report and supporting PMRs and AMRs will need to be reviewed by the NRC.
T2) Information is amply cross referenced.	All PMRs, TSPA-SR	Largely Resolved	The TSPA-SR is currently being performed. For this acceptance criteria to be closed, the TSPA-SR Technical Report and supporting PMRs and AMRs will need to be reviewed by the NRC.

# Objectives of Briefing

- **Overview of Presentations**
- **Messages**
  - iteration on TSPA
  - traceability (documentation hierarchy)
  - improvements
  - resolving issues
- **Reference Design**
- **TSPA-SR process**
- **Schedule**
- **Summary**

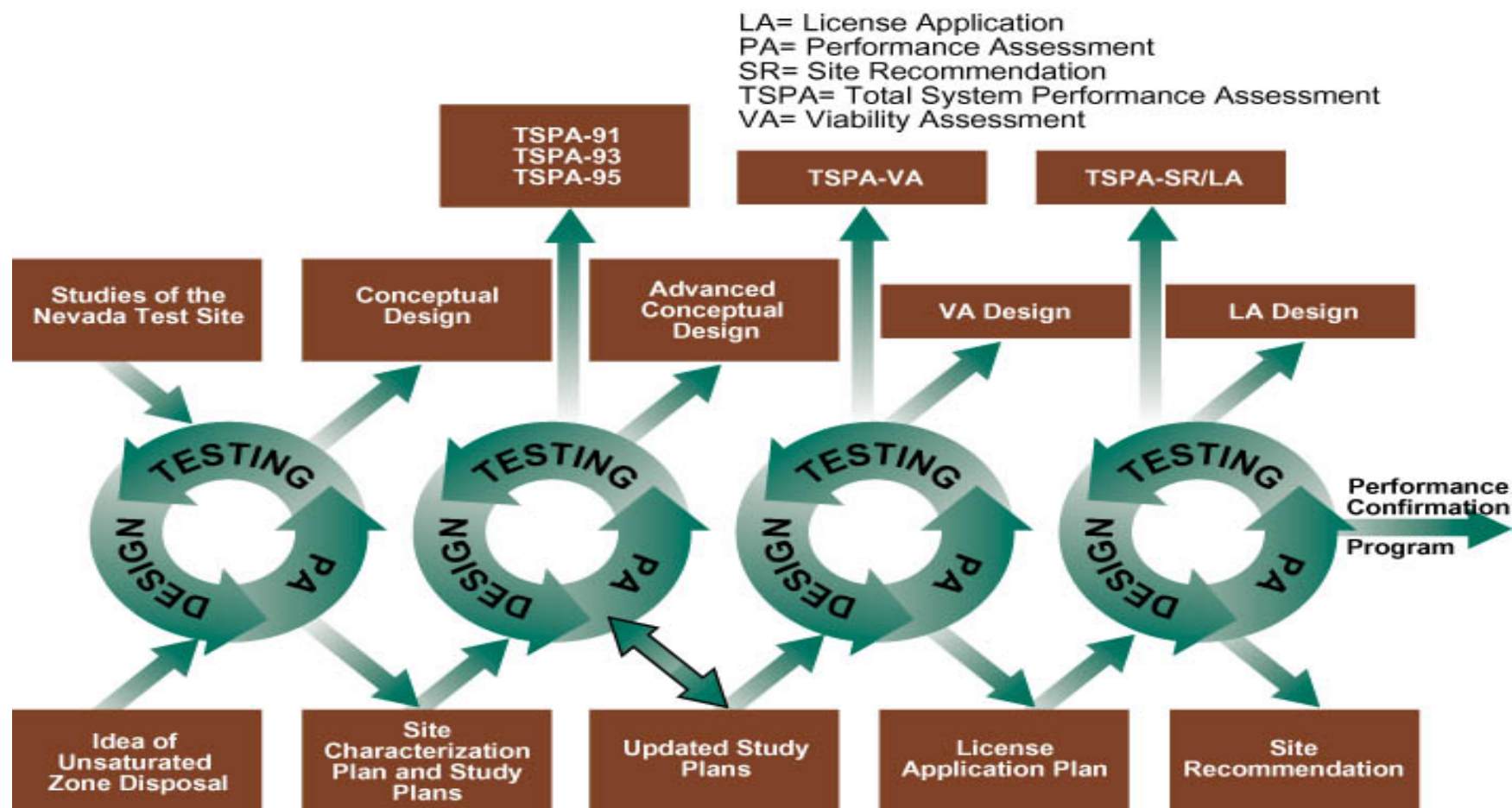
# Overview of Presentations

- **Overall Approach**
- **Features, Events and Processes (FEPs) Approach**
- **FEPs Details**
- **TSPA Subsystem Component Models**
- **Integrated TSPA Model**
- **Sensitivity and Uncertainty Analyses**
- **Human Intrusion Analysis**
- **Progress on Meeting TSPA&I Requirements**

# Overall Messages

- **Iteration on Previous TSPA**
- **Improvements from TSPA-VA**
- **Improved Traceability (documentation hierarchy)**
- **Resolving Issues**

# TSPA Iterations



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# TSPA-SR Major Improvements

## Technical Improvements

- Iteration of Viability Assessment
- Improve models to address review comments of VA
- Improved models include:
  - Climate and seepage
  - Coupled thermal processes
  - Waste package degradation
    - ◆ Stress corrosion cracking
    - ◆ Initial defects/weld flaws
  - Saturated zone transport
  - Volcanism
- TSPA approach modified to address NRC and EPA requirements

## Process Improvements

- All analyses, models, data, software controlled under common procedures
- TSPA-SR model developed to assure traceable data sets are used
- Q-status of all data, models, software is tracked

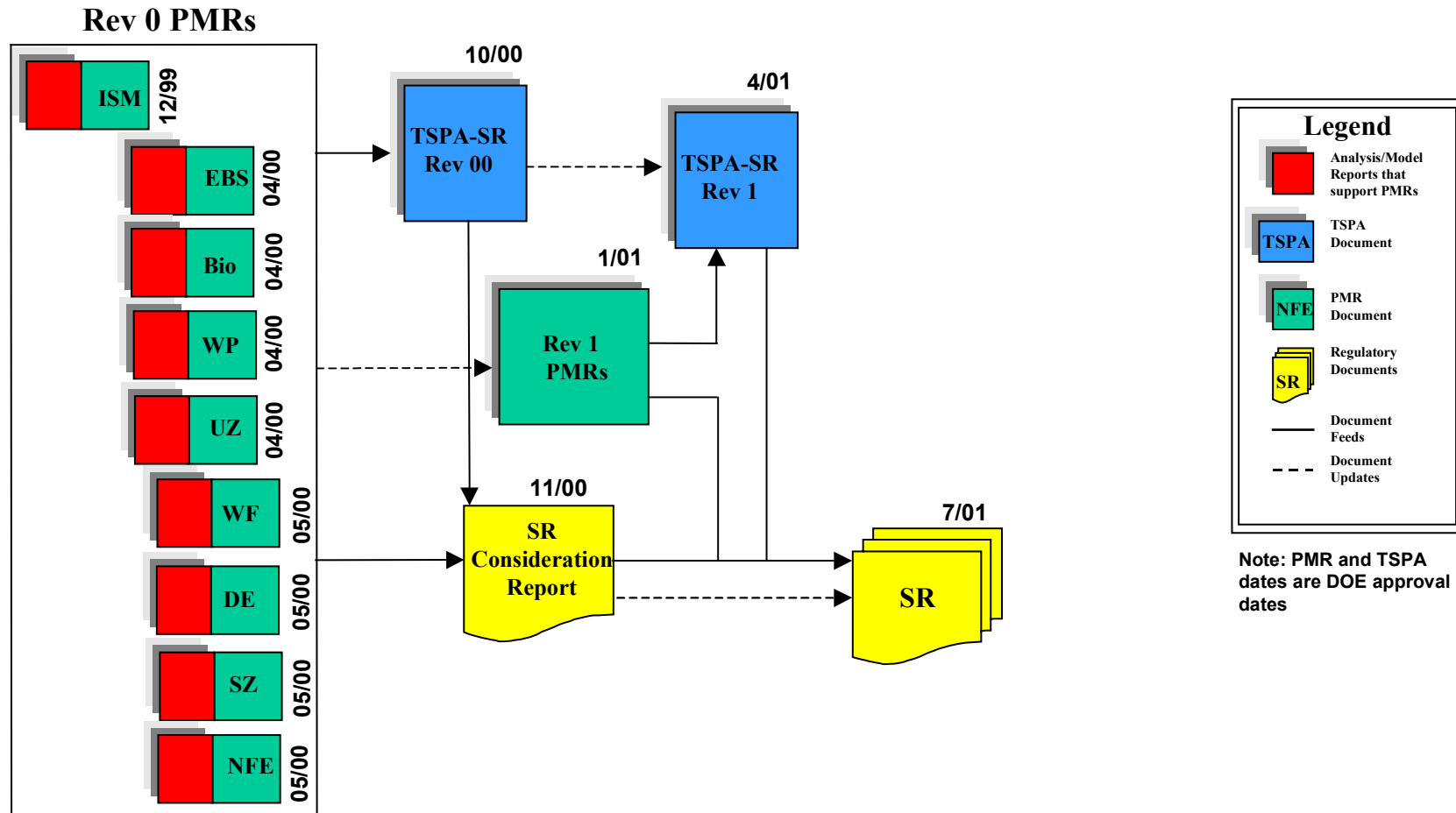


# TSPA-SR Documentation Hierarchy

- **Based on Analysis/Model Reports (AMR's) and Process Model Reports (PMR's)**
- **Preliminary information from data transmittals**
- **Feed information to SRCR**
- **Provides traceability back to models and data from TSPA model**



# TSPA-SR Documentation Hierarchy



# Resolving Issues

- **Issue: System Description/Demonstration of Multiple Barriers**
  - Transparency/traceability through process modeling, supporting analyses, and back to the data
  - Consistency from TSPA through supporting documentation
  - Numerous multiple barrier analyses to be conducted and documented in TSPA-SR
- **Issue: Scenario Analysis**
  - Identify FEPs, screening rationale, defend use of intermediate performance measures for screening

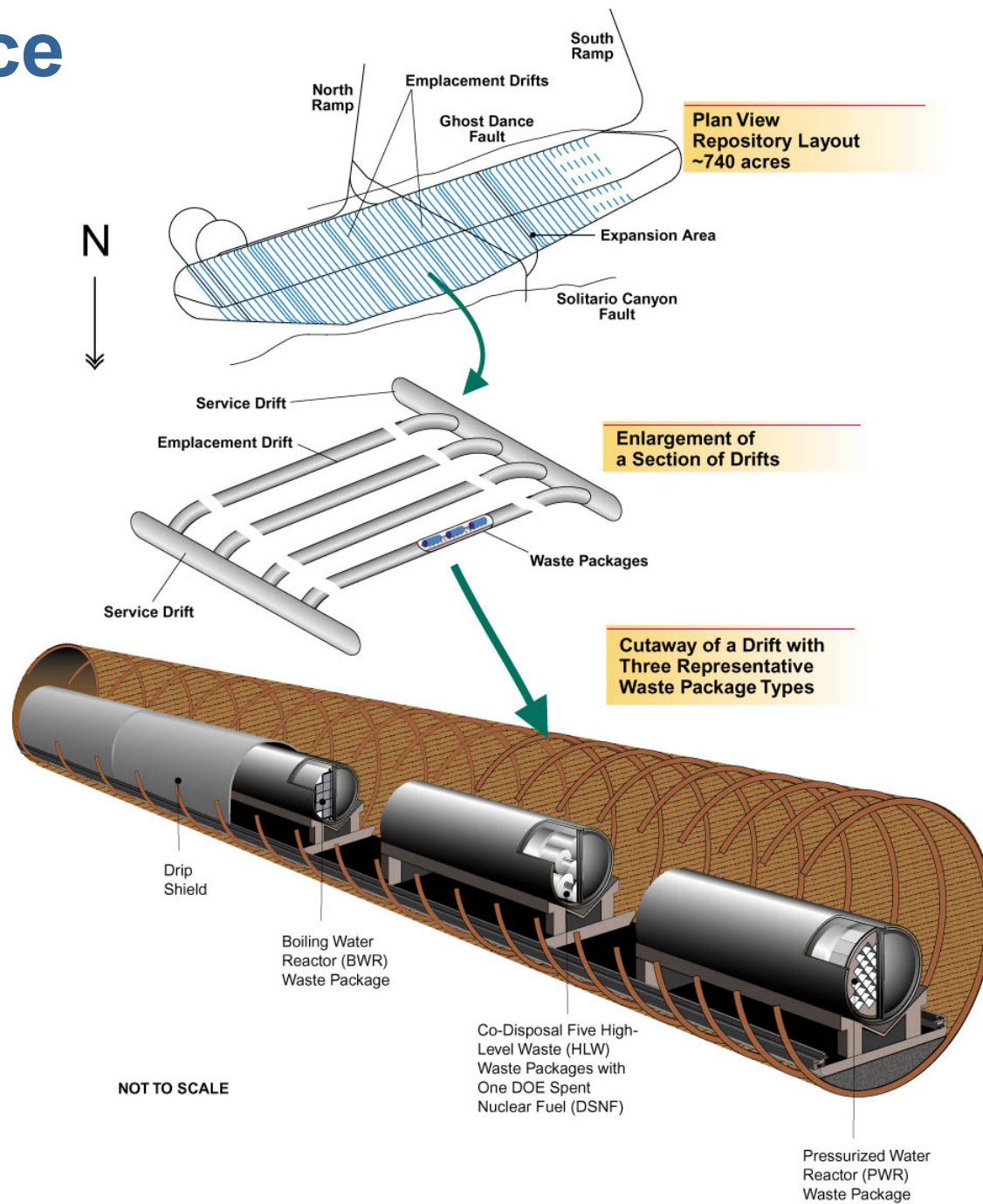
# Resolving Issues (continued)

- **Issue: Model Abstraction**
  - Integration of FEPs into TSPA-SR
  - Integrated model components to improve coupling
- **Issue: Overall Performance Objective**
  - Use TSPA-SR model to demonstrate performance objectives have been met

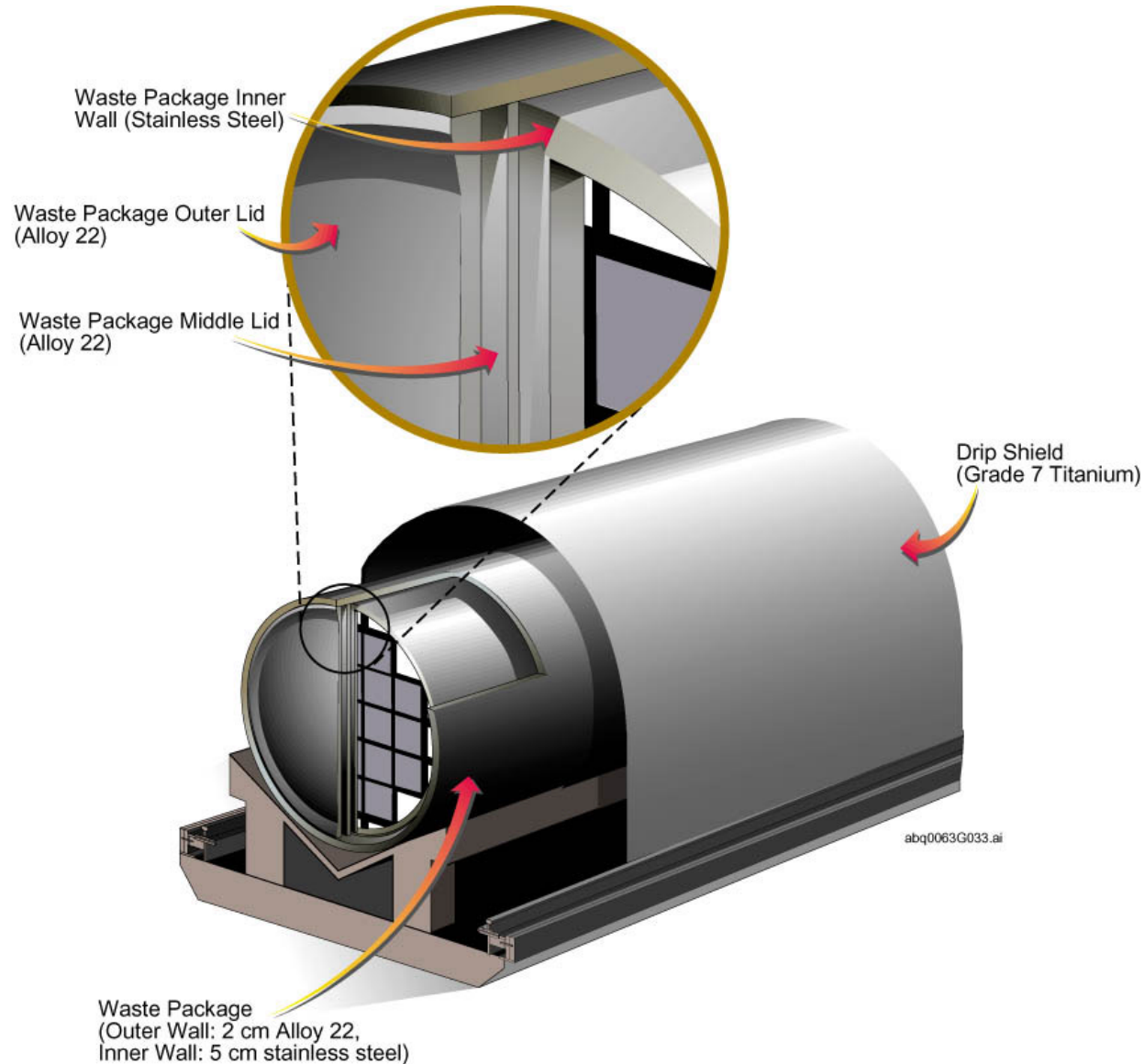
# Reference Design for TSPA-SR

- **TSPA-SR is based on the Site Recommendation Design**
- **Repository design**
  - Average thermal load of ~ 62 MTHM/acre (lower than VA)
  - 50 years of ventilation
  - Blending of fuel at surface to level thermal load
- **Engineered barrier system design**
  - Titanium drip shield placed over waste packages
  - No backfill
  - Waste packages placed end-to-end average (line load of ~ 1.4 kW/m)
- **Waste package design**
  - Waste packages for CSNF (21-PWR/44-BWR) and co-disposed DSNF and HLW
  - Outer layer of corrosion resistant Alloy 22 (20 mm) and inner layer of stainless steel (100 mm)
  - Dual-lid closure weld, outer lid closure weld stress mitigated by solution annealing, inner lid closure weld stress mitigated by laser peening

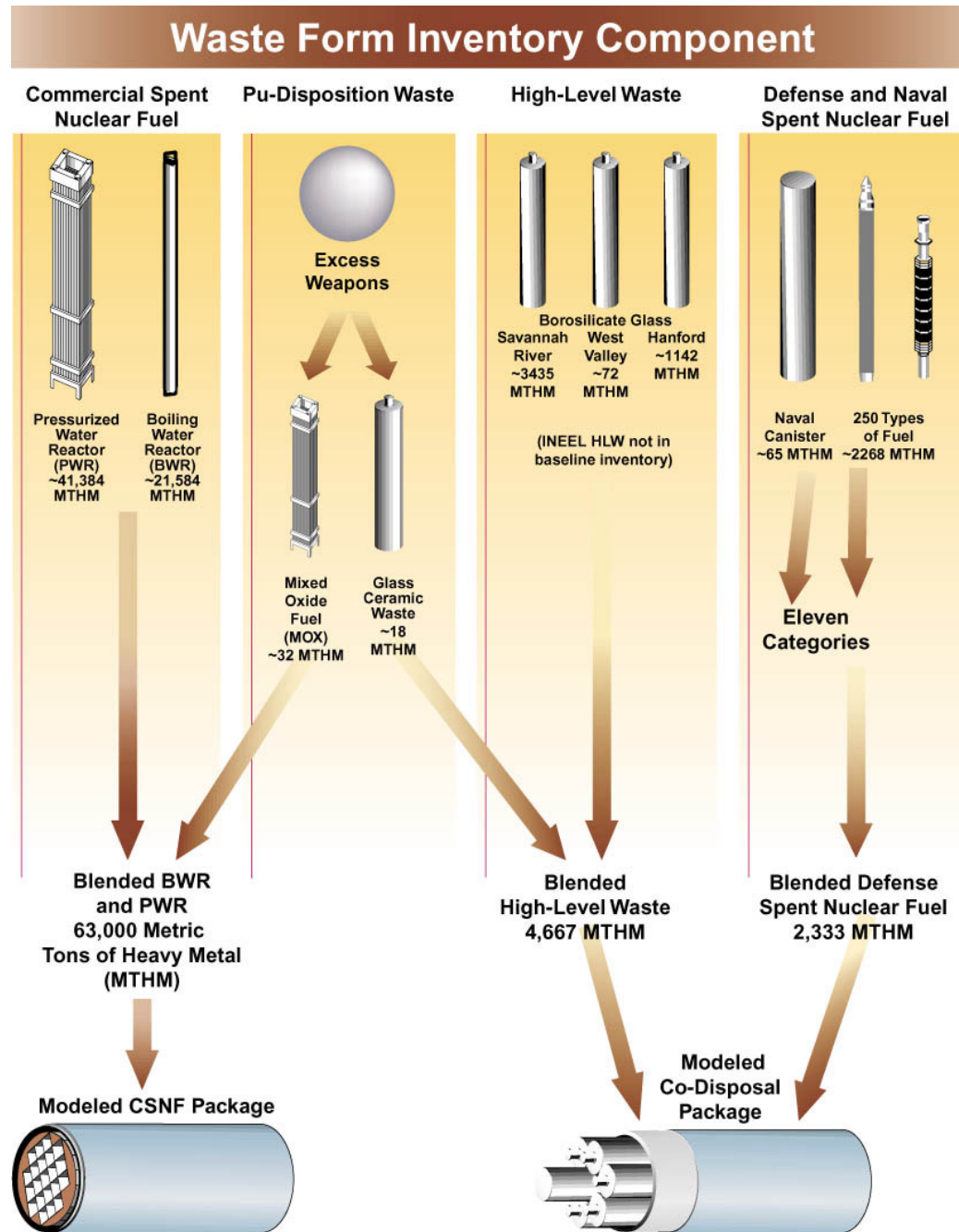
# Reference Design



# Reference Design - Waste Package



# Reference Design - Waste Form

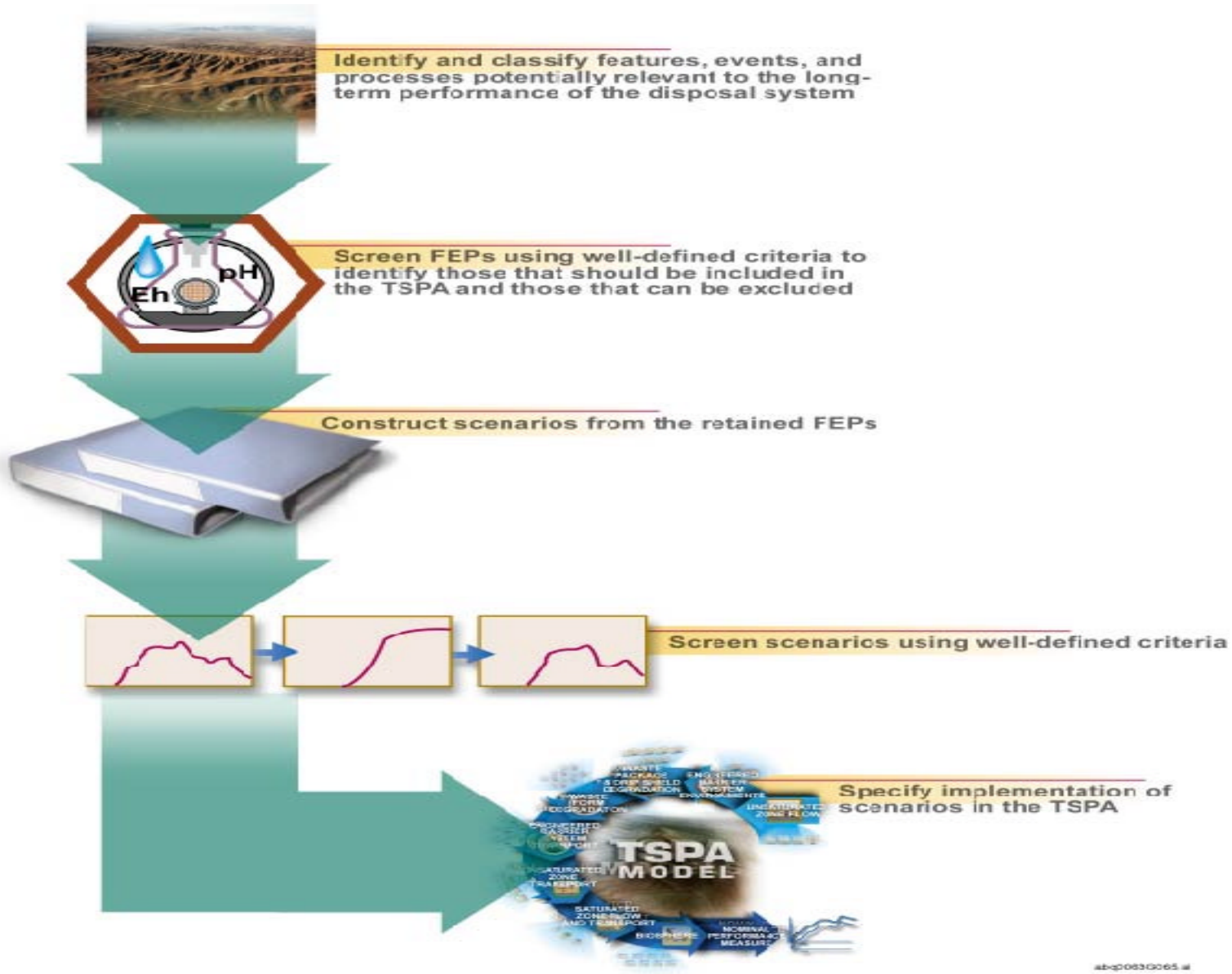


# Introduction – TSPA-SR Process

- **Screen features, events and processes to determine those that must be retained in performance assessment**
- **Develop models, along with their scientific basis, for each process included in TSPA**
- **Identify uncertainty in models and parameters**
- **Construct integrated TSPA model using all retained processes**
  - “Nominal” performance model contains all features, events and processes likely to occur
  - “Disruptive event” performance model contains low probability events (e.g., volcanism)
- **Evaluate total system performance (individual dose and groundwater protection) and significance of uncertainty**



# TSPA-SR Process



# TSPA-SR Process

## Oversight

NRC Technical Exchanges, Appendix 7 Meetings  
NWTRB Panel Meetings, Reports to Congress  
State of Nevada; Affected Units of Local Government  
Public

## Prior TSPAs

DOE TSPA-91, 93, 95, VA  
NRC IPA-1, -2, -3  
EPRI TSPA Phases 1, 2, and 3

## Process Model Abstraction

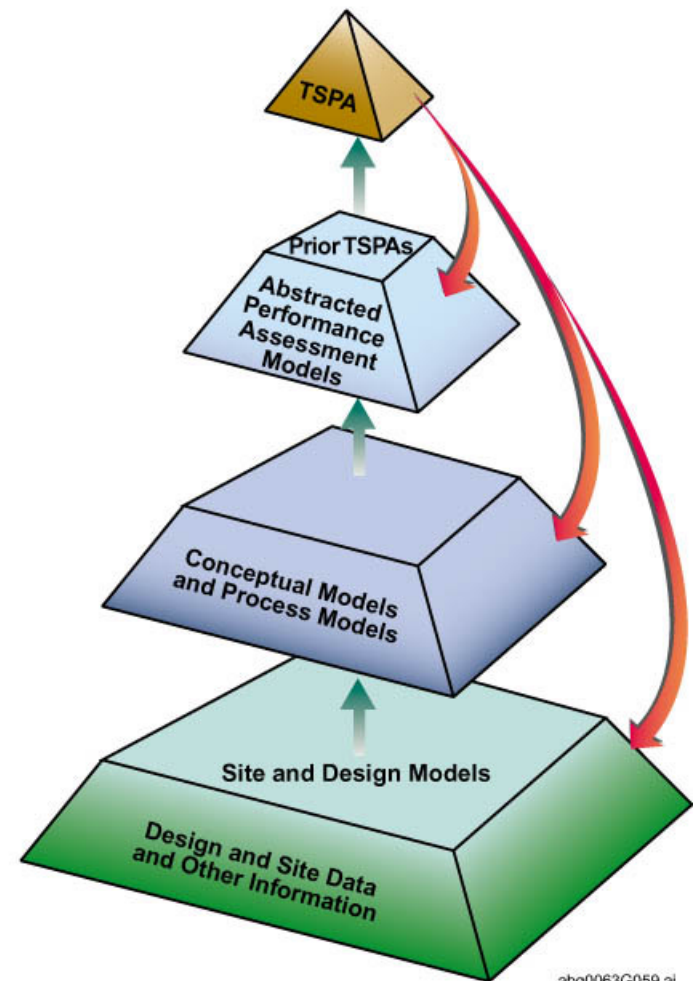
Unsaturated Zone Flow  
Engineered Barrier System Environments  
Waste Package & Drip Shield Degradation  
Waste Form Degradation  
Engineered Barrier System Transport  
Unsaturated Zone Transport  
Saturated Zone Flow and Transport  
Disruptive Events  
Biosphere

## Process Models

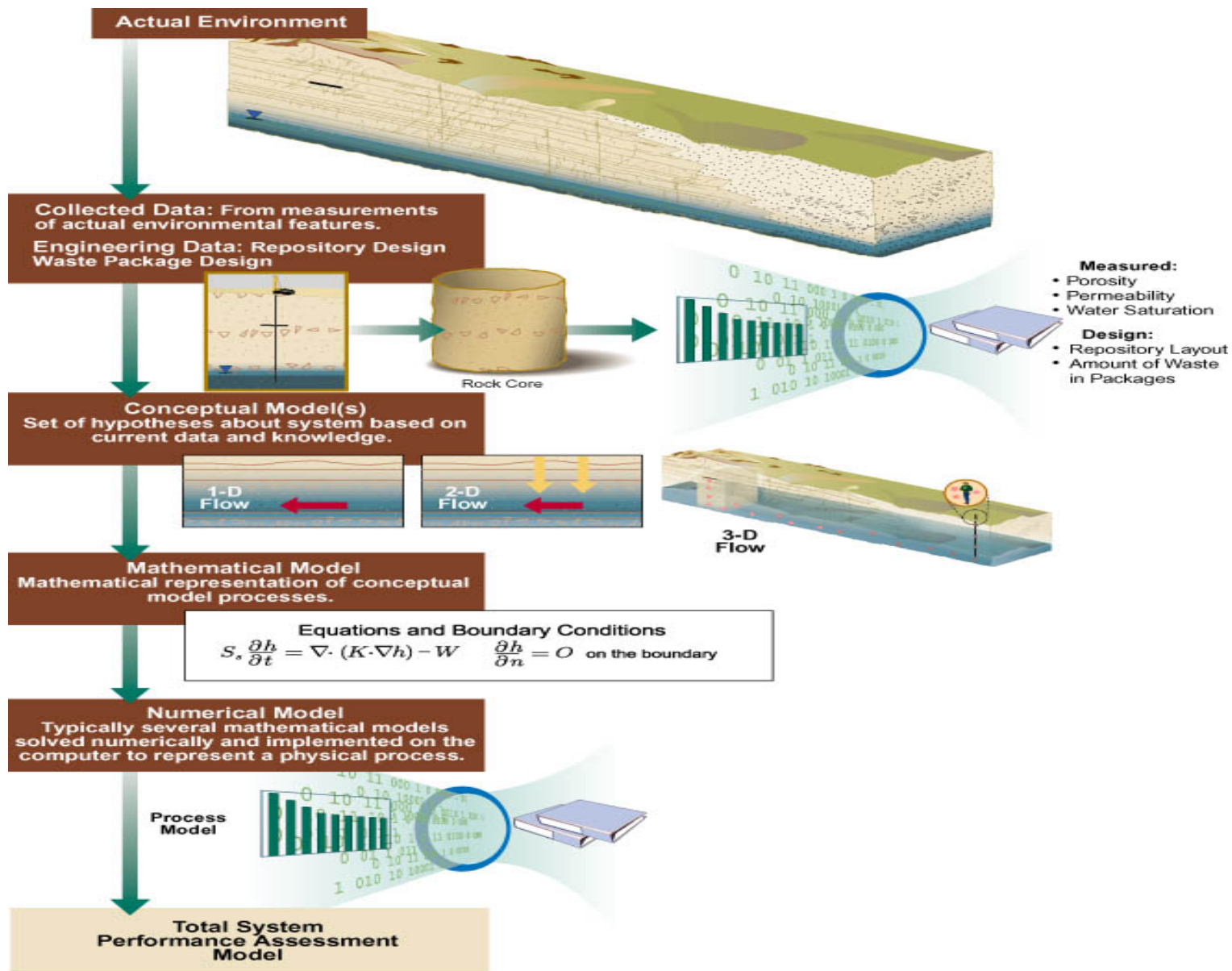
Unsaturated Zone Flow Model  
Seepage Model  
In-Drift Environment Model  
Waste Package and Drip Shield Corrosion Model  
Unsaturated Zone Transport Model  
Saturated Zone Flow and Transport Model  
Volcanic Eruption Model

## Site and Design Information

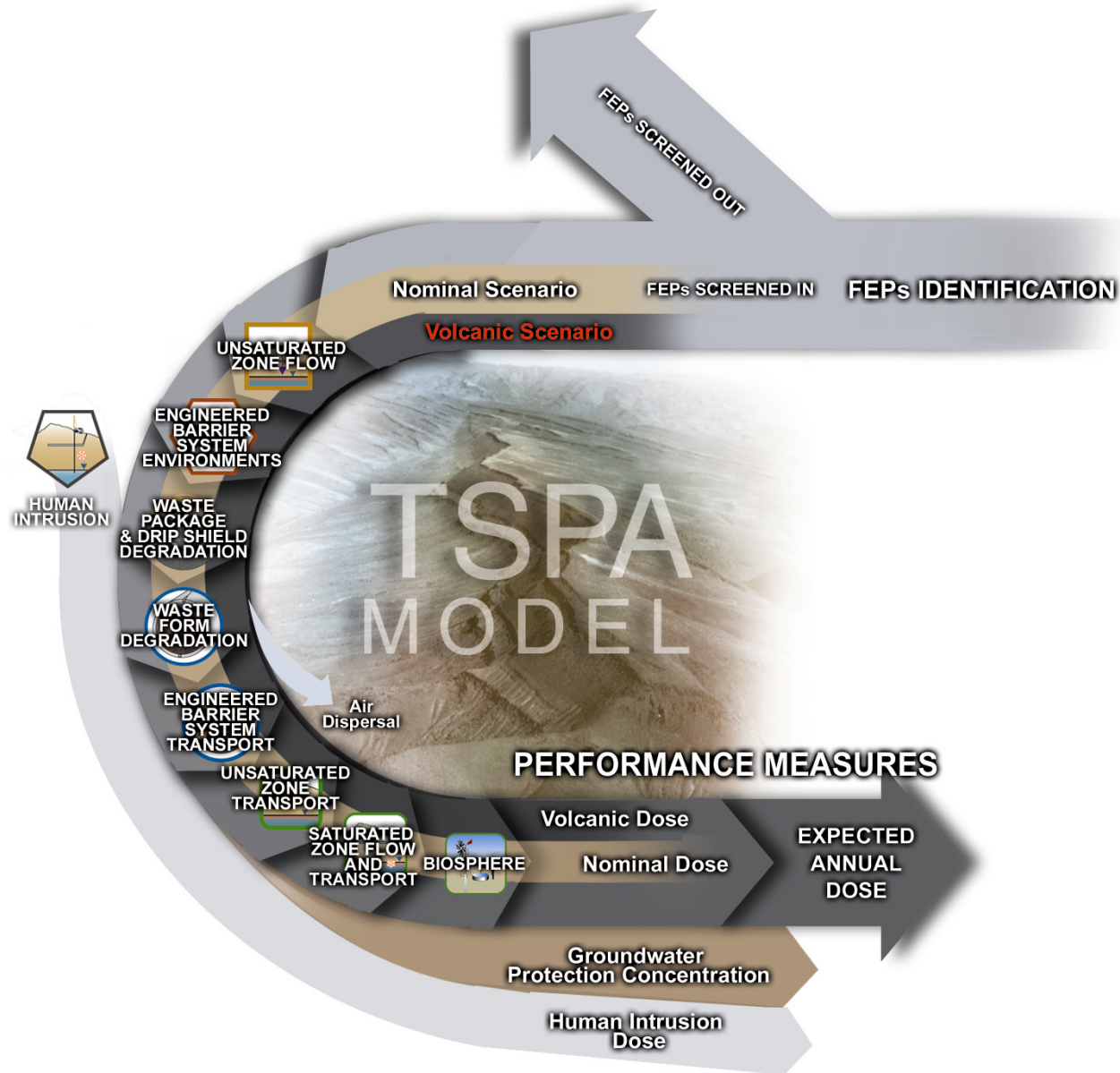
Site Description Document  
Repository Design  
Waste Package Design  
Laboratory Data  
In-Situ Data  
Analog Data



# TSPA-SR Process

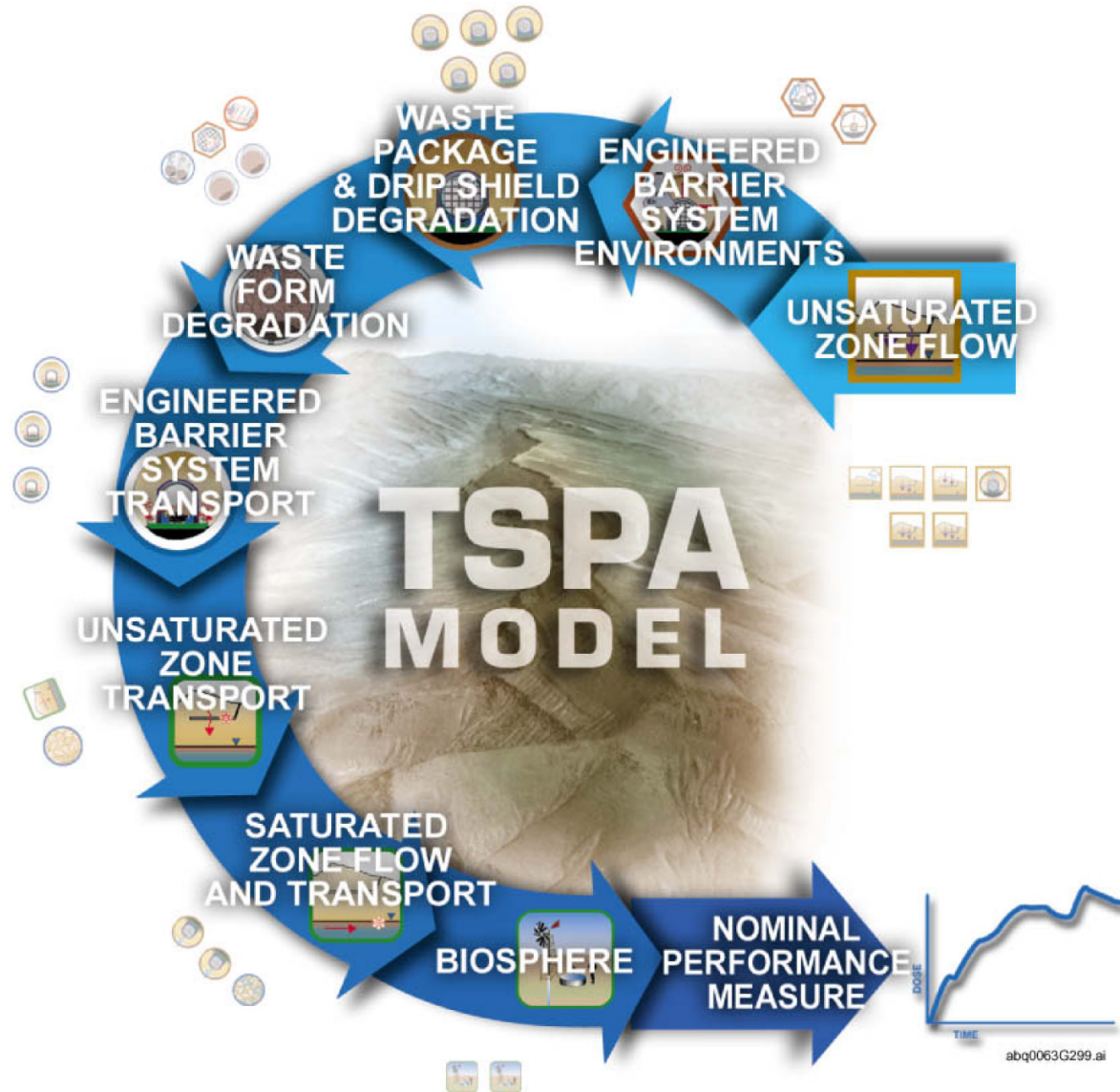


# TSPA-SR Model Analyses





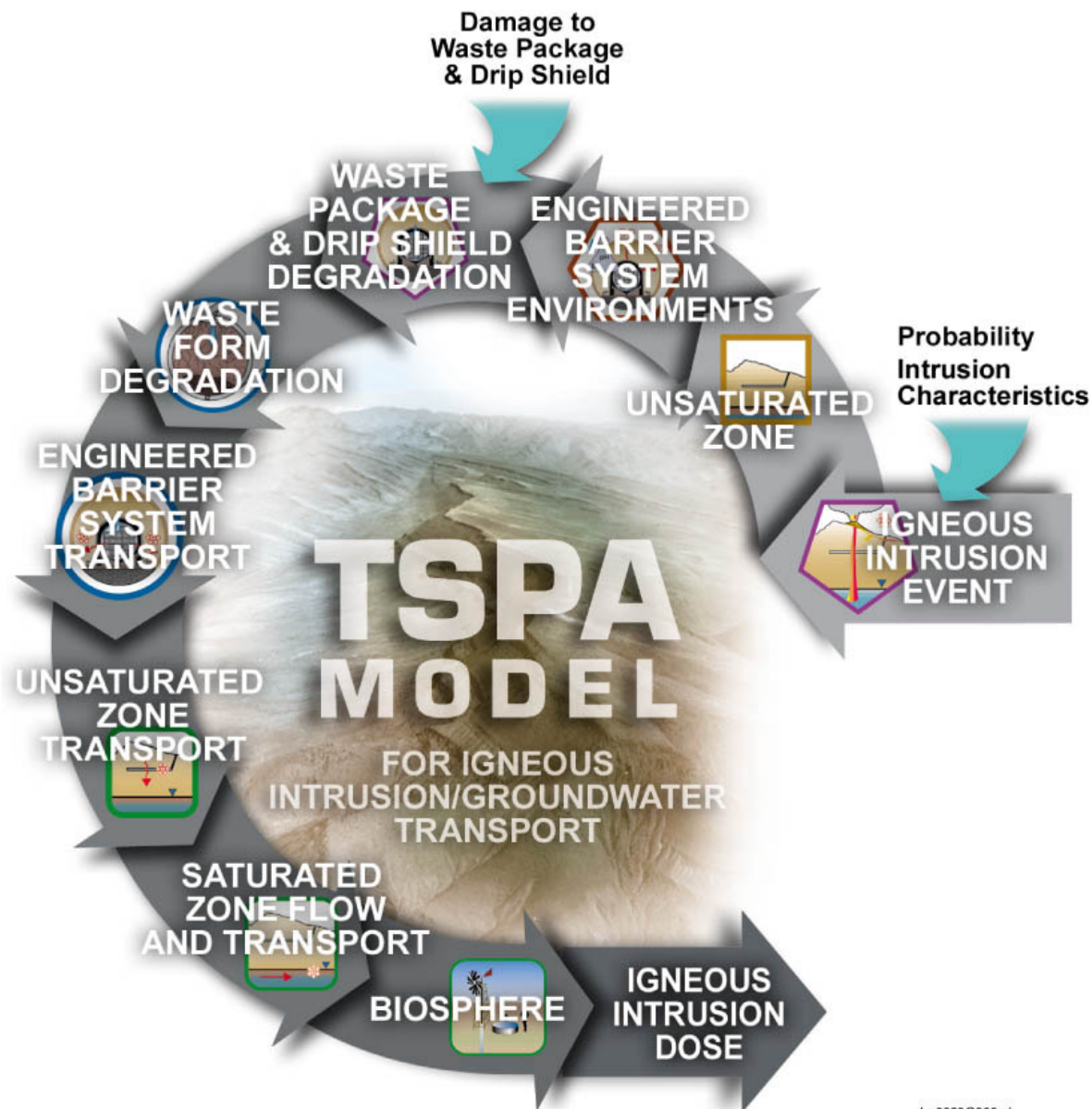
# TSPA-SR Nominal Scenario



# TSPA-SR Disruptive Events Scenario (Volcanic Eruption)

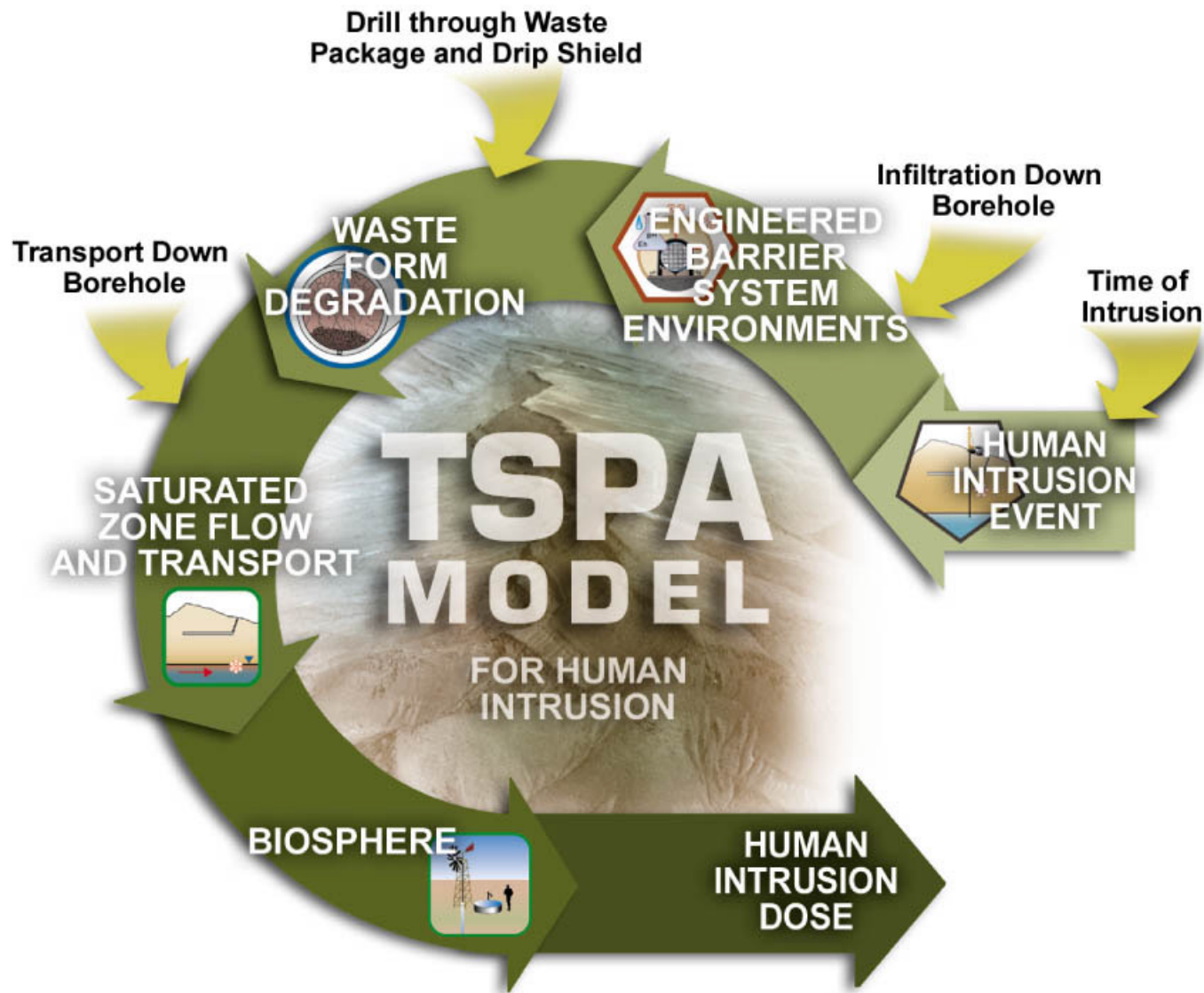


# TSPA-SR Disruptive Events Scenario (Igneous Intrusion/Groundwater Transport)



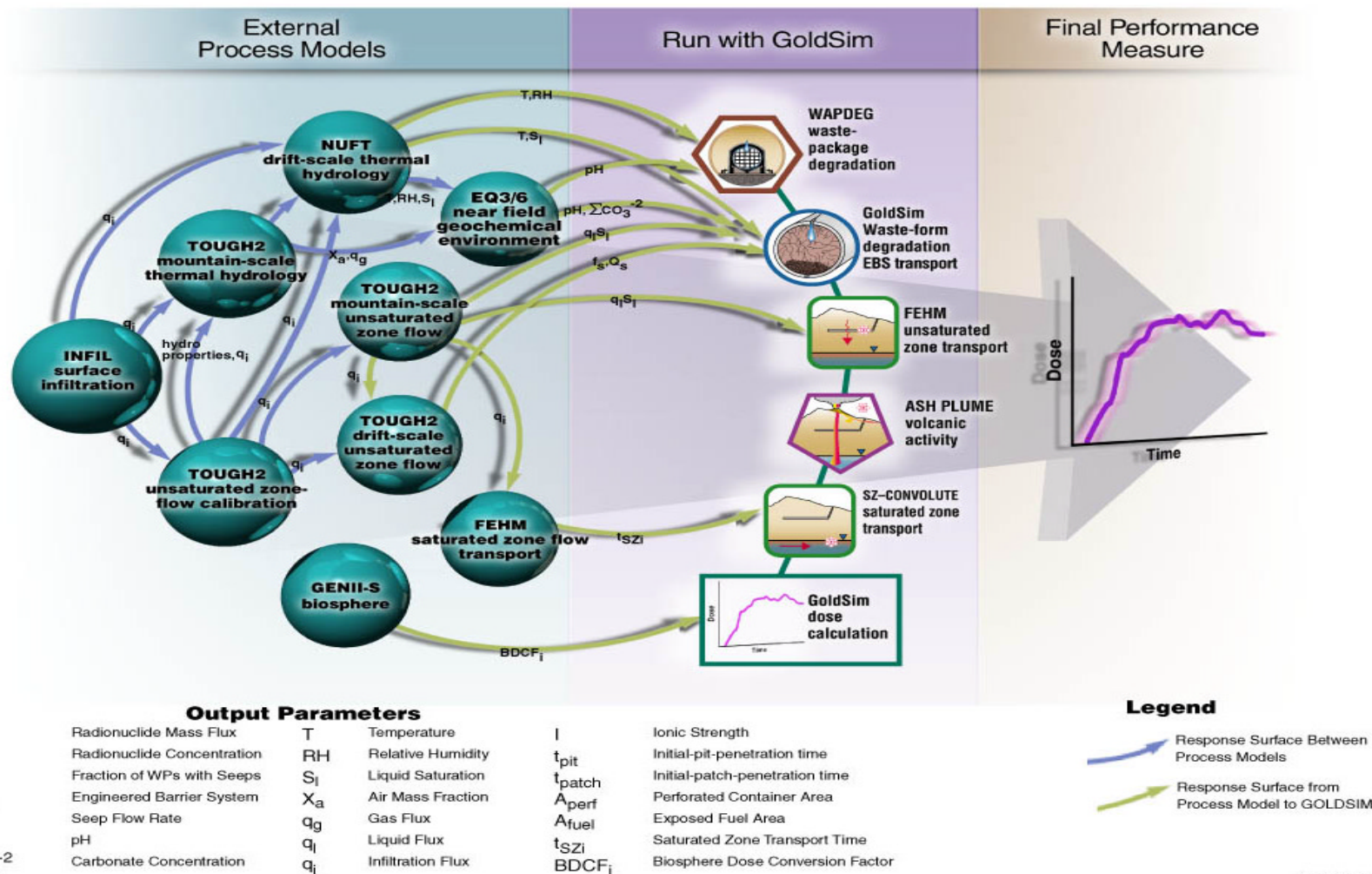


# TSPA-SR Disruptive Events Scenario (Human Intrusion)





# TSPA-SR Model: Configuration/Information Flow



# TSPA-SR Significance Analyses to Support Safety Case and 10 CFR 963 Compliance

- **Uncertainty analyses**
  - > 100 parameters in nominal performance scenario are represented with an uncertainty range
  - regression analysis, discriminant analysis, partial correlations and regression trees will be used to identify the most significant parameters
  - parameter importance will be quantified
- **Sensitivity analyses**
  - specific analyses will fix individual key parameters at their 5th and/or 95th percentile to illustrate contribution to performance of individual process model factors

# **TSPA-SR Significance Analyses to Support Safety Case and 10 CFR 963 Compliance**

(continued)

- **Barrier Importance analyses**
  - **specific analyses fixing groups of key parameters at their 5th or 95th percentile (depending on which leads to more conservative performance) will be used to illustrate contribution to performance of combined process model factors or barriers**

# TSPA-SR Schedule

- **Process models and analyses supporting TSPA-SR are essentially complete**
- **Process Model Reports (Rev 00) are being reviewed by DOE**
- **TSPA-SR model is complete, documentation underway**
- **TSPA-SR Technical Report (similar to VA Volume 3) is being developed, expect delivery to DOE in late August**
- **TSPA-SR sensitivity analyses and barrier importance analyses to support compliance evaluation and safety case are to be underway in June/July**
- **Draft Site Recommendation Consideration Report scheduled for DOE review in September**

# Summary of Technical Improvements for TSPA-SR

- Have addressed a number of issues raised by reviewers of VA, including DOE Peer Review, NWTRB, NRC, USGS, M&O TSPA-VA Peer Review, Clark County
- Major process model revisions to address issues include:
  - Climate and seepage
  - Coupled thermal-hydro-chemical processes
  - Waste package degradation (especially stress corrosion cracking)
  - Saturated zone transport
  - Igneous activity
- TSPA approach modified to address NRC and EPA requirements:
  - Explicit screening of features, events and processes in construction of model
  - “Expected” annual dose to reasonably maximally exposed individual
  - Groundwater protection of representative volume of aquifer
  - Stylized human intrusion scenario

# Summary of Process Improvements for TSPA-SR

- **All process models, abstraction models, analyses and calculations used to support TSPA-SR are being controlled under a set of procedures common to all participants**
- **Documented “validation” of process models developed in accordance with NUREG-1636 guidance**
- **All data sets, parameters and models/analyses inputs and outputs are being tracked and controlled to ensure traceability**
- **TSPA-SR model developed to ensure only traceable data sets are used as input**
- **Q-status of all data, developed or acquired, is tracked to identify qualification need, including software**

# Summary of Remaining Work for TSPA-SR

- **Complete analyses modifying conditions for no-backfill design**
- **Complete uncertainty, sensitivity and barrier importance analyses**
- **Complete documentation**
- **Complete contributions to Site Recommendation Consideration Report**
  - **Volume 1 – Technical Basis for Site Recommendation Consideration**
  - **Volume 2 – Compliance Evaluation**