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Monitoring and Performance Confirmation

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NNSA National Nuclear Security Administration

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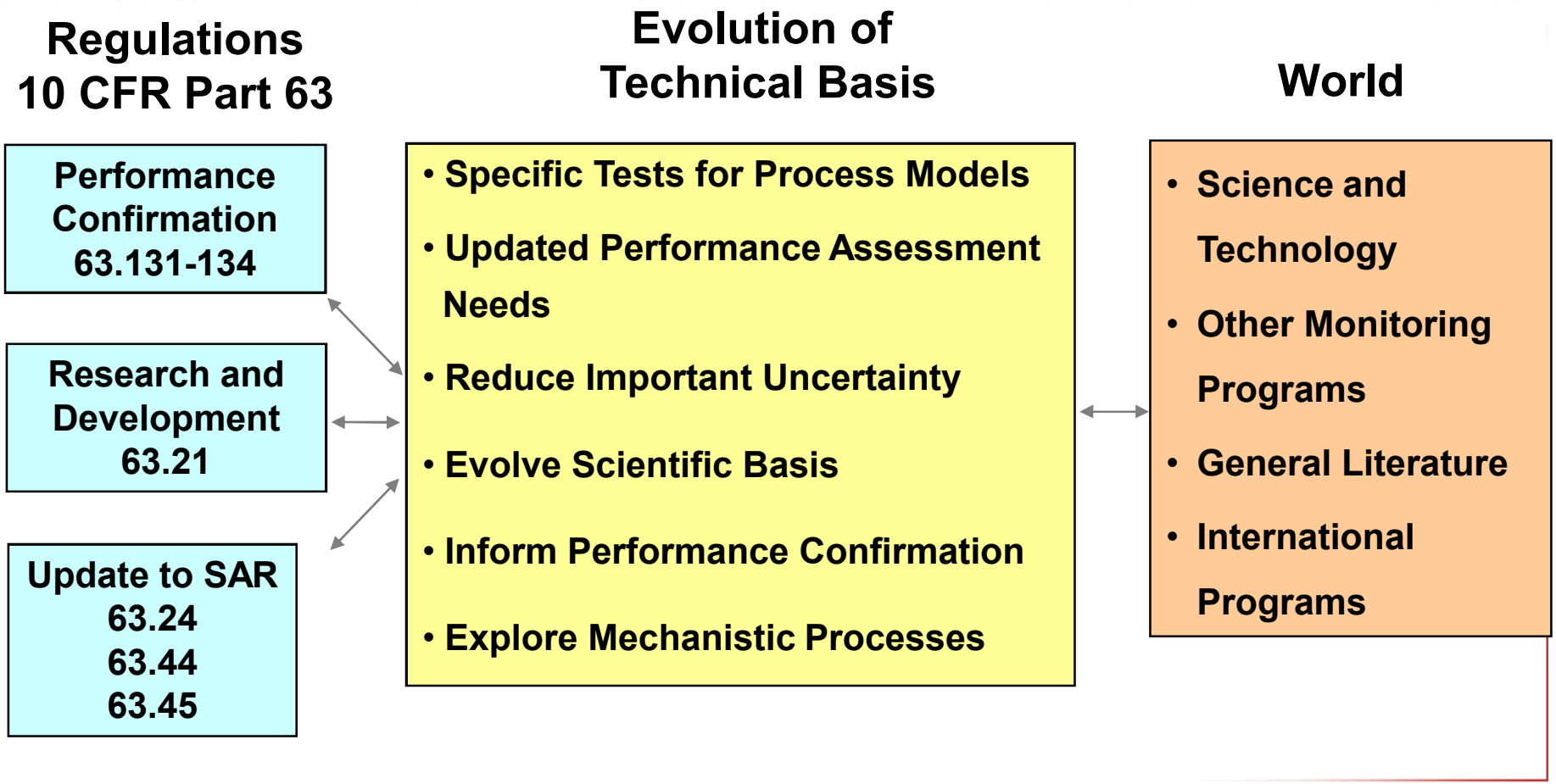
Introduction

Long-term Science and Monitoring programs support the Post-closure Safety Case

- Purpose of Long-Term Science and Monitoring
- Yucca Mountain Project (YMP) Analog – for Process
- Waste Isolation Pilot Plant (WIPP) Analog – for Implementation
- Components of Long-Term Science and Monitoring
  - Regulatory Requirements for Performance Confirmation
  - Influence of International Programs
  - Evolution of Technical Basis

Components of Long-Term Science

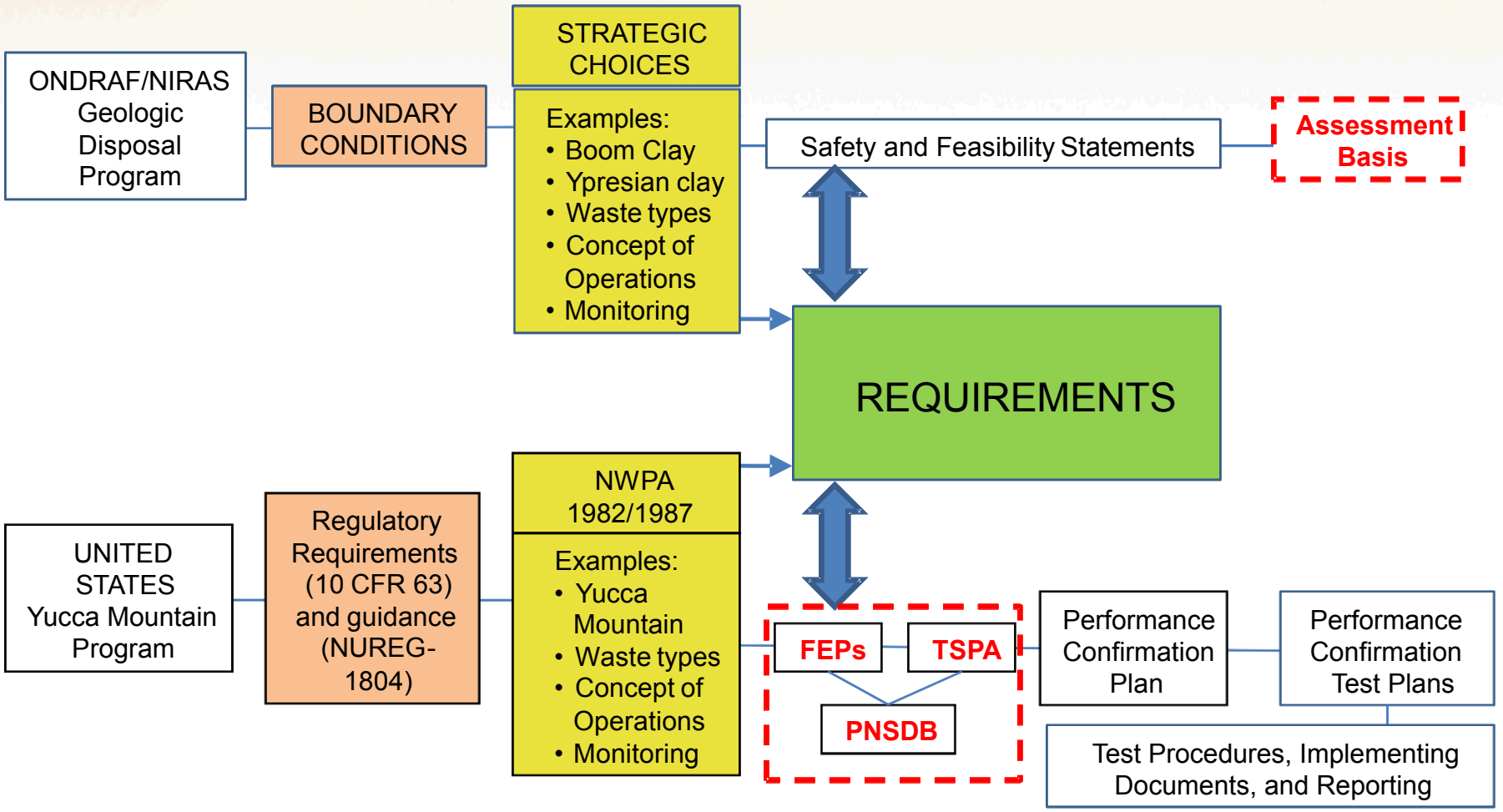


SAR - Safety Analysis Report

Performance Confirmation Process

- Regulatory requirements (Boundary Conditions) for Long-term Science and Monitoring, which includes Performance Confirmation
- Strategic Choices
- Requirements
  - Long-term Science and Monitoring includes elective activities
  - Performance Confirmation is driven by regulation
  - Required for License Application

Belgium/US Process Analog



FEPs – Features, Events, and Processes
TSPA – Total System Performance Assessment
PNSDB – Post-closure Nuclear Safety Design Basis
NWPA – Nuclear Waste Policy Act

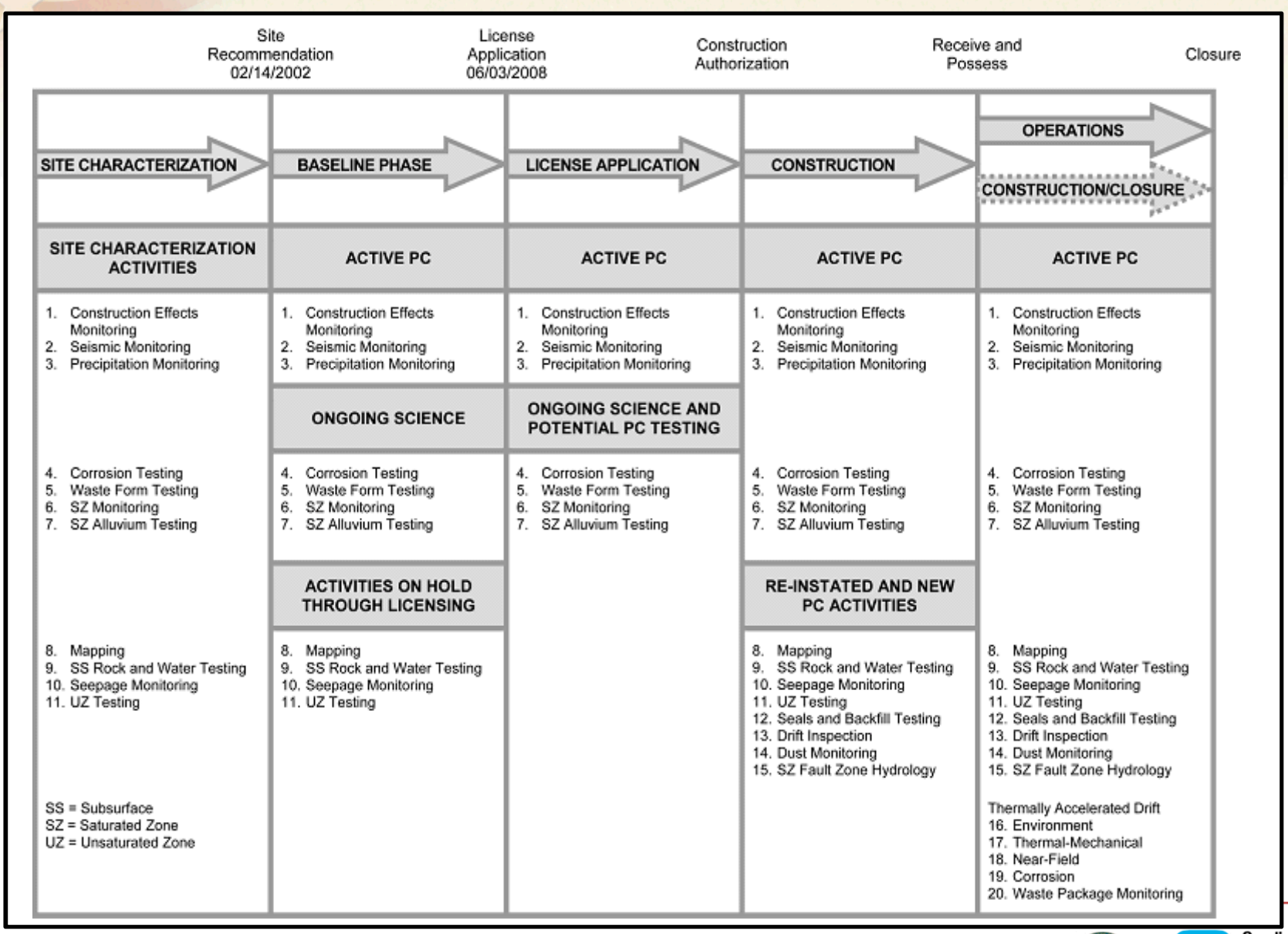
Expectations

- Public confidence
- Continuous assessment of evolving science and technology
  - State of knowledge
  - Emerging technologies
  - International perspective
  - Research and development
- Annual reporting

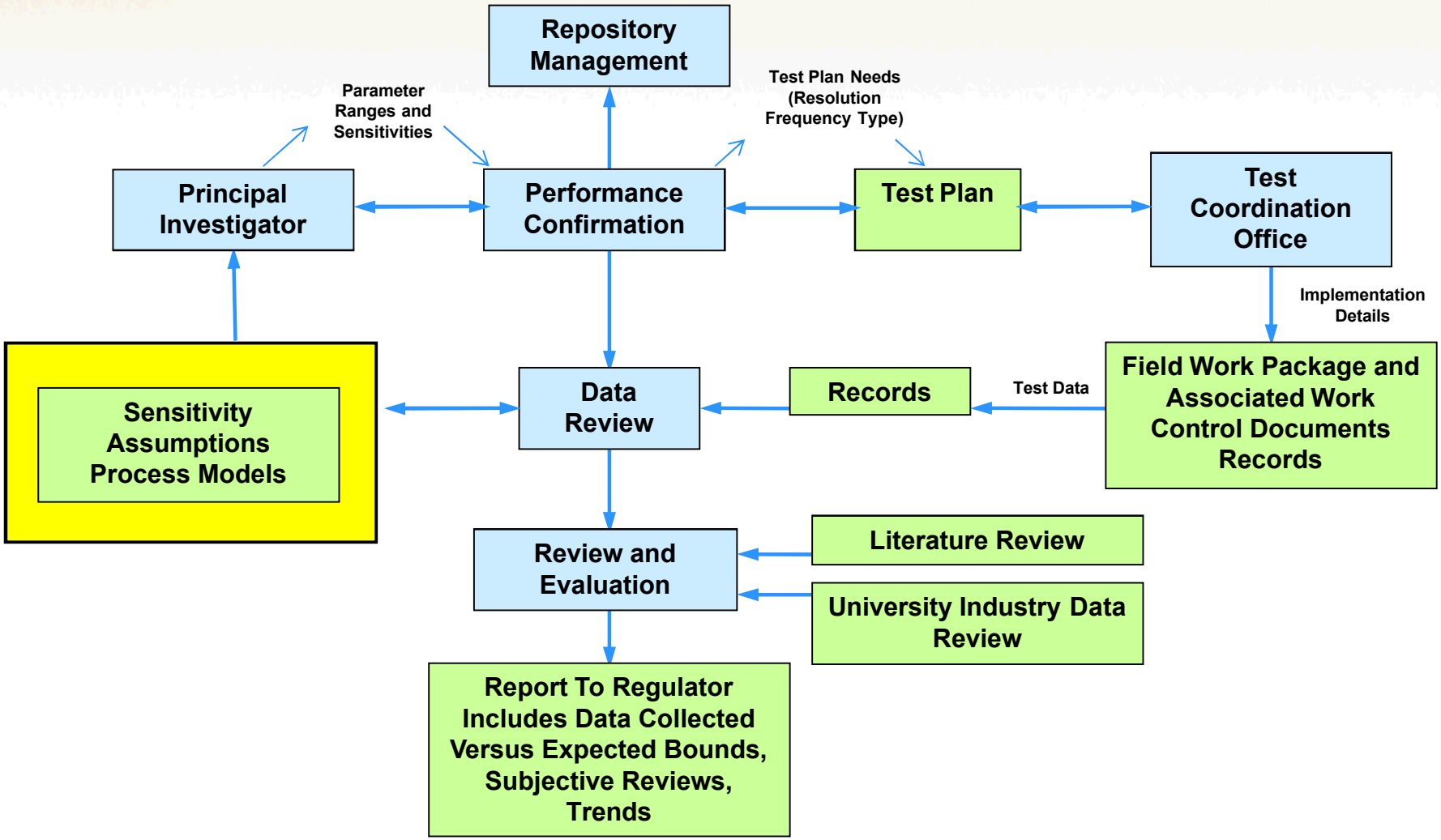
Implementation

- Management
- Planning
- Project Control
  - Test plans
  - Reporting requirements
  - Developed jointly
  - Integrated
  - Quality Assurance

YMP Example


Site Recommendation 02/14/2002
License Application 06/03/2008
Construction Authorization
Receive and Possess
Closure
SITE CHARACTERIZATION
BASELINE PHASE
LICENSE APPLICATION
CONSTRUCTION
OPERATIONS
CONSTRUCTION/CLOSURE
SITE CHARACTERIZATION ACTIVITIES
ACTIVE PC
ACTIVE PC
ACTIVE PC
ACTIVE PC
1. Construction Effects Monitoring
2. Seismic Monitoring
3. Precipitation Monitoring
1. Construction Effects Monitoring
2. Seismic Monitoring
3. Precipitation Monitoring
1. Construction Effects Monitoring
2. Seismic Monitoring
3. Precipitation Monitoring
1. Construction Effects Monitoring
2. Seismic Monitoring
3. Precipitation Monitoring
1. Construction Effects Monitoring
2. Seismic Monitoring
3. Precipitation Monitoring
ONGOING SCIENCE
ONGOING SCIENCE AND POTENTIAL PC TESTING
4. Corrosion Testing
5. Waste Form Testing
6. SZ Monitoring
7. SZ Alluvium Testing
4. Corrosion Testing
5. Waste Form Testing
6. SZ Monitoring
7. SZ Alluvium Testing
4. Corrosion Testing
5. Waste Form Testing
6. SZ Monitoring
7. SZ Alluvium Testing
4. Corrosion Testing
5. Waste Form Testing
6. SZ Monitoring
7. SZ Alluvium Testing
ACTIVITIES ON HOLD THROUGH LICENSING
RE-INSTATED AND NEW PC ACTIVITIES
8. Mapping
9. SS Rock and Water Testing
10. Seepage Monitoring
11. UZ Testing
8. Mapping
9. SS Rock and Water Testing
10. Seepage Monitoring
11. UZ Testing
8. Mapping
9. SS Rock and Water Testing
10. Seepage Monitoring
11. UZ Testing
12. Seals and Backfill Testing
13. Drift Inspection
14. Dust Monitoring
15. SZ Fault Zone Hydrology
8. Mapping
9. SS Rock and Water Testing
10. Seepage Monitoring
11. UZ Testing
12. Seals and Backfill Testing
13. Drift Inspection
14. Dust Monitoring
15. SZ Fault Zone Hydrology
Thermally Accelerated Drift
16. Environment
17. Thermal-Mechanical
18. Near-Field
19. Corrosion
20. Waste Package Monitoring
SS = Subsurface
SZ = Saturated Zone
UZ = Unsaturated Zone

Assessment Process



Summary

- Governed by boundary conditions (regulations)
- Long-term science and monitoring has less defined regulatory drivers
- Sequential, staged, flexible process
- Long-term science and monitoring demonstrates due diligence
- Continuously refined, consistent with staged repository program
- Testing and monitoring program
- Change and flexibility facilitated

WIPP Compliance Monitoring Example

- **WIPP Compliance Monitoring Program is based on an analysis of the performance assessment (PA) parameters and is required by the regulations**
- **Monitoring parameters must be assessed and reported to the U.S. Environmental Protection Agency (EPA) annually**
- **The EPA compliance monitoring requirements do not deal with operational releases; this compliance monitoring program addresses post-closure repository performance**
- **Each Compliance Monitoring Parameter (COMP) is assessed against PA expectations**
  - Impacts on PA conceptual model assumptions, data ranges or expectations of the modelers
  - Alert the project of conditions not accounted for or expected
  - Concept uses Trigger Values

Regulatory Requirements

- 40 CFR 194.42 (a) The Department shall conduct an analysis of the effects of disposal system parameters on the containment of waste in the disposal system and shall include the results of such analysis in any compliance application. The results of the analysis shall be used in developing plans for pre-closure and post-closure monitoring required pursuant to paragraphs (c) and (d) of this section.

Performance Confirmation

- **EPA Monitoring requirements constitute performance confirmation**
  - Determine list of parameters
  - Determine method to assess “significance” of each parameter using the WIPP PA
  - Analyze the parameters
  - Determine criteria using the analysis results to determine monitoring parameters
- **The DOE’s analysis that addressed the EPA pre-closure monitoring requirements was included in the original EPA compliance application (i.e., licensing application)**

Monitored Parameters

- Drilling Rate
- Probability of Encountering a Castile Brine Reservoir
- Waste Activity
- Subsidence
- Changes in Culebra Groundwater Flow
- Change in Culebra Groundwater Composition
- Creep Closure
- Extent of Deformation
- Initiation of Brittle Deformation
- Displacement of Deformation Features

Results of the Screening

Table 7-2. Potentially Significant Disposal System Parameters

NATURAL PARAMETERS

- Impure halite effective porosity
- Impure halite permeability
- Impure halite pore compressibility
- Impure halite far-field pore pressure
- Anhydrite permeability
- Anhydrite pore compressibility
- Anhydrite two-phase flow model choice
- Salado pore shape
- Salado residual brine saturation
- Salado residual gas saturation
- Salado brine quantity
- Salado brine flux
- Salado brine spatial distribution
- Salado brine composition
- Culebra transmissivity
- Culebra advective porosity
- Culebra fracture spacing
- Culebra diffusional porosity
- Culebra longitudinal dispersivity
- Climate change index
- Culebra groundwater quantity
- Culebra groundwater flux
- Culebra groundwater spatial distribution
- Culebra groundwater composition
- Castile brine volume in reservoir
- Castile brine reservoir volume selection index
- Castile brine reservoir pressure
- Castile brine reservoir permeability
- Castile brine reservoir rock compressibility
- Castile brine composition
- Castile brine flux
- Castile brine spatial distribution
- Natural temperature distribution

WASTE AND REPOSITORY PARAMETERS

- Closure rates and stresses
- Extent of deformation
- Initiation of brittle deformation
- Displacement of major deformation features
- DRZ permeability
- DRZ effective porosity
- DRZ brine flux
- DRZ brine quantity
- Waste area residual gas saturation
- Waste area residual brine saturation
- Brine wicking
- Waste area permeability
- Backfill porosity
- Backfill permeability
- Degree of backfill compaction
- Backfill reconsolidation
- Inundated steel corrosion rate with CO_2
- Inundated steel corrosion rate without CO_2
- Inundated microbial degradation rate
- Humid microbial degradation rate
- β-factor for microbial degradation process
- Probability factor for types of microbial degradation
- Gas quantity
- Gas composition
- Choice of oxidation state distribution
- Solubility of nine radionuclides in Salado brine
- Solubility of nine radionuclides in Castile brine
- Humic colloid concentration in Salado brine
- Humic colloid concentration in Castile brine
- Clay shaft seal member permeability
- Concrete shaft seal member permeability
- Asphalt shaft seal member permeability
- Shaft DRZ permeability
- Crushed salt seal component permeability (permeability selection index)
- Seal residual gas saturation
- Seal residual brine saturation
- Seal pore shape
- Waste- and repository-induced temperature distribution
- Salado K_ds for dissolved radionuclides
- Culebra K_ds for six dissolved radionuclides
- Salado K_ds for colloidal radionuclides

HUMAN INITIATED PARAMETERS

- Drilling rate
- Waste particle diameter
- Effective shear resistance to erosion
- Gravity correction factor for spalling
- Strength correction factor for spalling
- Time between intrusions
- Borehole location
- Probability of encountering a Castile brine reservoir
- Borehole diameter
- Borehole permeability
- Borehole plugging pattern (probability index)
- Change in Salado brine flow
- Change in Culebra groundwater flow
- Probability that mining will occur
- Mining index for adjusting Culebra transmissivity
- Waste activity
- Waste tensile strength

Results of the Screening (continued)

Table 7-4. Parameters Related to Significant Disposal System Properties (Continued)

Parameter	Significance to Containment	Significance to Verification
Inundated steel corrosion rate without CO_2	MEDIUM	MEDIUM
Inundated microbial degradation rate	LOW	LOW
Humid microbial degradation rate	LOW	LOW
Gas quantity	MEDIUM	MEDIUM
Gas composition	LOW	LOW
Choice of oxidation state distribution	HIGH	HIGH
Solubility of nine radionuclides in Salado brine	HIGH	HIGH
Solubility of nine radionuclides in Castile brine	HIGH	HIGH
Humic colloid concentrations in Salado brine	HIGH	HIGH
Humic colloid concentrations in Castile brine	HIGH	HIGH
Waste particle diameter	HIGH	HIGH
Effective shear resistance to erosion	MEDIUM	MEDIUM
Waste activity	HIGH	HIGH
Waste tensile strength	MEDIUM	MEDIUM
Gravity factor for spalling	MEDIUM	MEDIUM
Strength factor for spalling	LOW	LOW
ENGINEERED BARRIER PROPERTIES		
Shaft DRZ permeability	MEDIUM	MEDIUM
Backfill porosity	LOW	LOW
Backfill permeability	LOW	LOW
Degree of backfill compaction	LOW	LOW
Backfill reconsolidation	LOW	LOW
Clay seal member permeability	MEDIUM	MEDIUM
Concrete seal member permeability	MEDIUM	MEDIUM
Asphalt seal member permeability	MEDIUM	MEDIUM
Seal residual gas saturation	LOW	LOW
Seal residual brine saturation	LOW	LOW
Seal pore shape	LOW	LOW
Long-term borehole permeability	HIGH	HIGH

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Results of the Screening (continued)

Table 7-5. Listing of Parameters That Can Produce Meaningful Data During Monitoring Period

Parameter	Comment
SALADO PHYSICAL PARAMETERS	
Creep closure and stresses	Can be measured during operations
Extent of deformation	Can be measured during operations
Initiation of brittle deformation	Can be measured during operations
Displacement of deformation features	Can be observed during operations
SALADO HYDROLOGICAL PARAMETERS	
Salado brine composition	Can be measured during operations
NON-SALADO HYDROLOGICAL PROPERTIES	
Culebra groundwater composition	Can be measured for entire period
Castile brine reservoir location	Can be observed for entire period
Drilling rate	Can be observed for entire period
Culebra change in groundwater flow	Can be observed for entire period
WASTE RELATED PARAMETERS	
Waste activity	Can be calculated using measurements made during waste characterization

Trigger Values

- Monitoring results are used to indicate conditions that are not within the PA data ranges, conceptual model assumptions or expectations of the modelers and to alert the project of conditions not accounted for or expected
- Values and ranges were developed such that exceedance of identified values, referred to as "trigger values" (TV), indicate a condition that is potentially outside PA expectations

Conclusion

- **WIPP Compliance Monitoring Program is based on EPA-required analysis of PA parameters (40 CFR 194.42)**
- **Parameters must be assessed and reported to EPA annually**
- **Each monitored parameter is assessed against PA expectations:**
  - Impacts on PA conceptual model assumptions, data ranges or expectations of the modelers
  - Alert the project of conditions not accounted for or expected
  - Program uses Trigger Values to alert project of unexpected conditions

Collaboration

- Sandia is active partner on MoDeRn (http://www.modern-fp7.eu/)
- WIPP has successful confirmation monitoring program
- YMP brought comprehensive rigor to performance confirmation
- Is there a need for a joint over-arching long-term testing and monitoring strategy?

Performance Confirmation SAND Report Outline

1. **Introduction: Describe Performance Confirmation Program Goals and Objectives:**
   - a) Program Goals
     1. Regulatory Needs
     2. Performance Assessment Needs
     3. Barrier Capability
   - b) Objectives
     1. Model Validation and Confirmation
     2. Increase Confidence
     3. Public Acceptance
2. **Outline Performance Confirmation Program**
   - a) Framework
     1. Evaluation Methodology
     2. Activity Selection
     3. Measurable Parameters
   - b) Documentation
     1. Overarching Plan Strategy
     2. Specific Implementing Test Plans
   - c) Periodic Evaluations
     1. Ongoing Science—Internal and External
     2. Integration—Long-Term Testing and Monitoring Programs
3. **Examples of PC Programs**
   - a) Yucca Mountain
   - b) WIPP
   - c) International Programs – Belgium, MoDeRn
4. **Concluding Remarks**
5. **References**