Repository Development Plans

Presented to:
Nuclear Waste Technical Review Board

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Outline

- Total Life Cycle Cost (TSLCC) Analysis for the Civilian Radioactive Waste Management System
- Fee Adequacy (FA) Determination
- Life Cycle Cost Analyses for Flexible Operating Modes
- Modular Approach to Repository Construction and Operations

Total System Life Cycle Cost

- **TSLCC - Total system cost to emplace all planned quantities listed in CRWMS requirements document**
  - **2000 TSLCC: 97,400 Metric Ton of Heavy Metal (MTHM) (83,800 MTHM Commercial Spent Nuclear Fuel (CSNF), 13,600 MTHM Defense)**
  - **Detailed costs for reference system that is consistent with Monitored Geologic Repository Project Description Document Rev. 2**

Total System Life Cycle Cost

(Continued)

– TSLCC components:
  - Monitored Geologic Repository
  - Waste Acceptance, Storage and Transportation
  - Nevada Transportation
  - Program Integration
  - Institutional
– TSLCC includes a qualitative discussion of potential costs associated with lower temperature operating modes

Reference System Design Characteristics

• **Drift Spacing**	**81 m**
• **Drift Diameter**	**5.5m**
• **Waste Package Spacing**	**Line Loading: 10 cm**
• **Total Length of Emplacement Drifts**	**75.8 km**
• **Ground Support**	**Carbon Steel**
• **Invert**	**Carbon Steel / with Granular Ballast**
• **Number of WP**	**14,768**
• **WP Materials**	**2-2.5cm Alloy-22 over 5cm SS 316NG**
• **Max PWR WP Capacity**	**21 PWR Assemblies**
• **Drip Shield**	**15 mm Titanium**
• **Preclosure Ventilation Rate**	**15 m^3/sec**

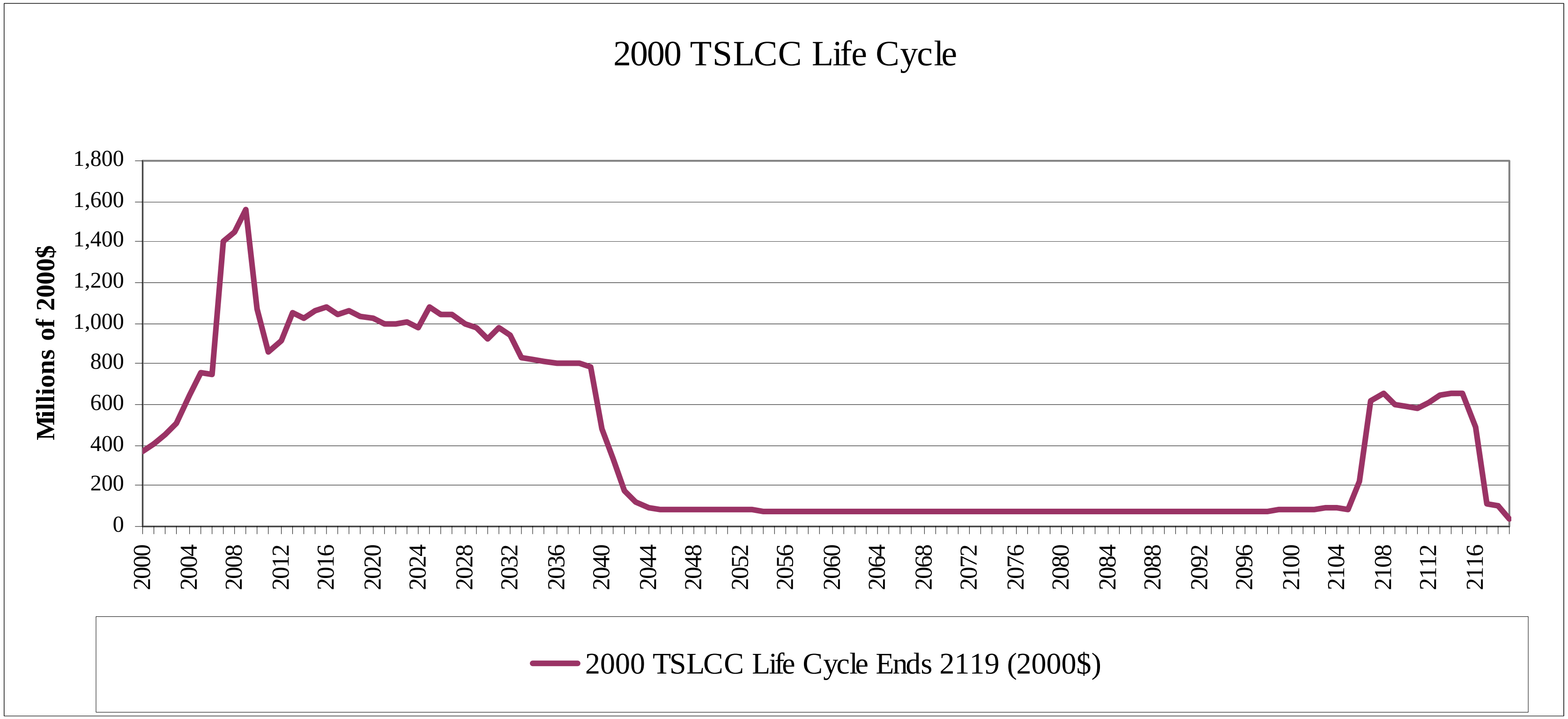
Summary of Reference System Results

2000 TSLCC Estimate Summary (In Millions of 2000$)

Cost Element		Total Cost
Monitored Geologic Repository Costs		$42,070
Development & Evaluation (1983-LA) Costs	$6,580	
Surface Facilities	7,700	
Subsurface Facilities	8,980	
Waste Package & Drip Shield Fabrication	13,290	
Performance Confirmation	2,270	
Regulatory, Infrastructure, & Management Services	3,250	
Waste Acceptance, Storage & Transportation		5,960
Nevada Transportation		840
Program Integration		4,070
Institutional Costs		4,580
Total CRWMS Cost		$57,520

2000 TSLCC Total Costs

- **Total Cost 2000 TSLCC is $57.5 Billion (2000$)**
- **Future Cost 2000 TSLCC is $49.3 Billion (2000$)**



Fee Adequacy Determination

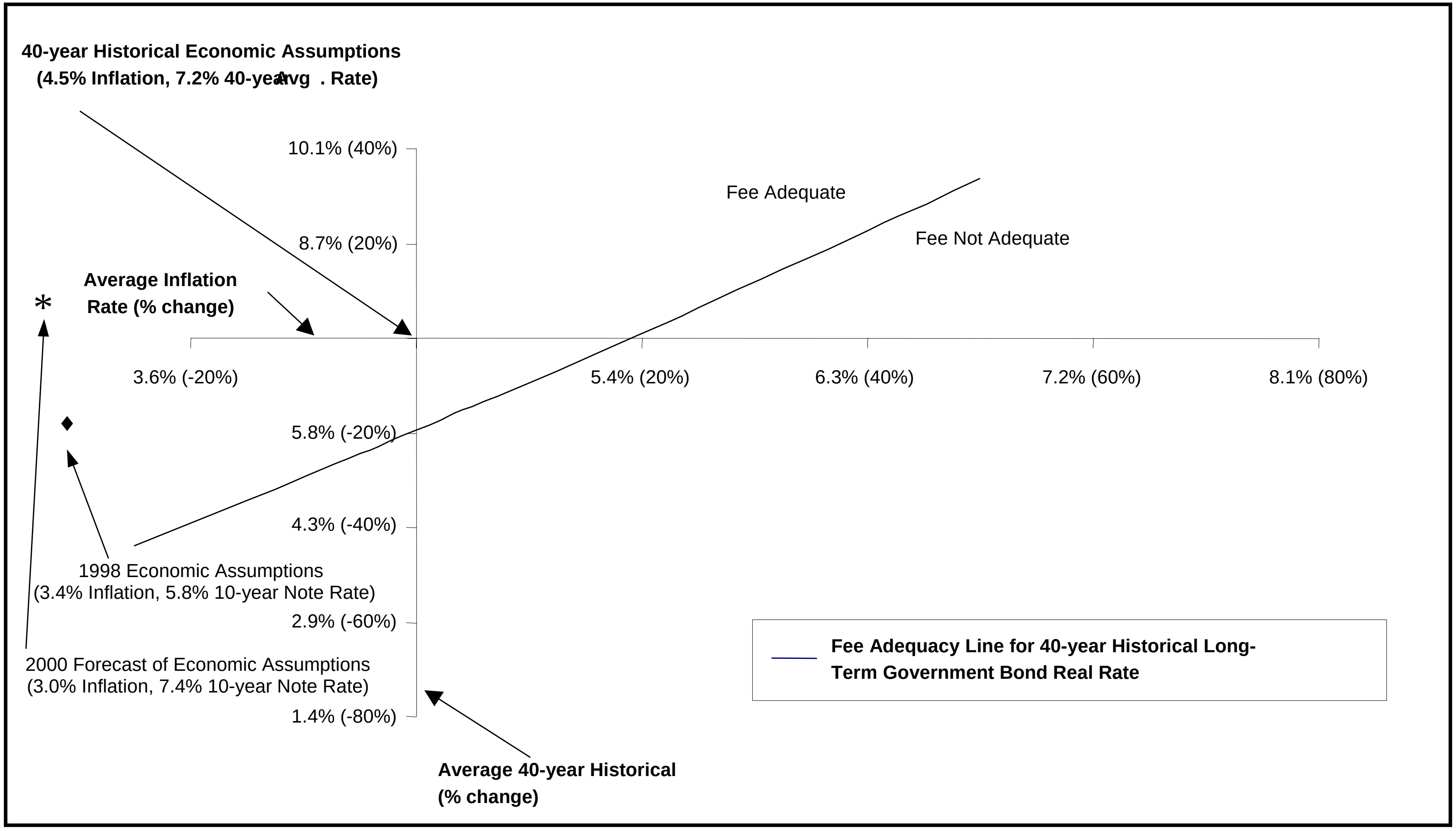
- **Nuclear Waste Policy Act (NWPA) mandates full cost recovery**
- **The TSLCC is an input to the Fee Adequacy Report that is required by law**
- **The adequacy of the current Nuclear Waste Fund (NWF) fee to meet the estimated TSLCC is determined for two sets of economic assumptions**
  - **Nominal 10-year U.S. Treasury Notes**
    7.38% Nominal Interest Rate
    3.03% Inflation Rate
    4.23% Real Interest Rate
  - **40-year Ibbotson Long Term Average**
    7.24% Nominal Interest Rate
    4.49% Inflation Rate
    2.63% Real Interest Rate

NWF Balance Calculation

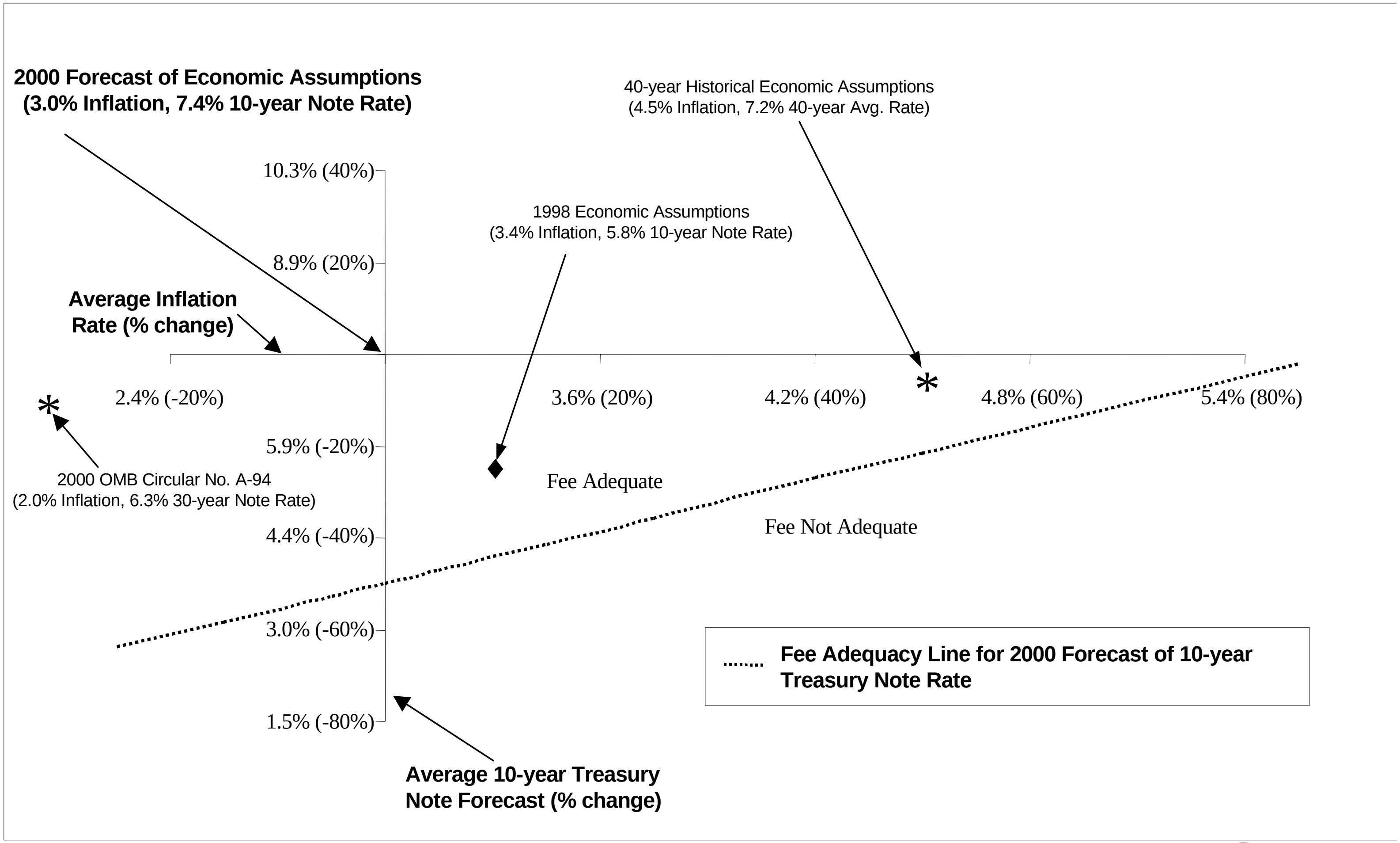
NWF Balance (current yr)=		NWF Balance (prior yr)
	-	Civilian Cost Share (current yr)
	+	Fee Payments (current yr)
	+	One-Time Fee Payments (current yr)
	+	Income from Investing (current yr)

- Fee Adequacy requires that the NWF balance at the end of emplacement be adequate to meet remainder of Program costs

Fee Adequacy Results/Sensitivities — Reference Case
(40-Year Historical Economic Assumptions)



Fee Adequacy Results/Sensitivities — Reference Case
(2000 Forecast of Economic Assumptions)



YUCCA MOUNTAIN PROJECT

Fee Adequacy Results for 2000 TSLCC

- **For both sets of economic assumptions, Fee Adequacy results show**
  - **A positive NWF balance at completion of emplacement**
  - **Target balances at completion of emplacement [i.e. net present value (NPV) of the remainder of program costs] are adequate**
- **Results show fee is adequate**

Flexible Operating Modes

- **The 2000 TSLCC included a qualitative evaluation of cost impacts for flexible (lower temperature) subsurface operating modes**
- **An additional parametric analysis is being performed to support the TSLCC on the cost impacts of lower temperature operating options**
  - **Seven lower temperature (<85°C) scenarios are being considered using the TSLCC waste inventory (97,400 MTHM)**
  - **These representative scenarios show the impacts of varying the basic design and operating parameters**

Flexible Operating Modes

- **Parameters that can be varied to achieve lower operating temperatures**
  - **Waste package spacing**
  - **Ventilation**
    - **Natural vs forced**
    - **Duration**
  - **Aging of SNF prior to emplacement**
  - **Drift spacing**
  - **Waste package size**
- **Varying these parameters to achieve lower temperatures will increase costs**

Seven Low Temperature Scenarios

- **Scenario 1 - Extended ventilation (50 years forced, 250 years natural), no aging, increased waste package (WP) spacing (1.8 meters)**
- **Scenario 2 - Extended ventilation (50 years forced, 250 years natural), no aging, smaller waste packages, reference WP spacing (0.1 meter)**
- **Scenario 3 - Extended ventilation (300 years forced ventilation), no aging, reference WP spacing, increased drift spacing (120 meters)**
- **Scenario 4 - Limited forced ventilation period (~100 years after last WP is emplaced), no aging, increased WP spacing (4.7 meters)**

Seven Low Temperature Scenarios
(Continued)

- **Scenario 5 - Limited forced ventilation period (~75 years after last WP is emplaced), aging of up to 40,000 MTHM of spent fuel, increased WP spacing (3.9 meters)**
- **Scenario 6 - Limited ventilation period (~55 years after last WP is emplaced), aging of up to 40,000 MTHM of spent fuel, increased WP spacing (4 meters)**
- **Scenario 7 - Extended ventilation (300 years forced ventilation), no aging, increased WP spacing (1.0 meter)**

Seven Low Temperature Scenarios

Parameter	Reference Design	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7
Number of WPs	14,769	14,769	~22,200	14,769	14,769	~14,700	~15,100	14,769
Average WP Spacing (m)	0.1	1.8	0.1	0.1	4.7	3.9	4.0	1.0
Surface Aging (years)	0	0	0	0	0	30	30	0
Emplacement Period (years)	31	31	31	31	31	71	61	31
Linear Thermal Loading at Emplacement (kw/meter)	1.45	1	1	1.45	0.7	0.5	0.6	1.13
WP Size	Reference	Reference	Small	Reference	Reference	Reference	Reference	Reference
Drift Center-to-Center Spacing (meters)	81	81	81	120	81	81	81	81
Years of Forced Ventilation after Emplacement	69	50	50	300	100	75	55	300
Years of Natural Ventilation after Force Ventilation Period is Complete	0	250	250	0	0	0	0	0
Percent of Characterized Subsurface Area Used	57	76	75	84	>100	99	100	67

= Parameters that differ from the TSLCC Reference Design

Low Temperature Scenarios — Preliminary Cost Results

Paramter	Reference Design	Scenario Number						
		1	2	3	4	5	6	7
CSNF Acceptance Through 2020 (MTHM)	25,200	25,200	25,200	25,200	25,200	25,200	25,200	25,200
Scenario End Year	2119	2349	2349	2349	2149	2155	2134	2349
Total Undiscounted Cost Through 2010 (B of 2000 $)	17.2	17.2	17.2	17.2	17.2	16.7	16.9	17.2
Total Undiscounted Cost (B of 2000 $)	57.5	64.4	67.5	71.8	64.4	72.4	69.2	71.5
Total Undiscounted Cost Through 2119 (B of 2000 $)	57.5	53.1	56.0	52.6	55.8	63.6	62.0	53.2
Total Undiscounted Cost 2120 Through End Year (B of 2000 $)	0.0	11.4	11.5	19.2	8.6	8.7	7.2	18.4
NPV of Costs 2120 Through End Year @ 1% (B of 2000 $)	0.0	2.6	2.6	6.1	7.0	6.8	6.6	5.5
NPV of Costs 2120 Through End Year @ 2% (B of 2000 $)	0.0	1.1	1.1	3.1	5.7	5.3	6.1	2.7
NPV of Costs 2120 Through End Year @ 3% (B of 2000 $)	0.0	0.7	0.7	2.1	4.7	4.2	5.6	1.8

Net Present Value Costs

- The NPV of evaluating a major project allows you to consider the "time value of money"
  - NPV helps you find the present value in "today's dollars" of the future net cash flow of a project
  - NPV is based on the concept that a dollar received today is worth more than a dollar received at some point in the future, because the dollar received today can be invested to earn interest
- For the lower temperature scenarios, the NPV is calculated at three different “real” future interest rates (to account for uncertainties)

Flexible Operating Modes Cost Analysis Conclusions

- **Lower temperature scenarios result in increased life cycle costs**
- **Factors that increase costs are**
  - **Increased drift space**
  - **Increased ventilation (volume and/or time)**
  - **Increased number of waste packages/drip shields**
  - **Increased emplacement period**
  - **Surface staging costs**

Flexible Operating Modes Cost Analysis Conclusions
(Continued)

- **Cost increases in NPV are smaller than increases in constant year dollars**
  - **Maximum increase = $ 14.7 billion (2000 $), but only $ 4.5 billion in NPV (scenario 5)**
  - **Due largely to additional costs occurring during monitoring period (e.g., ventilation), and deferral of large cost elements such as drip shields due to increased monitoring periods**

Fee Adequacy for Flexible Operating Modes

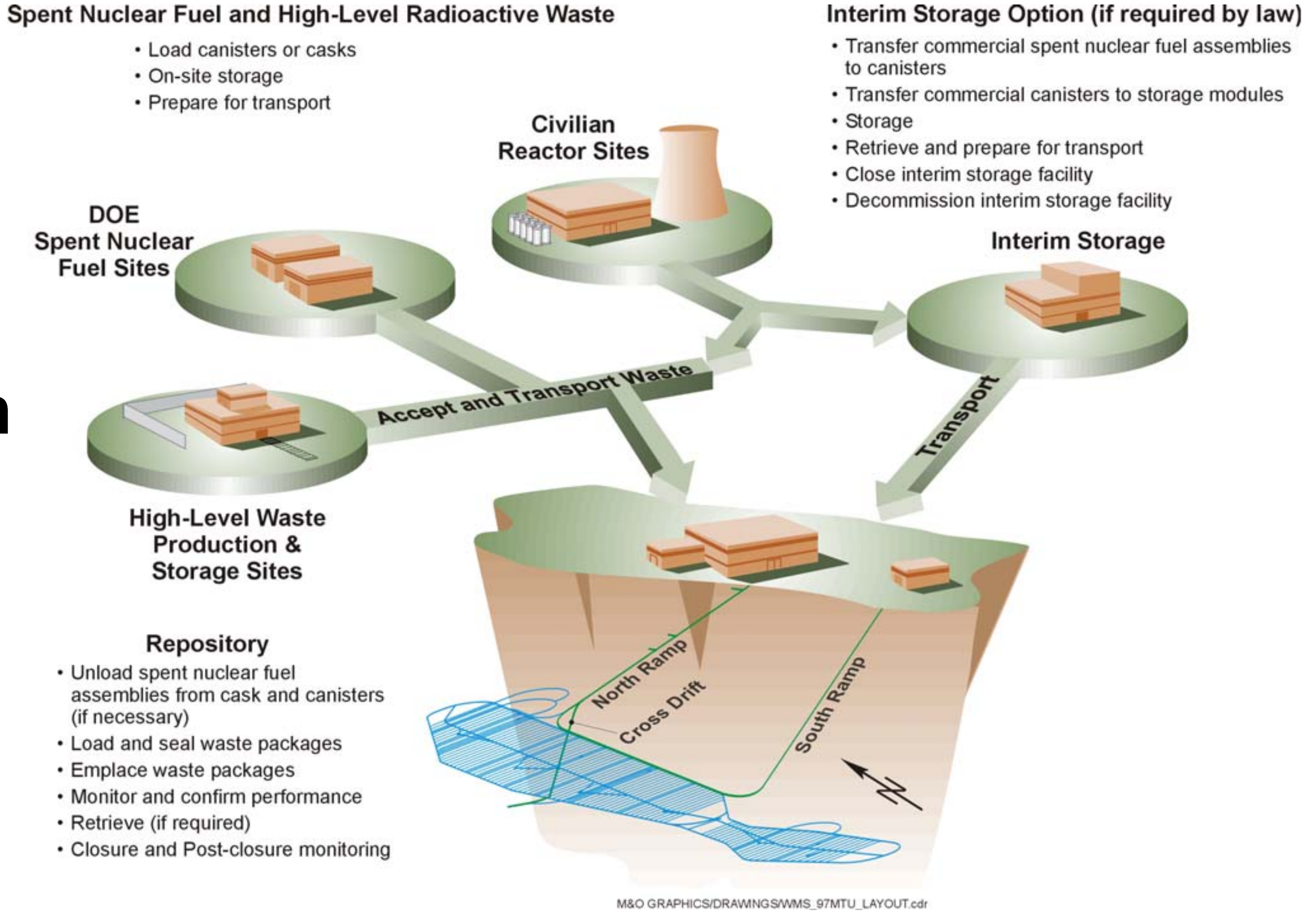
- A preliminary assessment for the seven low temperature scenarios using current methodology (10-year Treasury Bond interest rate) indicates that the fee is adequate for all scenarios
  - Fund balance at end of emplacement is reduced
- Fee Adequacy is sensitive to economic assumptions
  - Interest rates
  - Inflation
  - Possible future utility settlements and/or damages
  - Costs and timing of costs
  - Defense share costs (current model being reviewed)
- More work needed to further develop the Fee Adequacy methodology for flexible operating modes

CRWMS Modular Design/Construction and Operation Options Studies

- Series of studies issued 1998 - 2001 examined a modular approach supporting staged development
- Study objectives
  - Address ways to reduce peak construction costs
  - Investigate changes to system architecture, system operations, system requirements, or program implementation that would
    - Enhance the confidence of the CRWMS in meeting target schedules
    - Provide flexibility in accommodating different waste acceptance rates
    - Allow for the implementation of a small, inexpensive, initial acceptance and disposal capability
    - Supports operation over a range of thermal modes
    - Separate receipt rates from emplacement rates

System Architecture and Cost Drivers

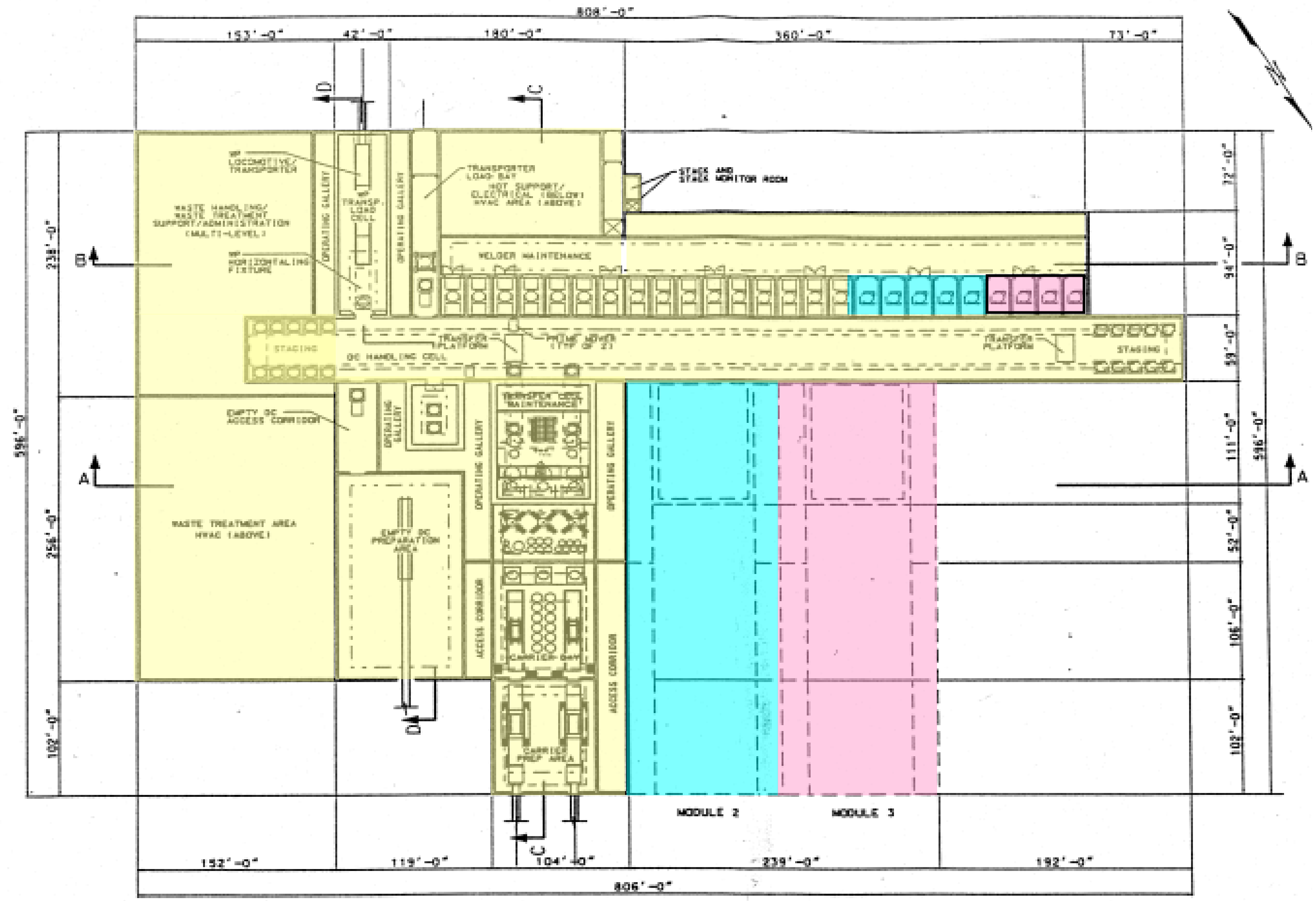
- Underground repository
- Surface facilities
- Nevada transportation mode
- Receipt, storage, and emplacement rates
- Infrastructure



CRWMS Modular Design/Construction and Operation Options Report

- The May 2001 modular study considered two basic approaches to increasing design and operations flexibility
  - Modular Dry Waste Handling Building with expandable surface storage
  - Modular subsurface construction
- Various design and operations scenarios were investigated, including:
  - Constrained funding
  - Early receipt
  - Flexible subsurface design (lower temperature operating modes)

Modular Dry Waste Handling Building



Module 1 Module 2 Module 3

Modular Study Key Conclusion/Findings

- **A modular design and implementation approach will address key programmatic and technical uncertainties faced by**
  - **Providing a significant reduction in peak costs to build/construct (reach initial operating capability)**
  - **Enhancing flexibility for**
    - **Blending/thermal management**
    - **Accommodating various thermal strategies (warm vs. cool vs. cooler)**
    - **Accommodating different utility fuel selections for delivery**
    - **Accommodating different fuel characteristics (burnup and enrichment) due to reactor license extensions**

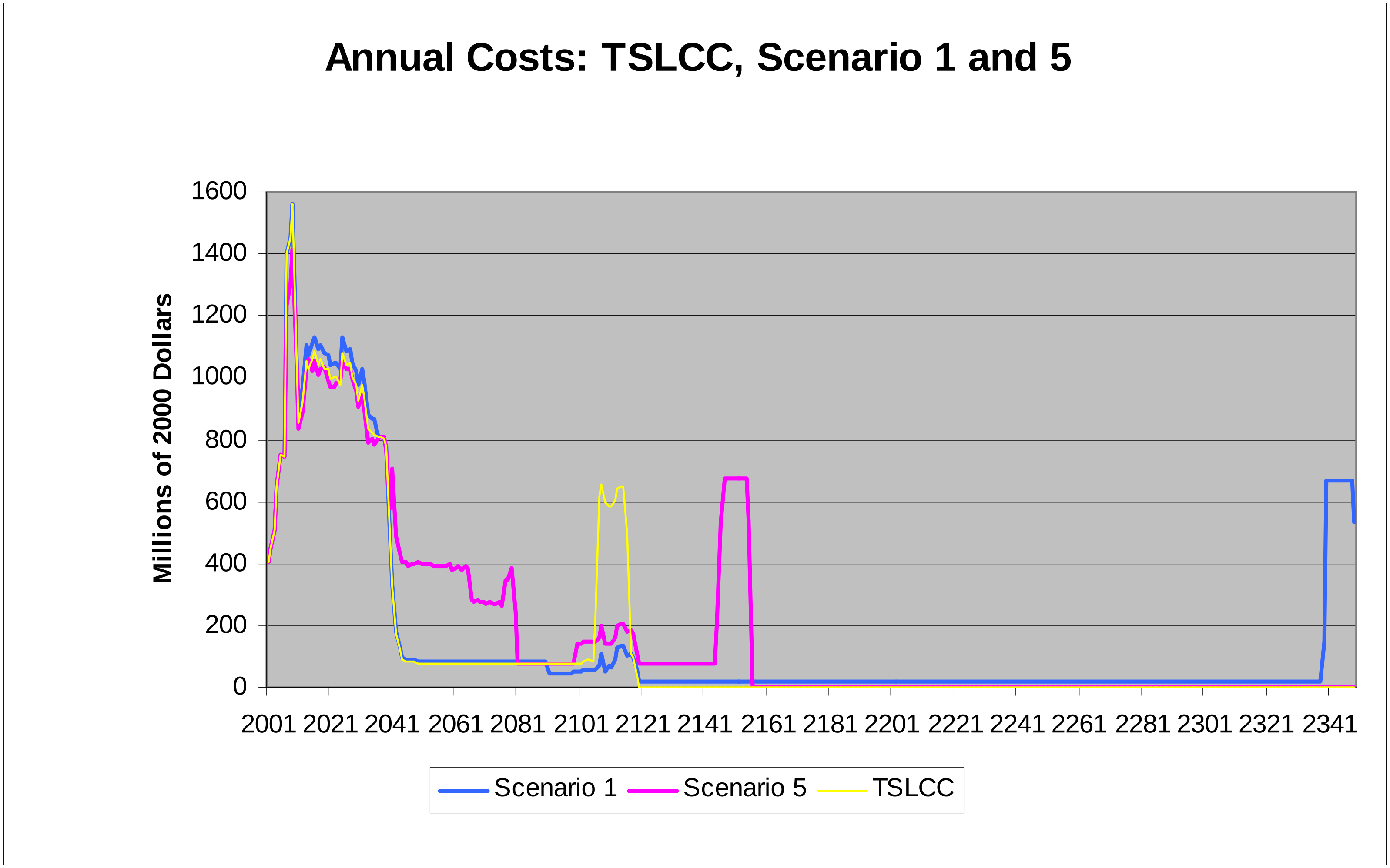
Modular Study Key Conclusion/Findings

(Continued)

- Providing significant schedule opportunities (increased confidence in meeting program commitments, opportunity for early performance)
- Significantly reducing sensitivity of program to uncertainties

Backup

Annual Cost Comparison of TSLCC with 2 Lower Temperature Scenarios



Lower Temperature Scenarios Cost Differentials from Reference Case

Cost Element	Billions of 2000 Dollars						
	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7
Design & Construction	0.0	0.0	0.0	0.0	-0.3	-0.3	0.0
Waste Packages	0.0	2.5	0.0	0.0	0.1	0.2	0.0
Storage Casks	0.0	0.0	0.0	0.0	1.2	2.0	0.0
Drift construction	1.2	1.2	0.0	2.9	2.5	2.5	0.7
Forced Ventilation	-0.2	-0.2	9.6	2.0	2.5	1.2	7.8
Waste Package Emplacement	0.0	0.2	0.0	0.0	0.0	0.0	0.0
Operating Cost During Emplacement	0.0	0.0	0.0	0.0	6.0	4.5	0.0
Operating Cost During Monitoring	1.7	1.9	1.7	0.2	0.0	-0.3	1.7
Drip Shields	1.3	1.4	0.0	1.3	1.3	1.3	0.8
PI&I, PETT, Benefits	3.0	3.0	3.0	0.4	1.6	0.6	3.0
Total Delta	**6.9**	**10.0**	**14.3**	**6.9**	**14.9**	**11.7**	**13.9**