

# Exelon's Critical Comparison of Two Source Term Reduction Methods at Byron and Braidwood

ISOE Symposium  
January 12-14, 2015  
Ft. Lauderdale, Florida

Barry Barton, RPM, Exelon Byron



# Braidwood-1,2 and Byron-1,2 Essentially Identical

- ❖ Westinghouse 4-Loop PWR
  - Unit 1 : 1190 MWe
  - Unit 2: 1156 Mwe
- ❖ Reactors on Two Sites
  - Byron-1 = Braidwood-1
  - Byron-2 = Braidwood-2
  - 4 Identical Designed Units
  - Unit 2' s have 600 TT SG



# Byron vs Braidwood

## Side by Side Test of Source Term Reduction Methods

---

- ❖ How Do Byron-1 and Braidwood-1 Compare?
- ❖ Essentially The Same
  - Design and Layout
    - All Equipment in Identical Location in Containment
  - Steam Generators
  - pH and Zinc Injection Programs
  - Fuel Duty and Core Design
  - CVCS Primary Resins for 8 years Prior to Change
  - Shutdown Sequence for 8 years Prior to Change
- ❖ Byron-1 has 1 operating cycle longer than Braidwood-1
- ❖ Excellent Similarities for Comparison

# Exelon Radiation Protection Benchmarking Identified Emerging Technology for Source Term Reduction

---

- ❖ Previous practice at both plants was use of macroporous resin overlay in shutdown demineralizers – previous 8 years
- ❖ Byron and Braidwood RP had identified PRC-01M resin technology that was showing positive benefits for source term reduction and dose control
  - Documented Significant and Sustained Reduction - Dose Rate Decline
  - Documented Significant and Sustained Reduction – Core Curie Release
- ❖ RP continued to follow industry data and continued to build the case for implementation of PRC-01M Technology

# “Vett or Compare ” the Different Methods and Technology

---

- ❖ Process Objective: Validate results and determine best approach to drive source term reduction to industry best
- ❖ Goal:
  - Determine “Best” process via results at Byron and Braidwood
  - Continue to drive for industry excellence and top quartile performance in CRE
  - Implement “Best” process at Exelon Fleet Wide
- ❖ “Vetting or Comparison” Process
  1. Braidwood-1,2: Implementation of the NPE Method and Technology in PRC Resin Media
  2. Byron-1,2: Exelon Standard Method and Ortho Macroporous Resin Technology
  3. Established a Critical Measurement Process
    - Established comparison duration to consist of 3 outages per unit
    - Shutdown template and process same for both plants and units
    - Careful comparison of exact base point survey data at both plants
    - Incorporated fleet procedure providing guidance of measurement methodology
    - Expanded reference point locations and required CZT Gamma Spectroscopy measurements
    - Conduct the vetting process sufficient in length to yield **Certainty** of solution

# Robust RP and Chemistry Data Collected

---

- ❖ RP Metrics: Crud Traps, Components, Pipe Runs
  - Base Point Data: 45 Measurement Locations
    - Instruments: Ion Chamber, GM to Compensated Ion Chamber
  - Electronic Dosimeters: Specific Locations
  - Containment Penetration Monitors
  - Plant Installed Process Radiation Monitoring
  - CZT Gamma Spectroscopy - Expanded Reference Locations
  - Standard Radiation Monitoring Points
  - Shutdown Protocols
- ❖ Expanded Chemistry Sampling to support decision
- ❖ All Data to Support Measuring the Rate of Change in Source Term from Refueling Outage to Next Refueling Outage

# Side by Side Comparison

## Byron-1 vs. Braidwood-1

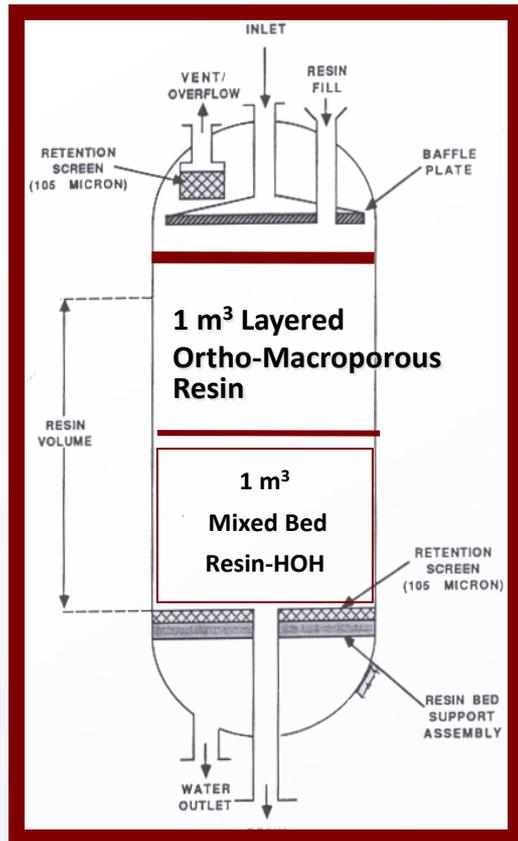
---

- ❖ Braidwood-1 followed 3rd Party Subject Matter Experts Specified Protocols for Rx Shutdown, Start-Up and Technology Utilization
  - Implementation performed by Chemistry, Outage Management and Operation Departments
  - Data collected by Radiation Protection on Dose Rates, Gamma Spectrums
- ❖ Only 2 Key Changes at Braidwood-1:
  - Different CVCS Clean-Up Resin, PRC-01M
  - Protocol Called for Adherence to EPRI Guidelines and RCP Run time to 0.7 uCi/cc goal prior to Last RCP stop
- ❖ Braidwood-1 Specific Changes:
  - CVCS Resin at Power and Shutdown, PRC-01M. Eliminated Layered Ortho-Macroporous
  - RCP Run time Post Forced Oxygenation from 4 hours to Running RCPs to Goal, 0.7 uCi/cc Co-58 in RCS
  - Increased RCS Filter Size from 0.1 micron to 0.45 micron for shutdown

# One to One In Plant CVCS System Comparison

## Existing Plant Systems PWRs: CVCS, SFP

- ❖ PWR: PRC-01M (bead)
- ❖ Technology Exclusively Licensed from Los Alamos National Laboratory
- ❖ Existing Plant Equipment, CVCS Demineralizer Vessel

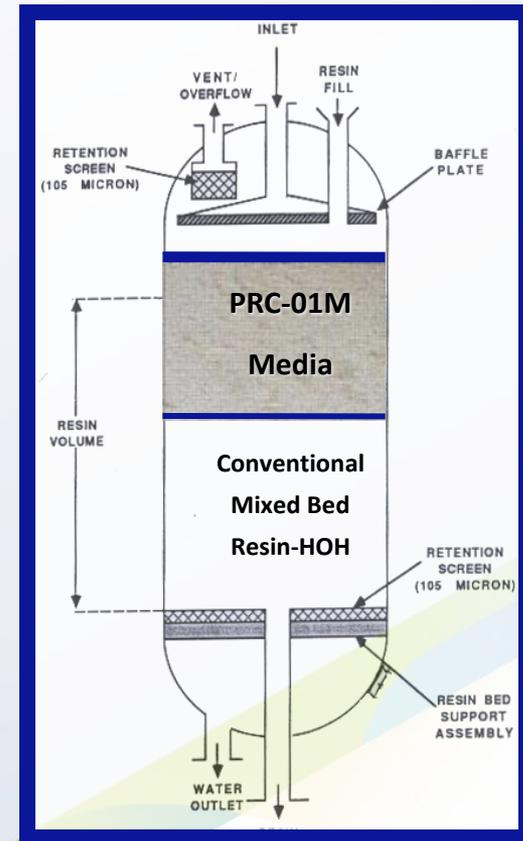


Old Resin: 2006 to 2014  
Byron-1,2

Byron-1,2  
Macroporous  
Resin  
CVCS & SFP



Braidwood-1,2  
PRC-01M  
Resin in  
CVCS & SFP



New Resin: 2010 to 2014 Braidwood- 1,2

# What Was the Difference in Performance?

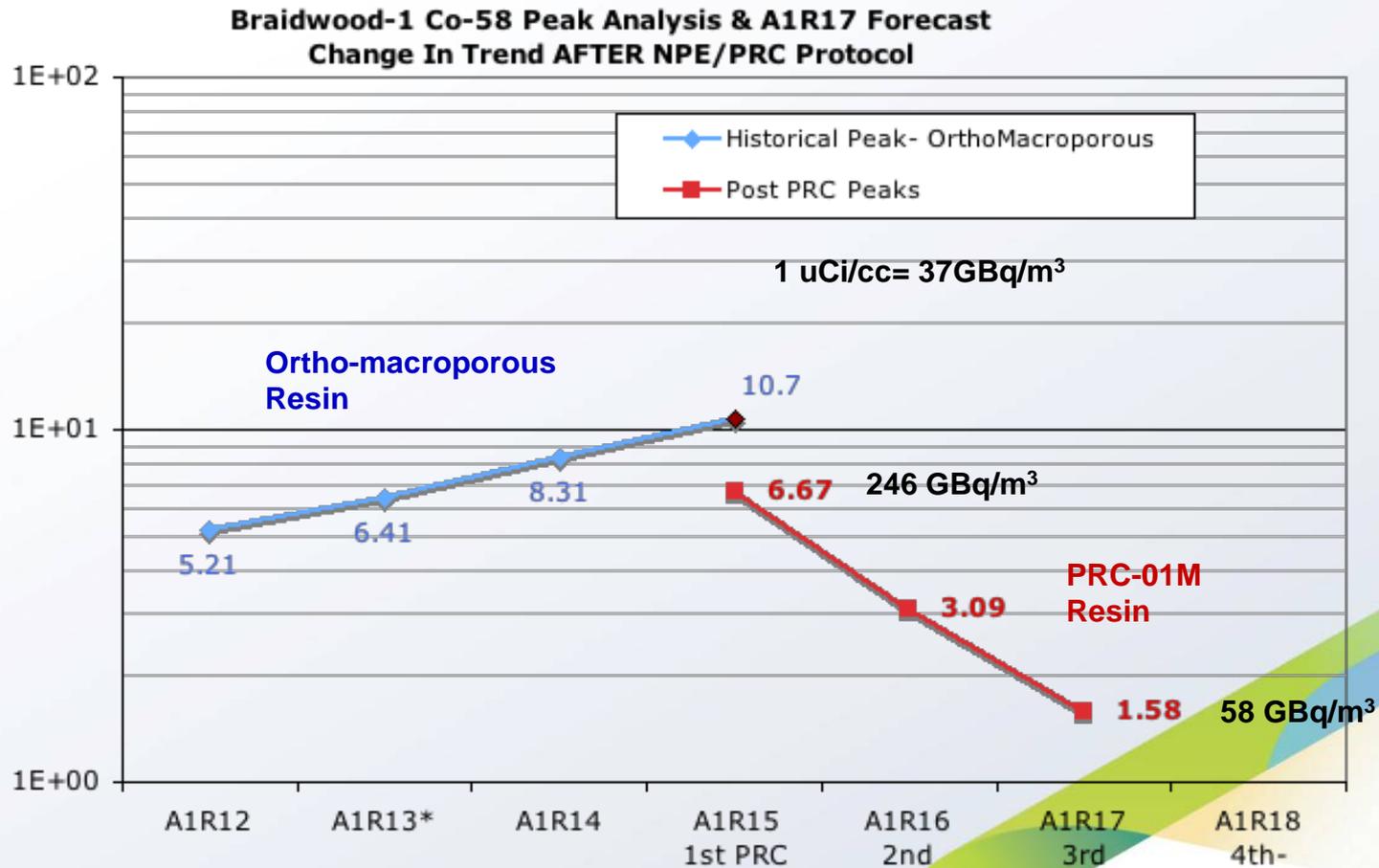
---

- ❖ One to One Comparison Byron-1 and Braidwood-1 Completed
- ❖ Comparison Process Established and Strictly Followed
  - Results Separated Performance between Byron-1 and Braidwood-1
  - Braidwood-1 out performed Byron-1 in Rate of Change of Source Term
- ❖ Data Clearly Identifies the Braidwood-1 Method of PRC-01M/Protocol Produced a Rapid Change in Source Term
  - Not Attributed to Zinc, as Other Stations Not Using Zinc See The Similar Rates of Decline Using PRC-01M.
  - Cannot be Attributed to Differences in Design or Operation
    - Both Units follow EPRI Guidelines
    - Both Units follow Shutdown and Start-up Protocols that are almost identical
      - o Except RCP run to 0.7 uCi/cc being different, but not in control of achieving 87% overall decline in dose rates

# Results: Braidwood-1

## Reversal of Trend for Peak Co-58

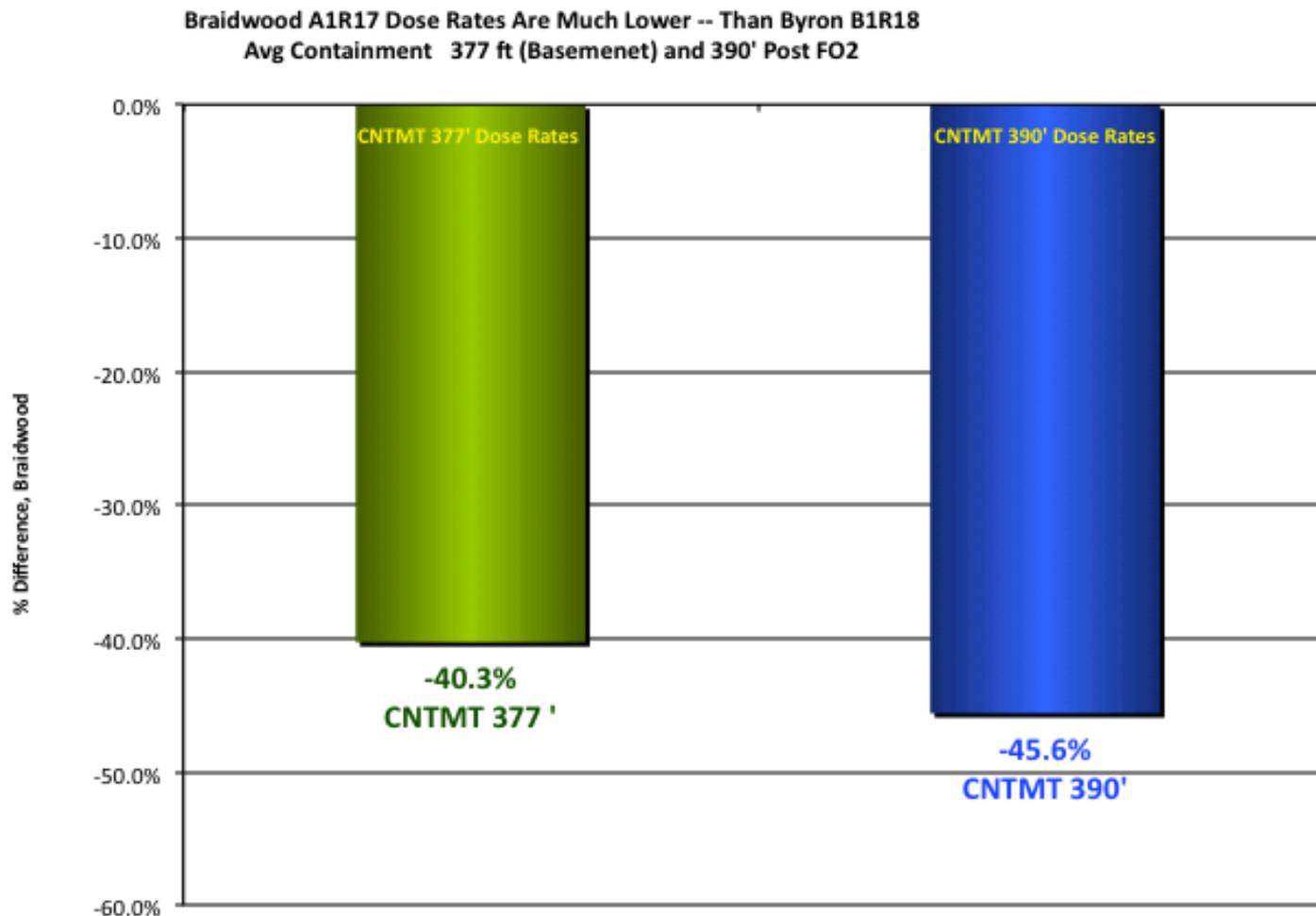
- ❖ Degrading Trend of Core Curie Release
- ❖ Reversed Trend of Core Curie Release- Declined by 3 X from A1R15 to A1R17



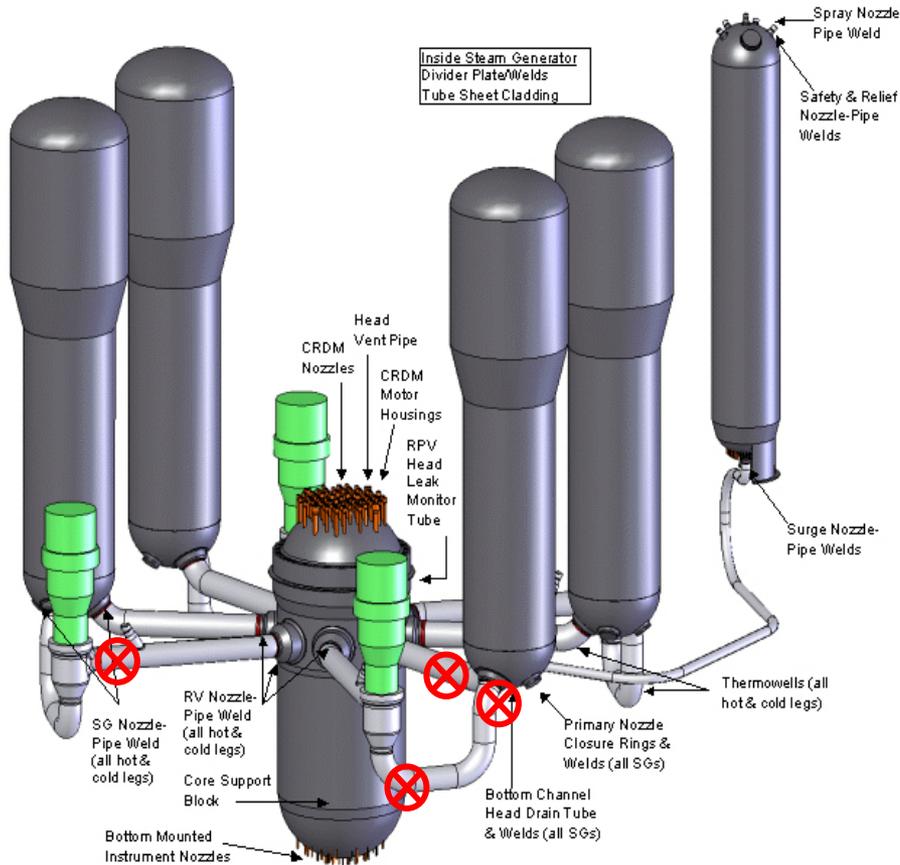
# Byron-1 B1R18 vs Braidwood-1 A1R17

## Dose Rates -44 to -45% Lower Than B1R18

Two lower levels of containment



# Braidwood-A1R17 Vs. Byron-B1R18



## ❖ Braidwood-1 A1R17 (PRC-01M Integrated)

- RFO: 21 days 18 hours
- Planned: 49 REM
- Challenge Goal: 42 REM
- **Actual: 25.352 REM**
- PCE's: 5

## ❖ Byron-1 B1R18 (Layered Ortho-Macroporous)

- RFO: 27 days, 23 hours
- Planned: 66 REM
- Challenge Goal: 49.9 REM
- **Actual: 50.735 REM**
- PCE's: 10

# Exelon Sr. Executives: Expanded Fleet Deployment Based on Comparison Results Byron-1 B1R19 March 2014



This page contains information confidential and proprietary to Exelon Corporation, LLC. It may not be reproduced, used for any other purposes, or given to a third party without the prior written consent of Exelon.

# Byron-1 B1R19

---

## ❖ Modified Protocol for Shutdown

- Ensure Early Acid Reducing Achieved
- Ensure PRC-01M Technology In-Service and Fully Enables
- Ensure Outage Schedule can be maintained by Managing H<sub>2</sub> Gas Inventory
- Turned Zinc Off to Mitigate Particle Formation and Transport into Crud Traps

## ❖ Shutdown Timeline Accomplished:

- +5.75 Hours Cooldown to < 200 F
- +13 hrs Pressurize Solid
- +19 hrs Forced Oxygenation with Peroxide Injection
- +48 hrs Reached 0.05 uCi/cc BYRON BEST
- RCS Activity Prior to Flood Up : 8.87 E-4 uCi/cs BYRON BEST

# Byron-1 B1R19 Refueling Outage, March 2014

---

- ❖ 1<sup>st</sup> PRC-01M Integration
- ❖ 18 days Refueling Outage
- ❖ Scope:
  - Routine Refueling Outage with Normal Scope Maintenance
    - High Duty Core
  - Significant valve scope
    - > 110 Valves
- ❖ Outage Collective Radiation Exposure Goals
  - 54.4 REM Planned CRE Based on B1R18 Source Term and Dose Rates
  - 49 REM Stretch Goal

# Byron-1 Refueling B1R19

## Shutdown Core Release and RCS Purification

---

### ❖ Shutdown RCS Results

Byron B1R19 Shutdown	RCS Activity [uCi/cc]
Actual: Peak Co-58	0.66(*)
Goal: Last RCP Stop	0.5
Goal: Prior to Flood Up	0.05
Actual: RCS at Flood Up	1.47E-03

(\*) Unit lowest RCS peak

# Byron-1 B1R19 Refueling Outage, March 2014

---

## ❖ Actual Final

- 22.1 REM

**BYRON BEST**

## ❖ Improvement

- **-47.9% Decline over previous RFO**
  - Dose Rates Reduced RCS, CVCS and RHR

## ❖ Personnel Contaminations:

- Goal: < 10
- Actual: 3

**BYRON BEST**

# Byron-1 B1R19 (1<sup>st</sup> PRC-01M RFO)

---

- ❖ Final Cavity Decontamination
  - Reduced Critical Path 4-hours, ~ \$200,000 value
- ❖ High Radiation Areas Down Posted Due to Lower Dose Rates
  - Residual Heat Removal Pump Rooms
  - Residual Heat Removal Heat Exchanger Rooms
  - Containment Penetrations
  - Auxiliary Building Penetrations
  - Containment Spray (ECCS) Pump Rooms
  - CV System valve aisles
- ❖ Released Many Areas From Contaminated Area
- ❖ Reduced Generation of Dry Active Waste
- ❖ Reduced Personnel Contamination Clothing Use

# Byron-2 Refueling B2R18

## Shutdown Core Release and RCS Purification

---

### ❖ Shutdown RCS Results

Byron B2R18 Shutdown	RCS Activity [uCi/cc]
Actual: Peak Co-58	2.09
Goal: Last RCP Stop	0.5
Goal: Prior to Flood Up	0.05
Actual: RCS at Flood Up	8.9E-03

# Byron-2 B2R18 Refueling Outage, Oct 2014

---

## ❖ Actual Final

- 52.6 REM

11.1 REM

41.5 REM

## Total Outage Dose

(Incl. Rx Head Repair and Full Scope Primary / Sec. PM's)

Rx Head Repair

**UNIT BEST (excl. head repair)**

## ❖ Improvement

- **Up to 25% Decline Over Previous RFO**
  - Dose Rates Reduced RCS, CVCS and RHR

## ❖ Personnel Contaminations:

- Goal: < 10
- Actual: 1

**BYRON BEST**

# Byron-2 B2R18 (1<sup>st</sup> PRC-01M RFO)

---

- ❖ Final Cavity Decontamination
  - Reduced Critical Path Time Based on U-1 Performance - Achieved
- ❖ High Radiation Areas Down Posted Due to Lower Dose Rates
  - Residual Heat Removal Pump Rooms
  - Residual Heat Removal Heat Exchanger Rooms
  - Containment Penetrations
  - Auxiliary Building Penetrations
  - Containment Spray (ECCS) Pump Rooms
  - CV System valve aisles
- ❖ Released Many Areas From Contaminated Area
- ❖ Reduced Generation of Dry Active Waste
- ❖ Reduced Personnel Contamination Clothing Use

# Impact and Value for Byron and Braidwood Far Reaching in O&M Costs and Dose Savings

---

- ❖ Dose Rate Decline Enables Outage Performance Improvement
  - Decline in Number of Locked High Radiation Areas(LHRA)
  - Reduced Number of HRAs to Radiation Areas
  - Worker Efficiency Gained
- ❖ Critical Path Reduced
  - Worker Efficiency Gain
  - Final Cavity Decon Time, Reduced 4 Critical Path Hours, \$200K
- ❖ “Cleaner” Core
  - Lower Peak Activity, Less Time to Clean-Up and Lower Containment Dose Rates During Peroxide Injection
  - Reduced Crud Related Fuel Risks, Axial Off-Set, Crud Induced Failures
- ❖ Fuel Cleaning No Longer Needed
  - Not Required, No CRUD to Clean
  - Cancel Capital Costs: \$2.7 M for Fuel Cleaning Equipment
  - No Service: \$80K/ RFO
- ❖ Rad Waste Costs:
  - Impact of Waste Storage/Disposal
  - Less Curie Surcharge
  - Future Class A Resins, Saving ~\$600K/ shipment

# Conclusion

---

- ❖ Exelon Innovative Method of Vetting Technology Between Sister Units
  - Determined Best Technology to Drive World Class Performance in CRE
  - Eliminated Controversy and Unknowns with Careful Comparison
  - Provided a Solution and Process to Drive Top Quartile CRE Performance
- ❖ Excellent Performance in Dose as a Result of the Change Process
- ❖ Exelon Corporate Executives Expanded Best Technology Use to Fleet
  - Three Mile Island - Unit 1
  - Byron-Units1&2
  - Braidwood-Units1&2
- ❖ Exelon is Determined to Lead World Nuclear Industry in Collective Radiation Exposure

**"Good ideas are not adopted automatically.  
They must be driven into  
practice with courageous patience. "  
----- Admiral H. Rickover, US Navy**



**Thank You!**

