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Industry Update on PWR RCS Zinc Addition

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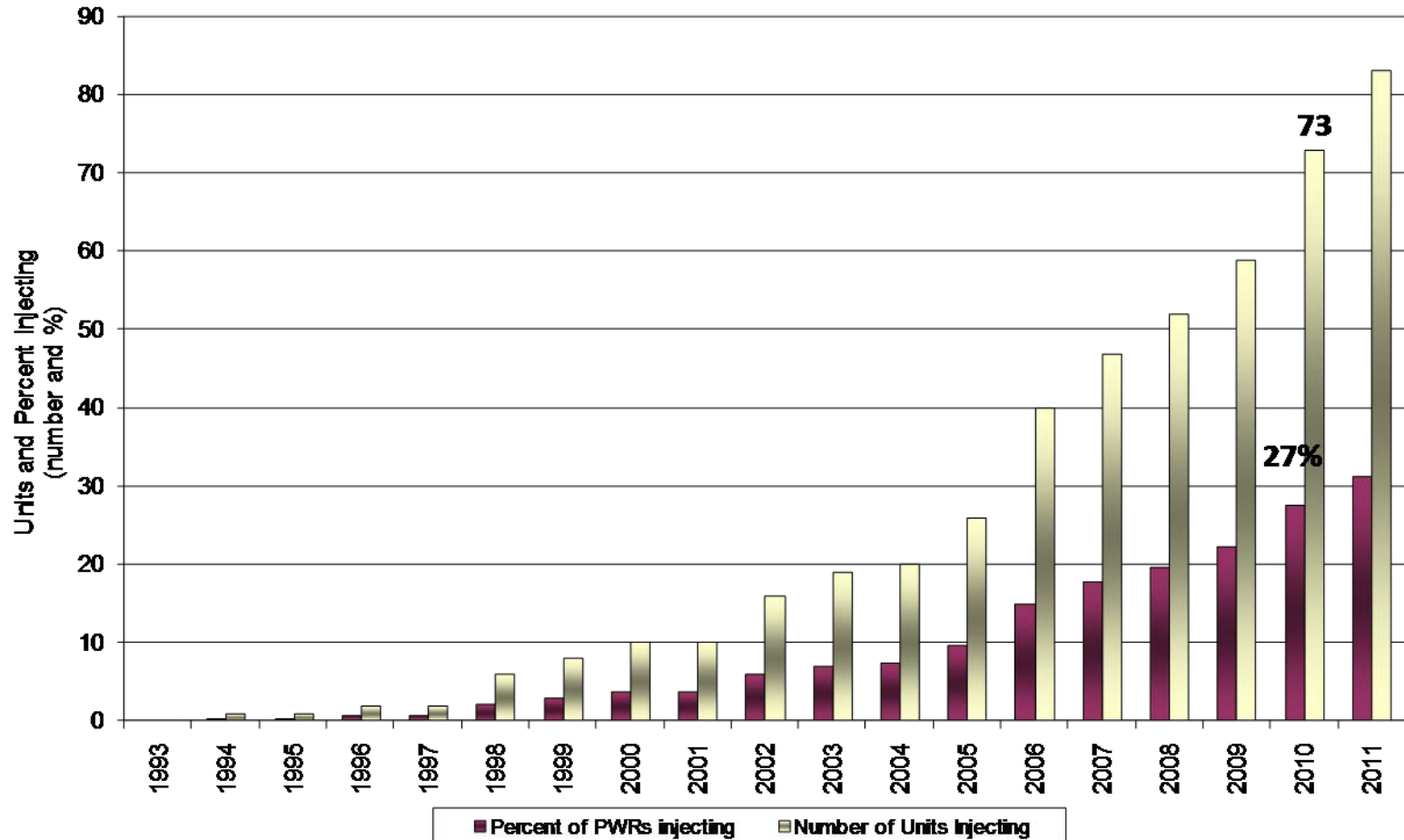
Overview

- Industry Update
- Impact on Operating and Shutdown Chemistry
- Impact on Fuel Performance and Integrity
- Impact and Trends on Doserates

PWR Zinc Addition Industry Update

PWR Zinc Addition Worldwide

Worldwide PWR Zinc Injection
Actual and Projected



PWR Zinc Addition

Drivers

- Reported Goals and Drivers for PWR Zinc Addition
 1. Dose Rate Reduction
 2. Primary Water Stress Corrosion Cracking
 3. Crud Mitigation
 - a. Reduce corrosion rate
 - b. Reduce corrosion release rate

PWR Zinc Addition

Program Trends

- Gradual change in program strategies
 - All high target RCS zinc programs (30-40 ppb) transitioned to lower targets
 - “Natural” zinc plants transitioning to depleted zinc
 - Initial injection delayed until later in the cycle

Operating and Shutdown Chemistry

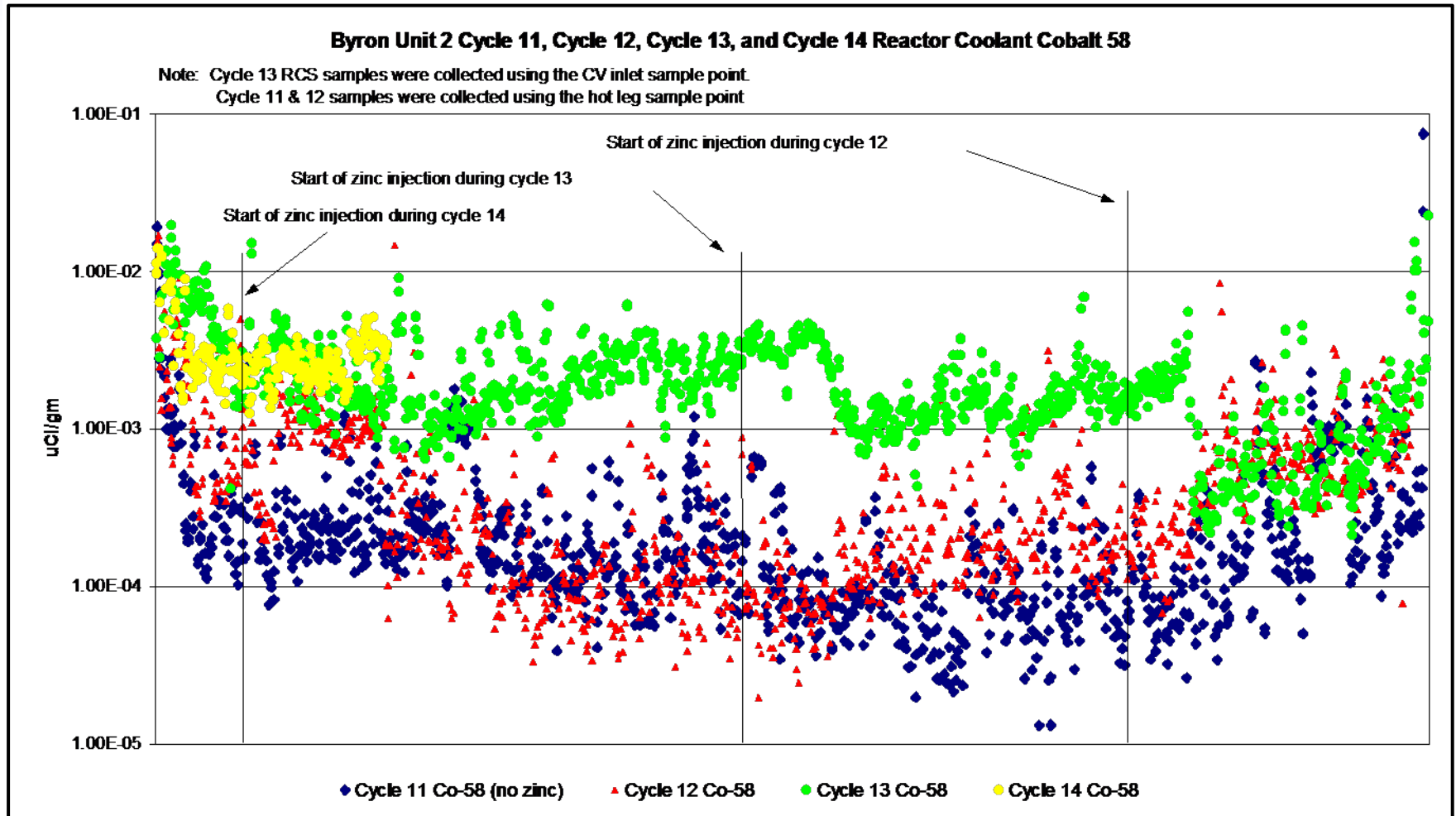
PWR Zinc Addition

Impact on Operating Chemistry

- Radiocobalts
 - RCS radiocobalt increases *do not* occur at all plants
 - Unable to determine leading indicator for radiocobalt response
- Nickel
 - Limited pre-zinc data
 - No statistically significant Ni response identified for all plants evaluated
- Iron
 - Limited iron data
 - Unable to assess

Byron Unit 2

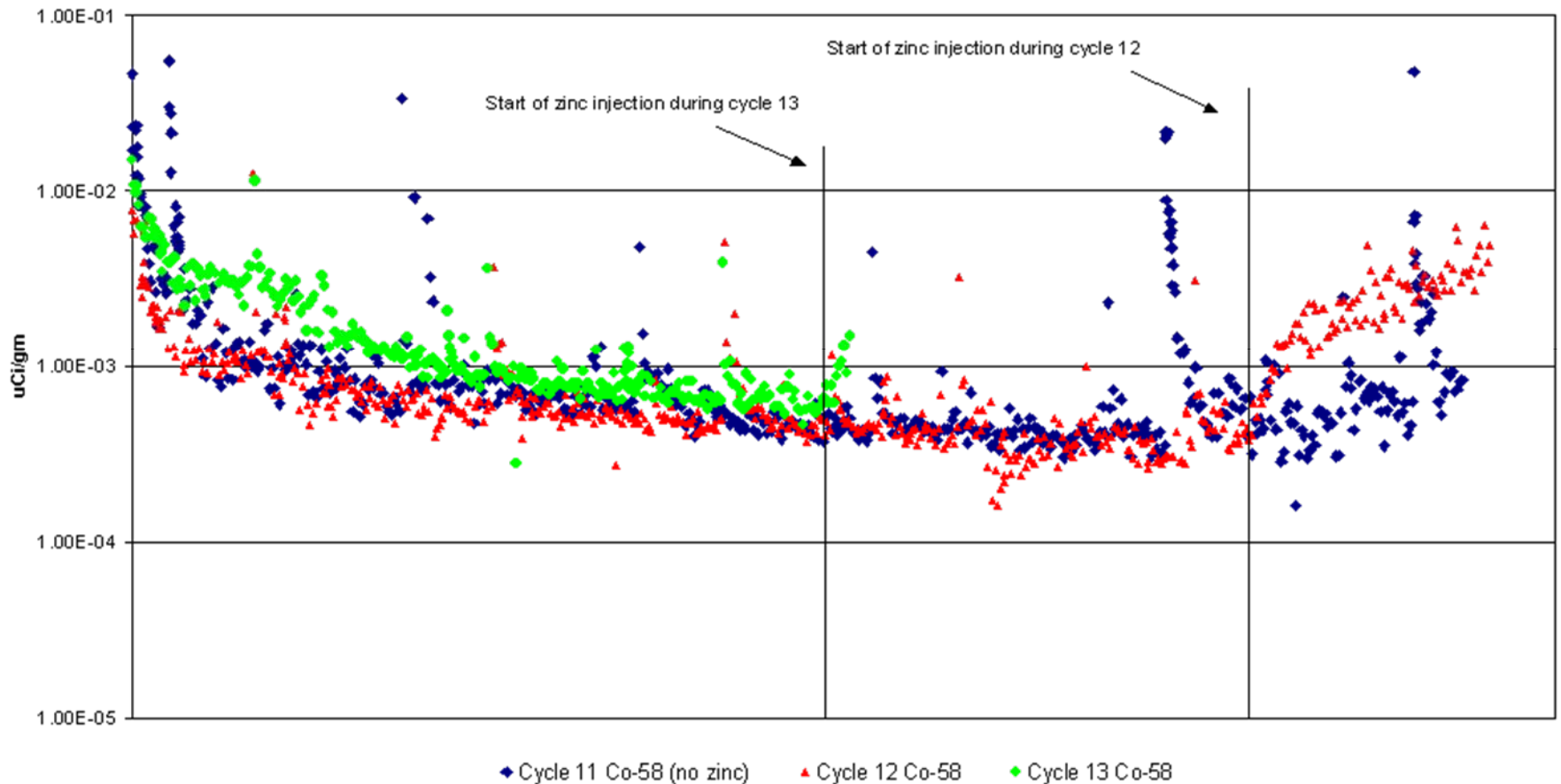
⁵⁸Co Response to Zinc Addition



Braidwood Unit 2

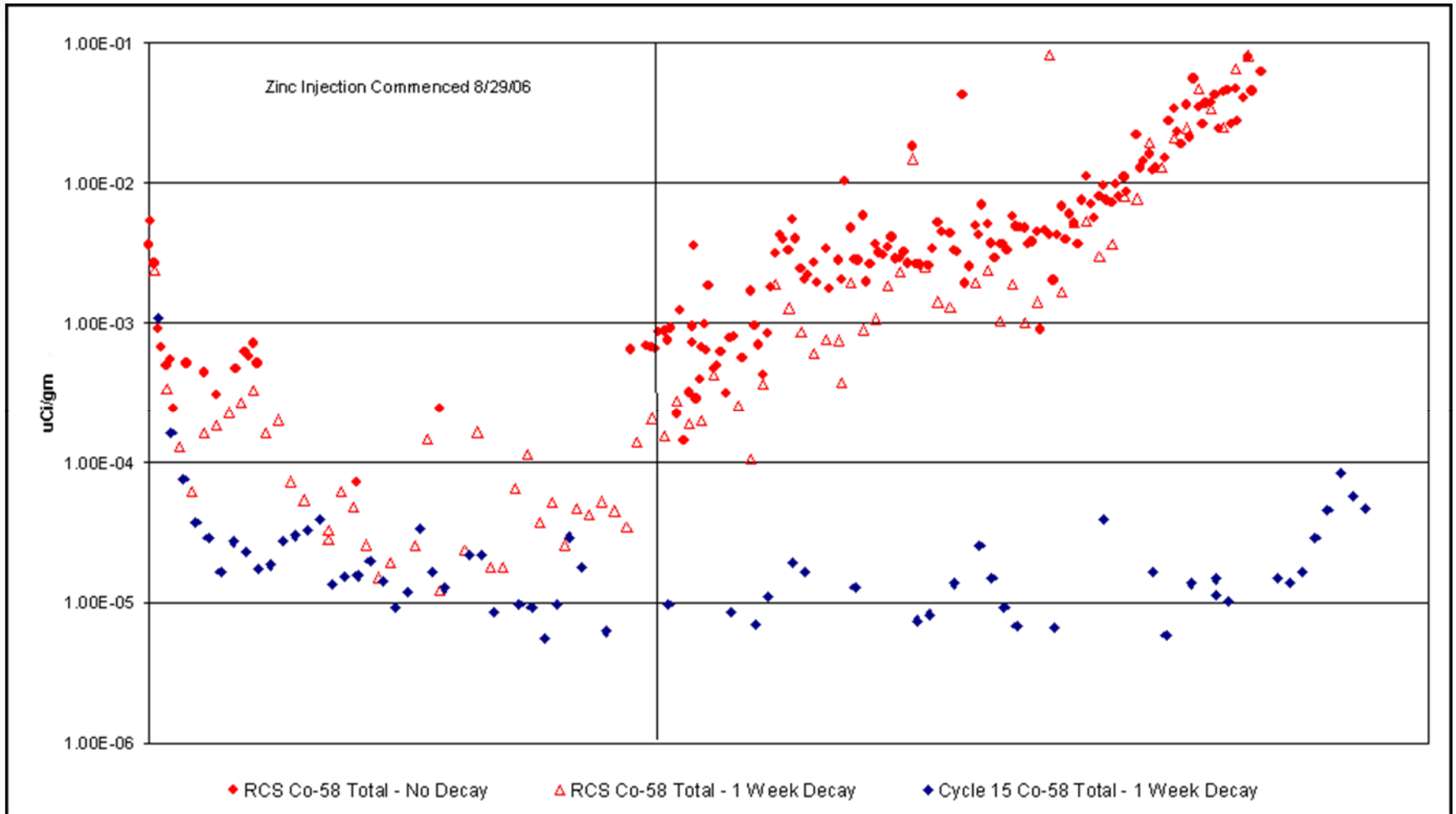
⁵⁸Co Response to Zinc Addition

Braidwood Unit 2 Cycle 11, Cycle 12, and Cycle 13 Reactor Coolant Cobalt 58



Three Mile Island Unit 1

⁵⁸Co Response to Zinc Addition



PWR Zinc Addition

Impact on Shutdown Releases

- Radiocobalts
 - RCS radiocobalt increases *do not* occur at all plants
 - No clear trend in shutdown releases
- Nickel
 - No changes in shutdown release trends
- Iron
 - Insufficient data to assess

Fuel Performance and Integrity

EPRI Fuel Reliability Program

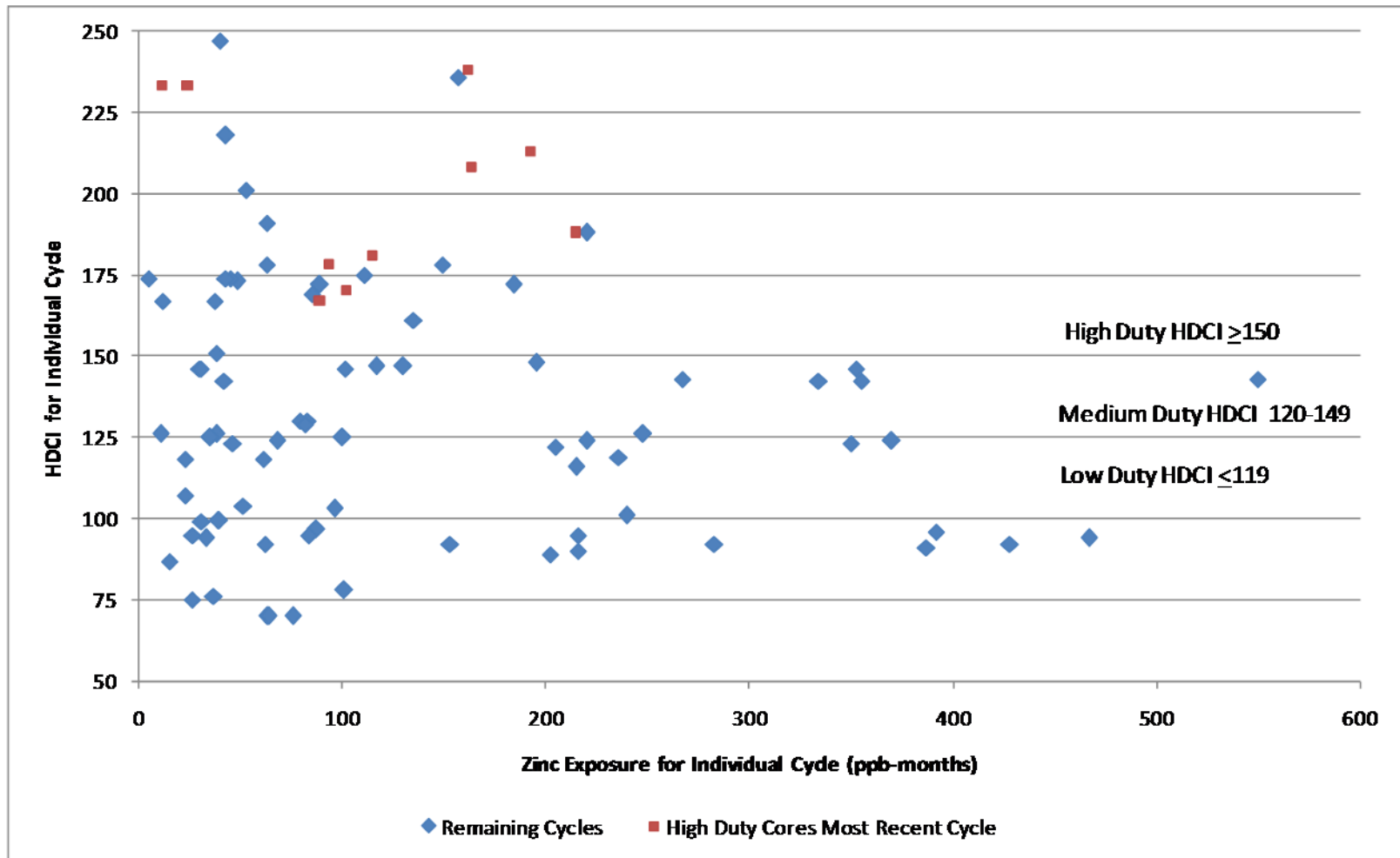
Program Results to Date

- Zinc has **not** caused an increase in **fuel cladding corrosion** at any of the FRP-sponsored surveillances or other reported campaigns
- **No abnormal buildup** of crud has been observed
- **No fuel performance issues** (i.e. AOA) have been reported that were linked directly to zinc injection.
 - Three PWRs have reported AOA during a zinc cycle
 - These units had experienced AOA in previous cycles. A root cause investigation at one unit suggested a number of factors, including zinc addition, could have contributed to the AOA and none of the factors could be ruled out or considered the principal factor.

PWR Zinc Addition Experience Base

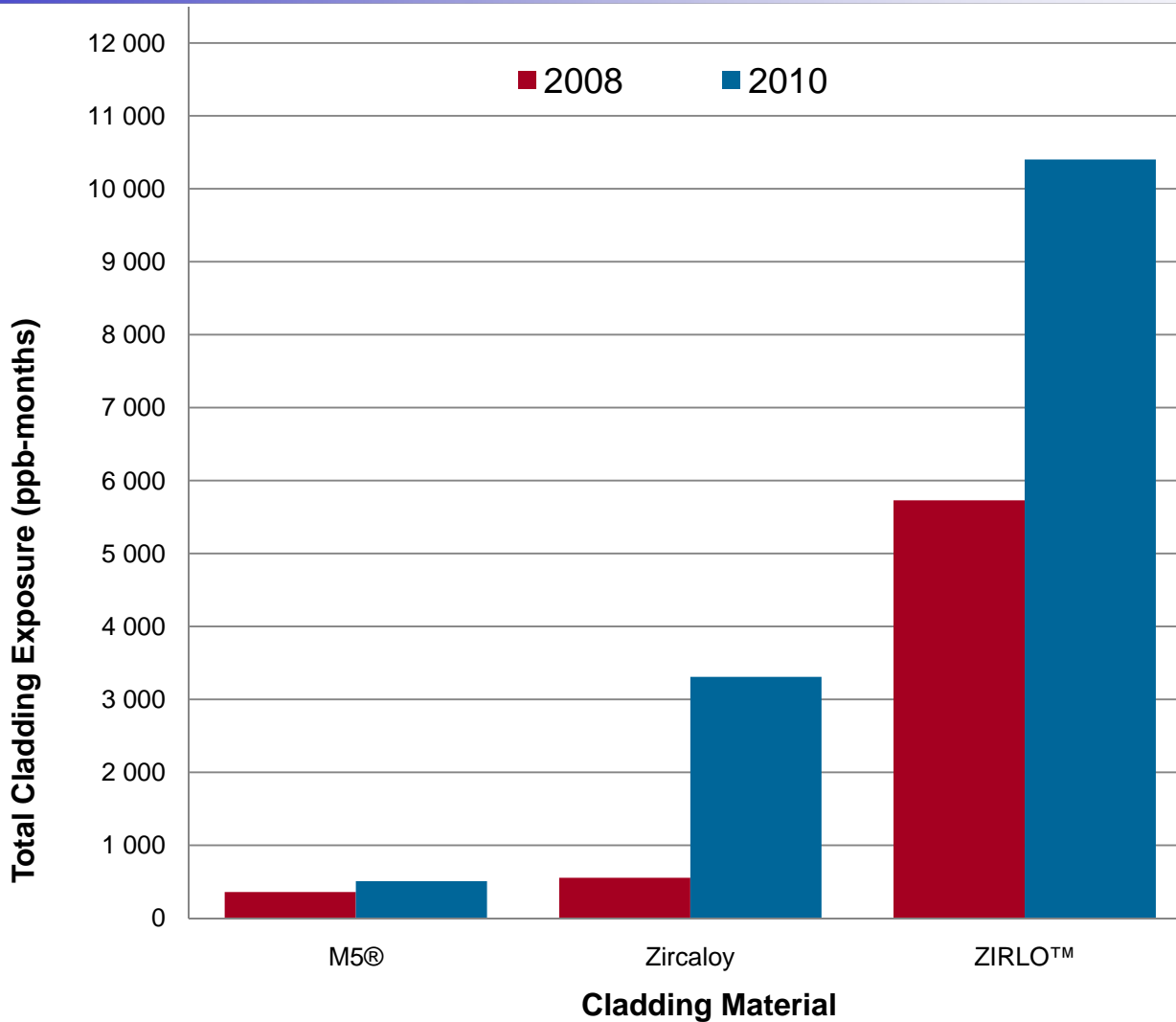
Fuels

Increasing Zinc Exposure for High Duty Cores



PWR Zinc Addition Experience Base

Fuels



Impact on Doserates

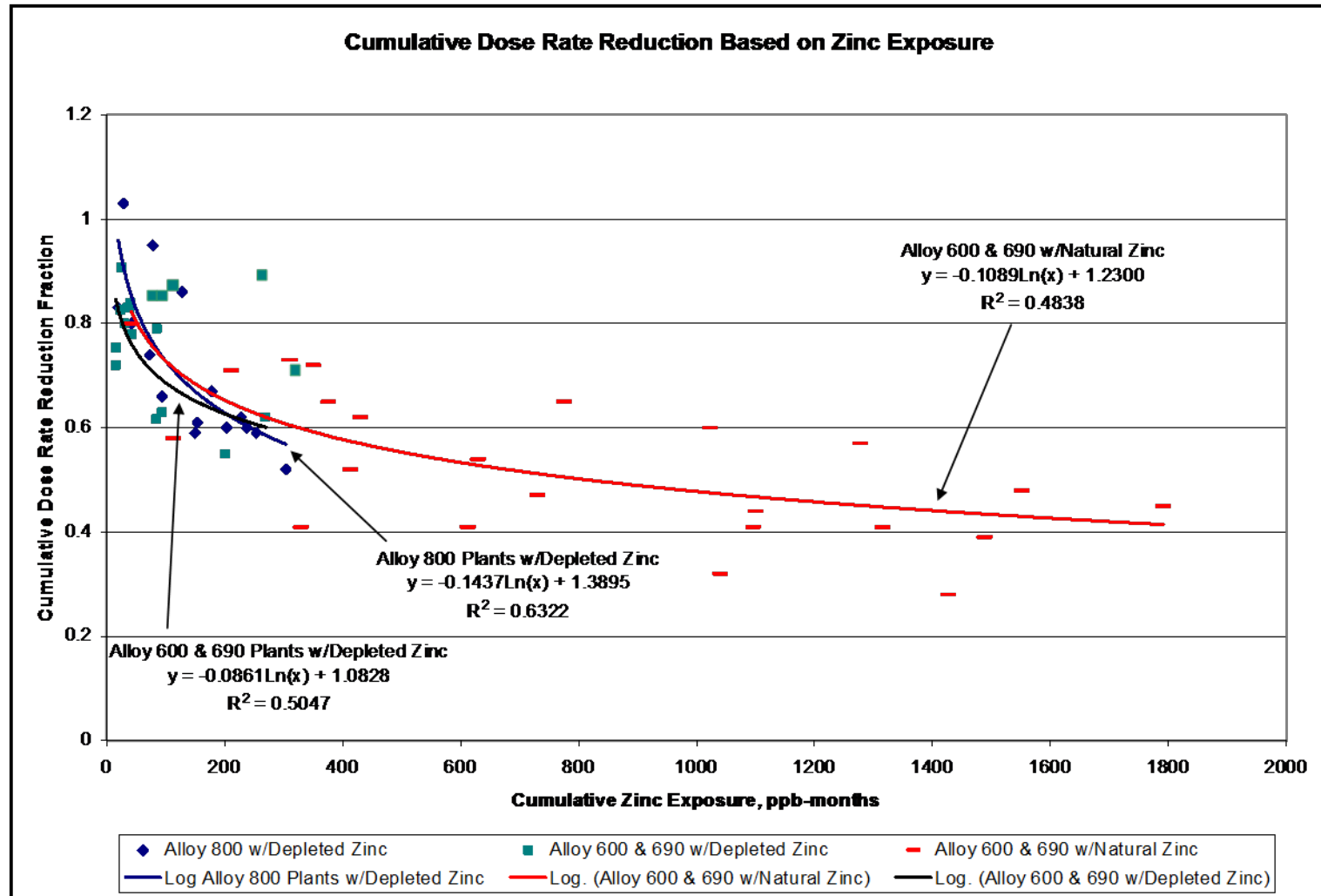
PWR Zinc Addition

Dose Rate Reduction

- Plants injecting zinc see dose rate reduction benefits
 - Reductions as high as 75% reported after long term injection
- Low target zinc concentration programs provide significant long term dose rate and PWSCC benefits
- Predicting short term dose rate benefits challenging

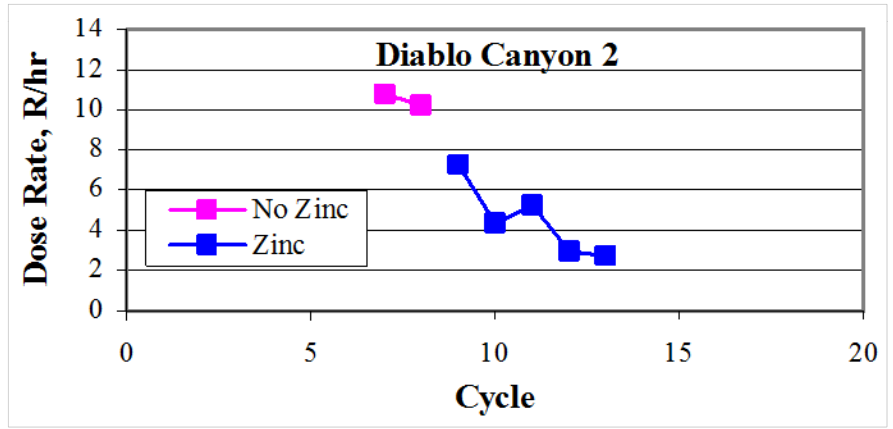
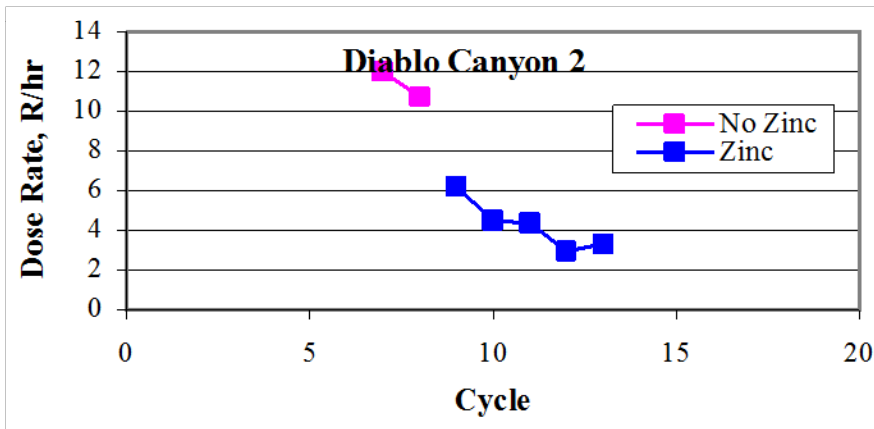
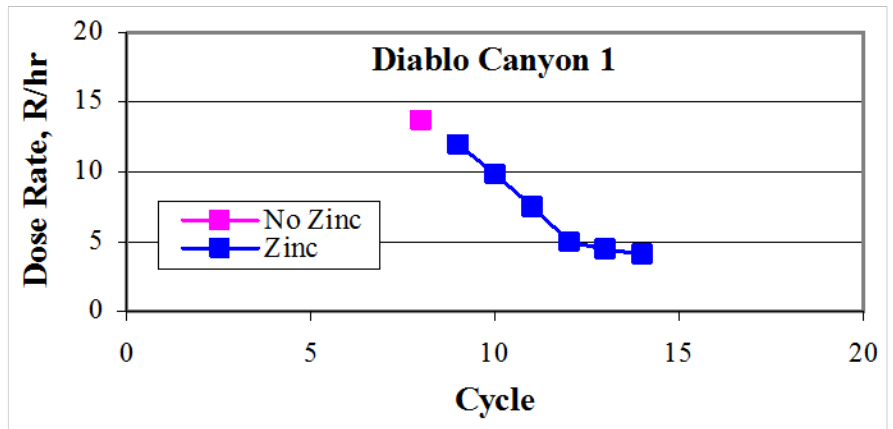
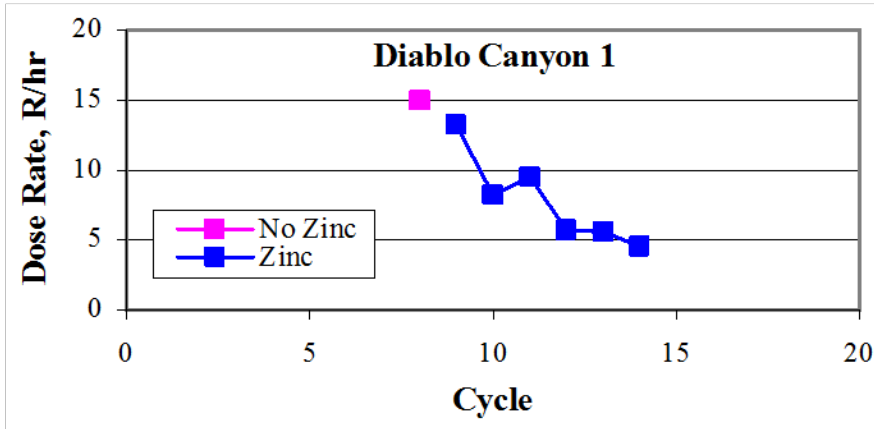
PWR Zinc Addition

Dose Rate Reduction Correlations



Diablo Canyon Units 1 and 2

Channel Head Dose Trends



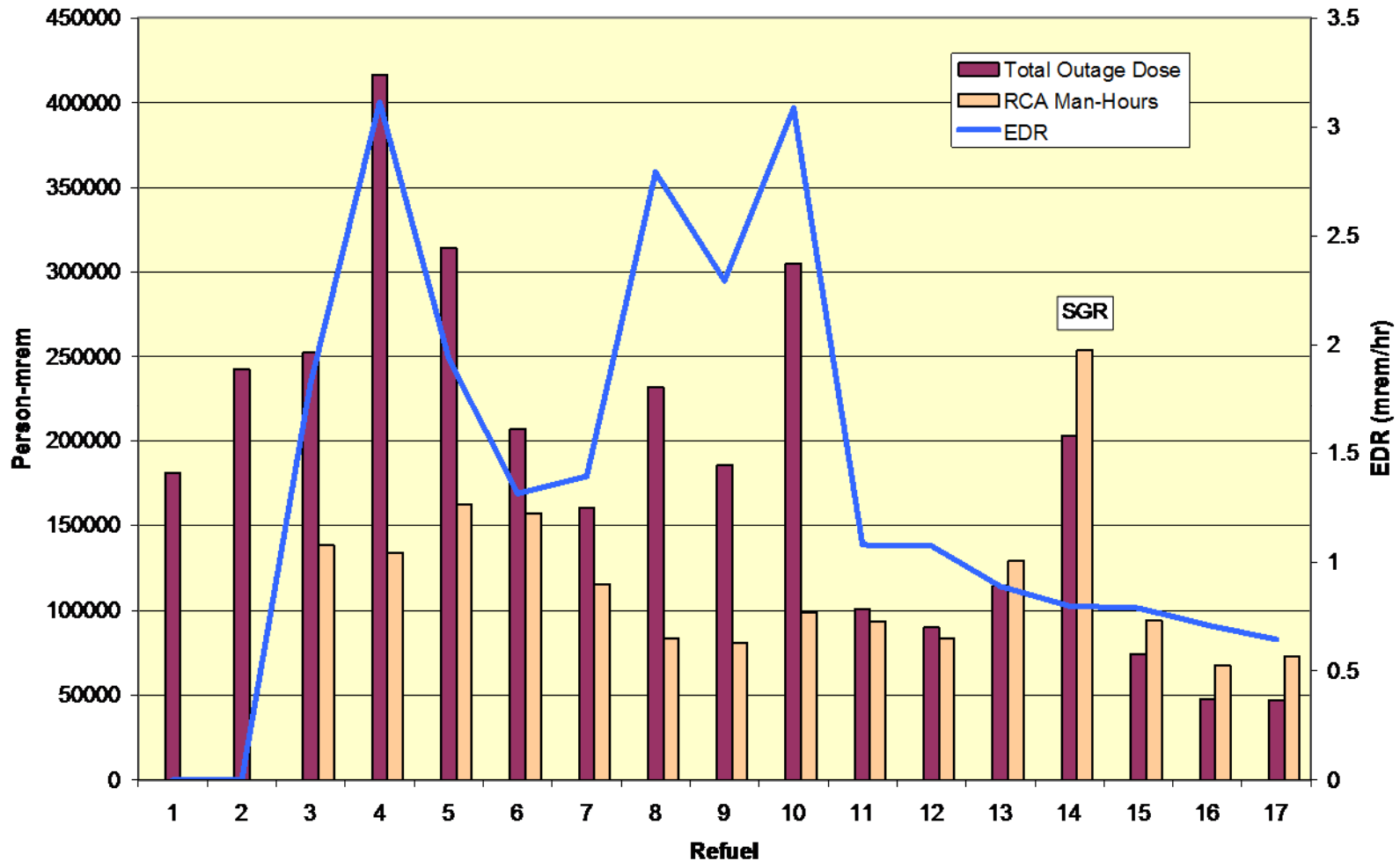
Cold Leg

Hot Leg

Callaway Plant

Refuel Dose Trends

Callaway Total Refuel Dose Trend





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