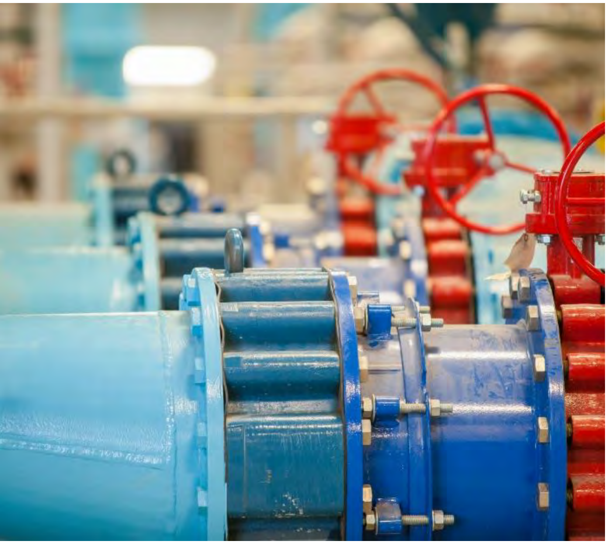
REINHOLD ENVIRONMENTAL Ltd.

2017 APC & Wastewater Round Table & Expo Presentation

July 17 & 18, 2017 in Charlotte, NC / Hosted by Duke Energy



Water Reuse.

Maximizing Existing Equipment while Minimizing Compliance Impacts

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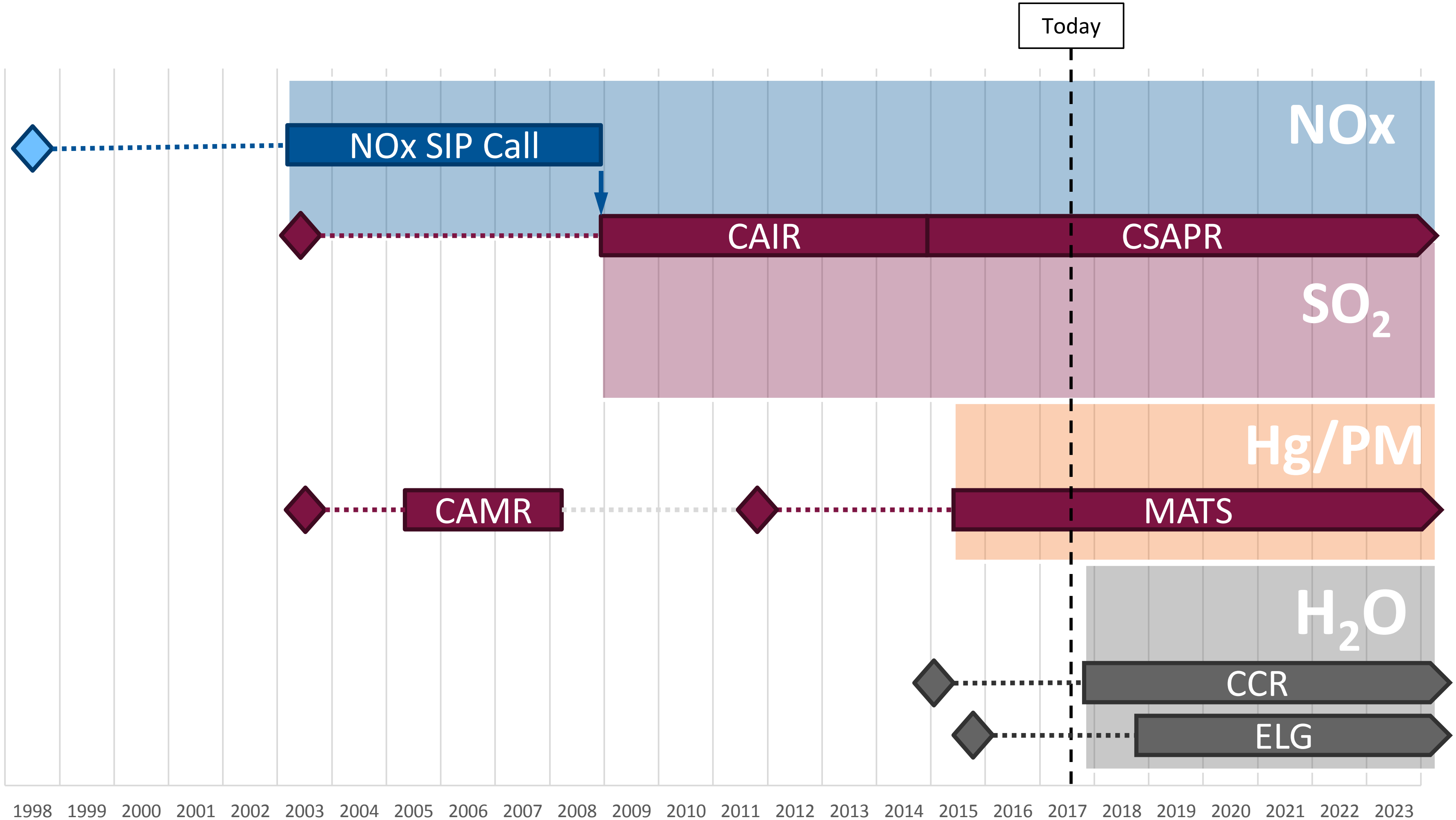
APC Wastewater Conference July 17, 2017

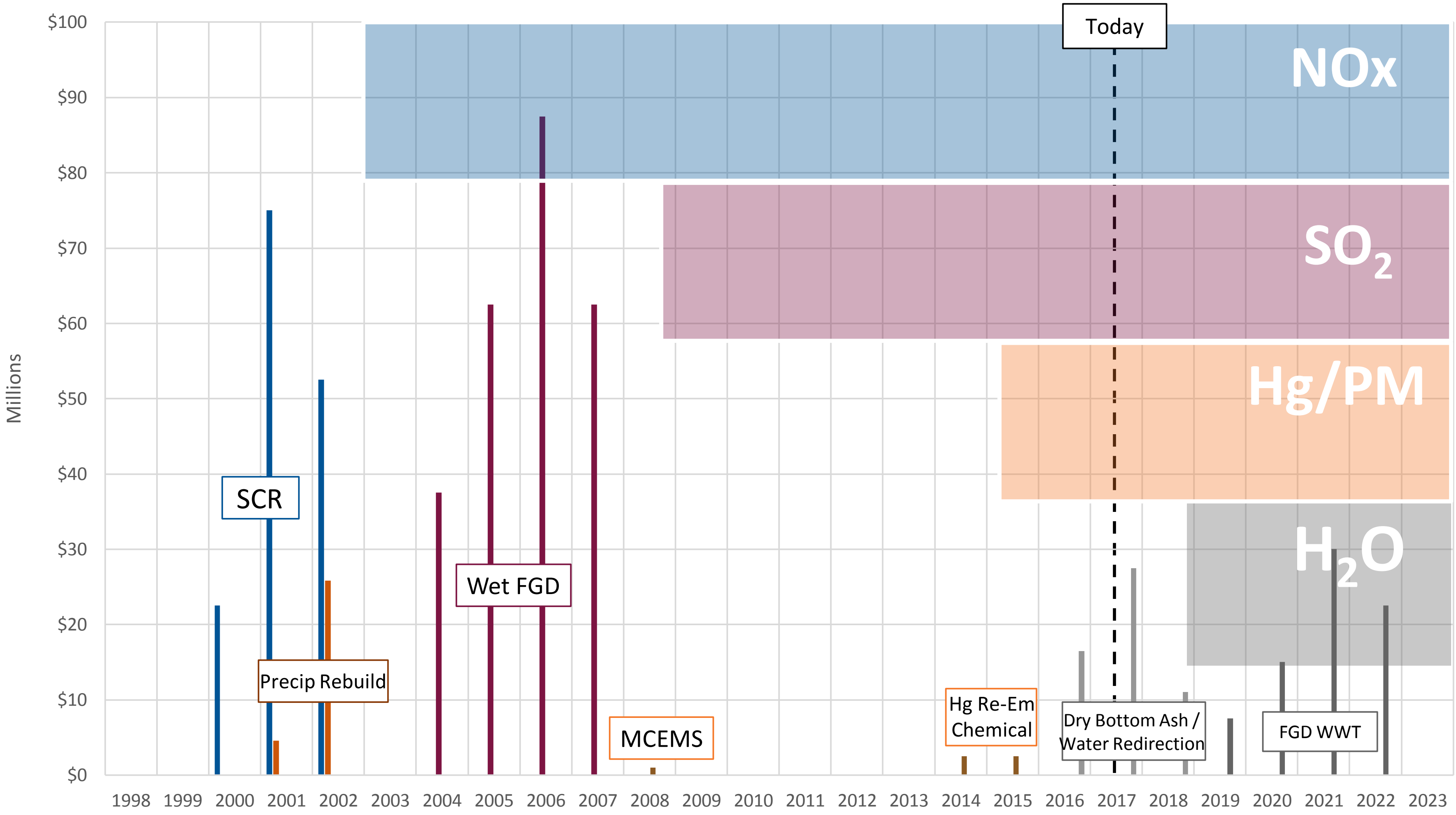
Outline

- A Look Back at Federal Regulations
- Water Regulations Today
- Water Reuse as a Compliance Tool
- Case Study
- Challenges to this Approach
- Questions / Discussion

A Look Back at Federal Regulations



Compliance Strategy Example



Total Capital Cost ~$600M over 25 yrs

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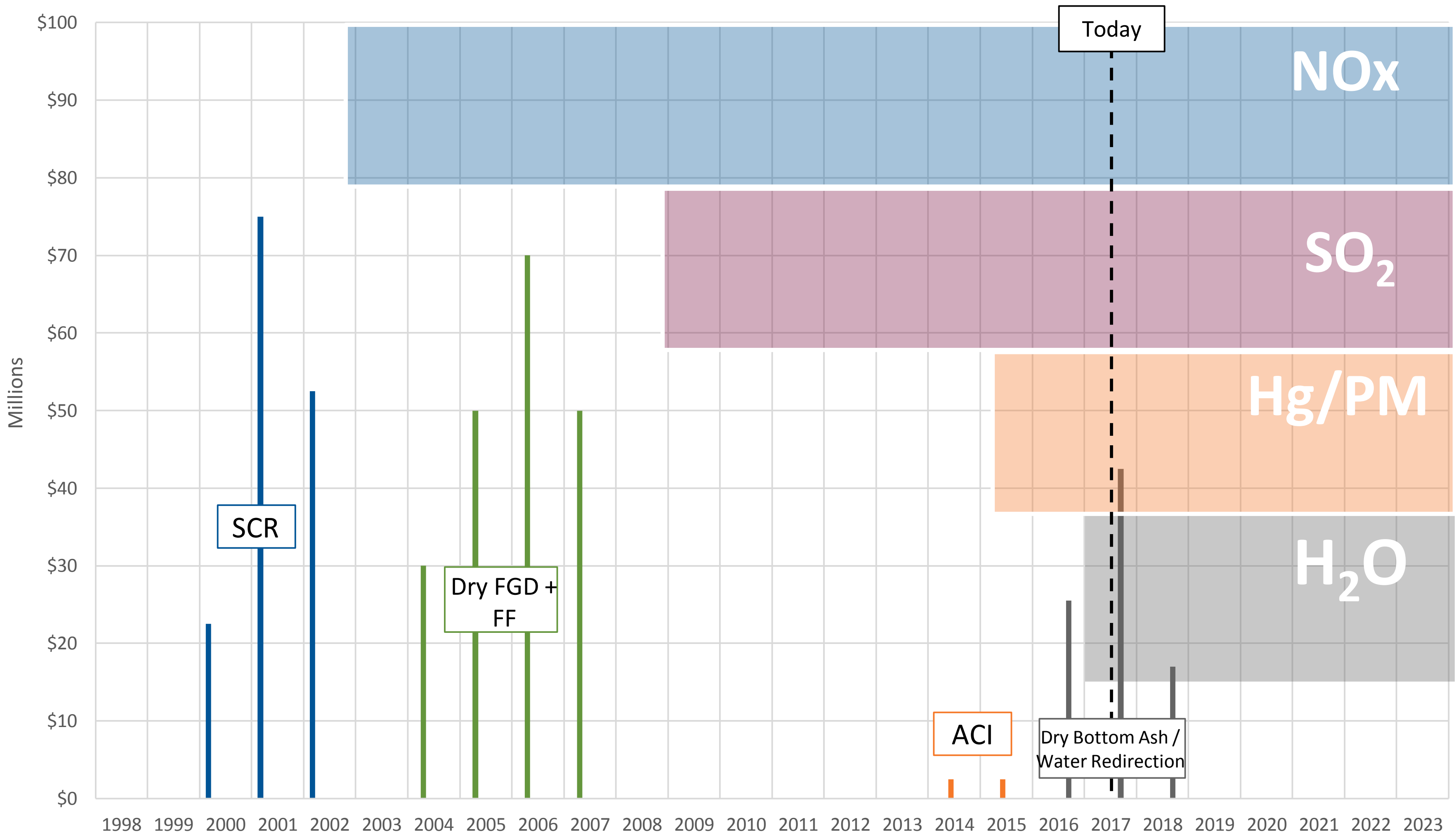
Hindsight is 20/20



Total Capital Cost ~$440M over the same 25 yrs

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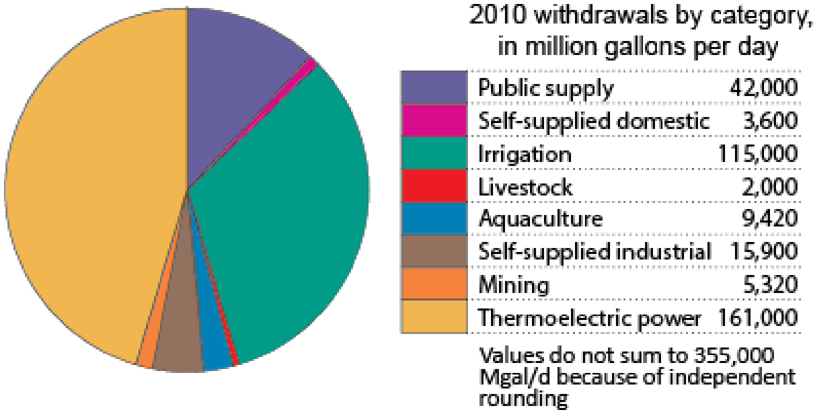
Value of Hindsight

- Why a wet FGD?
  - Decision Drivers: CAIR, Scrubbing Efficiency, Gypsum Sales

- Alternative: Dry Scrubber + Fabric Filter
  - Avoids Precip rebuild, Re-emissions chemicals, FGD wastewater treatment
  - Value of Hindsight: Gypsum market flooded, SO2 market value plummeted due to unit retirements
  - Other factors: Pluses and minuses in operating costs, future FGD zero discharge alternatives yield same results as dry scrubber +FF

Water is the new Air.



Courtesy of USGS

- Current Wave: ELG, CCR
  - Dry Ash Handling
  - FGD Wastewater Treatment
  - Groundwater Protection
- Regulatory Trends
  - Increased pressure on water use (316b, local)
  - Pressure on zero discharge of FGD wastewater (local WQ, ELG incentive, construction of systems, overall pressure on coal generation)
  - Administration change – Knowns to Unknowns
- Largest consumer of water – Power Generation
  - Pressure will not go away
  - Lowest priority for water allocation after residential, commercial, industrial, and agricultural uses[1]

[1] Reference: *"Water Conservation Options for Power Generation Facilities."* Power. Zammit Sept 2012

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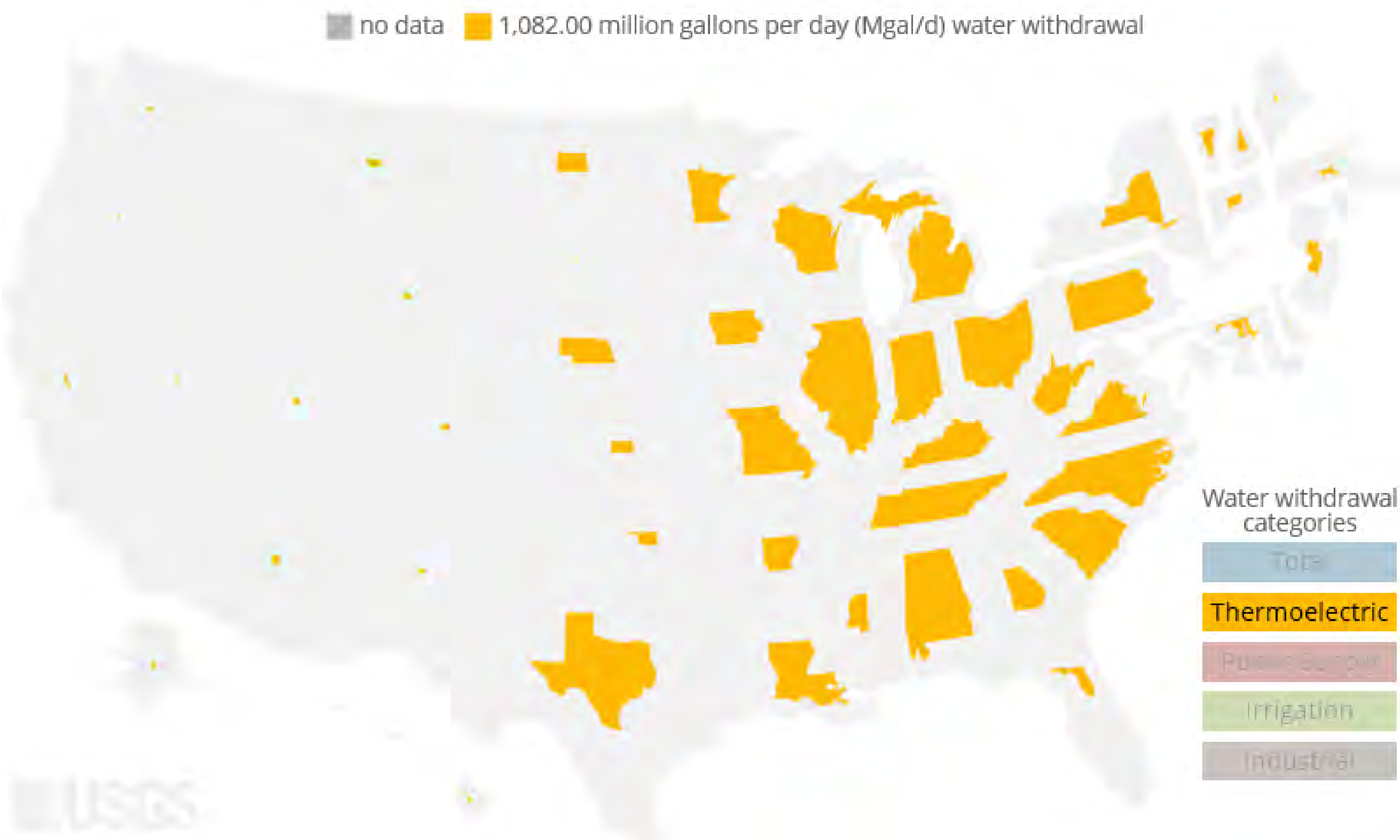
2010 Water Withdrawals



Courtesy of USGS

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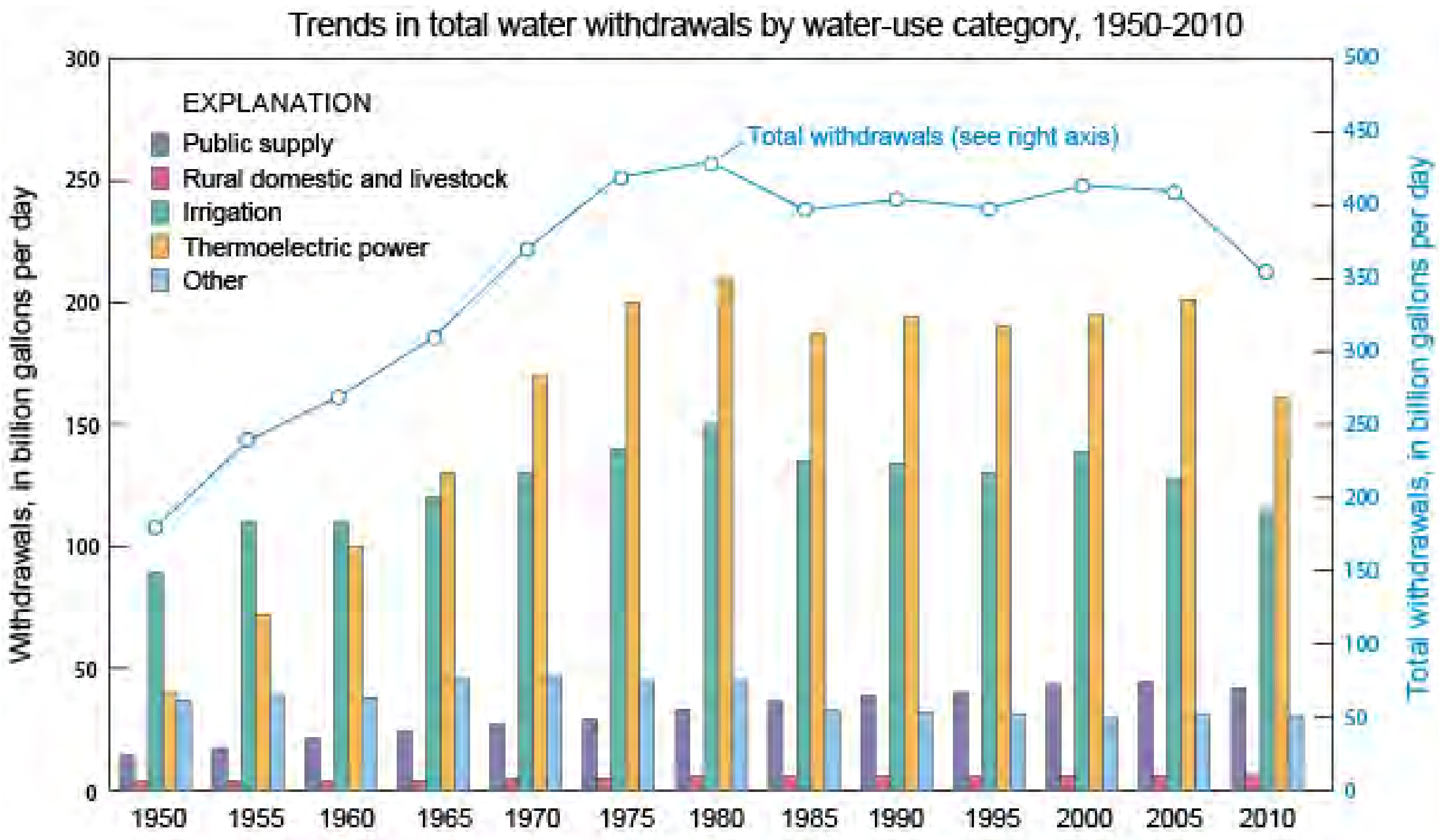
Water Use Historical Trend



Courtesy of USGS

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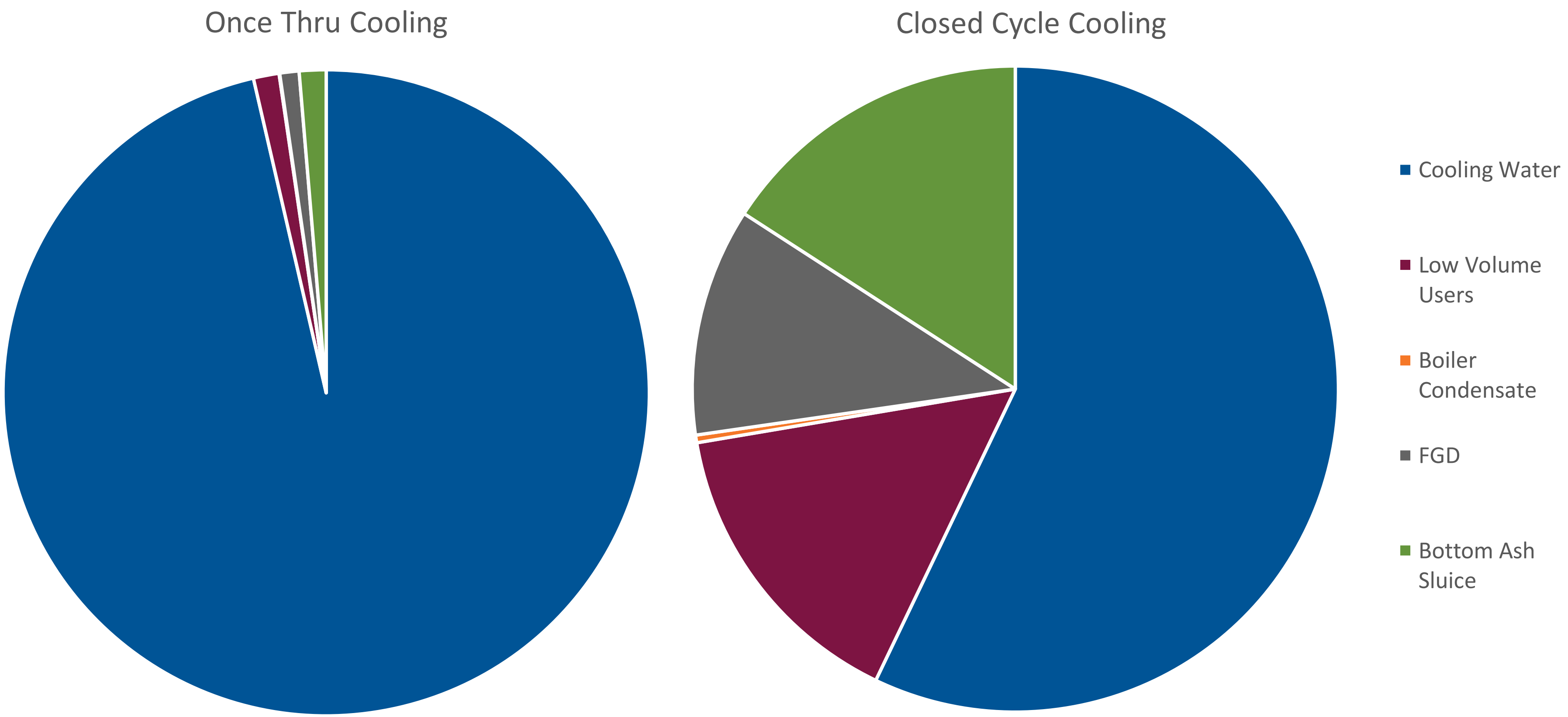
Industry Reducing Water Withdraws

- MATS retirements – Older units, mainly once thru cooling
- Increased Fleet Efficiency (CC plants)
- Cooling Tower Zero Discharge
- Reclaimed Water (Municipal Greywater) for cooling and FGD makeup
- Dry Cooling (Air Cooled Condensers)

Coal Plant Water Use



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Reuse as a Compliance Tool

- Matches Regulatory Trends
  - Focus on minimizing withdraws
  - Reliance on external resources
- Significant water infrastructure modification to comply with CCR and ELG
  - Low Volume Waste Management
  - Dry Bottom Ash Systems
  - FGD Wastewater Treatment
- Considering Water Reuse Now
  - Can reduce compliance costs and/or operating costs while reducing consumption
  - May save future retrofit requirements

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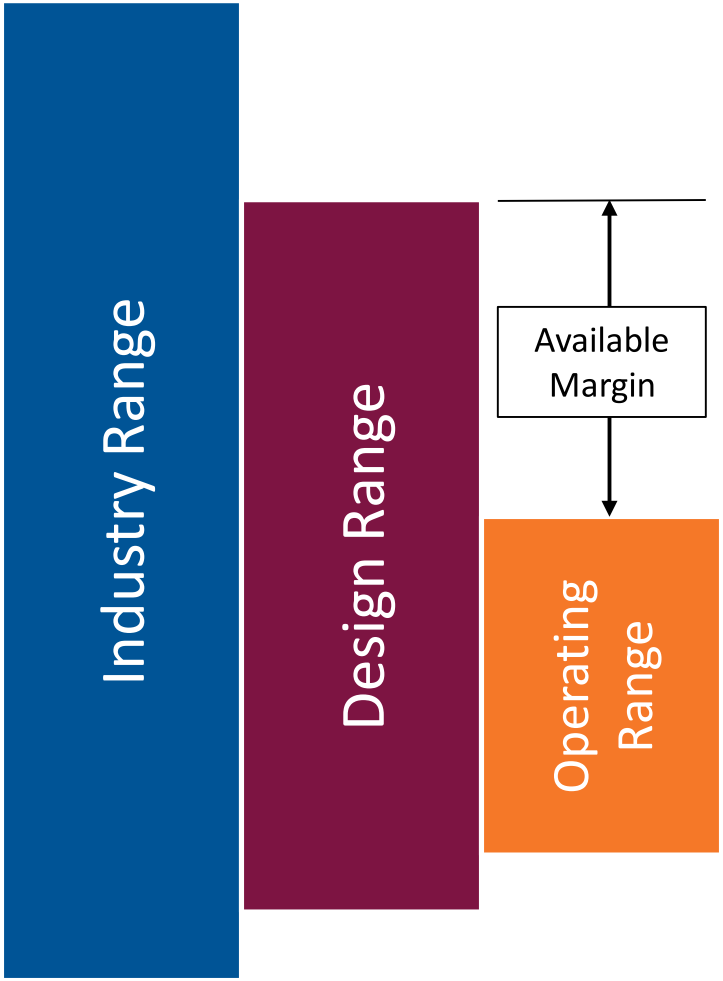
Design vs Actual

- Good Engineering Practice to design for operating margin
- FGD Design Example
  - Design Sulfur fuel
  - Design Fuel Chlorine
- This conservative approach leaves operational room for reuse



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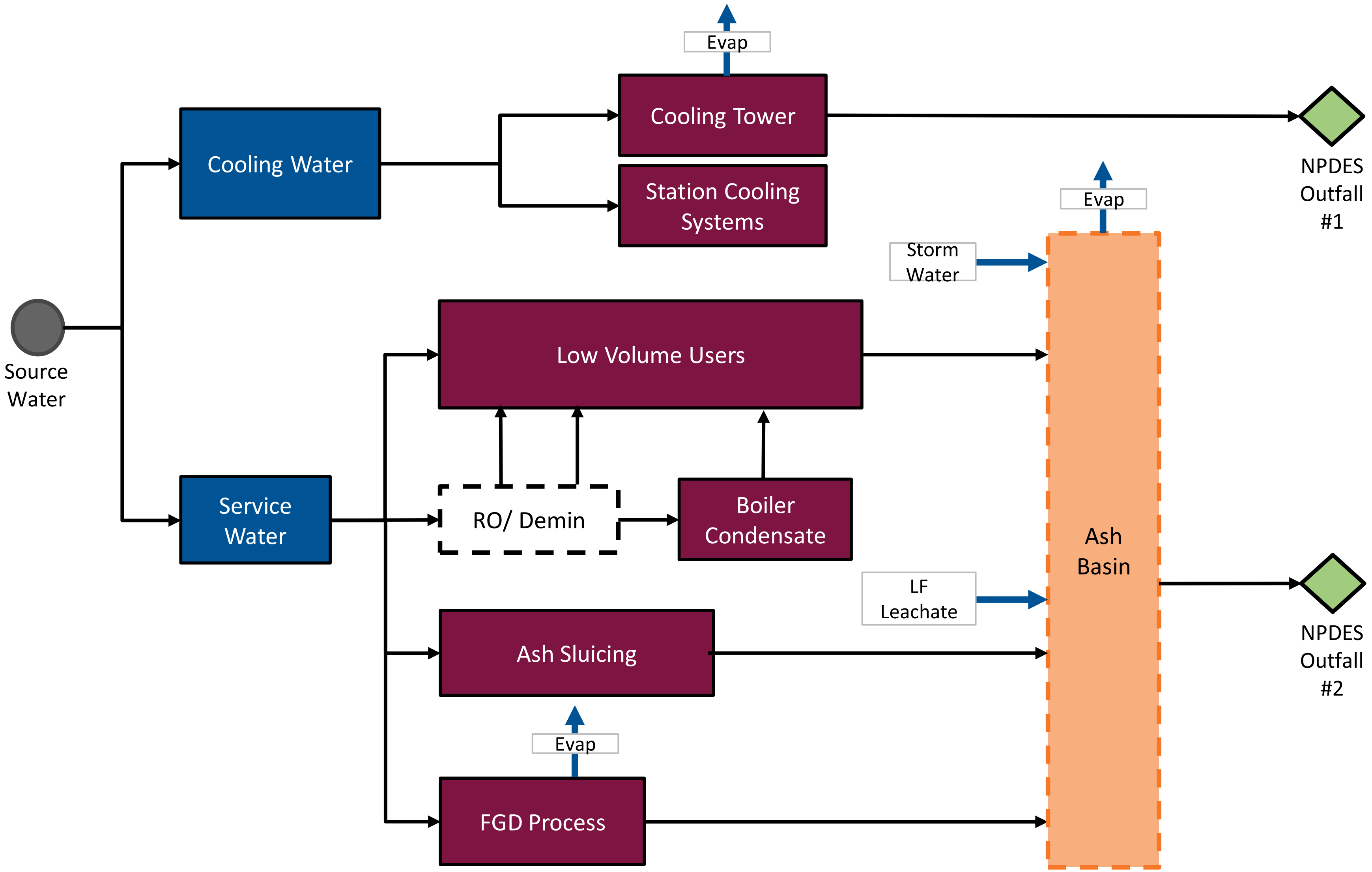
Case Study – “Typical” Coal Plant



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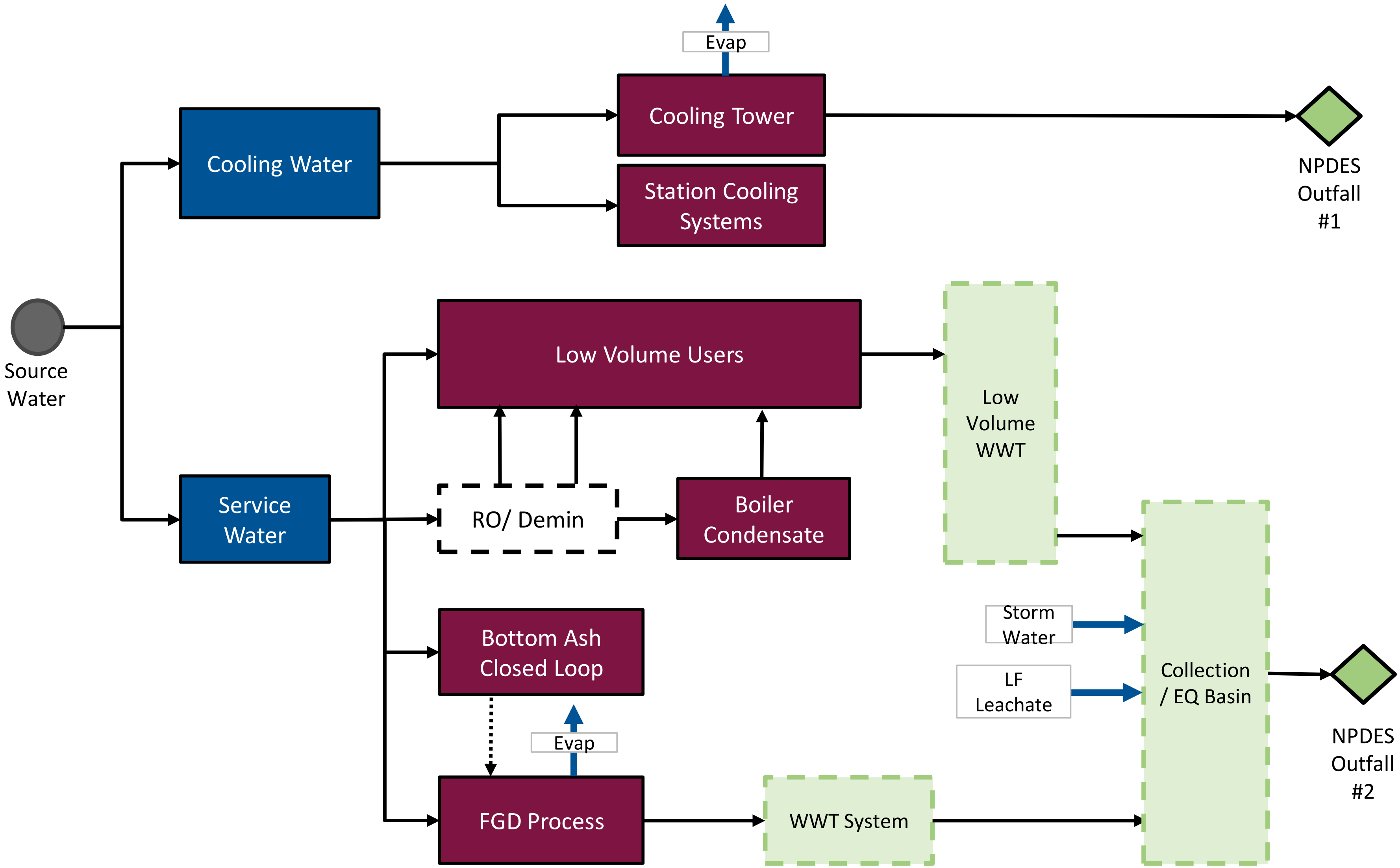
CCR-ELG Water Redirection Impact



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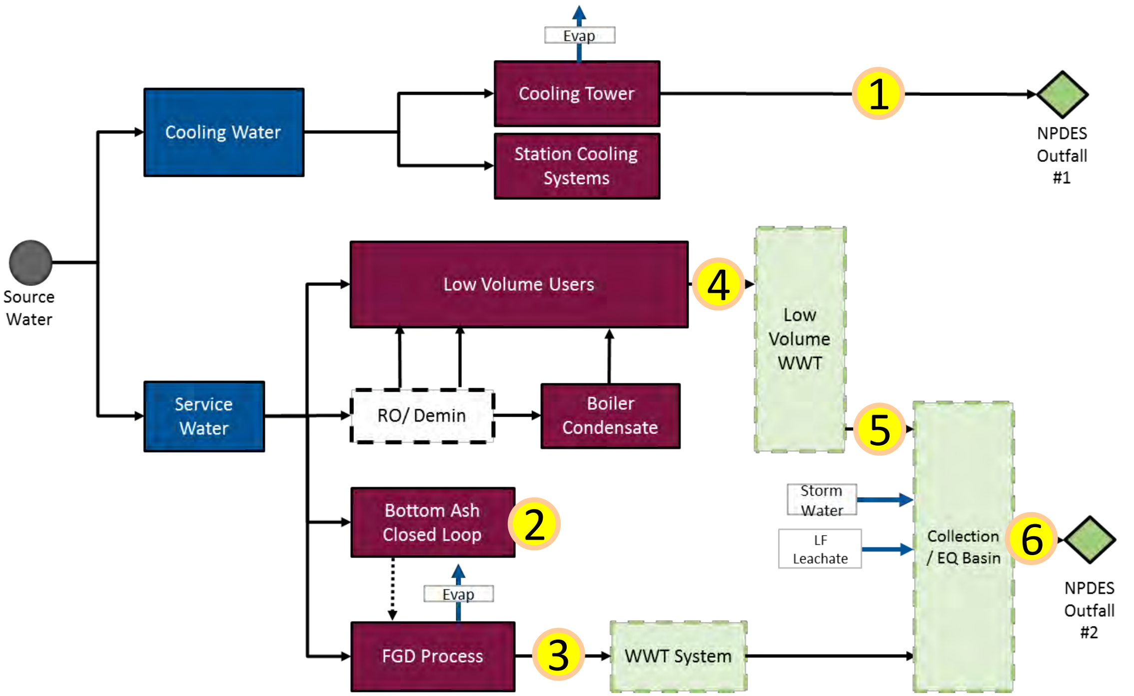
Potential Re-users

1. Cooling Tower Blowdown
2. Bottom Ash Sluice
3. FGD Purge
4. Low Volume Waste
5. Treated Low Volume Waste
6. Blended Station Discharge



Reusing streams ahead of new CCR-ELG systems or features can minimize sizing and costs.

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Factors to Consider for Users of Re-users

- Flow
- Water Quality – Chlorides, TSS, TDS, Metals
- Existing System Constraints
  - Materials of construction for corrosion
  - Pump Seal designs
  - Strainers and/or filtration
  - Treatment system designs
- Process Stream Behavior
  - Variability – Flow and Chemistry
  - Cycling versus Once Thru

Process Characteristics

User	Flow	Water Quality	Nature of Process	Material of Construction
Source Water	Collective of All. Moves with Load	Strained River Water (Low TSS, Low chloride)	Blend. Once thru & Cycling	Full Plant. Carbon Steel the constraint
Low Volume Users	Moves with Load & site activities. Influenced by stormwater	River Water + Process waters (variable TSS, low chlorides)	Once Thru.	Carbon Steel, Concrete
Boiler Condensate	Very small flow	Treated source water to high quality, Demineralized water	Cycling. High quality water demand	Carbon Steel, Alloy steel
FGD Process	Consistent with Load, Influenced by coal	High chloride	Cycling – Designed purge rate	High alloys, FRP, plastics, coatings

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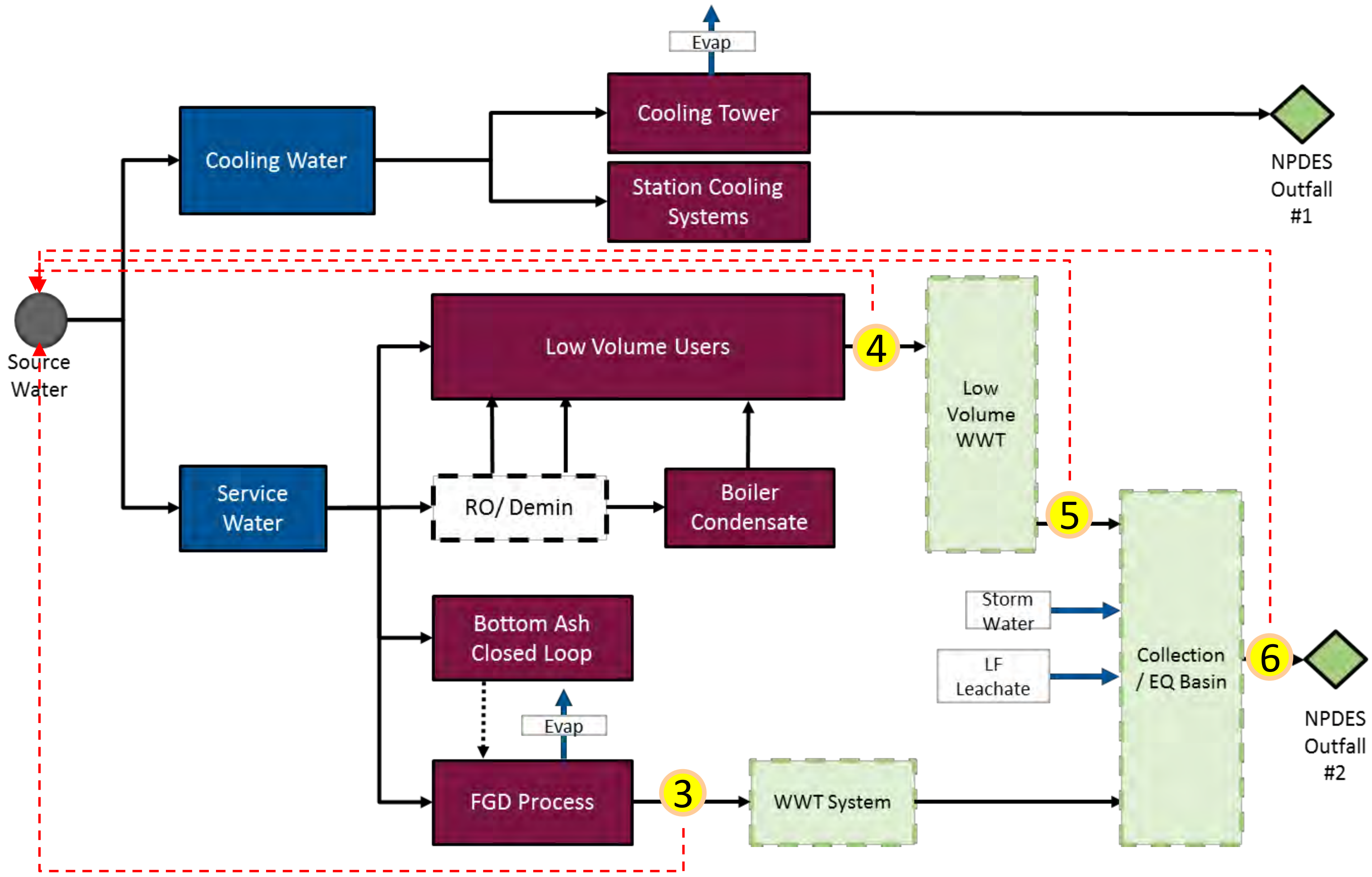
Case Study – Direct Source Water



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Case Study – Direct Source Water

- Shares the impact of the recycled stream with all users
- Largest flow to minimize the impact
- Infeasible at this site
  - Direct discharge of wastewater in water intake structure not permitted
  - Dependent on intake arrangement
  - Many sites may face this issue

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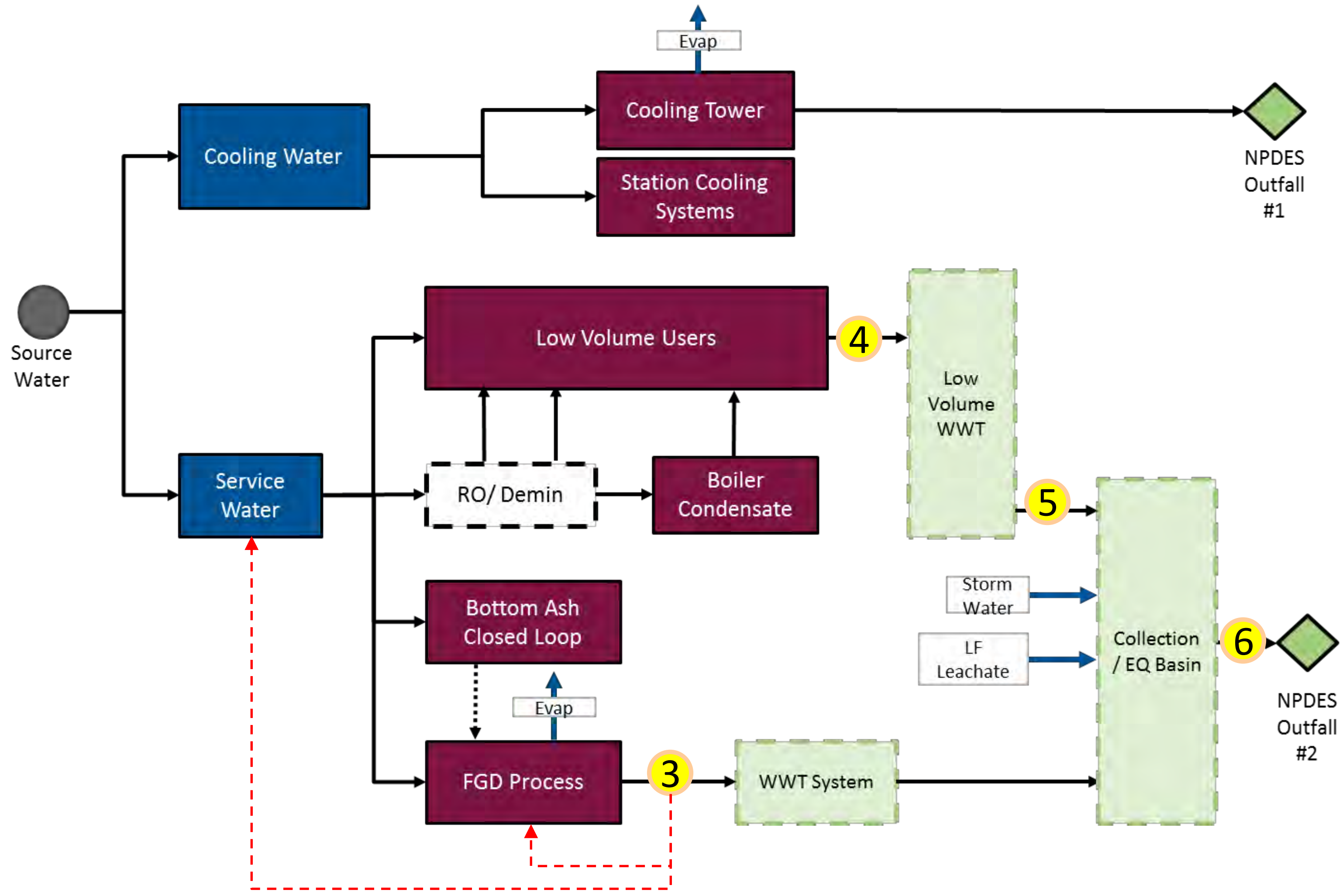
Case Study – FGD Purge



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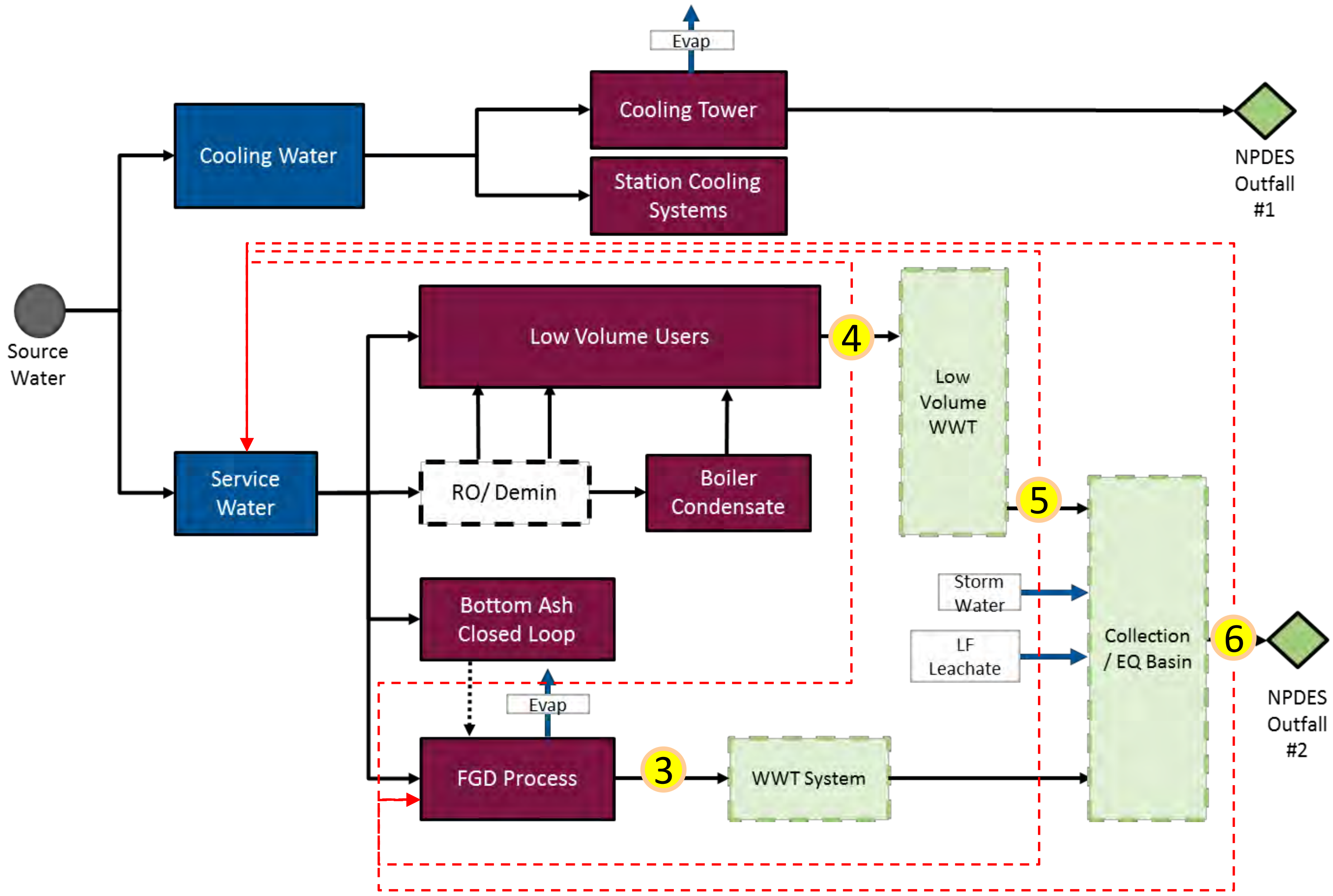
Case Study – FGD Purge

- To Service Water
  - Not feasible - High Chlorides of the FGD exceeds the system's MOC
- To FGD process (reducing purge rate)
  - Normal Operating Chloride level 5,000
  - Absorber Material – Stebbins Tile with Hastalloy attachments, FRP piping
  - Client comfortable with 15,000 ppm Chloride limit
  - 75% reduction in flow
    - Main driver for WWT sizing will be flow although it is not linear
    - Reducing the overall purge will likely cycle up dissolves metals as well.
    - TSS will remain unchanged due to hydroclone sizing

	FGD Purge Flow (gpm)	Chloride Level (ppm)
Base Line	350	5,000
Reuse Case	90	15,000

Case Study – Low Volume Waste



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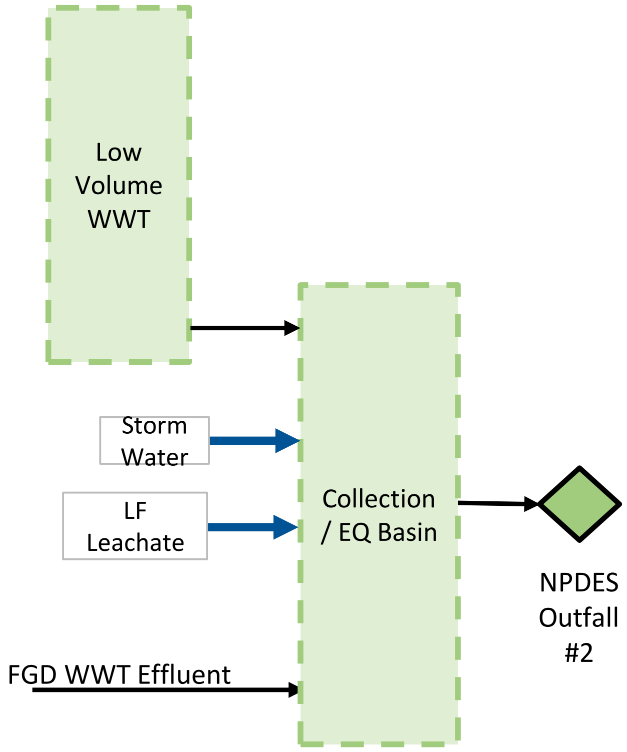
Case Study – Low Volume Waste

- Farther back in the process the reuse the larger opportunity to reduce costs
- Untreated Low Volume Waste – Variable flows, chemistry, medium TSS loading
- Station using wastewater basin for solid removal with polymer addition & pH adjustment
  - NPDES Limit 30 ppm TSS



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Low Volume Waste vs Service Water

Description	Water Quality		
	TSS	Chloride	TDS
Source Water	66	35	350
Low Volume Waste	355	41	1800
Treated Low Volume Waste	20	41	1800
Blended Station Discharge	20	350	2600

- Low Volume Waste
  - ~3 to 1 flow ratio
  - Highly variable from operations input
    - Higher solids than system constraints
    - 5 x increase in TDS loading to the system
- Treated Low Volume Waste
  - Lower solids loading than untreated and source water
  - TDS remains unchanged
- Screening Result: Untreated and Treated LVW could be problematic due to TDS loading.

Low Volume Waste vs FGD Makeup

Description	Water Quality		
	TSS	Chloride	TDS
FGD Process (FGD Purge)	10,000	5,000	18,000
Low Volume Waste	355	41	1800
Treated Low Volume Waste	20	41	1800
Blended Station Discharge	20	350	3200

- Low Volume Waste
  - ~1 to 1 flow ratio
  - High Solids loading (Equipment limitation potential)
  - TDS loading an order of magnitude from the equilibrium value
  - Highly variable from operations input
- Treated Low Volume Waste
  - Treatment removes of solids loading restriction
- Screening Result: Treated Low Volume Waste is a good candidate for FGD makeup water vs. service water.

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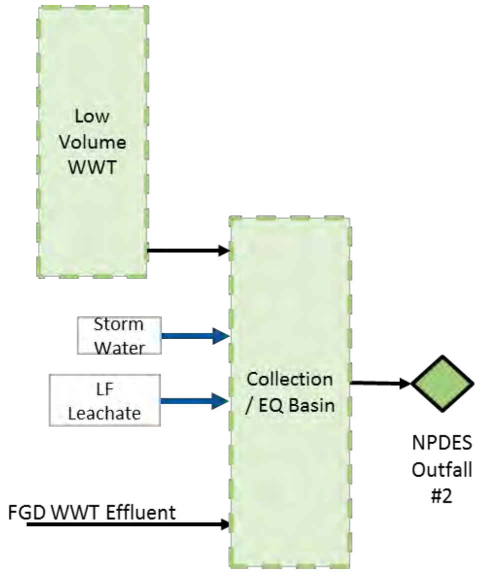
Low Volume Waste as FGD Makeup

- Treated Low Volume Waste
  - ~1 to 1 flow ratio during dry conditions
  - TSS loading is lower than source water
  - Chlorides essentially the same as source water
  - Operational variability dampened by basin volume and pH adjustment



- So what is the issue?
  - The blended downstream impacts
  - The process will likely not be the concern
  - NDPES permit limitations will limit the ratio

		Flow	Hg (ppt)
Base	FGD Process (FGD Purge)	350	150
	Low Volume Waste	1394	10
	Blended Station Discharge	**1,744**	**38.1**
50% Reuse	FGD Process (FGD Purge)	350	150
	Low Volume Waste	697	10
	Blended Station Discharge	**1,047**	**56.8**

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Impact of Blended FGD Wastewater

- Another word of Caution: Careful of compounding process impacts

Description	Water Quality		
	TSS	Chloride	TDS
Source Water	66	35	350
Low Volume Waste	355	41	1800
Treated Low Volume Waste	20	41	1800
Blended Station Discharge	20	950	3200

- Reuse in the FGD will have a compounding effect downstream
- The FGD purge stream is troublesome in maximizing reuse

Other Challenges with this Approach

- Balancing the impacts across processes
- Increased equipment risk (corrosion, scaling)
- More complicated water management / operational practices
- Impacts from Stormwater

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Conclusions

- As was shown true with Air regulations, it is important to consider all current and future impacts to develop a robust compliance strategy
- Water Use in Power Generation will continue to be pressured.
- Existing plant systems have margin that allows for water reuse with the plant process
- This approach can save compliance costs and operating costs if considered now.
- This approach is challenges by concentration based permitting requirements and compounding process effects

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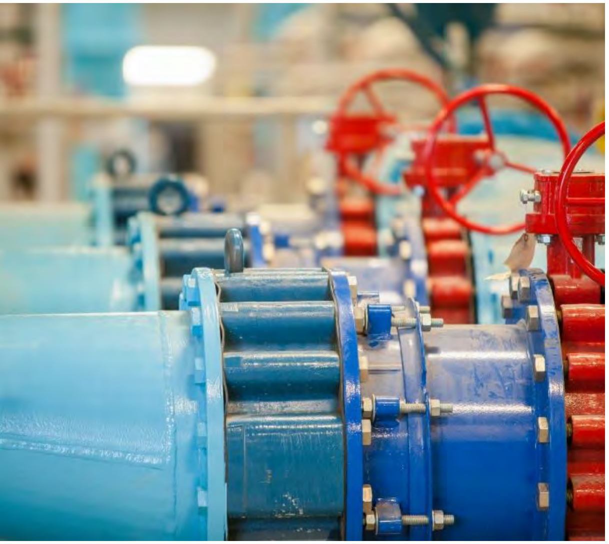
Questions / Discussion



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