2017 Joint Conference
Mine Drainage Task Force

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Water Treatment: Planning for Forever, New Options

Dan Eyde – St Cloud Mining Company
David Baker – Consulting Associate

Two Views – Problem/Opportunity

Dave Baker – 35+ Years in Mining – Retired Chief Sustainability Officer at Newmont.

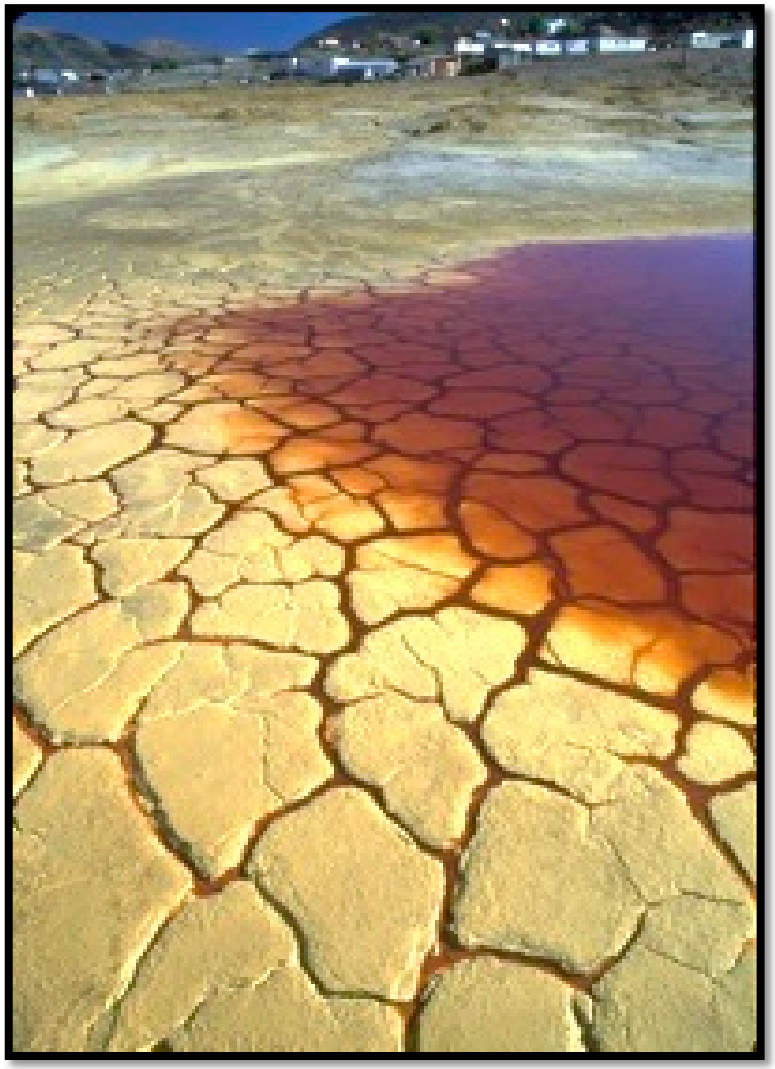
Dan Eyde – developed innovative products for radioactive, mining and other wastes.

Discussions from a Company/Problem Perspective

- Evaluating the potential financial threats to mining companies who do not adequately account for post-closure site water management
- Assessing the significant impact of poorly managed legacy mine sites on local environments, water tables and communities
- Tackling the actual source controls to minimize contamination and reduce the amount of water left to actually treat
- The increasing costs of in perpetuity water treatment costs.

Closure Good Practice

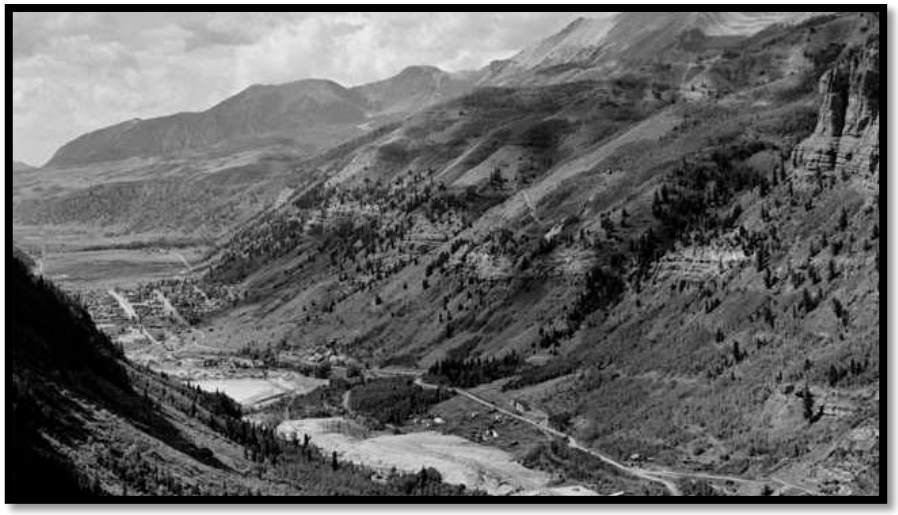
An integrated approach to closure is one which takes the environmental and social considerations into account from an early stage and continues throughout a site's lifetime.



Legacy Sites: Defined broadly as those mining sites that did not utilize the Integrated Approach to closure, typically ranging from the 1860's to 1990's.

Mining Legacy Sites Present a Complicated Calculus

The Variables:



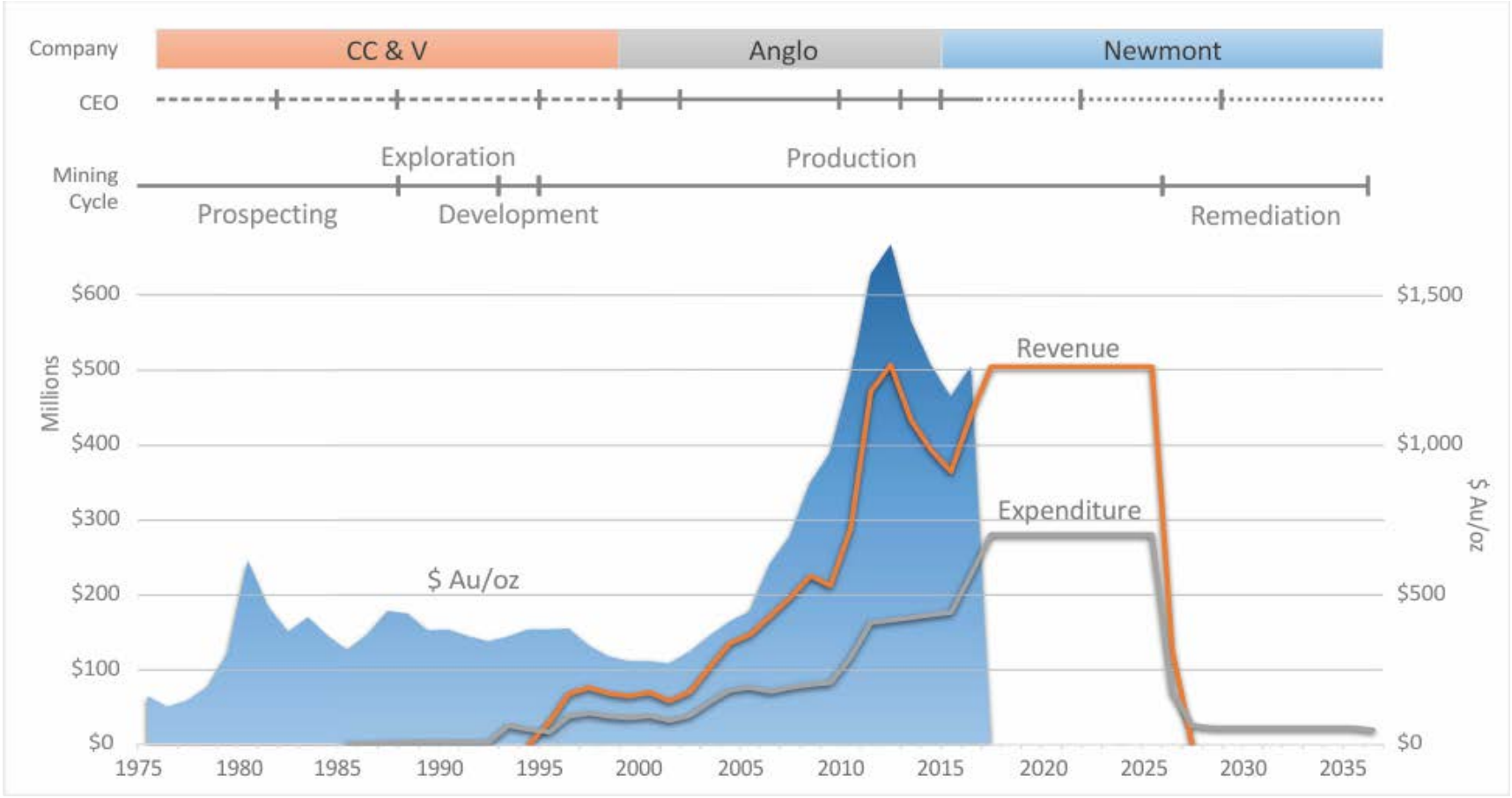
- Technical Challenges
- Liability
- Litigation
- Community Perspective(s)
- Political Perspective(s)
- Reputation
- Water Management
- Limited or Difficult Technical Solutions and Options
- Timeframe
- Cost

The Financial Threat to a Company

- Direct Cost of Implementing and Maintaining the Mitigation
- Social Costs
- *In Perpetuity* Water Management
- Possible Fines or Penalties
- Impact on Reputation Capital

Any Gold Mine, Ltd – Gold Operation

Any Gold Mine Ltd.



Newmont facing up to $1.2B impairment charge due to upcoming Yanacocha closure

The largest U.S. gold company said in a filing with the US Securities and Exchange Commission that it will likely record a non-cash impairment charge of between $1 billion and $1.2 billion in the fourth quarter due to runaway costs associated with closing the mine, which is nearing the end of its life.

Southern Coal Corporation to Make System-Wide Upgrades to Reduce Water Pollution from Mining Operations in Appalachia

WASHINGTON – The U.S. Environmental Protection Agency (EPA) and the U.S. Department of Justice (DOJ) today announced a settlement with Southern Coal Corporation and 26 affiliated mining companies that requires the companies to make comprehensive upgrades to their coal mining and processing operations to prevent discharges of polluted wastewater from their mines in Appalachia. The estimated cost of these measures is $5 million.

The settlement also requires the establishment of a $4.5 million letter of credit and a standby trust that will guarantee sufficient funding for, and a mechanism to accomplish, compliance with the Clean Water Act and the work the companies have agreed to perform under the settlement, should the companies fail to do so. The companies will also pay a $900,000 civil penalty, divided among the federal government and the four state co-plaintiffs, Alabama, Kentucky, Tennessee and Virginia.

The settlement resolves alleged violations of state-issued Clean Water Act National Pollutant Discharge Elimination System (NPDES) permits by illegally discharging various pollutants at the companies' mining and processing operations in Alabama, Kentucky, Tennessee, Virginia and West Virginia and violations of the companies' legal responsibilities to sample the quality of their discharges to rivers and streams. The estimated annual pollutant reductions through implementation of the settlement is approximately five million pounds.

"Discharging pollution from coal mining into waterways is a serious threat to clean water, and that's why EPA stepped in on behalf of communities across Appalachia," said Assistant Administrator Cynthia Giles for EPA's Office of Enforcement and Compliance Assurance. "Company-wide compliance programs like the one Southern Coal Corporation will establish are critical to protecting our lakes, rivers and streams and the people who depend on them."

Water Management

Passive Water Treatment - Anaerobic, Aerobic, Surface Flow Wetlands, etc.

Active Water Treatment - Lime Neutralization, High Density Sludge, Reverse Osmosis, etc.

Dear Regulators, we're in a quandary, aren't we?

André Sobolewski
Impact Assessment and Water Treatment Specialist

- Lime-based treatment plants generate a lot of sludge.
- We handle potentially acid-generating (PAG) waste more carefully.
- We reclaim reactive waste rock much better than before.
- New regulations cover different classes of contaminants like selenium or sulphate.

New Regulatory Environment

- We are in a very different regulatory landscape. Contaminated streams at new mines are rarely acidic or metal-laden. Under these conditions, lime-based treatment plants are far less effective. This tried and true technology, which has proven itself many times in the past, does not make sense in this case. Nowadays, mine drainage at closure will be voluminous, but with low levels of contaminants.

Discussions From a Treatment/Opportunity Perspective

- Investigation of the range of treatments for legacy and new mines including active mechanical treatments
- Appraising the use of passive and semi-passive water treatments against standard lime treatment plans – i.e. sulphate reducing bio reactors and in situ treatment using bio agents – what are the latest results showing?
- Budgeting the capital expense of acquiring water rights and then water treatment' which can be on par with the mobile equipment or production facilities

Project Oriented Approach to Water Treatment Problems

- Implementing a project approach to particular water treatment objectives.
  - We use typical project cost estimates for determining whether sorptive media systems are an effective alternative for specific mine water treatment.
    - Costs associated with initial equipment installations
    - Costs of operations and maintenance of the system
    - Costs for media disposal

The Project Approach to Media-based Treatment

- System Configuration
  - Media Process Vessels
    - Flow Configurations to Match Process-Specific Needs
      - Upflow and Downflow
      - Pressure Vessels and Atmospheric Vessels
      - Vertical and Horizontal Cylindrical Vessels
    - Media Retaining Systems
      - Hydraulic Distribution
      - Uniform Media Contaminant Loading
      - Bed-depth and Media Contact Time
    - Single and Multiple Treatment Stages
      - Sensitivity of Discharge Excursions
      - Maximizing Media Loading Rates

Media Sorption Treatment Systems

- Media sorption systems are well suited to mining water treatment.
  - Conceptually, the process selectively removes contaminants onto a solid phase media material for safe and convenient disposal, creating no or minimal additional waste streams.
  - Can be designed to treat small and large (greater than 10.0 MM gal/day treatment streams.
    - Designs can accommodate long-term and temporary installations.
  - Media sorption can implemented as a complimentary treatment to existing or additional treatment processes as BACT to assure very low compliance requirements.

Natural Zeolite-based Media Systems

- Natural zeolites are readily available. The resources are large, well-tested and consistent in performance.
- There are a number of available technologies that improve sorbent selectivity or increase capacity for specific contaminants.
- Technology is proven in municipal and drinking water, nuclear, and industrial water treatment applications and is becoming more common in polishing mine effluents prior to discharge.

Zeolite-based Media Systems

- Natural zeolite ion exchange properties are well documented and studied.
  - Cation exchange directly allows removal of lead, zinc, cadmium and copper.
  - Raw natural zeolites for once-through processing of waste water is very cost effective compared to synthetic ion exchange materials or other adsorbants where removal performance is similar.
  - Surface modified zeolites have shown effective removal of oxy-anion metal complexes of selenium, manganese, arsenic and chrome from waste streams.
  - Natural zeolites are easily processed to facilitate their use in water treatment systems.

Passive and Semi – Passive Approaches

Advantages

- Lower Cost
- Lower Maintenance
- Higher Volumes
- Generally fewer moving parts and well suited for remote sites

Disadvantages

- Less Flexible
- Can have a larger footprint

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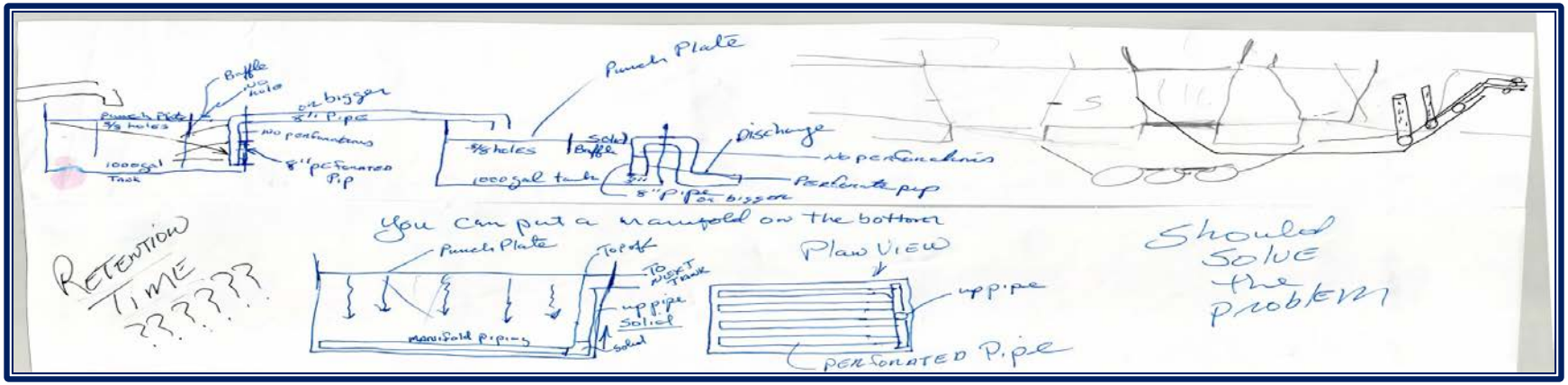
Zeolite Practical Application



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WRT

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SHC

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Southwest Hazard Control, Inc.

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Active Systems -Sorption Media Treatment

- Primary Targeted Contaminants Suitable for Media Sorption
  - Metals: Arsenic, Molybdenum, Lead, Mercury, Selenium, Copper, Chromium, Cadmium, Thallium
  - Radionuclides: Uranium, Radium, Gross Alpha-emitters
- Why
  - Concentrations of these constituents in most waste waters are low enough to provide reasonable service volumes between media exchanges.
  - Media sorption provides the best opportunity to reduce effluent concentrations to extremely low trace levels. The technologies were developed in the treatment of radioactive wastes. The largest most recent application was the Fukushima disaster in Japan.

Thallium Removal Set-up at CR Kendall Hilger Mine Montana

Full-scale Media Treatment System

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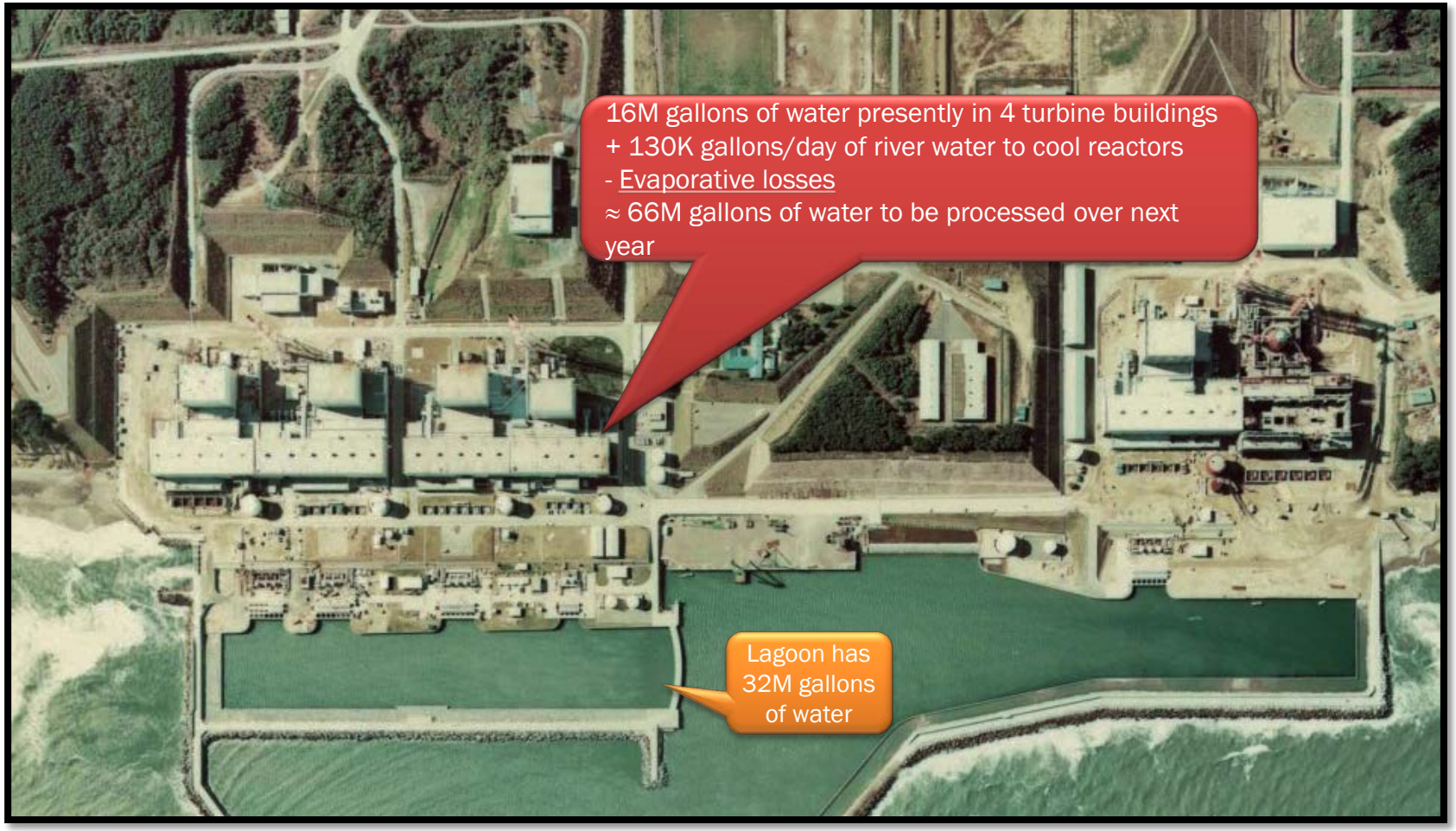
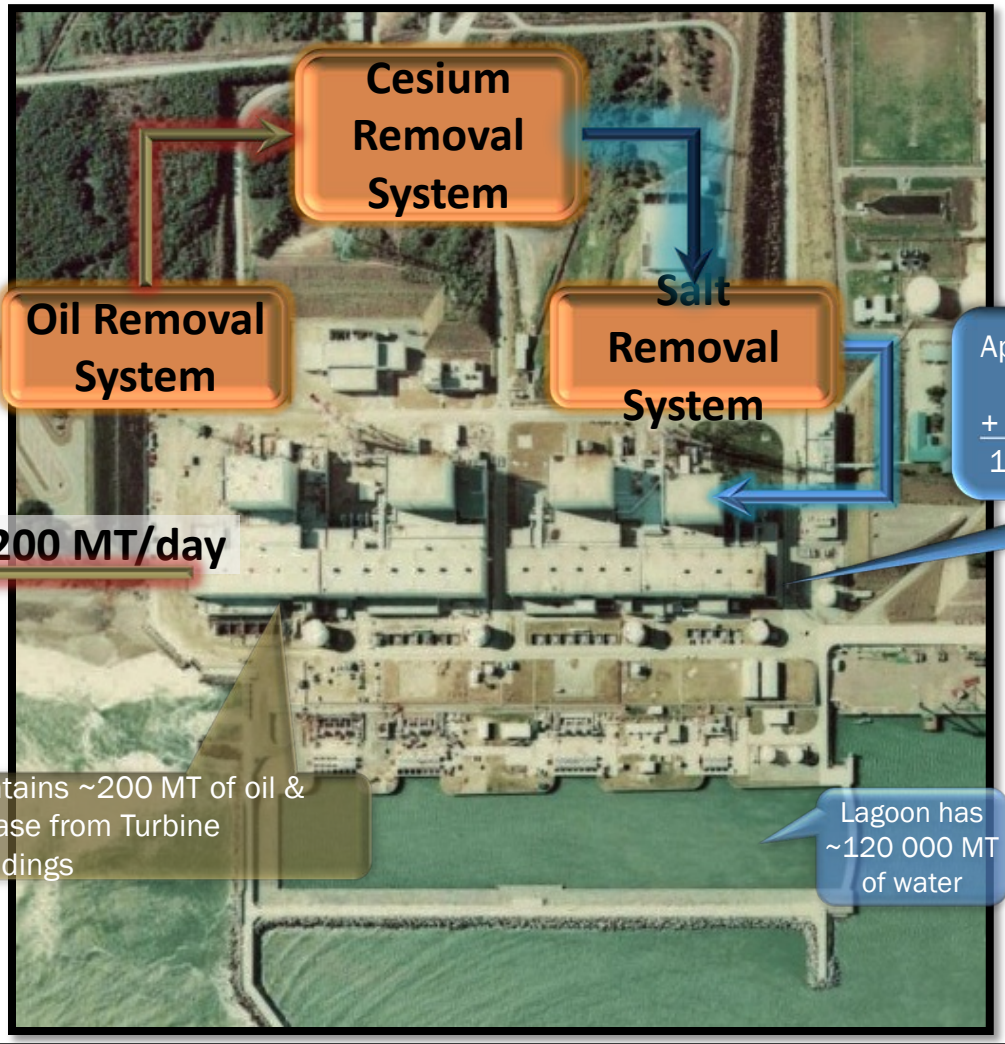
Magnitude of Water Processing



Goal: Create 1st Ever External Reactor Water Cooling System



Approximate volumes:
67 500 MT of highly contaminated water (April 20)
\+ 800 MT/day cooling water, rain, in-leakage
120 000 MT of highly contaminated water (June 28)

Additionally:

- Near continuous aftershocks to > Magnitude 7
- Summer Rainy Season came early – mid May
- Many unknowns about site conditions
- Protestors, police, camera crews on streets

Unprecedented Challenges: Saline Oily Water, Volume, Schedule, & Mother Nature

Sources TEPCO, Wikipedia FNPP and WSJ

Thank you – Any questions?

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