CCR IMPOUNDMENT CLOSURE USING DISCRETE IN-SITU SOLIDIFICATION – SITE UPDATE

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PRESENTATION OBJECTIVES AND OUTLINE

To present an in-situ closure technology that meets regulatory requirements of minimizes groundwater infiltration in all direction, is permanent, implementable, minimally disruptive and cost effective.

- Overview of Discrete In-situ Solidification Closure Technology
- Implementation – Site Overview
- Construction Quality Assurance
- Cost Summary
- Shareholder Acceptance
- Questions/Discussion

Technology Overview – Hydraulic Containment via Discrete *In Situ* Solidification (ISS)

ISS: In-place mechanical mixing of media with dry reagent or an injected engineered grout mixture

Result: Engineered structure with decreased permeability and increased strength

Typical Reagents: Portland Cement, Slag Cement, Bentonite, Lime

Typical Performance Goals

- Decreased Permeability (e.g. ≤ $1x10^{-6}$ to $1x10^{-8}$ (cm/sec))
- Increased Compressive Strength (e.g. ≥ 50 psi)

Construction Techniques

- Conventional full depth ISS
- Discrete zone ISS

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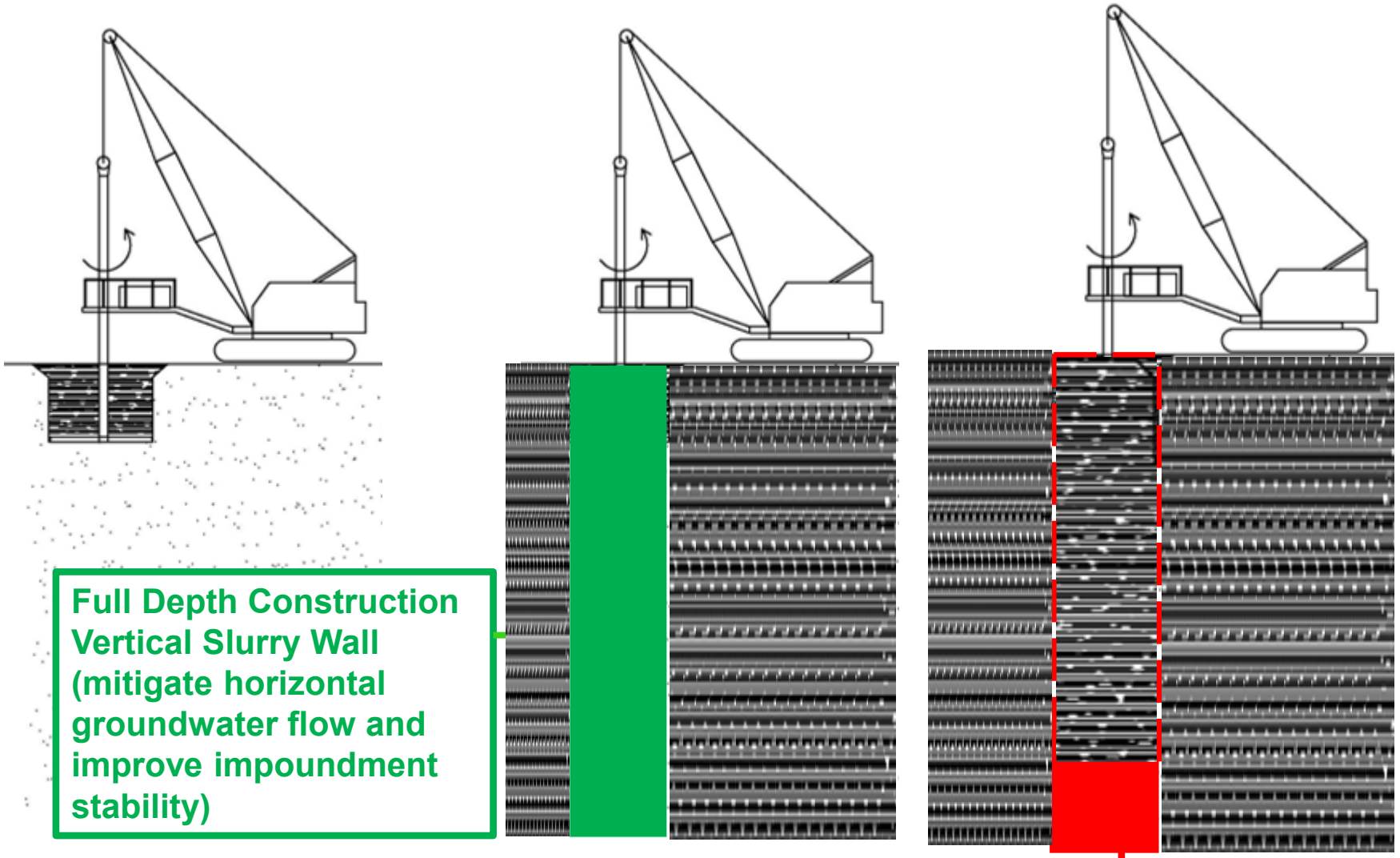
ISS Drilling Methods



Full Depth Construction Vertical Slurry Wall (mitigate horizontal groundwater flow and improve impoundment stability)

Discrete Zone Construction Horizontal Hydraulic Barrier (vertical and horizontal groundwater flow)

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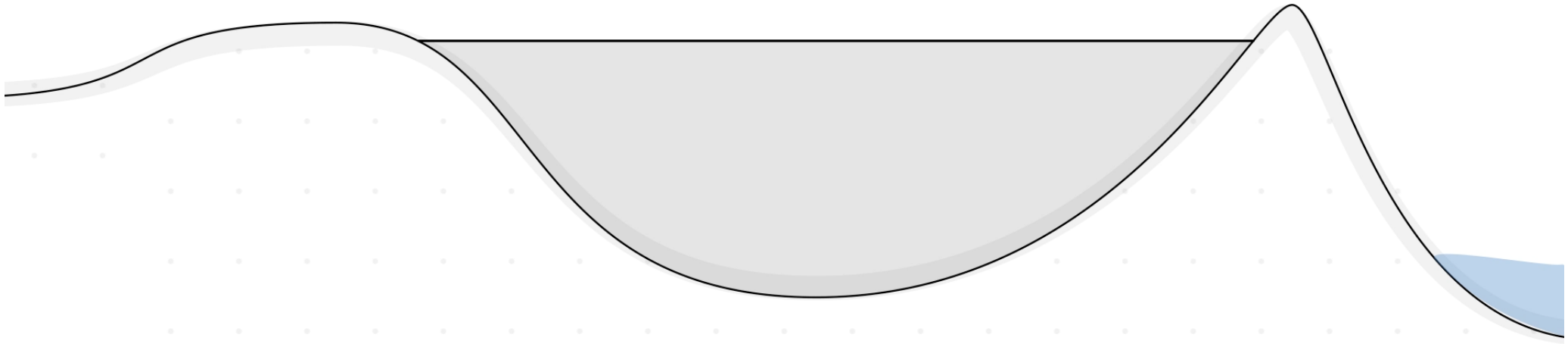
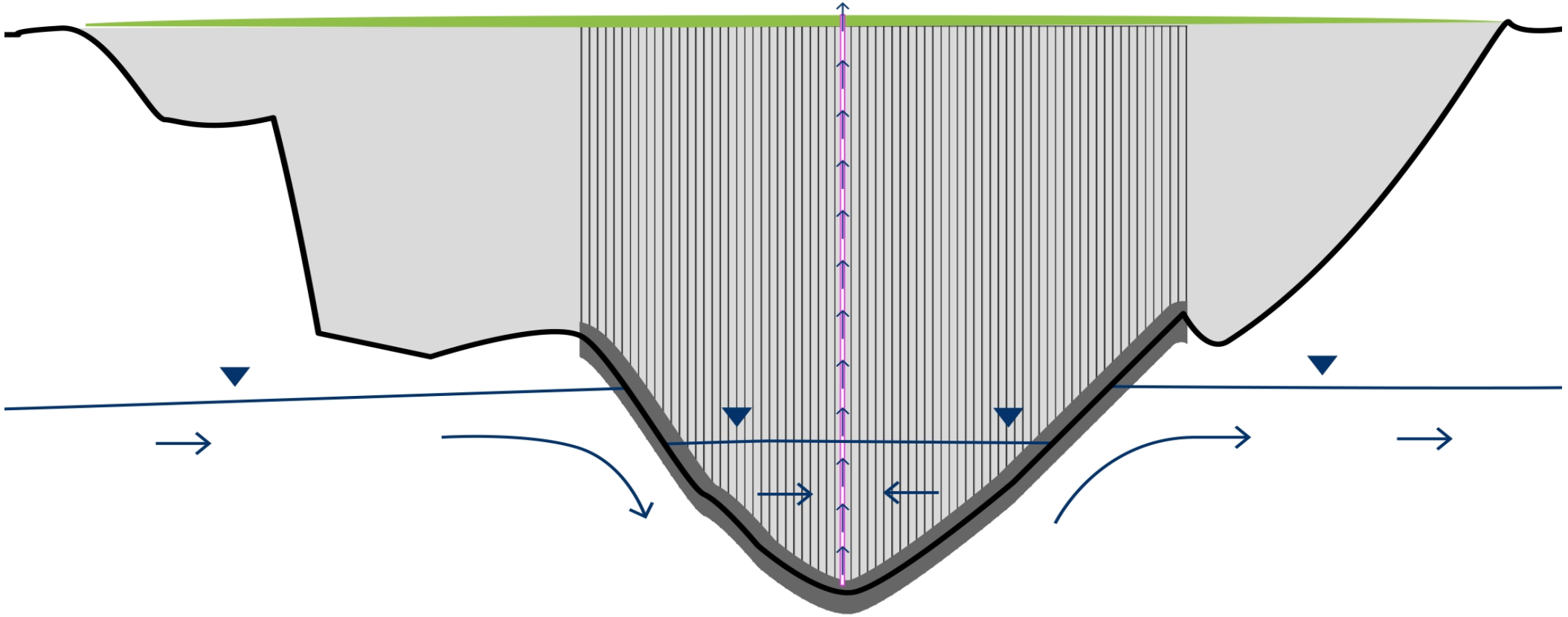
LINK TO ANIMATION CLICK ANYWHERE ON IMAGE



In Situ Waste Remediation and Systems US Patent No. 9,909,277 B2 by SSi

FOCUSED DISCRETE ISS

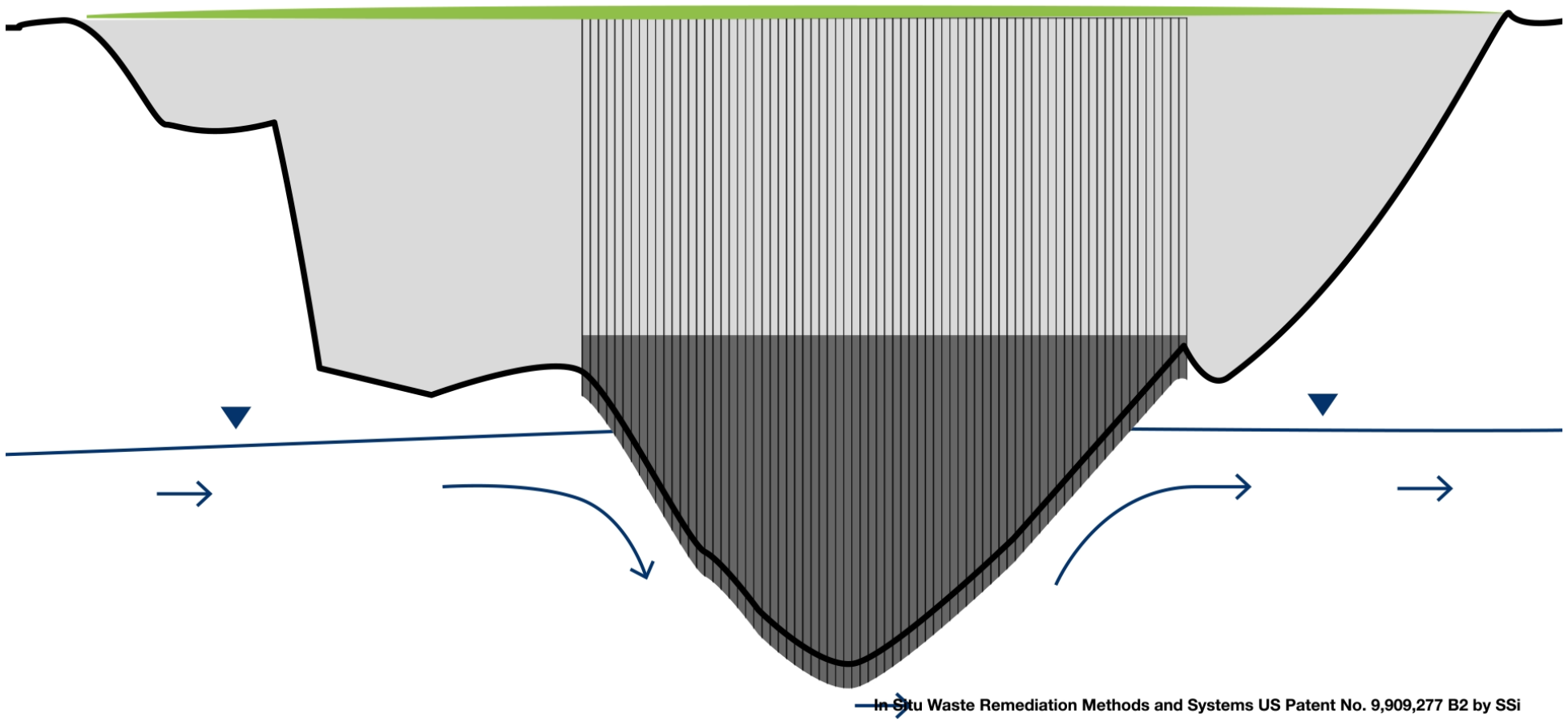
Impoundment with defined and limited saturated area, DISS to mitigate groundwater flow in and out of defined saturated zone. Dewatering may still be required.



In Situ Waste Remediation Methods and Systems US Patent No. 9,909,277 B2 by SSi

EXPANDED FOCUSED DISCRETE ISS

Impoundment with defined and limited saturated area, DISS to eliminate saturated zone.



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Implementation Site Discussion

- Conceptual Site Model
- Closure Objectives
- Summary of Activities

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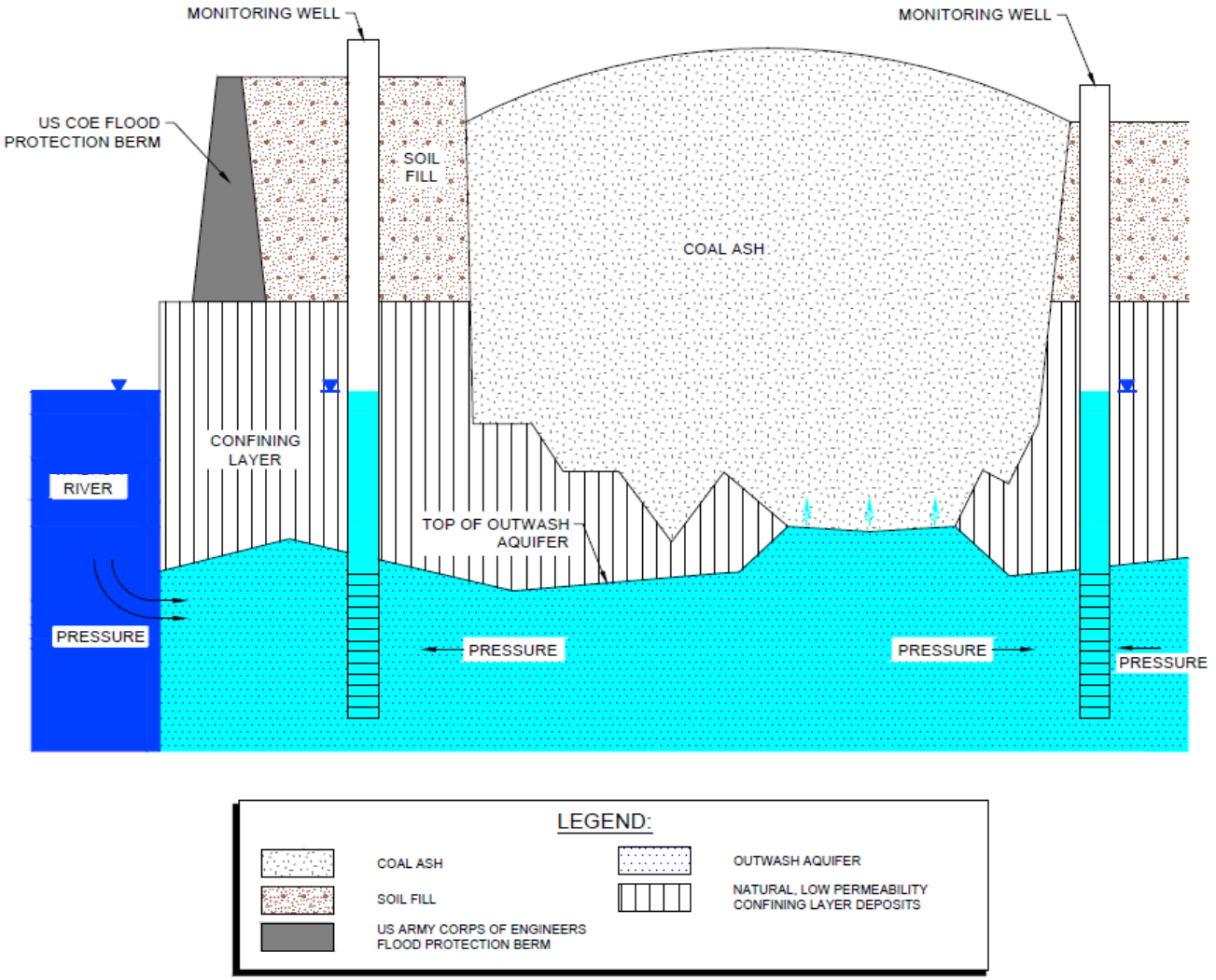
Conceptual Site Model: CCR Impoundment with Vertical Groundwater Migration

- Limited horizontal groundwater flow into impoundment – Pre-existing confining layer
- Impoundment underlain by sand and clay (glacial outwash)
- 135+ acre impoundment with natural clay (confining) layer, ~35 acres where ash is deep or confining layer is not continuous
- Depth of ash up to 60 feet below ground surface
- Closure Plan includes an area of discrete ISS construction to mitigate vertical groundwater infiltration in and out of the impoundment



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Site Closure Objectives

- Design and construct an engineering control that will control, minimize, or eliminate to the maximum extent feasible the movement of liquids from all directions.
- Gain stakeholder approval of the closure approach
- Reduce cost and schedule to achieve closure

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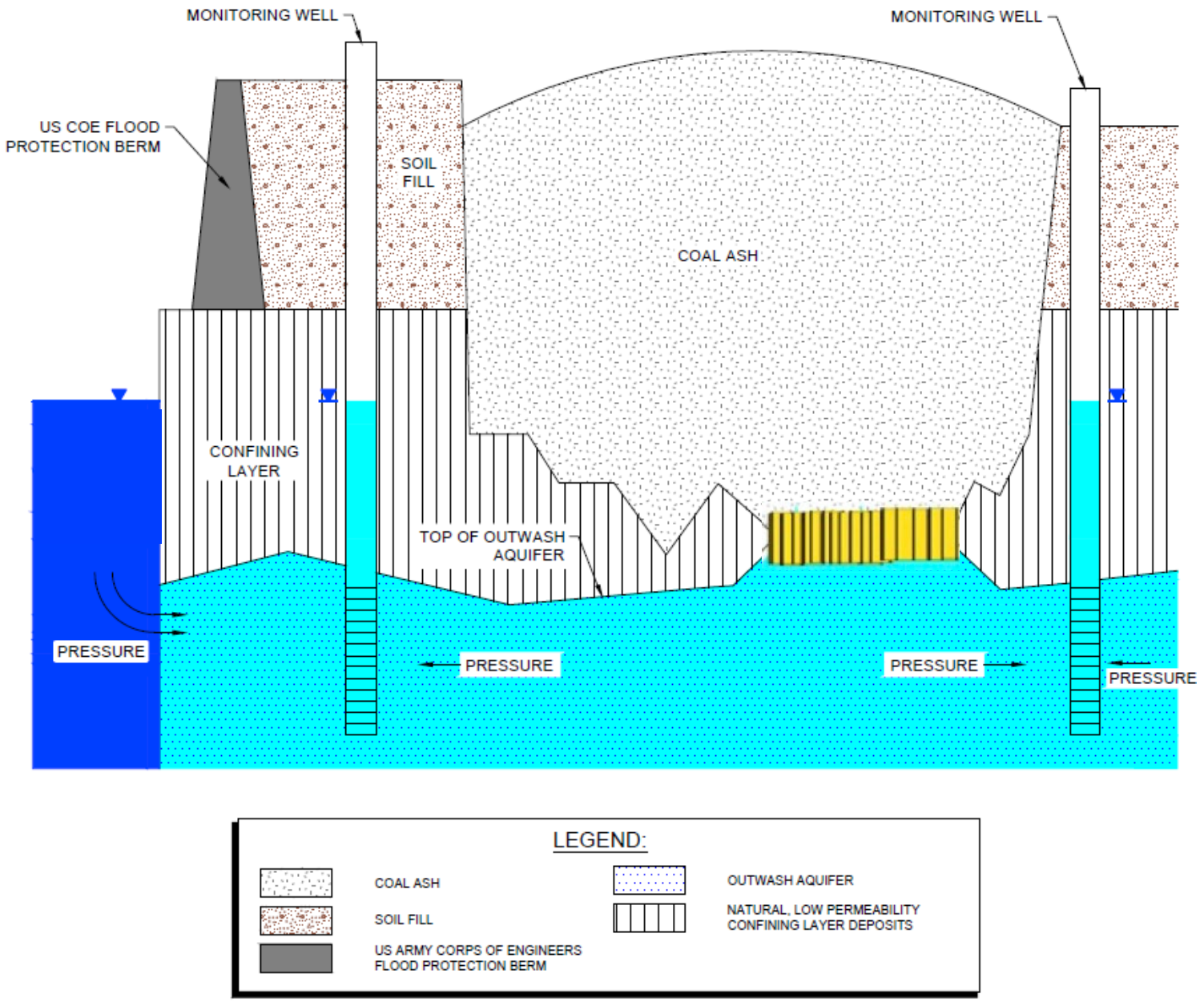
Post- Closure Conceptual Site Model: Vertical Groundwater Flow Mitigated

- Construction of a minimum 4’ thick low permeable zone at the interface of ash and natural material where the ash is deep or confining layer is absent
- Construction of engineered cover system



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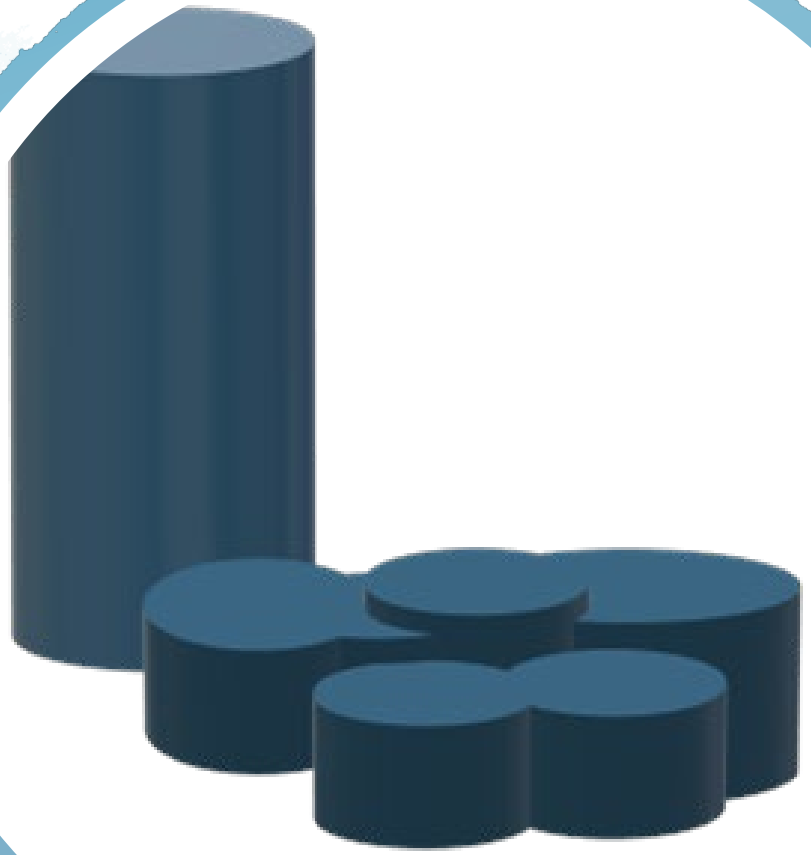

Summary of Major Activities

- Field Investigation to evaluate impoundment characteristics and collect bulk samples for bench scale treatability studies
- Basis of Design
- Bench Scale Treatability Studies
- Contractor prequalification
- Pilot Study
- Full Scale Design and Specifications
- Full Scale Bid and Implementation – Ongoing

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Construction Quality Assurance (CQA)

The following are CQA activities specifically related to the discrete ISS construction and included in the regulator-approved CQA Plan:

- Pre-construction qualifying of material sources;
- Field evaluation/ monitoring;
- Field sample collection and laboratory testing; and
- Deficiencies/Corrections.

Highlights of selected activities follow

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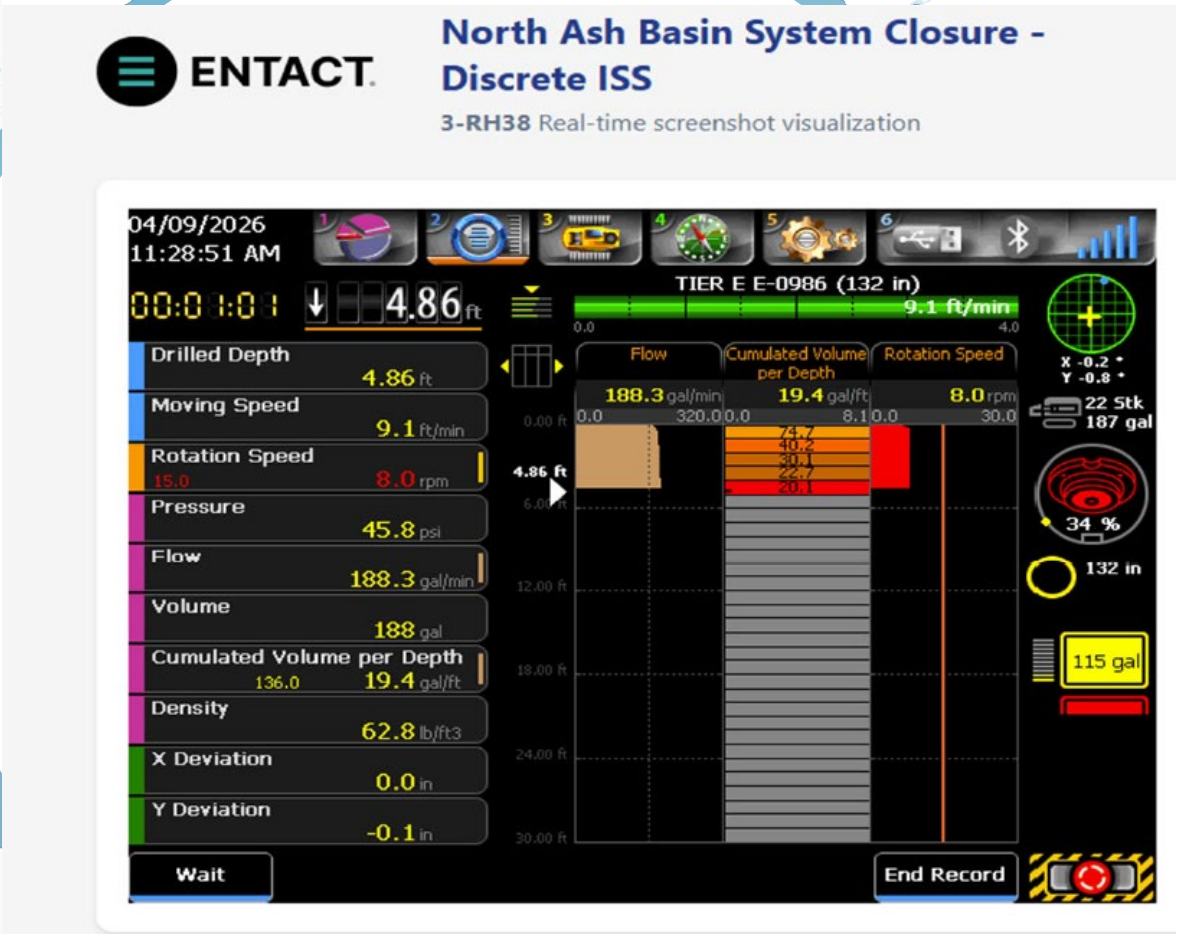
Construction Quality Assurance (CQA)



Field Evaluation/Monitoring

CQA personnel monitor and record data for each ISS column. Examples below:

- Times;
- Locations and elevations;
- Column geometry (tool diameter, overlaps, effective area, length, effective volume);

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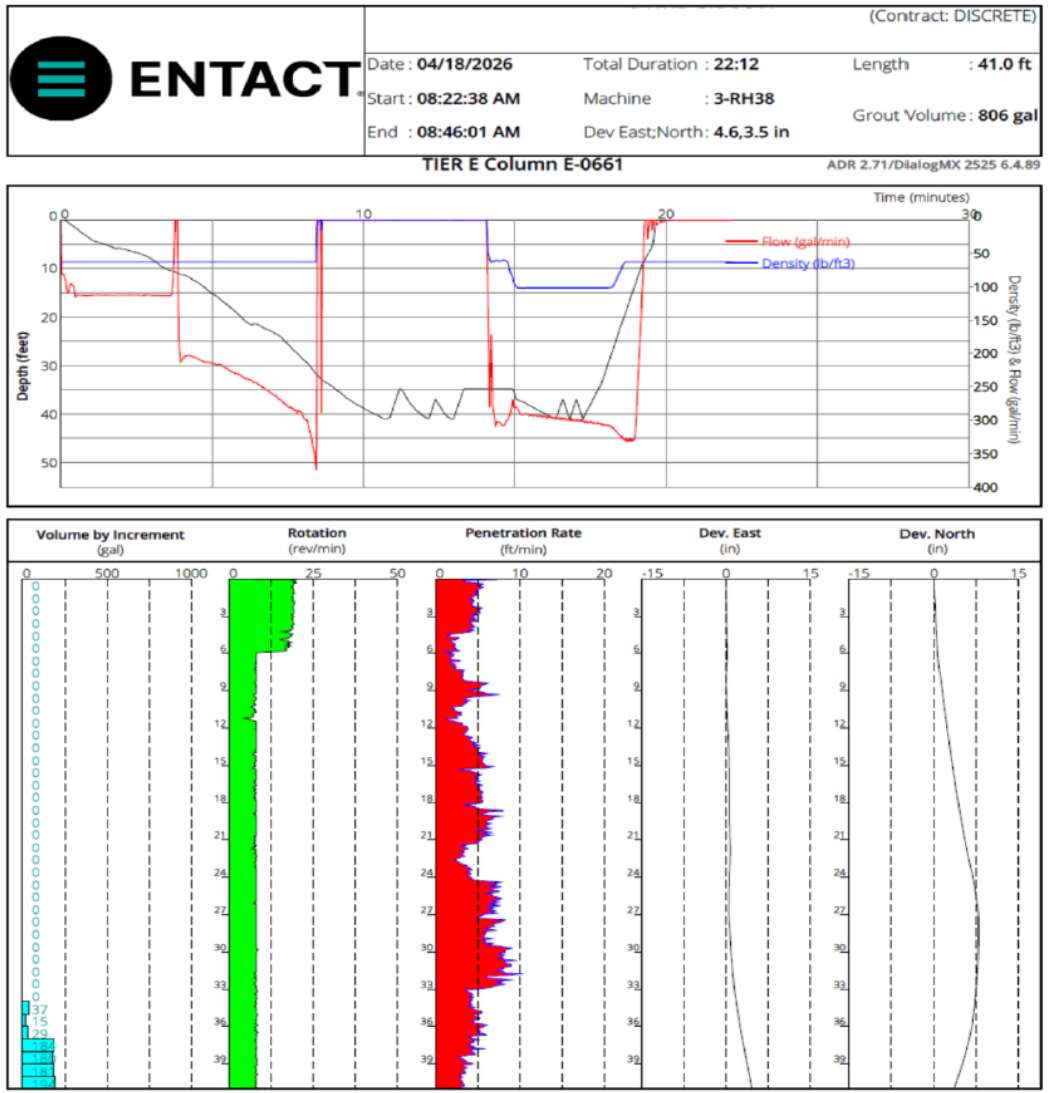

Construction Quality Assurance (CQA)

Field Evaluation/Monitoring

CQA personnel monitor and record data for each ISS column. Examples below:

- Design calculated and actual grout and reagent quantities;
- Mixing passes;
- Obstructions encountered, etc.

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Construction Quality Assurance (CQA)

TEST DESCRIPTION	TEST STANDARD	FIELD SAMPLING FREQUENCY	ISS CONFORMANCE CRITERIA
Hydraulic Conductivity	ASTM D5084	1 sample every 250 cubic yards or 1 every day of ISS production	• 80% of samples ≤ 1×10^{-6} cm/sec • No samples > 1×10^{-5} cm/sec • Geometric mean of all samples ≤ 1×10^{-6} cm/sec
UCS	ASTM D1633	1 sample every 250 cubic yards or 1 every day of ISS production	• 80% of samples ≥ 50 psi • No samples < 35 psi • Average of all samples ≥ 50 psi

Field Sample Collection and Laboratory Testing

- Sample frequency *for each drill rig*: 1 sample/ 250 CY of material treated; minimum of 1 sample/day of discrete ISS production.
- Sampling devices must be capable of being advanced to the target sample depth, opened at that depth and closed before retrieving the samples so that representative samples are collected.
- CQA personnel prepare sample molds and forward to an independent geotechnical laboratory unconfined compressive strength (UCS) and hydraulic conductivity (or permeability) analyses.

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Construction Quality Assurance (CQA)

Deficiencies/Corrections

- If data from the dialog monitoring system indicates incomplete column overlap, the column shall be reprocessed or an additional column installed to address the area of incomplete overlap.
- Reprocessing will be required for all columns represented by samples that fail to meet Performance Criteria for UCS or hydraulic conductivity, subject to the data tolerance limits described in the table above.
- Additional criteria – adjacent samples, consecutive samples

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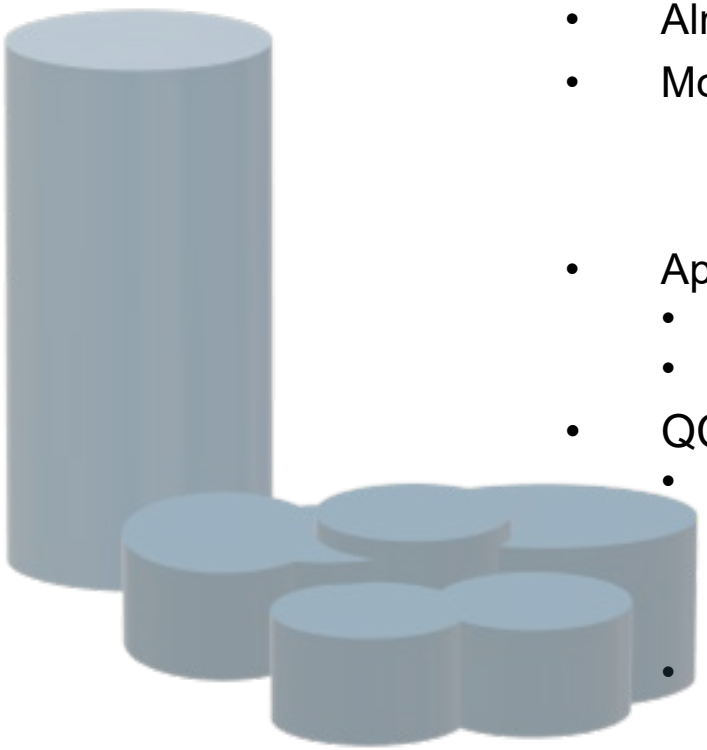
CQA RESULTS TO DATE



Quality Control Activities to Date

- Almost 25,000 columns completed to date
- More than 1,800 QC samples collected to date

Performance Criteria Compliance

- Approximately 80 areas of incomplete column overlap identified and remedied
  - None since switching to larger diameter augers (i.e., greater overlap)
  - Areas of incomplete column overlap can be identified in real time and corrected
- QC Sample Results
  - Hydraulic Conductivity
    - 89.6% of sample results $\leq 1 \times 10^{-6}$ cm/s
    - Geometric Mean of hydraulic conductivity of 2.4×10^{-7} cm/s
    - 2 sample results $> 1 \times 10^{-5}$ cm/s (0.1%) resulting in reprocessing of columns
  - Unconfined Compressive Strength
    - 98.1% of sample results $\geq$ 50 psi
    - Average UCS of 339 psi
    - 20 sample results < 35 psi (1.1%) resulting in reprocessing of columns

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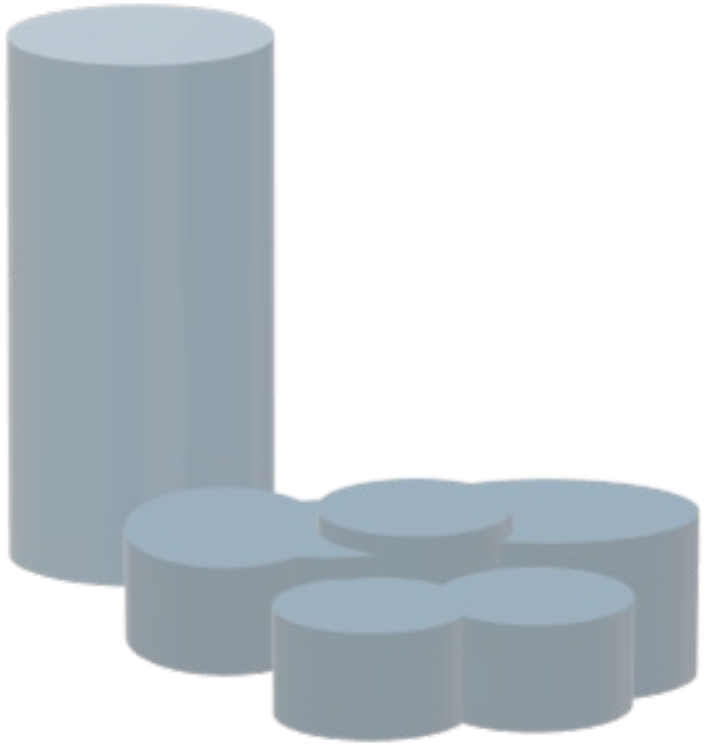
COST EVALUATION:

Discrete ISS compares favorably to Excavation and Disposal and Full Depth ISS of entire impoundment



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Cost Evaluation

Assumption: Impoundment volume is approx. 1.29 million cubic yards (40 acres – 20' thick), bottom 5' of impoundment is saturated

Excavation Assumptions:

- Excavation volume is 1.29 million cubic yards
- Excavated ash will be disposed within 20 miles of the impoundment
- One cubic yard of ash weighs 2,700 lbs
- Excavation will require dewatering and water treatment
- Impoundment will be partially backfilled and vegetated

***In situ* Closure Full ISS Assumptions:**

- ISS volume is ***1.29 million cubic yards***
- Dewatered groundwater will be used in ISS batch plant
- Impoundment will be capped with geotextile, and soil cover

***In situ* Closure Discrete ISS Assumptions:**

- ISS volume is ***366,000 cubic yards*** including 5' thick discrete bottom liner
- Dewatered groundwater will be used in ISS batch plant
- Impoundment will be capped with geotextile, and soil cover

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Cost Summary

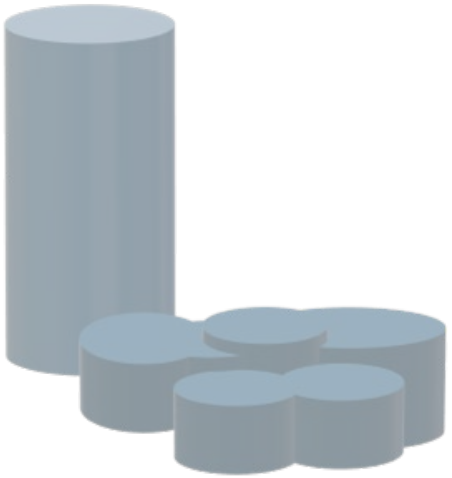
- Excavation/Off-Site Disposal - Total Cost $96,000,000
  $2,400,000 per acre

- Full ISS - Total Cost $97,000,000
  $2,425,000 per acre

- Discrete ISS – Total Cost $42,500,000
  $1,062,500 per acre

Site Cost Summary

- Closure options for Site as per regulators:
  - excavate 135 acres of ash
  - discrete ISS 35 acres
- Utility estimate to excavate impoundment was $300 to $400 million ($2.2-3.0 million/acre).
- Bid price to discrete ISS 35 acres is ~$50 million ($1.42 million/acre)



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Different Stakeholders – Shared Goals

Stakeholders: Impoundment Owners, Regulators, Environmental Groups, General Public, Rate Payers

In-situ Closure Technology with Discrete Zone ISS Satisfies Key Objectives & Reduces Risk

- **Minimizes groundwater infiltration both horizontal and vertical**
- **Combined closure and corrective action avoids potential environmental impacts and risks associated with siting and permitting new landfills, ash excavation/handling, ash transportation, etc.**
- **Closure technology is a cost-effective remedy that will meet regulatory closure requirements**
- **Timely implementation of closure**

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Summary of Key Points/Beneficial Outcomes

- Hydraulically isolates, both horizontally and vertically, CCRs from groundwater meeting regulator requirements
- Eliminates need for removal of CCR from impoundments and allows for future harvesting
- Reduces costs & risks
- Provides environmental benefits: landfill space, emissions, etc.
- Relies on proven technology with readily available resources

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Thank you

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2019 WOCA Paper "*In-Situ* Impoundment Closure and Groundwater Corrective Action Technology"

In Situ Waste Remediation and Systems

US Patent No. 9,909,277 B2

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Questions ???

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