In Situ Solidification Approaches at MGP Sites to Reduce Costs/ Uncertainties and Address Challenging Site Conditions

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Outline

1. Background
2. ISS Source Zone Remediation
   A. Key Design/Implementation Considerations
   B. Implementation at Three MGP Sites
3. Use of ISS Soil Mix Wall at MGP Site
4. ISS Benefits and Conclusions

Yesterday's power source

- Early 1800s to 1950s
- Industrial facilities produced gas from coal or oil feedstocks
- Gas was stored and piped to the surrounding area for lighting, cooking, and heating homes and businesses
- Process generated a variety of waste products, notably coal tar
- Replaced by natural gas

MGP Remediation challenges

- Coal tar DNAPL
- Difficult to treat PAHs
- Large quantities
- Challenging subsurface conditions
  - Highly variable fill materials
  - Debris
  - Relic subsurface structures and piping
- Proximity to sensitive features (buildings, roads, railroads, utilities)

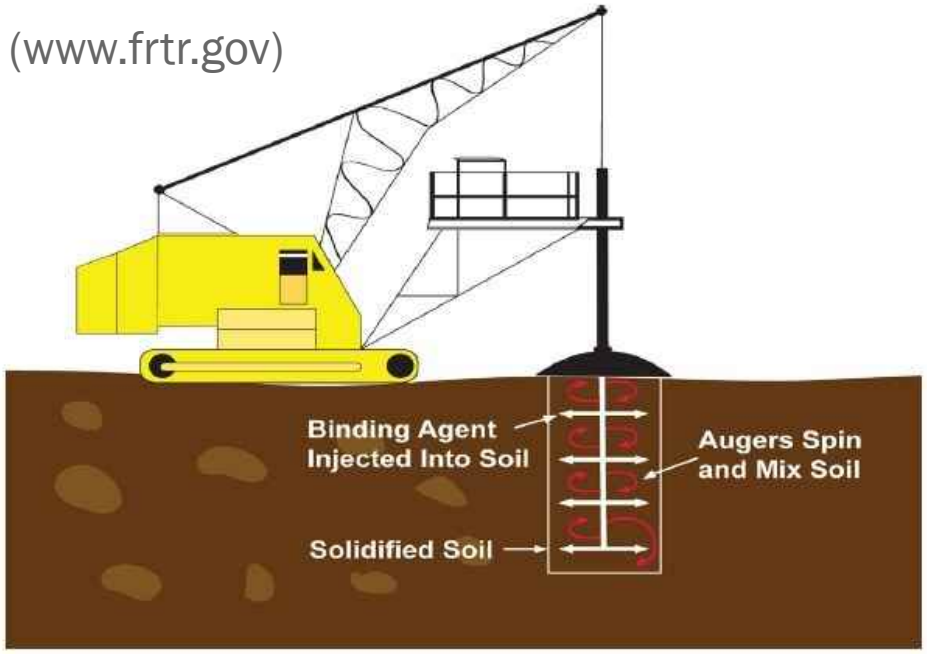
How to address these challenges?

In Situ Solidification (ISS)

ISS

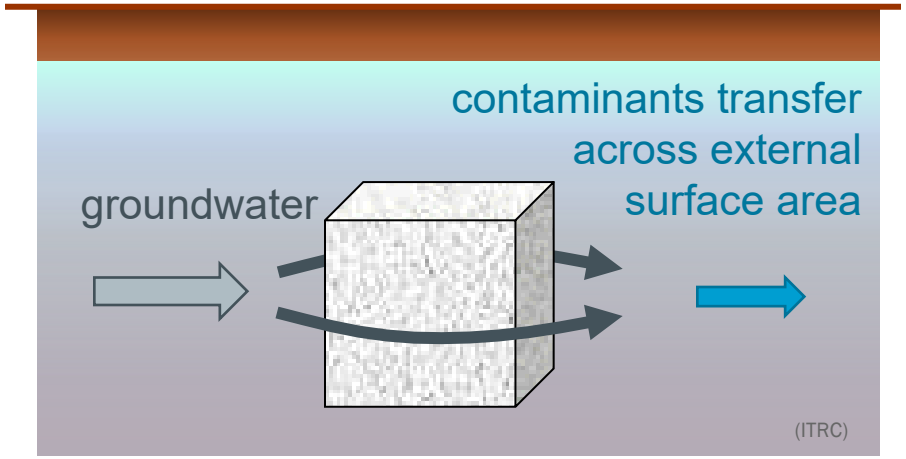
- Mixes various binders/additives into soil/sediment to physically entrap or chemically treat contaminants
- Mixing can occur using large diameter augers, excavators, or through grout injection
- Bucket mixing generally preferred approach for these sites:
  - Can handle fill with high quantities of debris
  - More efficient in dealing with obstructions (pipes, structures)
  - Depth generally limited to ~30-35 feet

(www.frtr.gov)



ISS source zone remediation

Encapsulates coal tar impacts and impacted soil within a low permeability monolith to restrict NAPL mobility and reduces groundwater interaction with COCs



Key design/implementation considerations

Performance criteria

- Typical parameters: UCS and Permeability
  - UCS: indicator of chemical reaction/binding and durability
    - UCS > 50 psi (also don't want too high – want to be excavatable)
  - Hydraulic Conductivity (K): measure of water movement through media
    - K < 1e-6 cm/s
- Leachability (e.g., SPLP)
  - Confirmed through bench testing or prior experience
  - Usually not a parameter tested for during implementation

Bench Testing

- Confirm ability to meet performance criteria
- Evaluate different mix designs
- Evaluate different water:cement ratios

Field Testing

- Confirm selected mix can meet criteria in field
- Confirm equipment capabilities
- Can be done pre-mob or post-mob

Key design/implementation considerations

ISS Treatment Zone

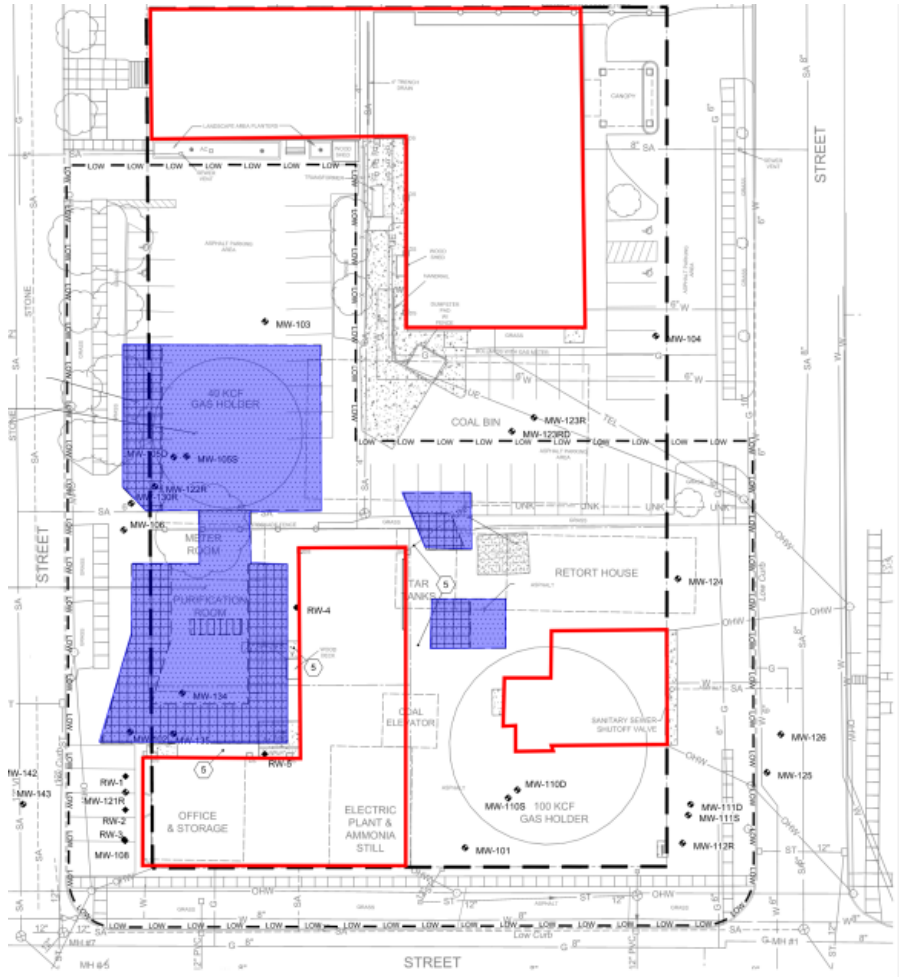
- Pre-define the lateral extents and depth transitions through boring program
- How is bottom being defined?

What else is in the treatment zone?

- Utilities
- Subsurface structures – investigate thoroughly
- Pro-actively manage utilities and obstructions – re-route or design around utilities and pre-clear obstructions as much as possible

Proximity to sensitive features

- Establish off-sets
- Is ISS protective alone or is shoring needed?
- Monitoring vibrations, settlement, and cracks

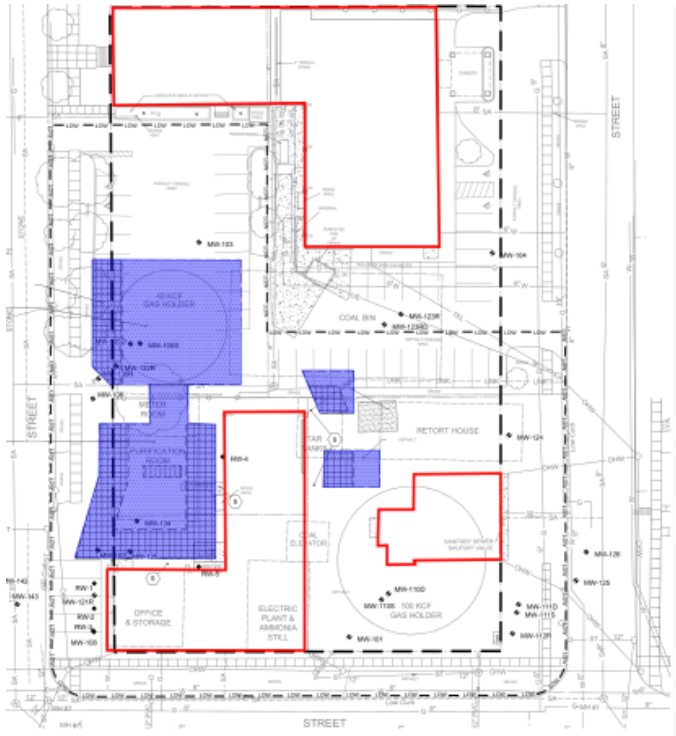


Key design/implementation considerations

- Impact on groundwater flow: groundwater modeling may be needed
- Swell: typically 5-20% and needs to be accounted for in design
- Surface cover: frost protection may require thick cover in northern climates
- Adequate space: requires space for grout plant, material silos, and large machine
- Contractor submittals: for final cell layout and grout addition tables tailored to equipment to be used and production rates
- Performance monitoring: visual observation of the mix, sample collection for physical testing (UCS and perm), coring
- Pre-ISS excavation: control surface migration, accommodate swell, establish operating platform for deep mixing, pre-clear obstructions
- ISS mixing XYZ control/confirmation: GPS and/or surveying
- Post-ISS excavation: remove swell, achieve final grades, and accommodate surface cover

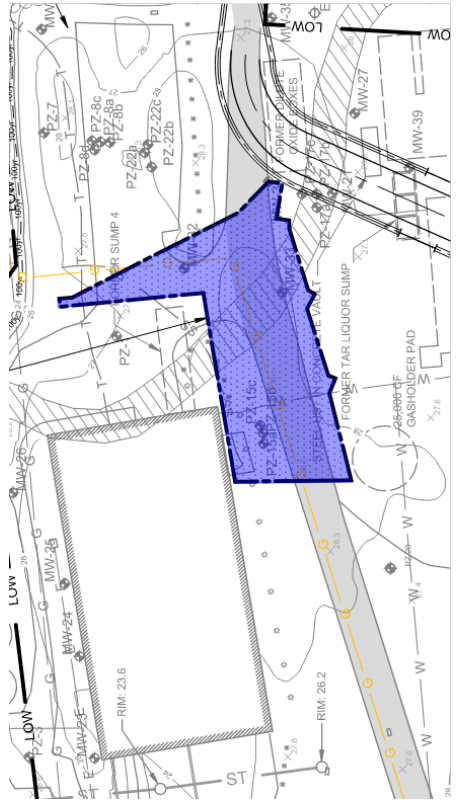
ISS source zone remediation – in action

Performed to treat source zones – areas with visible coal tar and/or elevated concentrations of PAHs (>500 ppm)



MGP Site 1

MGP Site 2



MGP Site 3

MGP Site 1

- Small site
- Surrounded by active businesses
- Buildings, utilities, roads
- Dense glacial till

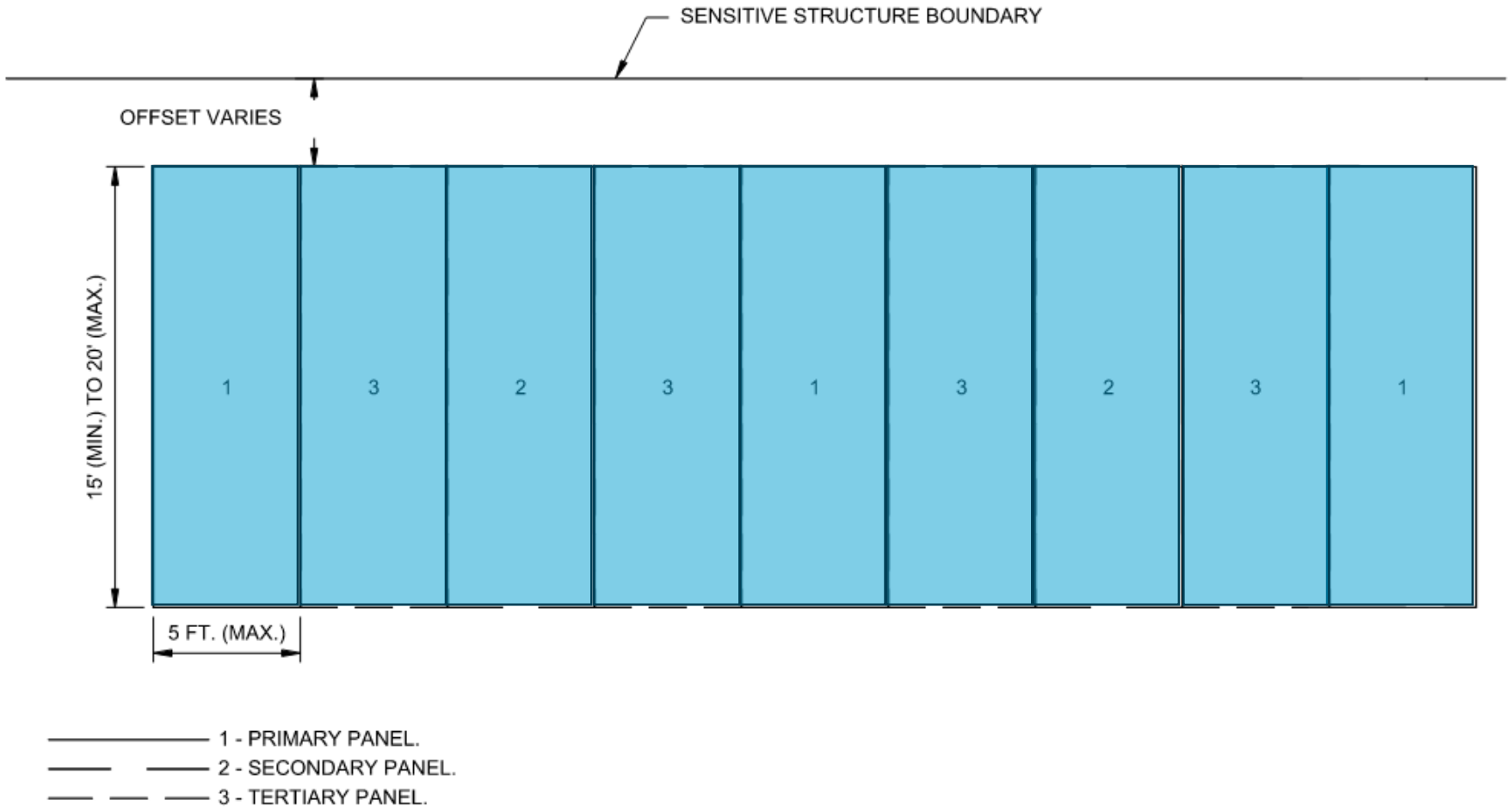
MGP Site 2

- Large site
- Buildings, utilities, roads
- Weathered bedrock surface
- Proximity to river

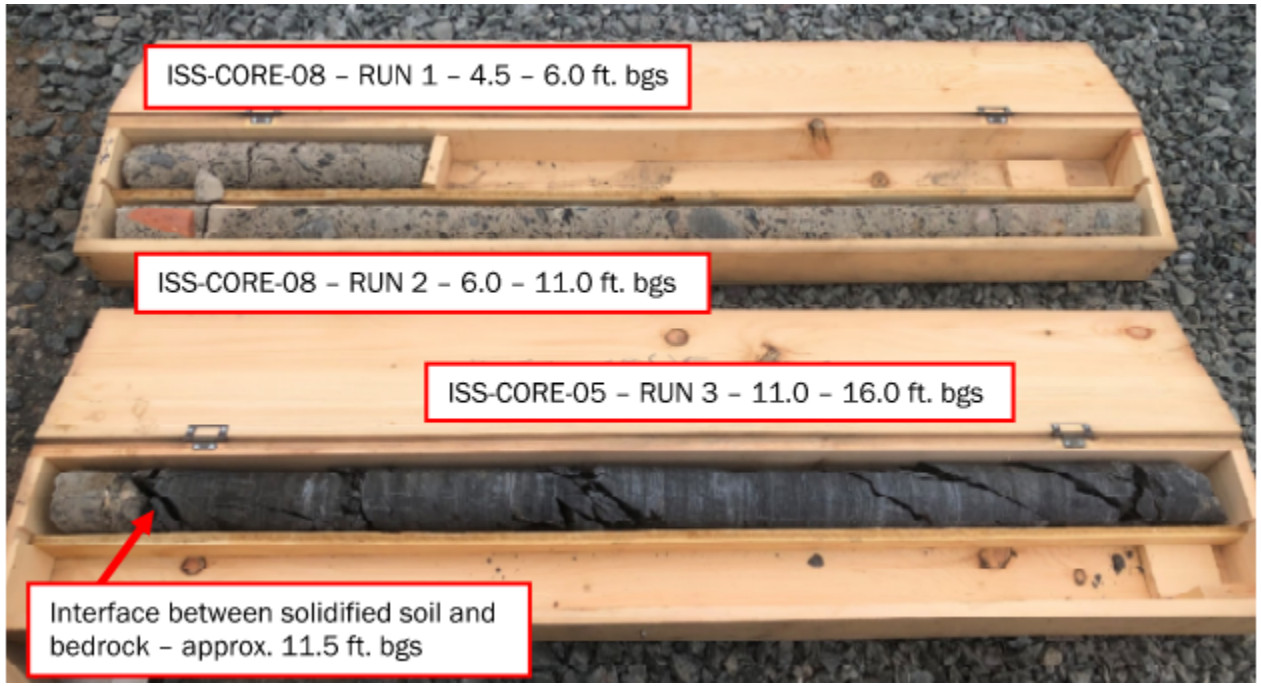
MGP Site 3

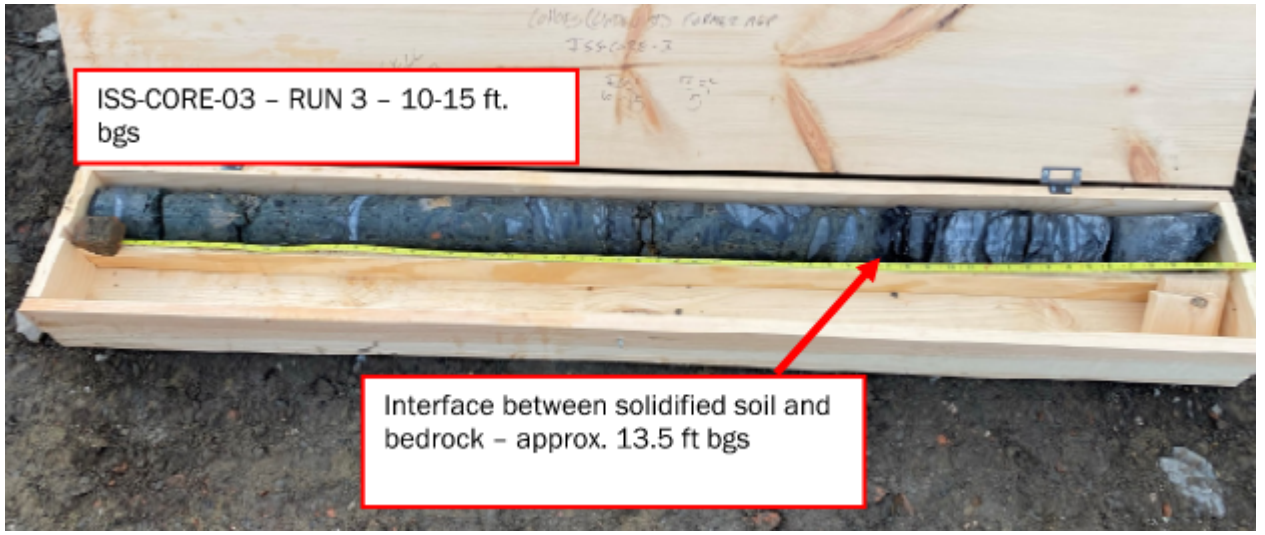
- Large site (first phase)
- Buildings, utilities, roads
- Extensive structures and difficult fill
- Deep
- Soft bottom

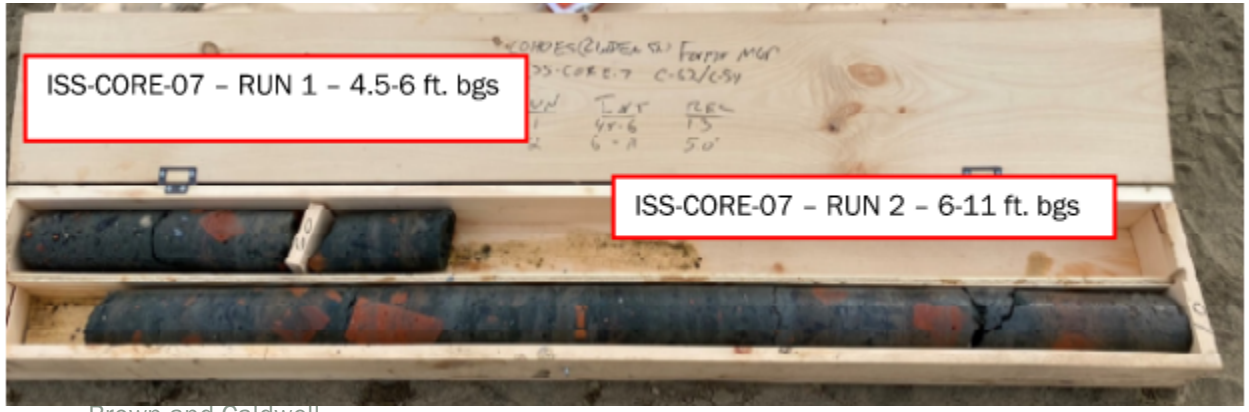
ISS Near Sensitive Features

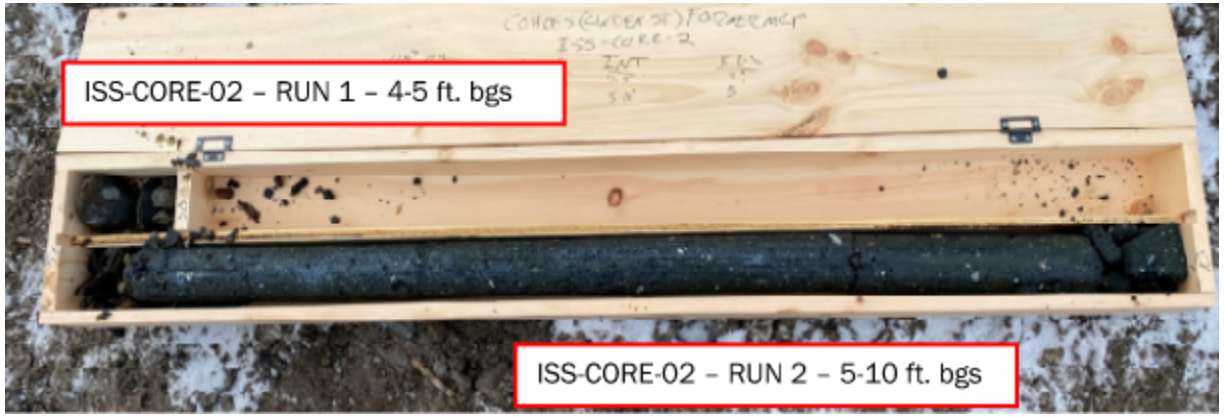


ISS Cores


ISS-CORE-08 – RUN 1 – 4.5 – 6.0 ft. bgs
ISS-CORE-08 – RUN 2 – 6.0 – 11.0 ft. bgs
ISS-CORE-05 – RUN 3 – 11.0 – 16.0 ft. bgs
Interface between solidified soil and bedrock – approx. 11.5 ft. bgs


ISS-CORE-03 – RUN 3 – 10-15 ft. bgs
Interface between solidified soil and bedrock – approx. 13.5 ft bgs


ISS-CORE-07 – RUN 1 – 4.5-6 ft. bgs
ISS-CORE-07 – RUN 2 – 6-11 ft. bgs


ISS-CORE-02 – RUN 1 – 4-5 ft. bgs
ISS-CORE-02 – RUN 2 – 5-10 ft. bgs

Summary Stats – ISS Source Zone Remediation

MGP Site	Mix Design	Water:Cement Ratio	ISS Area (sf)	ISS Volume (cy)	Max Depth (ft)	Cells	Duration (weeks)	Pre-Cut (cy)	Post-Cut (cy)	Avg Swell (%)	Avg UCS (psi)	GoeMean K (cm/s)
1	10-12% 60:40 PC/GGBFS	1:1 to 1.7:1	10,500	6,300	25	70	14.5	1,200	1,400	17%	200-300	3.6E-07
2	12% 60:40 PC/GGBFS	0.8:1 to 1:1	75,500	26,000	23	203	20.5	9,100	7,400	20%	300	6.2E-07
3	10% 60:40 PC/GGBFS + 0.1-0.2% Bentonite	1.25:1	13,400	13,600	34.5	54	8	2,570	1,390	15%	400	3.1E-07

ISS Soil Mix Wall - MGP Site 4

MGP Site 4

- 10% dosage rate (by wet-weight of soil) of a 60:40 blend of PC
- 1.25:1 water to cement ratio in grout
- 8,000 cy of ISS to create 1,800 linear feet of soil mix wall
- Installed to bedrock (deepest to 15 feet), 0.9 Width to Depth Ratio
- ISS soil mix wall facilitated over 32,000 cy of excavation within walls
- UCS ~ 100-300 psi
  - Goal > 50 psi
- K: 1e-6 to 1e-7 cm/s range
  - Goal < 1e-5 cm/s (higher than for ISS application)

ISS Benefits

- Approx. 75,000-ton reduction in T&D on these 4 sites alone
- More than 50,000 cy reduction in imported fill
- Avoided need for sheeting/shoring
- Reduced dewatering requirements
- No detrimental impacts to buildings, utilities, roads
- No added long-term O&M requirements

To date, ISS has resulted in an estimated **$12 MM** capital cost avoidance for these four projects (total actual costs to date ~$30 MM).

This will ***increase substantially*** as additional ISS phases are completed at several of the sites.

Cost certainty. All four projects came in at or below the initial contract amount (+0.1%, -2%, -5%, and -7%, respectively).

Thank you.

Questions?

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