Sediment Cap Design, Modeling, and Construction

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Agenda

- Site background
- Capping considerations & objectives
- Sediment cap design & modeling
- Cap construction challenges
- Construction implementation

Background – former MGP in Flint, MI

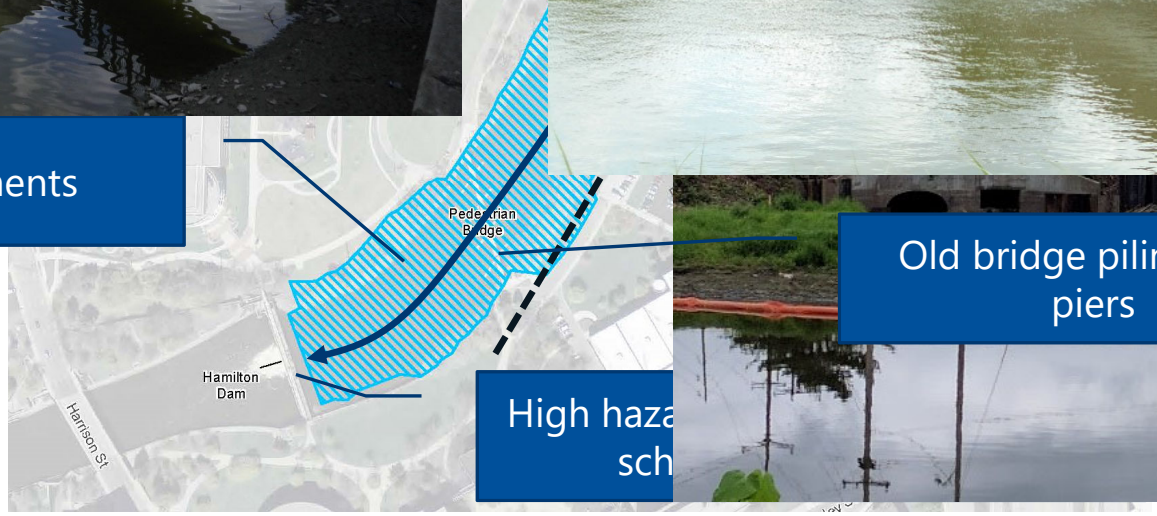
Photo courtesy of Special Collections and University Archives, Kettering University

Sediment cap objectives

1. Create a barrier between remaining impacted sediments below the cap and the river
2. Provide stable riverbanks and riverbed
3. Develop channel /cap geometry compatible with river hydrodynamics
4. Incorporate bedform diversity elements for improved aquatic habitat

Capping considerations – site layout & features

Soft sediments



High haza
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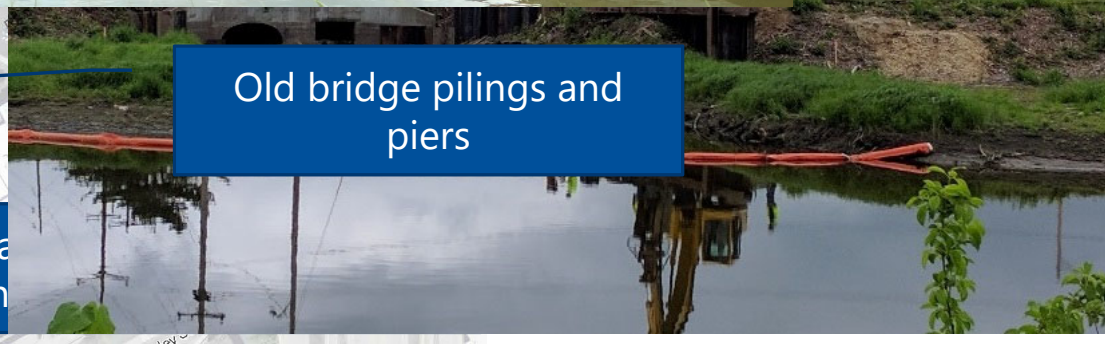


Old bridge pilings and piers

Sediment cap design: liner evaluation

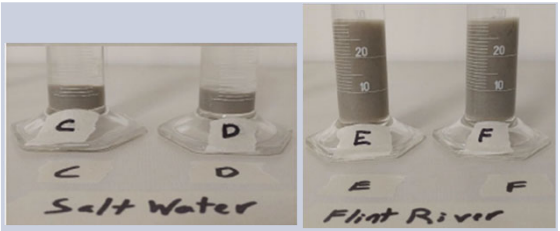
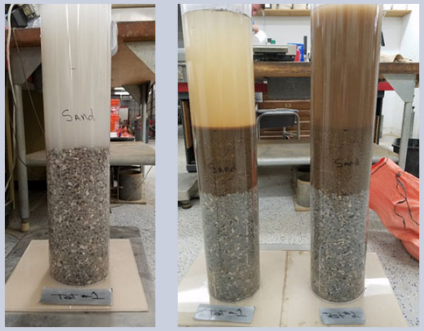
Liner options:

- Bentonite (clay)
- Bentonite (clay) and aggregate
- Geocomposite clay mat
- Geosynthetic fabrics and geomembranes

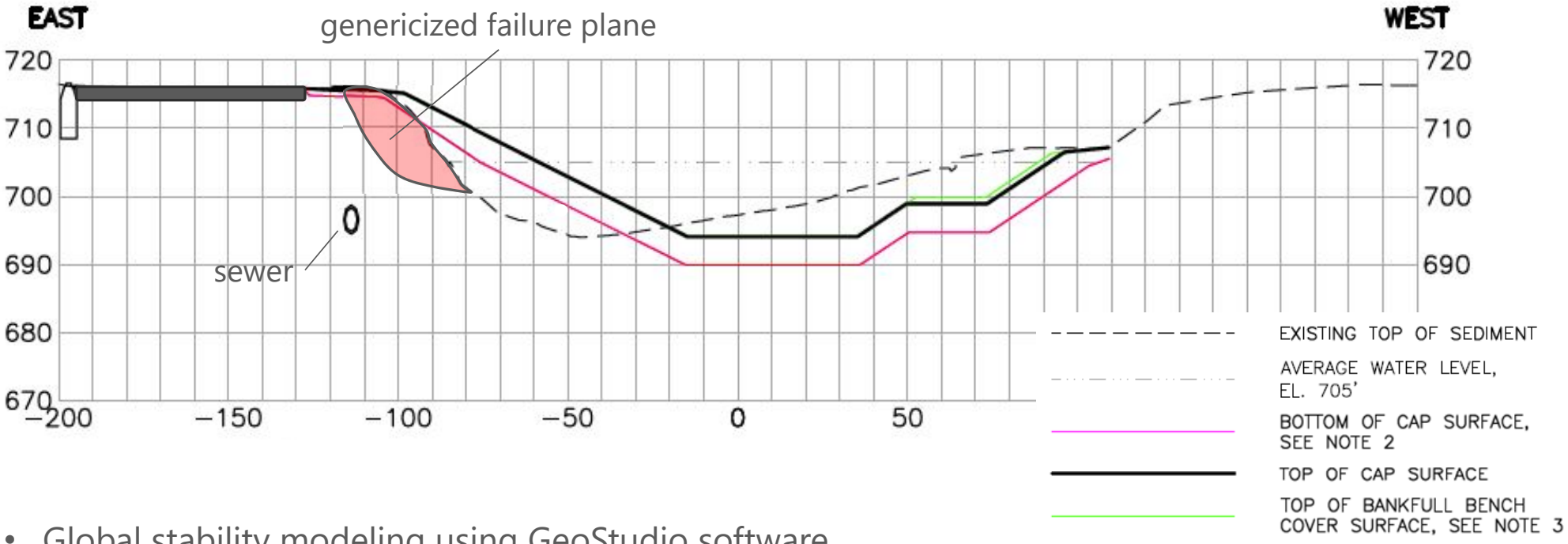
Blended Barrier

Textured HDPE

Sediment cap design – assessing technical limitations

Blended Barrier	Assessment and Result	Test	Construction Consideration
Ability to form adequate barrier (low permeability) in river conditions	Bentonite swell tests confirmed behavior.		Maintaining integrity of AquaBlok material during installation essential to success.
Potential lack of material strength and stability limitations	Triaxial compression tests provided inputs for stability modeling and slope angle selection.		Material will stay on slope if reasonably densified.
Maintaining integrity of capping material during installation and resilience to deterioration	Column capping tests aided in cover timing determination: density and strength w/ unconfined vs. confined hydration.		Timing important, but not critical; minimal segregation with controlled placement. Risk of erodibility if not covered expeditiously.

Sediment cap design – stability modeling



- Global stability modeling using GeoStudio software
- Global stability models were revised by incrementally setting the blended barrier and underlying soils to be impenetrable to simulate a veneer failure scenario
- USAA, ESAA, and rapid DD simulations performed

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Sediment cap design – use of stability modeling results

Design Values	Construction Consideration
Blended barrier in place density set at 95 pcf (min) to provide adequate strength to resist shear failure	Achievable with intended controlled construction approach
Slope angle below water set at 3H:1V (min)	Achievable with controlled (GPS) dredging and filling operations following BMPs
Geomembrane friction angle set at 27° (min) to provide adequate factor of safety against sliding	Achievable with commercially available textured HDPE liners

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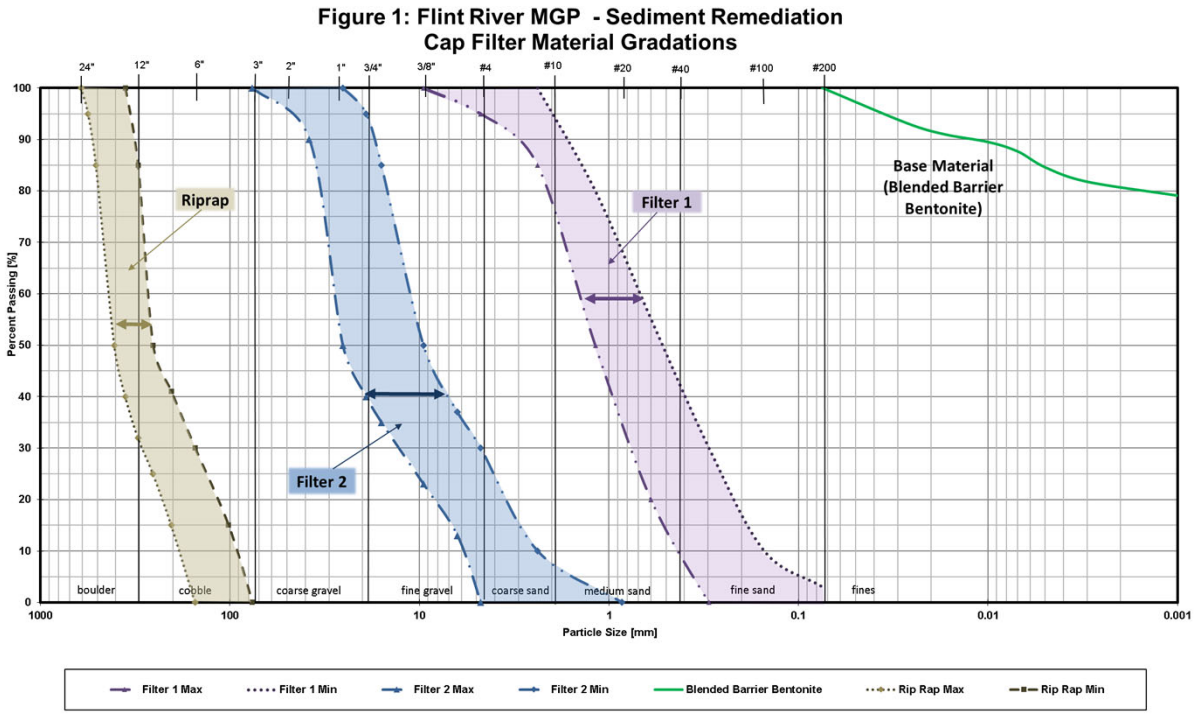
Sediment cap design – filtering & clay hydration

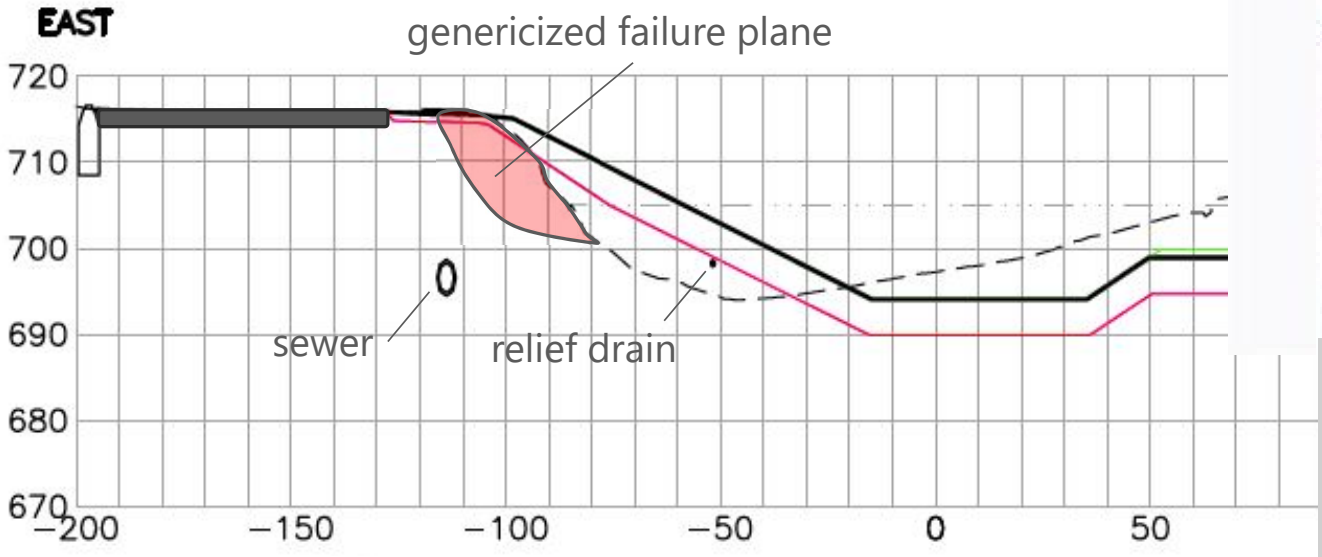
Design Requirement	Construction Consideration
Adequate filtering – from clay sized fraction (AquaBlok) to large rip rap surface to avoid fines migration	Achievable with multi-layers
Protection of clay from DNAPL during hydration	Provision of sand under layer



Sediment cap design – uplift protection

Mitigate potential uplift of barrier due to hydrostatic pressure buildup

- Relief drain installation
- Installation of vibrating wire piezometers below cap to monitor pressures



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Sediment cap design – including bedform diversity

Bedform diversity elements

- Bankfull bench
- Riffles
- Rip rap surface infilling

Please refer to "Balancing Remedial and Restoration Objectives for Sediment Capping on an Urban River" presentation by Tom MacDonald for more on this topic

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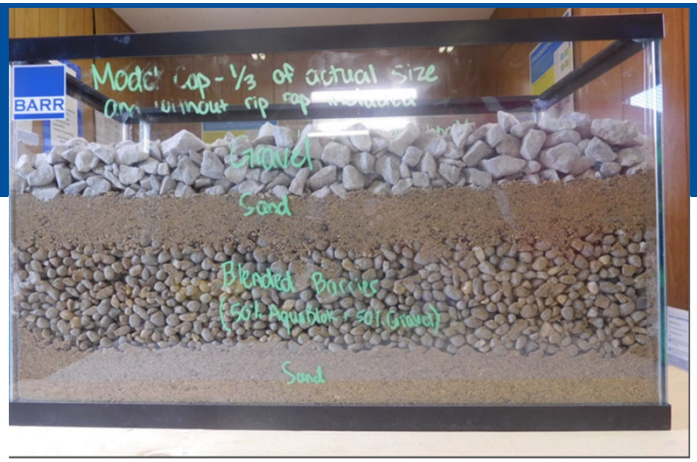
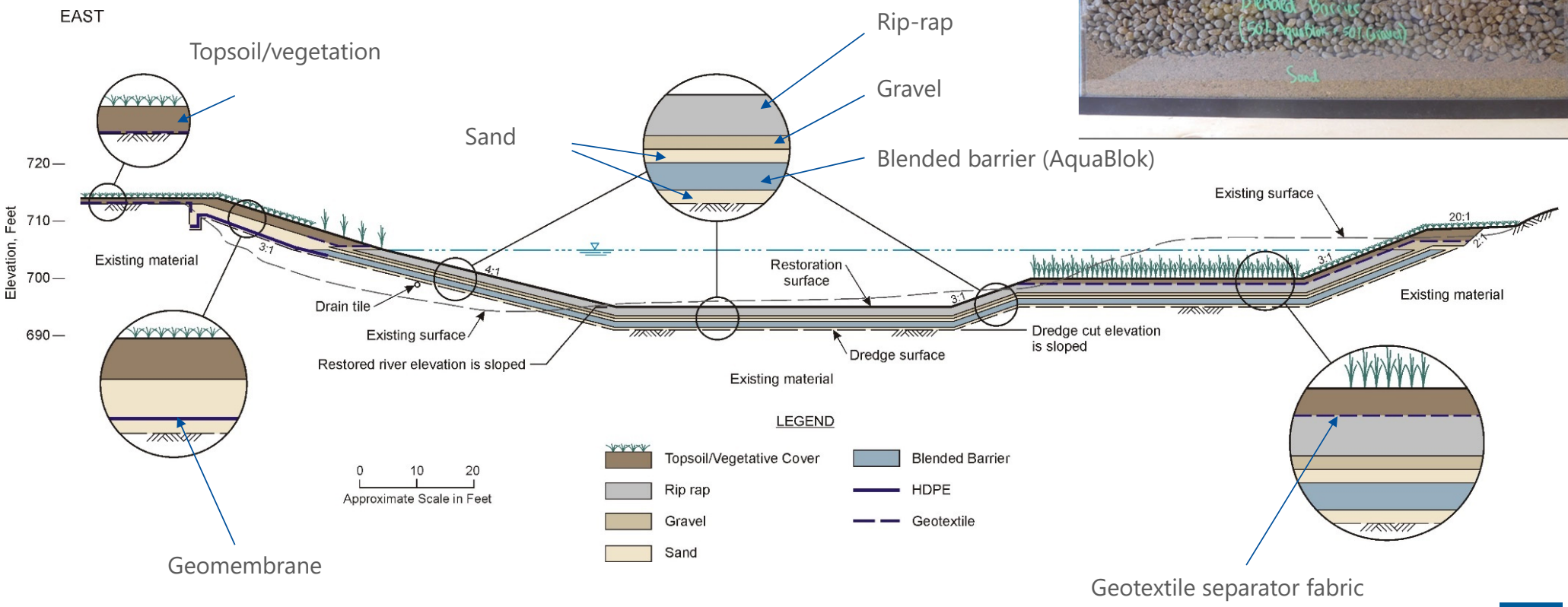
Sediment cap design – final product





Geomembrane

Geotextile separator fabric

Sediment cap performance specifications

Focused on cap material integrity

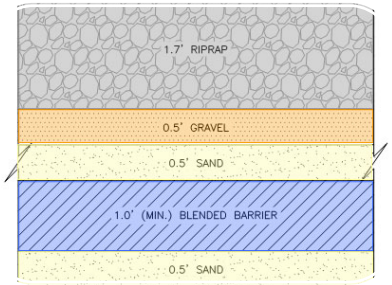
1. Capping material handling – from receipt to deployment
2. Mixing blended barrier
3. Placement of capping material
4. Meeting capping thickness tolerances

careful phasing/sequencing/controlled placement processes needed to realize design intent

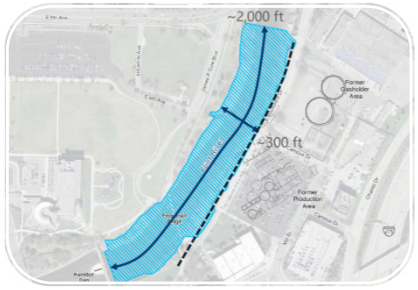
Implementation challenges

Aggressive Schedule

Handling of Capping Materials



Careful Sequencing & Phasing of Placement



Working within Operational Constraints

Timely Capping Survey and Approval Process

Adapting to Site Conditions

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Mobilization – significant & expedited

- Mobilized 100+ pieces of equipment
- Assembled two sectional barge platforms
- Constructed a 35,000 sf lined asphalt dewatering pad
- Erected two temporary fabric structures; one with air handling units
- Constructed a temporary waste water treatment plant
- Constructed two steel sheet pile, waler supported platforms on the bank of the Flint River

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Process: Mixture -> Placement

- AquaBlok and AASHTO #8 stone loaded into feed hoppers to produce Blended Barrier
- Stockpile Blended Barrier in temporary fabric structure (TFS)
- Transport material from TFS to offloading platform
- Load scows with Blended Barrier
- Barge mounted excavator with clamshell bucket removes Blended Barrier from scow and places into river

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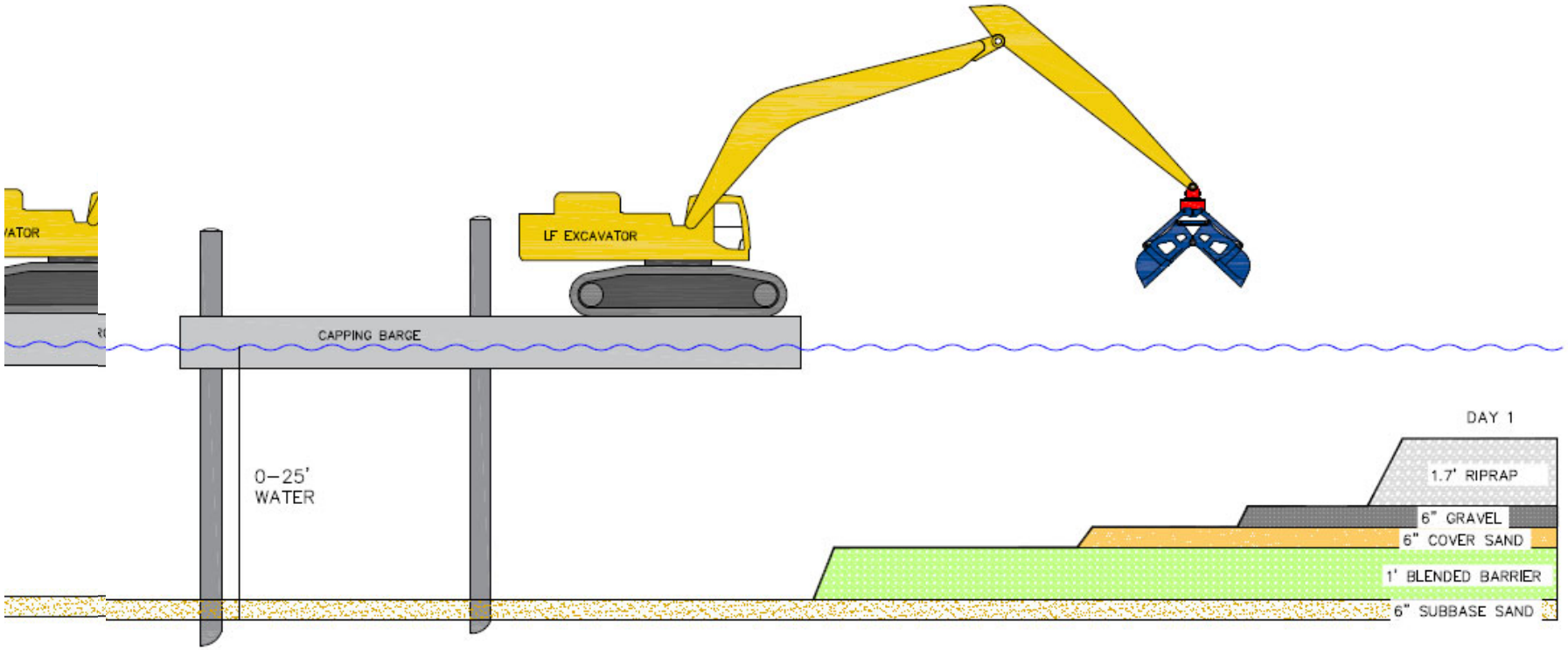
Capping sequence: layered cake



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Operational constraints & challenges

- Concurrent dredging & capping work
- Fastidious capping process
- Spudding restriction
- Infrastructure protection
  - Dam, retaining wall, bridge, large sewer, storm pipe outfalls
- Changing river conditions

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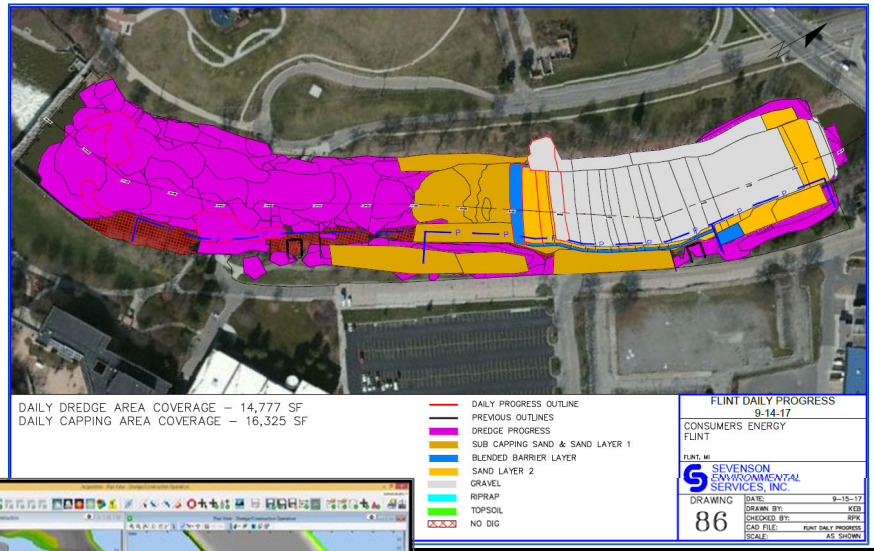
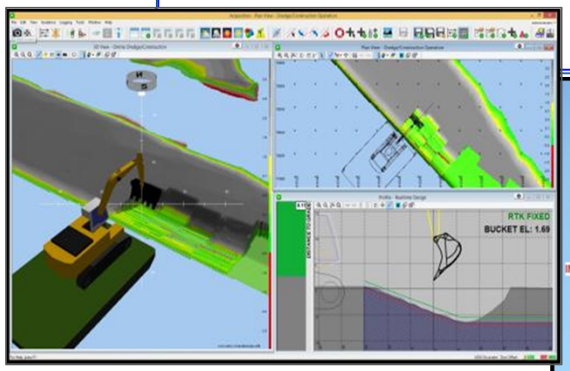
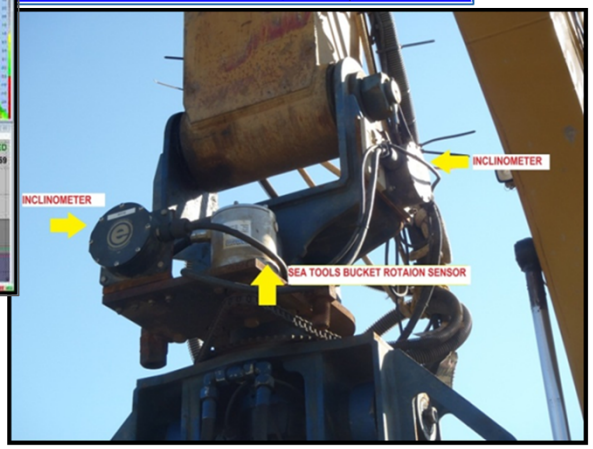
Fastidious capping process







- Extensive coordination between field crews was needed to install different capping layer materials daily
- Blended Barrier layer to be covered within 24 hours of placement to meet density requirements and avoid bentonite erosion
- Uncompromising management of capping materials
- State of the art positioning hardware & software to meet capping thicknesses and tolerances
- Daily survey, review, and approval process used to move forward with confidence

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River condition challenges

- Changing current velocity, and drastic water elevation fluctuations
- Cap installation within close proximity of a deteriorated dam
- Deep excavation for sump installation adjacent to the river, diver assisted drain installation
- Turbidity management – proactive & adaptive

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Maintaining slope stability

- Coordinated water platform and land based approach
- Equipment setbacks to offset load from slope crest
- Toe to top, thin lift capping material placement to mitigate underwater slope failure
- Pore pressure monitoring

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Safety

- 2018 WEDA Project Safety Award Winner
  - Team effort (owner, engineer, & contractor) resulting in +65,000 safe work hours

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Final product

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