Sediment Cap Design, Modeling, and Construction at a Former MGP Site

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Great Lakes Environmental Remediation and Redevelopment Conference

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Photo courtesy of Special Collections and University Archives, Kettering University

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agenda

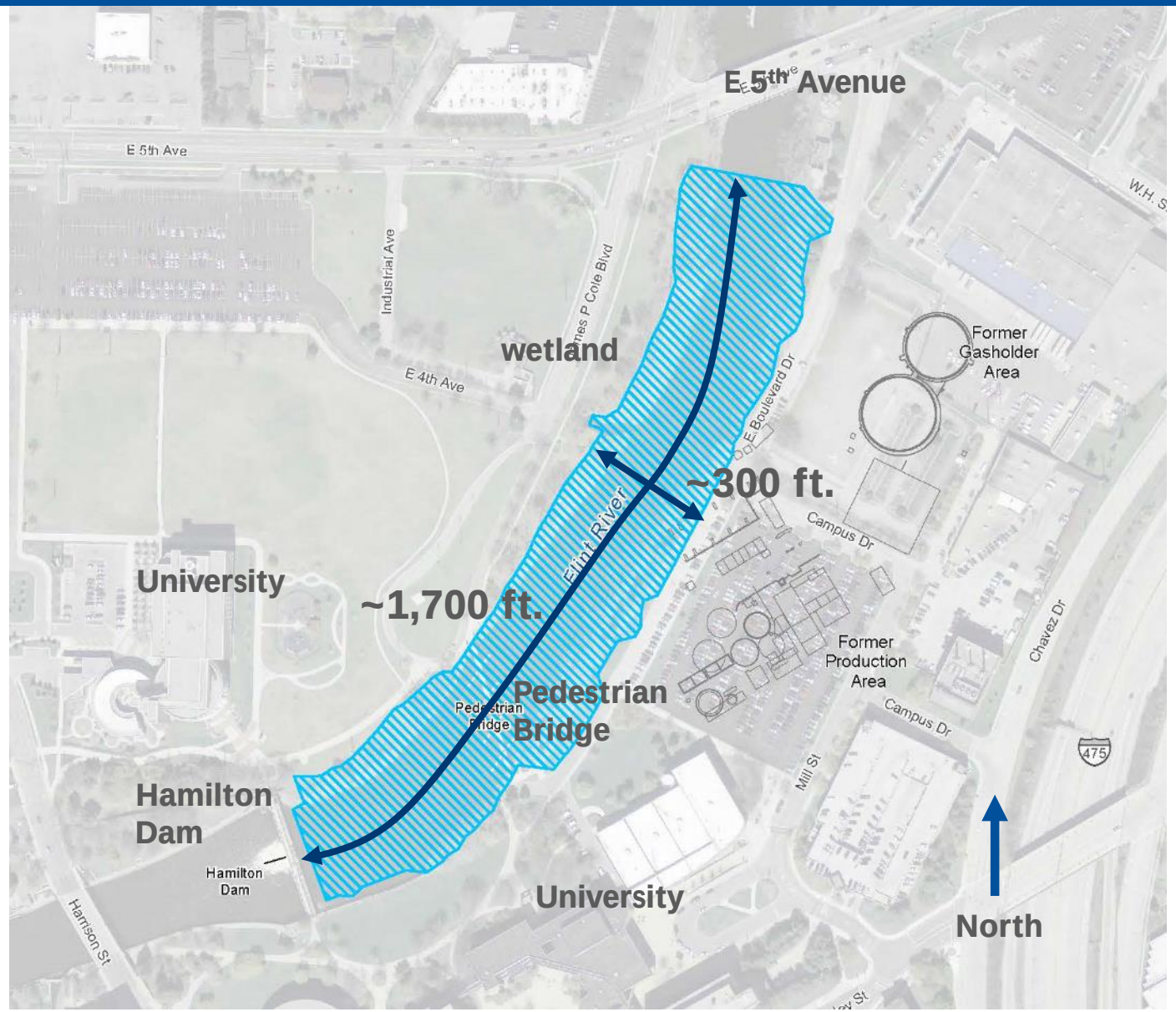
- site background
- cap components
- hydrodynamic modeling
- groundwater modeling
- design changes during construction

site background

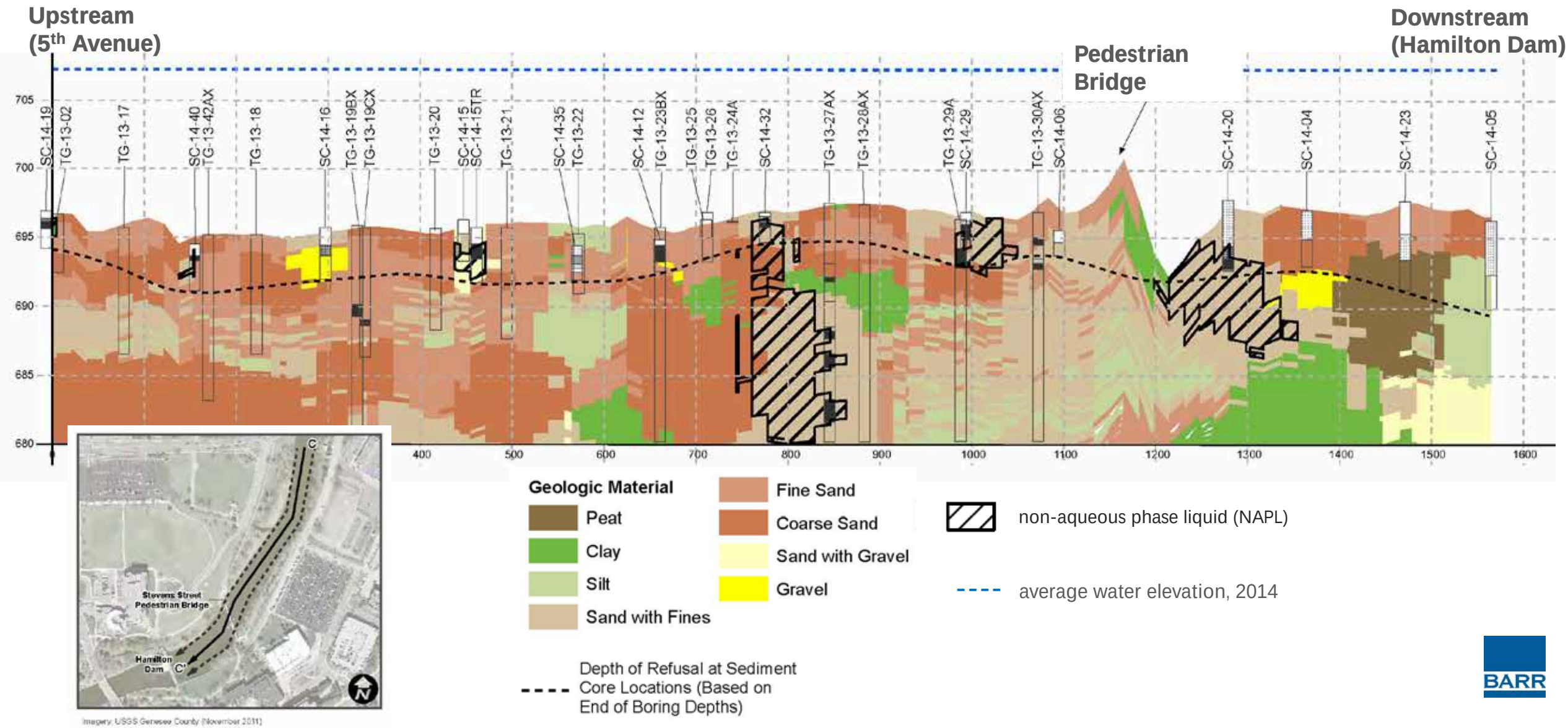
former MGP in Flint, MI

Photo courtesy of Special Collections and University Archives, Kettering University

project reach



consideration #1 - presence of NAPL

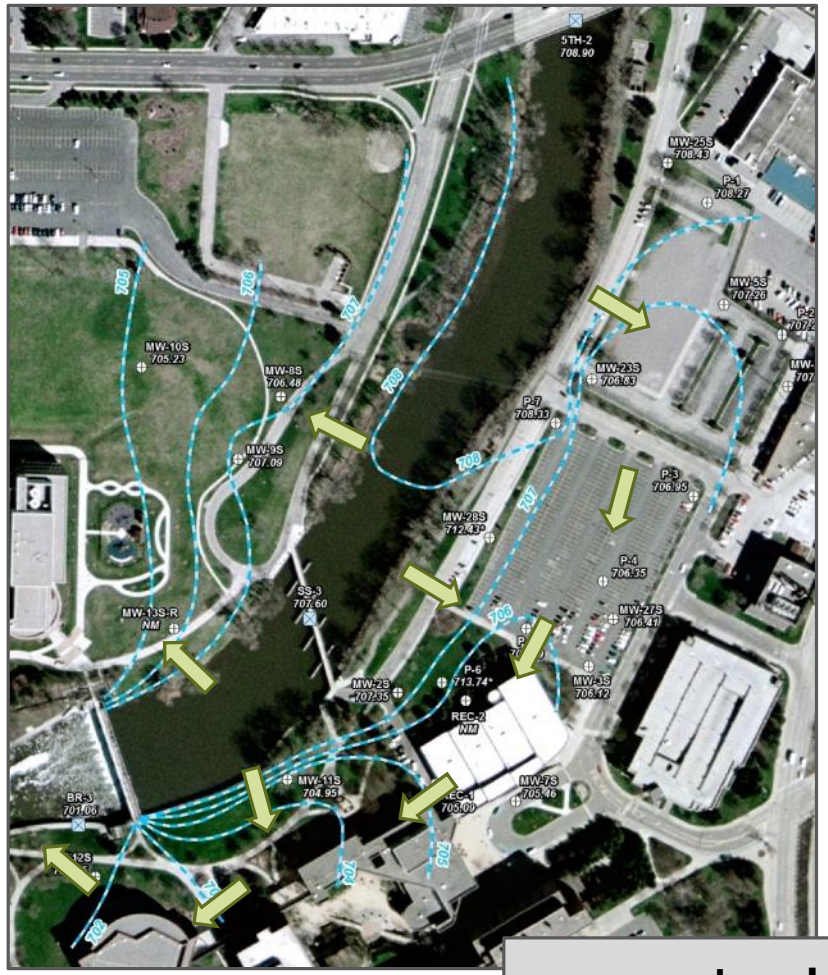


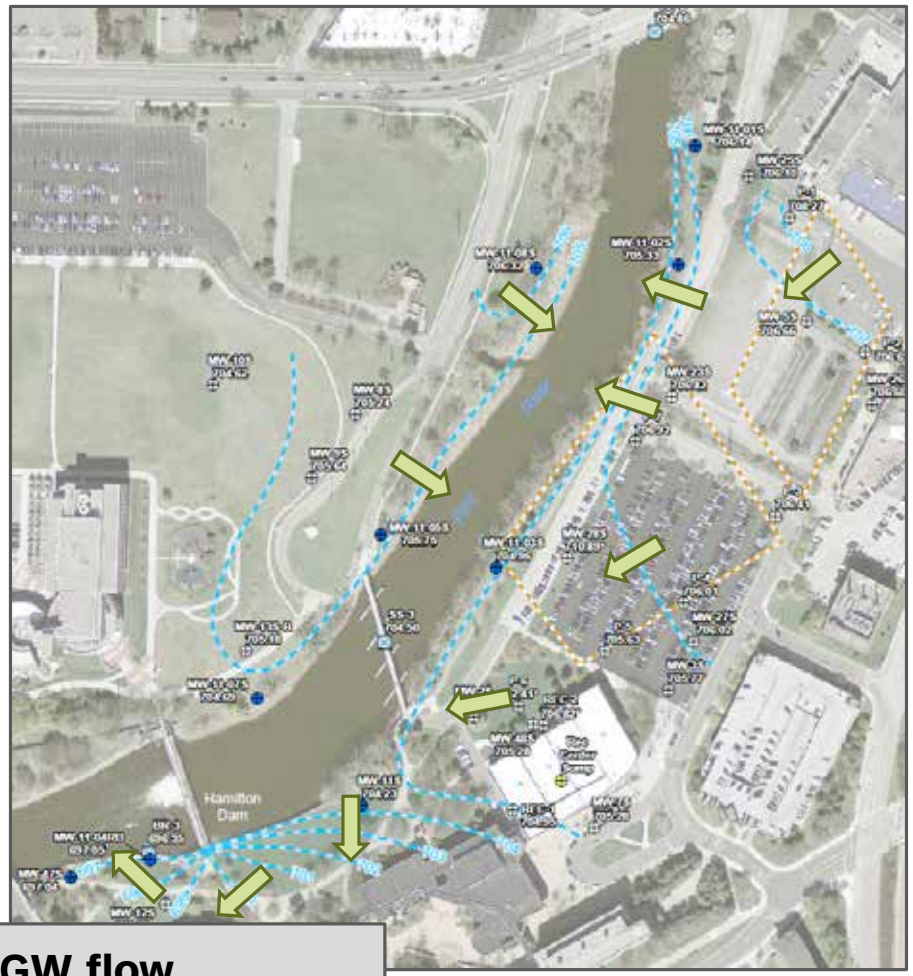
consideration #2 - changing groundwater flow

pre-dam lowering

post- dam lowering

losing reach



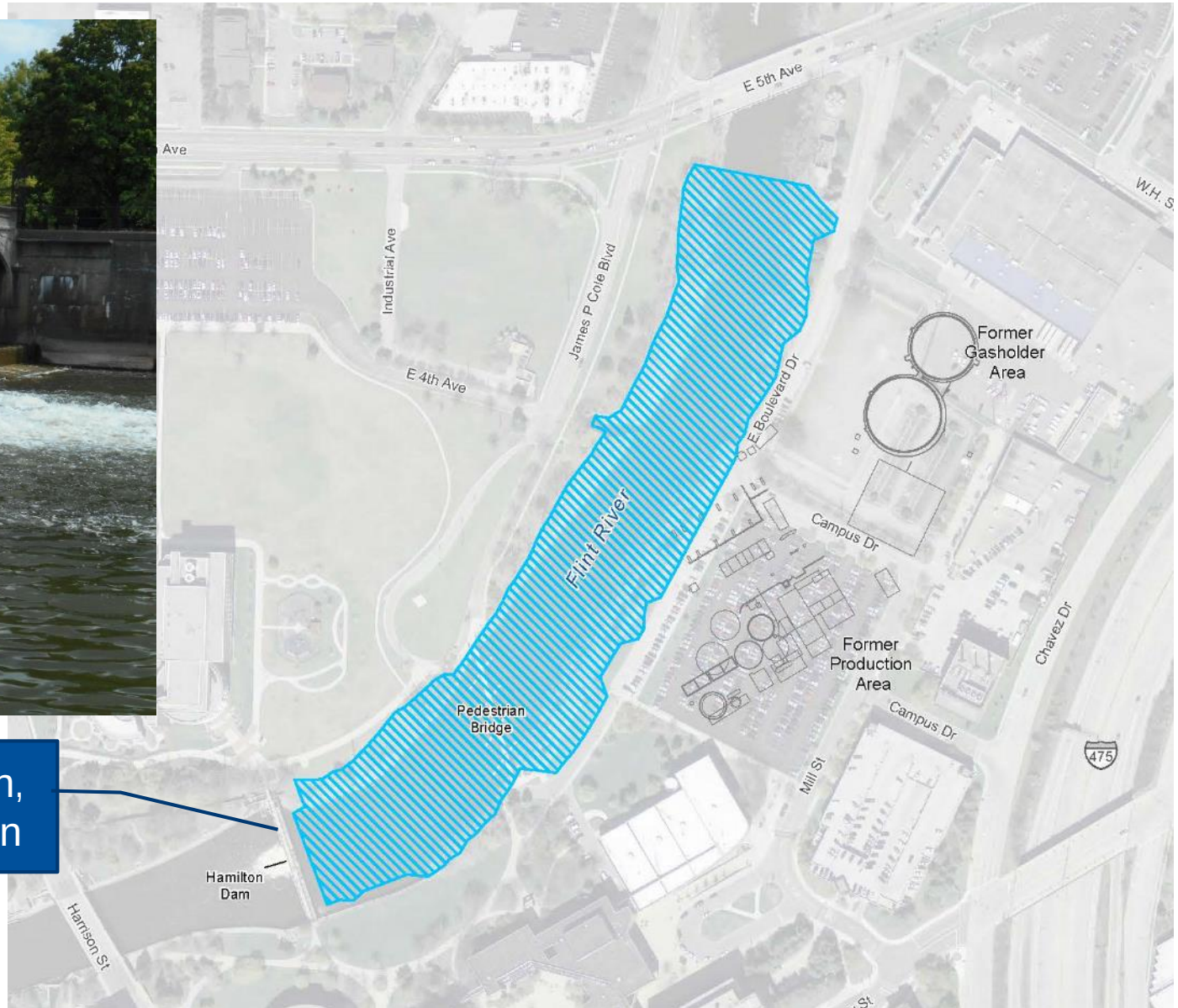


gaining reach

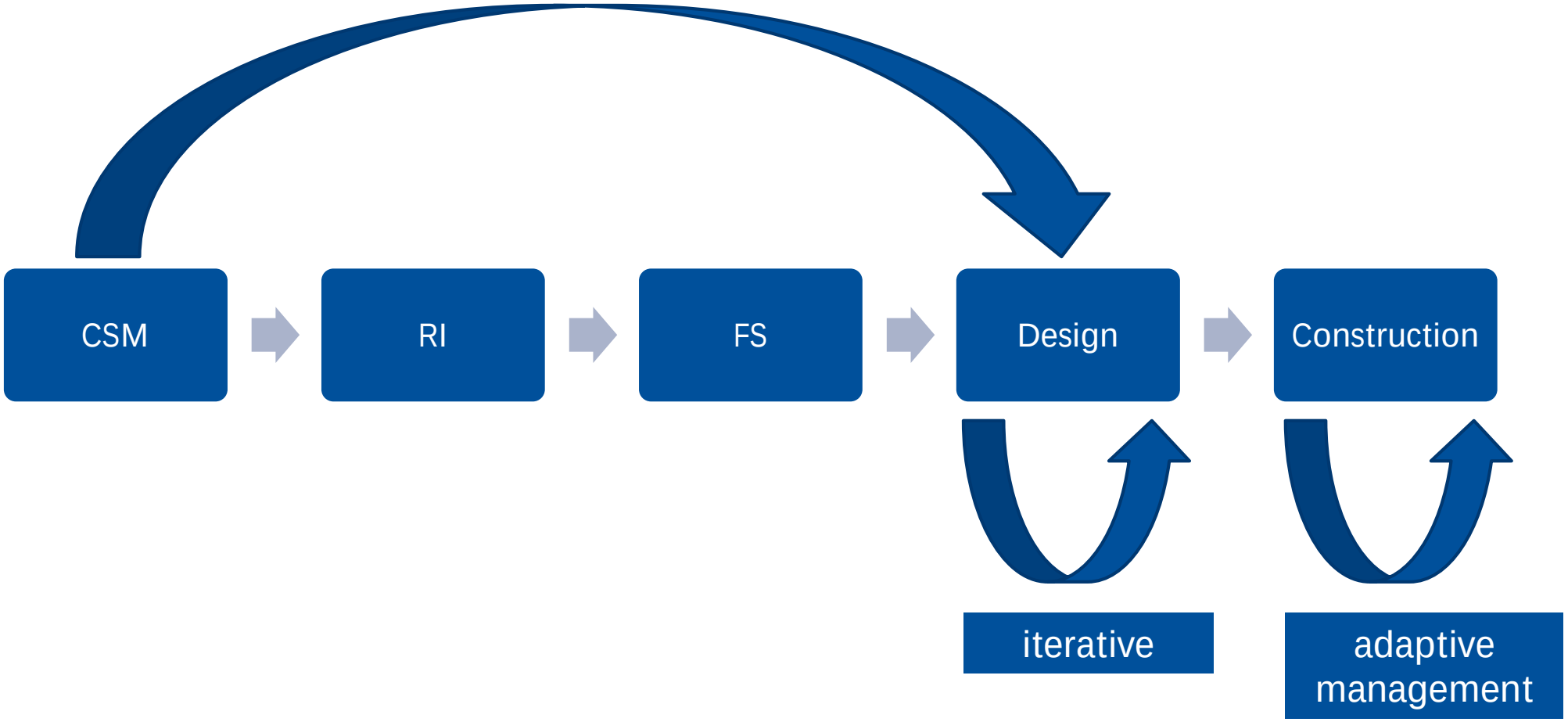
← **Local GW flow direction**

consideration #3 – evolving Hamilton Dam plans

high hazard dam – poor condition, pending removal at time of design



typical design process

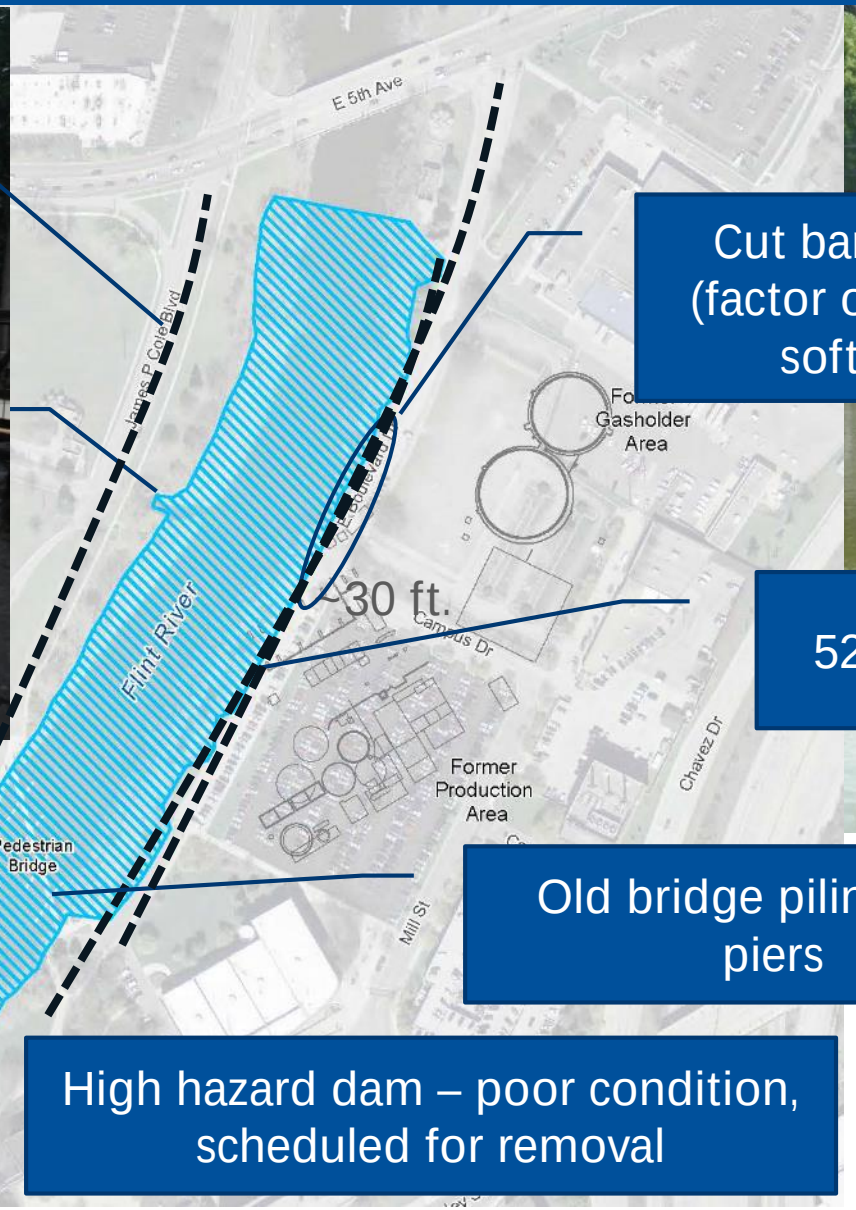


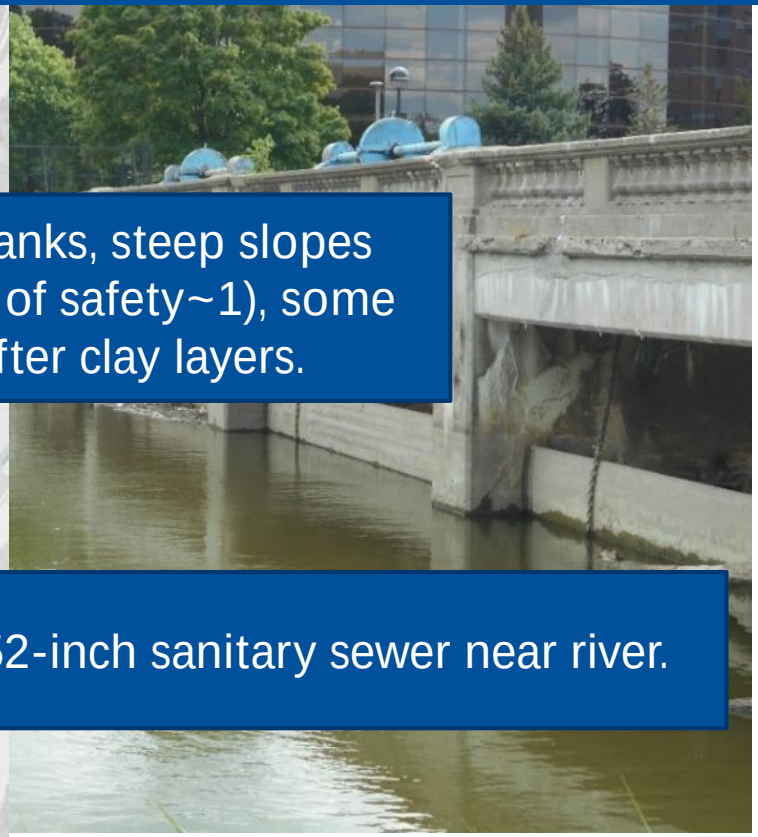
sediment cap objectives

1. create a barrier between remaining impacted sediments below the cap and the river
2. provide stable riverbanks and riverbed for future dam scenarios
3. develop channel /cap geometry compatible with river hydrodynamics
4. incorporate bedform diversity elements for improved aquatic habitat

capping considerations – site layout & features

road on either side of river





Cut banks, steep slopes (factor of safety~1), some softer clay layers.

52-inch sanitary sewer near river.

Soft sediments

Old bridge pilings and piers

High hazard dam – poor condition, scheduled for removal

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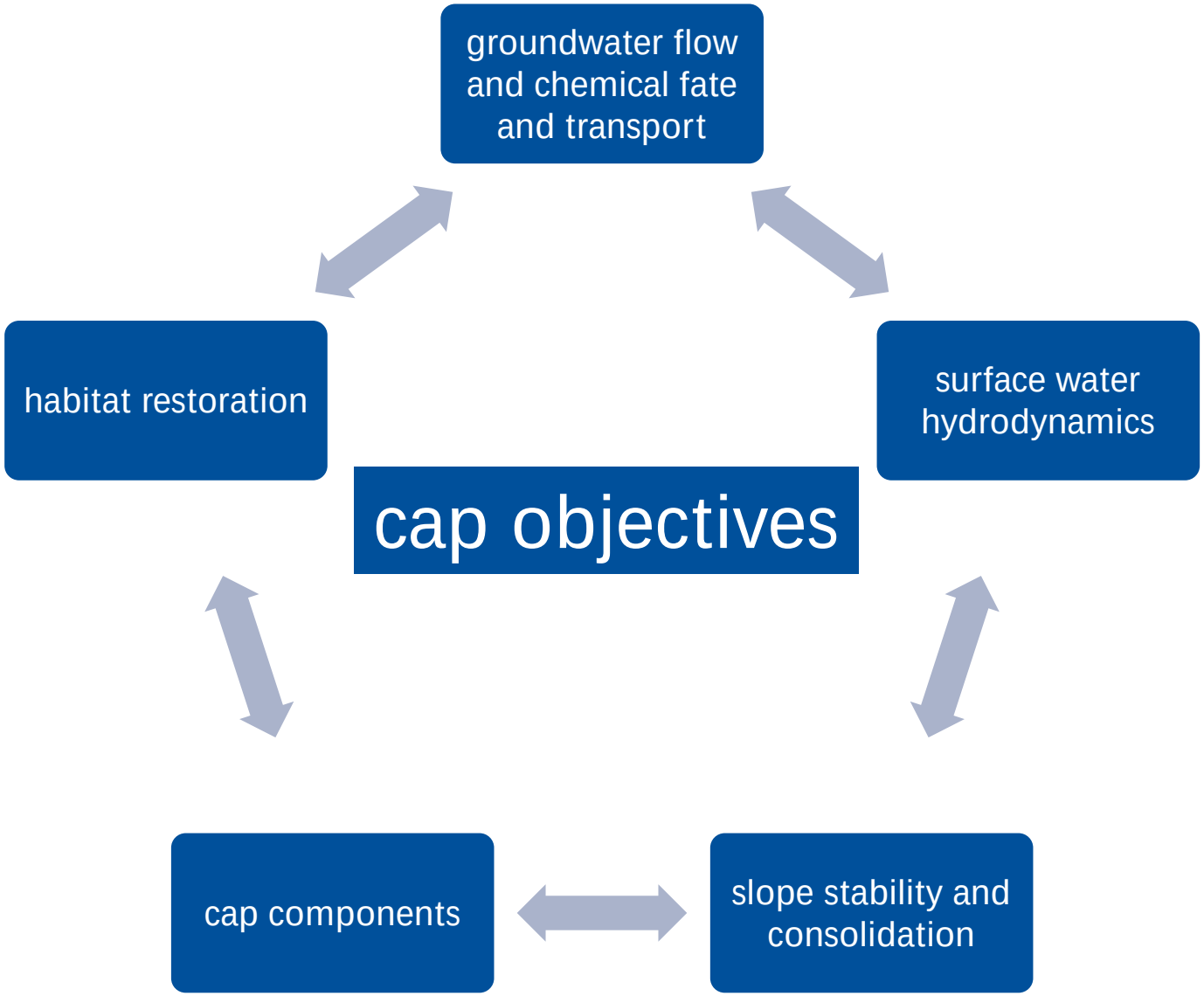
simplified iterative dredge and impermeable cap design



cap components

liner evaluation

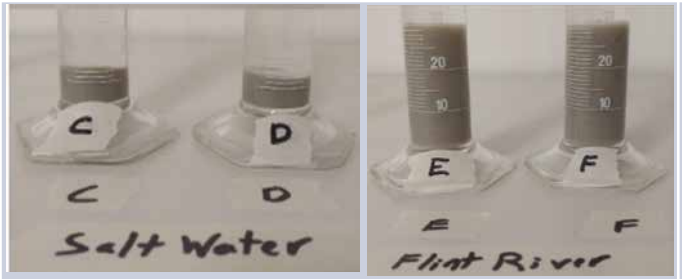
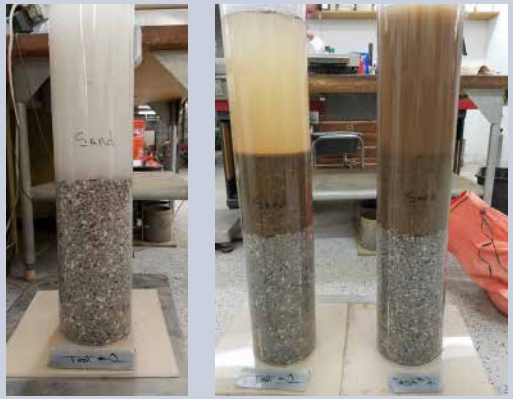
liner options:

- bentonite (clay)
- bentonite (clay) and aggregate
- geocomposite clay mat
- geosynthetic fabrics and geomembranes

Blended Barrier

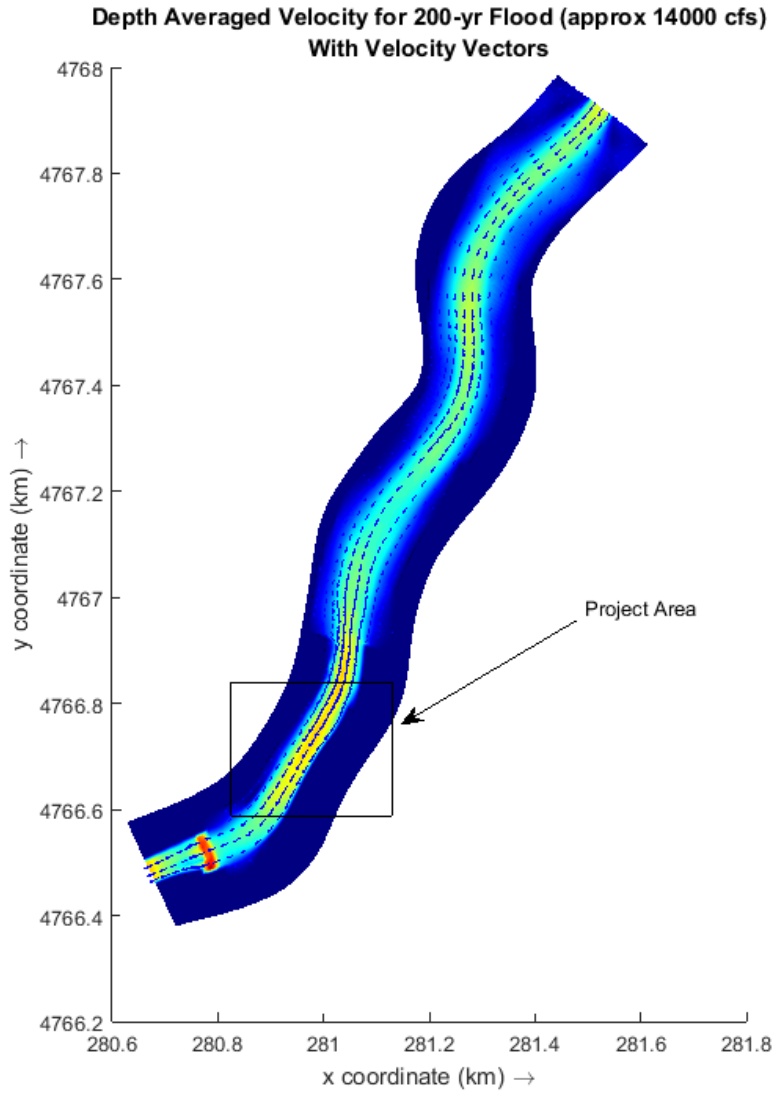
Textured HDPE

assessing technical limitations

Blended Barrier	Assessment and Result	Test	Construction Consideration
Ability to form adequate barrier in river conditions	Bentonite swell tests confirmed behavior		Maintaining integrity of AquaBlok material essential to success
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 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

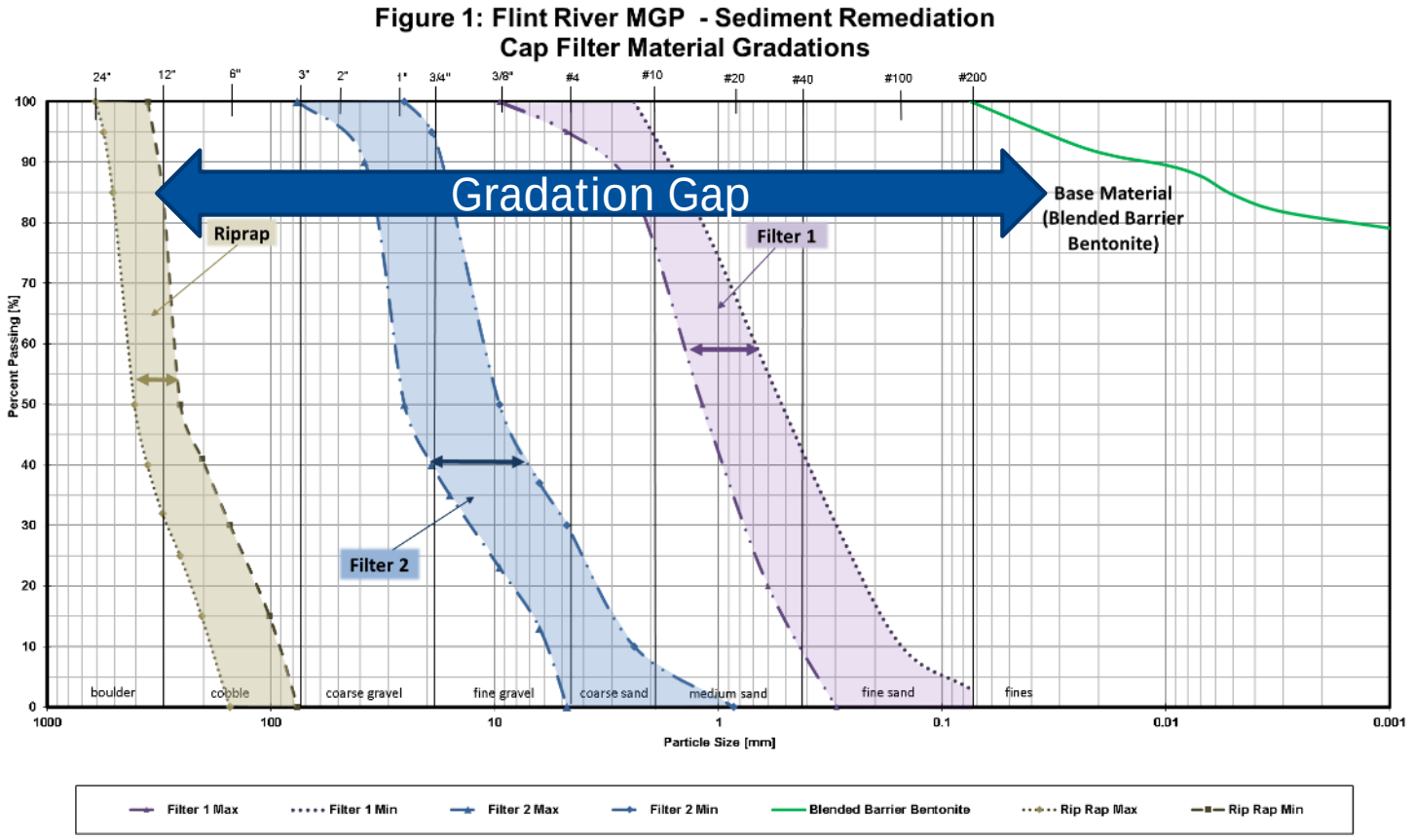
armoring

Design Requirement	Construction Consideration
Protect blended barrier and hdpe cap from erosion and scouring	Achievable with 10” D50 rip rap below el. 705 ft and vegetation above el. 705 ft
Protect blended barrier from rip rap	Can’t place rip rap on blended barrier; evaluate passive filter layers

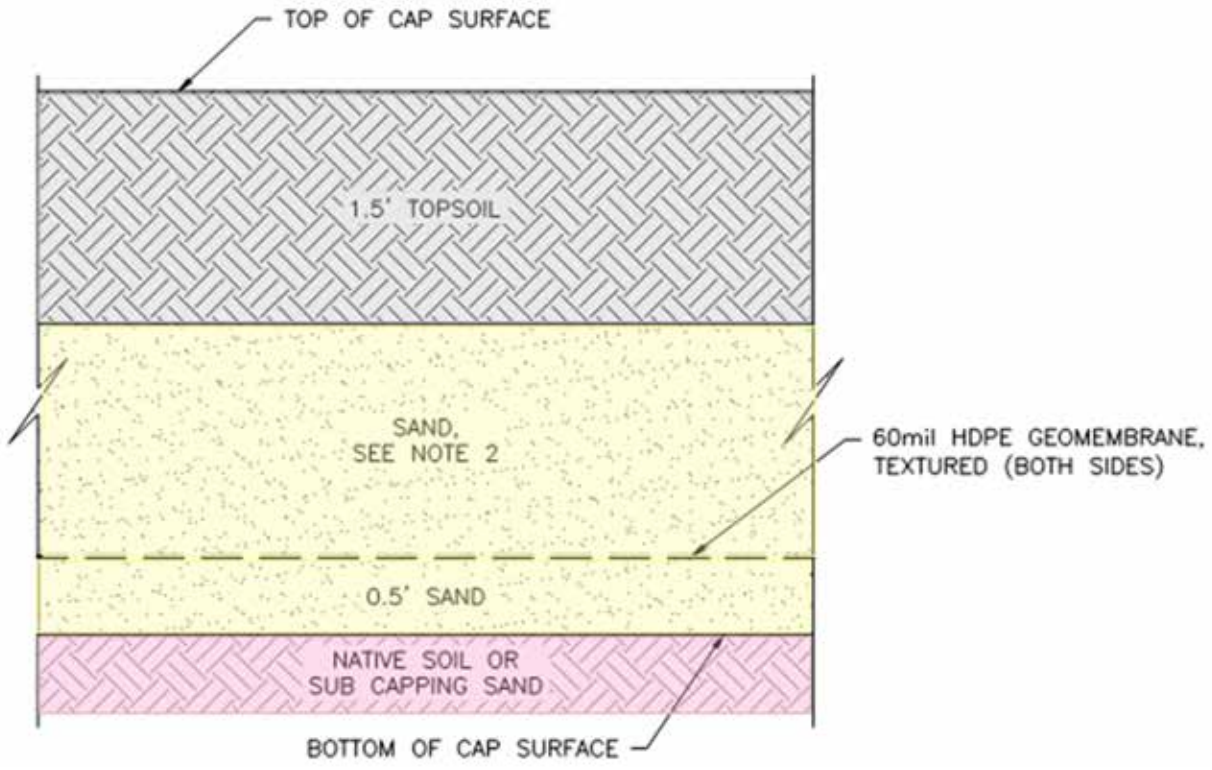


filtering & clay hydration

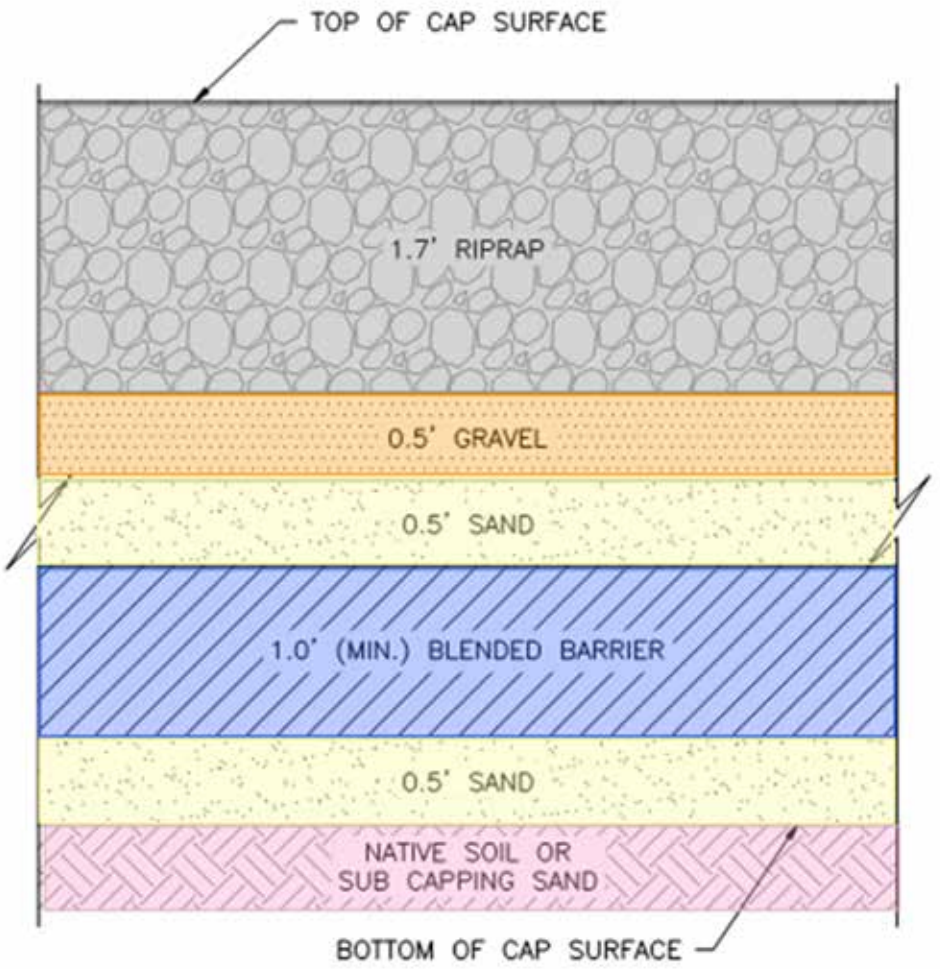
Design Requirement	Construction Consideration
Adequate filtering – from clay sized fraction in blended barrier to large rip rap surface to avoid fines migration	Achievable with multi-layers
Protection of clay from NAPL during hydration	Provision of sand under layer



cap components

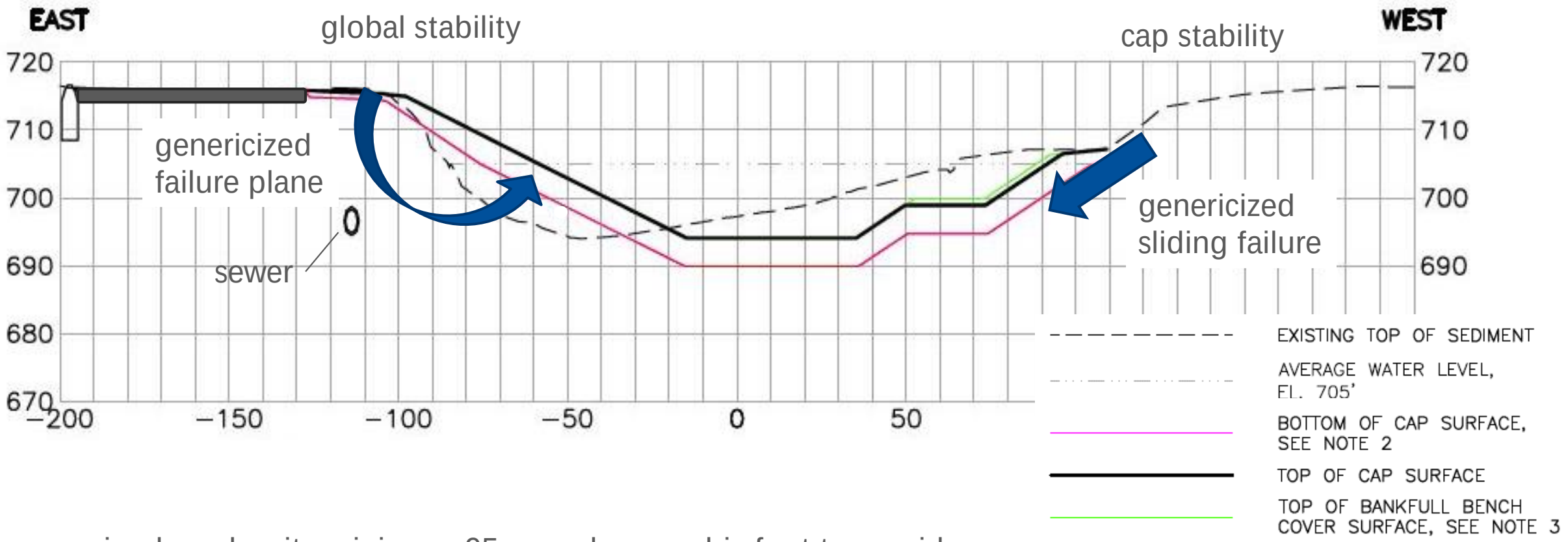


above water section



below water section

stability modeling



- in place density minimum 95 pounds per cubic foot to provide adequate strength to resist shear failure
- minimum slope angle below water 3H:1V
- geomembrane friction angle minimum 27^{o} to provide adequate factor of safety against sliding

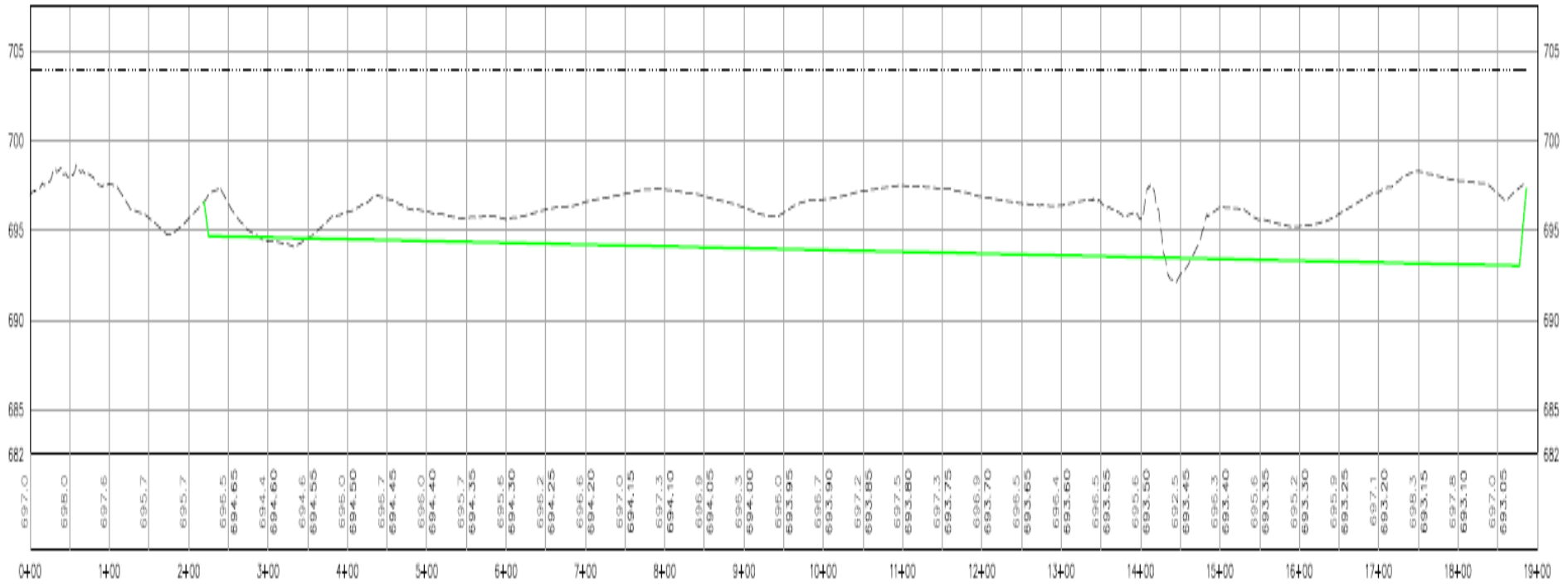
hydrodynamic modeling

existing and proposed slope

Upstream
(5th Avenue)

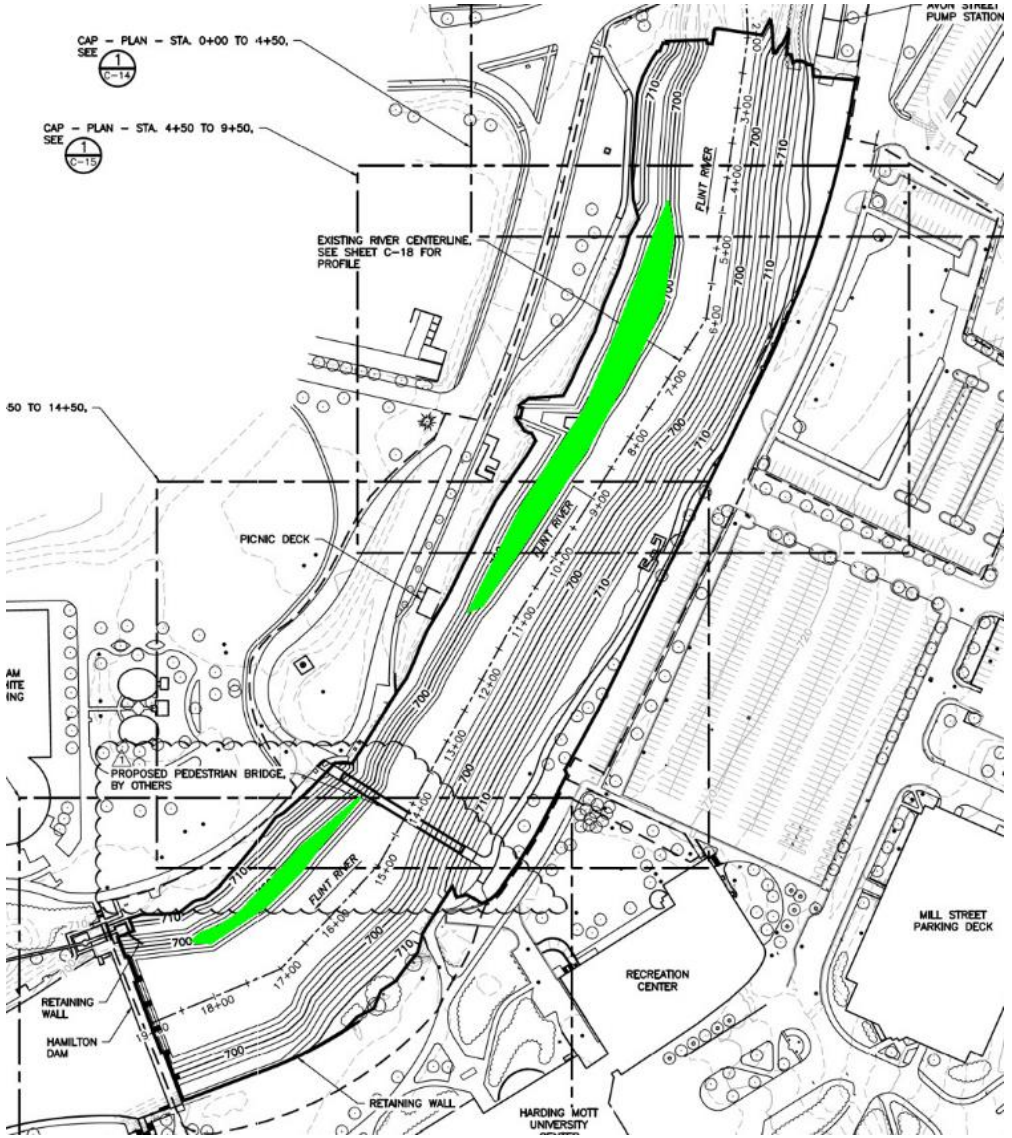
RIVER CENTERLINE

Downstream
(Hamilton Dam)



incorporating bedform diversity elements

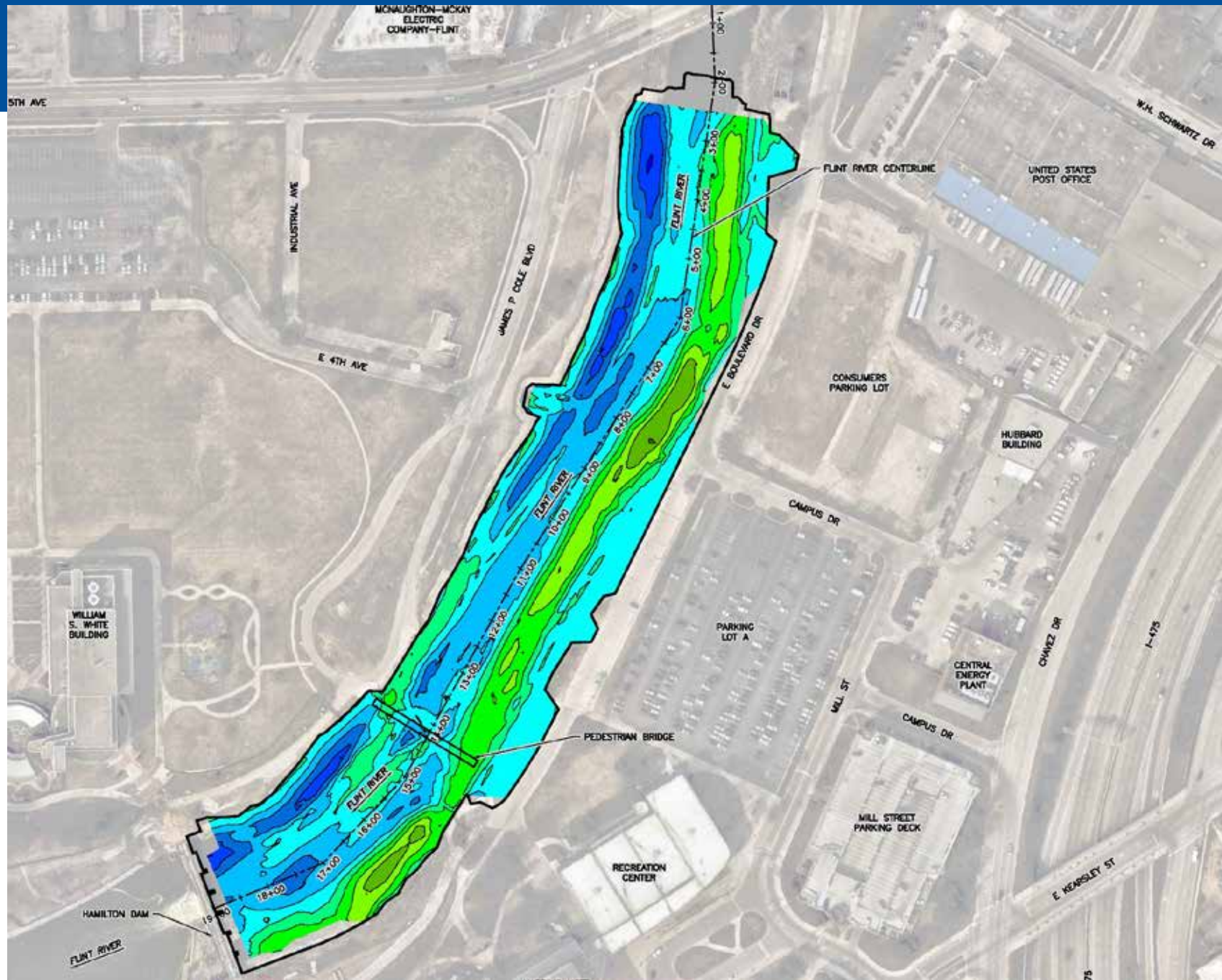
- slope on river bed
- bankfull bench
- rip rap surface infilling with gravel
- native bank vegetation



final bathymetry

LEGEND

- CAP EXTENT
- RESTORATION THICKNESS (FILL) 10.0'+
- RESTORATION THICKNESS (FILL) 7.5' TO 10.0'
- RESTORATION THICKNESS (FILL) 5.0' TO 7.5'
- RESTORATION THICKNESS (FILL) 2.5' TO 5.0'
- RESTORATION THICKNESS (FILL) 0.0' TO 2.5'
- RESTORATION THICKNESS (CUT) 0.0' TO 2.5'
- RESTORATION THICKNESS (CUT) 2.5' TO 5.0'
- RESTORATION THICKNESS (CUT) 5.0' TO 7.5'
- RESTORATION THICKNESS (CUT) 7.5' TO 10.0'
- RESTORATION THICKNESS (CUT) 10.0'+

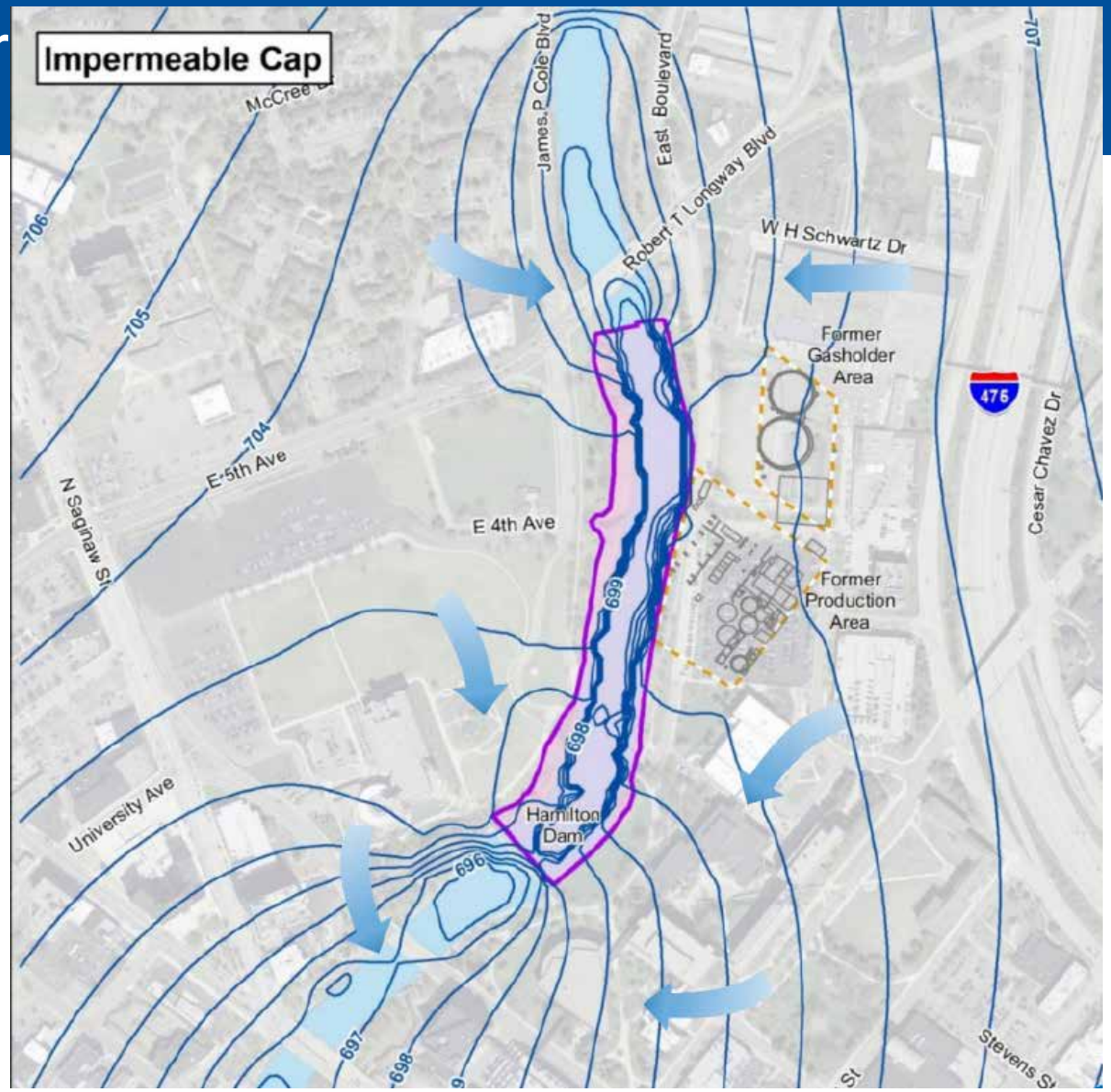


groundwater modeling

why use a groundwater model?

- groundwater flow dependent on river conditions
- partially penetrating river
- dam with uncertain future operation
- many stakeholders
  - state agency
  - city
  - property owners
  - public

groundwater



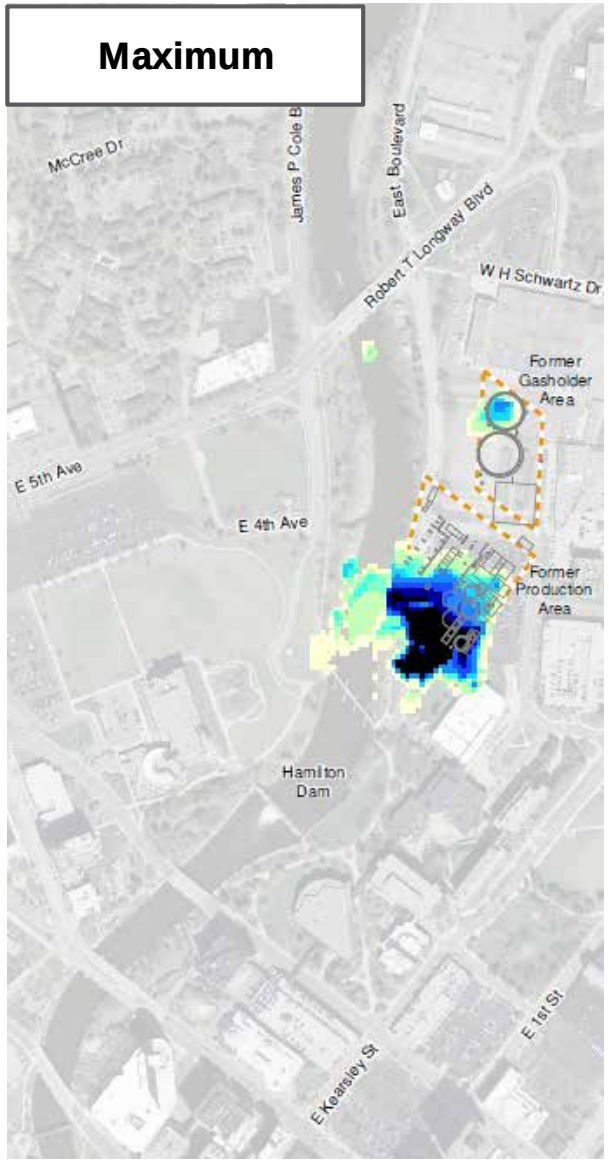
Local Modeled Groundwater Flow Direction

Layer 2 Modeled Groundwater Elevation Contour (Contour Interval 1 ft)

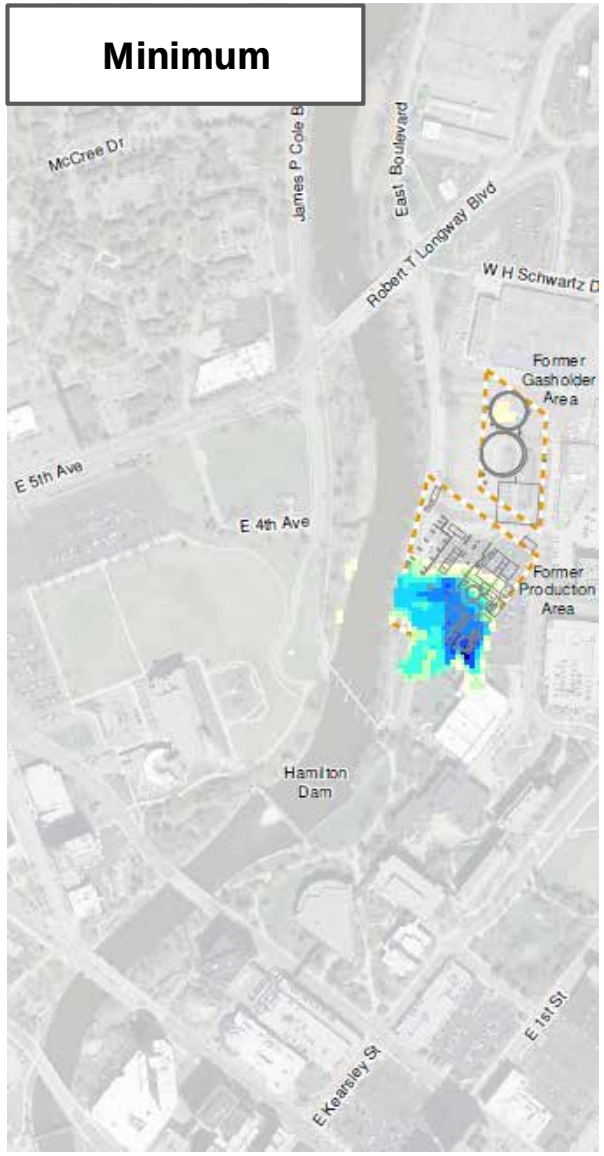
groundwater cap modeling – fate and transport

Benzene Concentration (ug/L)
DW Criteria = 5.0 ug/L
1 - 5
5 - 50
50 - 100
GSI Criteria = 200 ug/L
100 - 200
200 - 500
Final Acute Value = 1,900 ug/L
500 - 1,900
1,900 - 5,000
5,000 - 10,000
10,000 - 20,000
Former MGP Property
Historical Features

Maximum



Minimum



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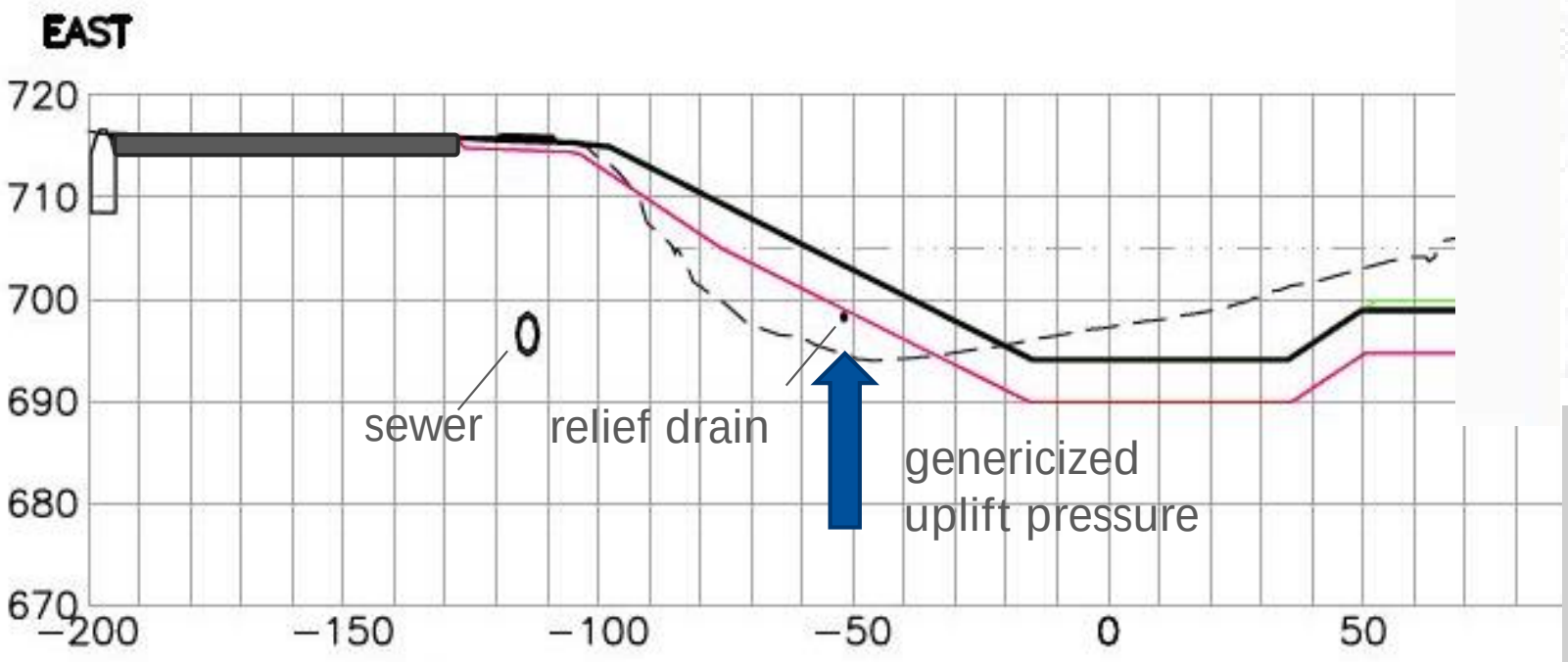
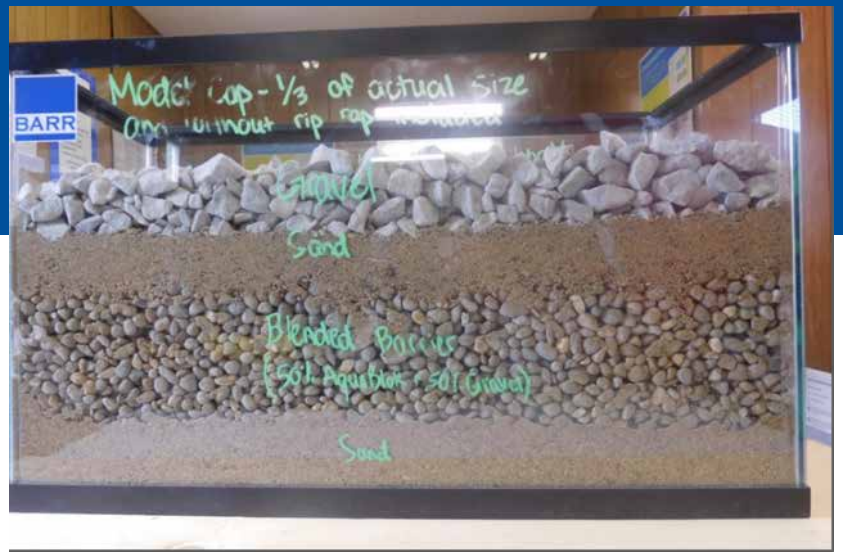
uplift protection

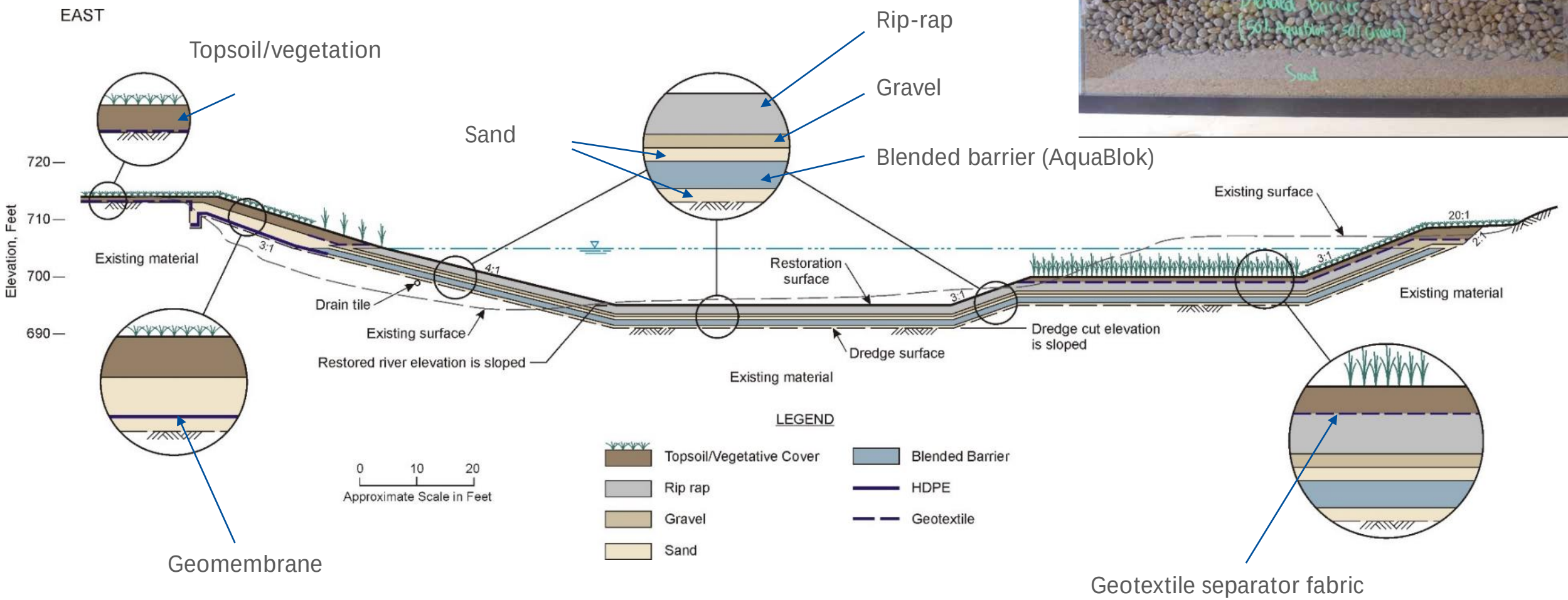
- model used to predict volume of water
- relief drain installation
- installation of vibrating wire piezometers below cap to monitor pressures



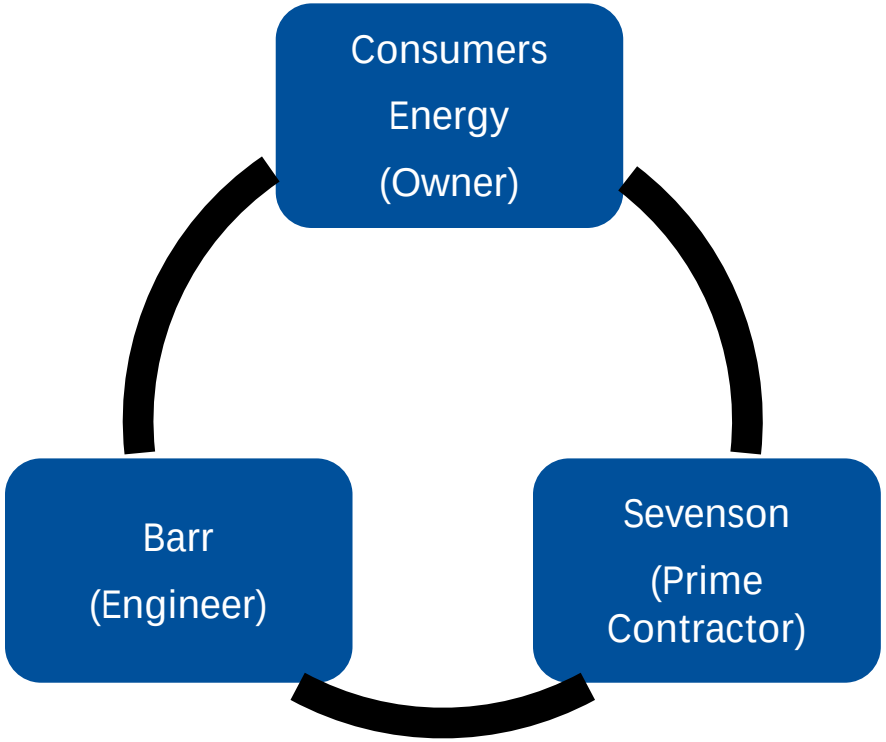
final design

final design





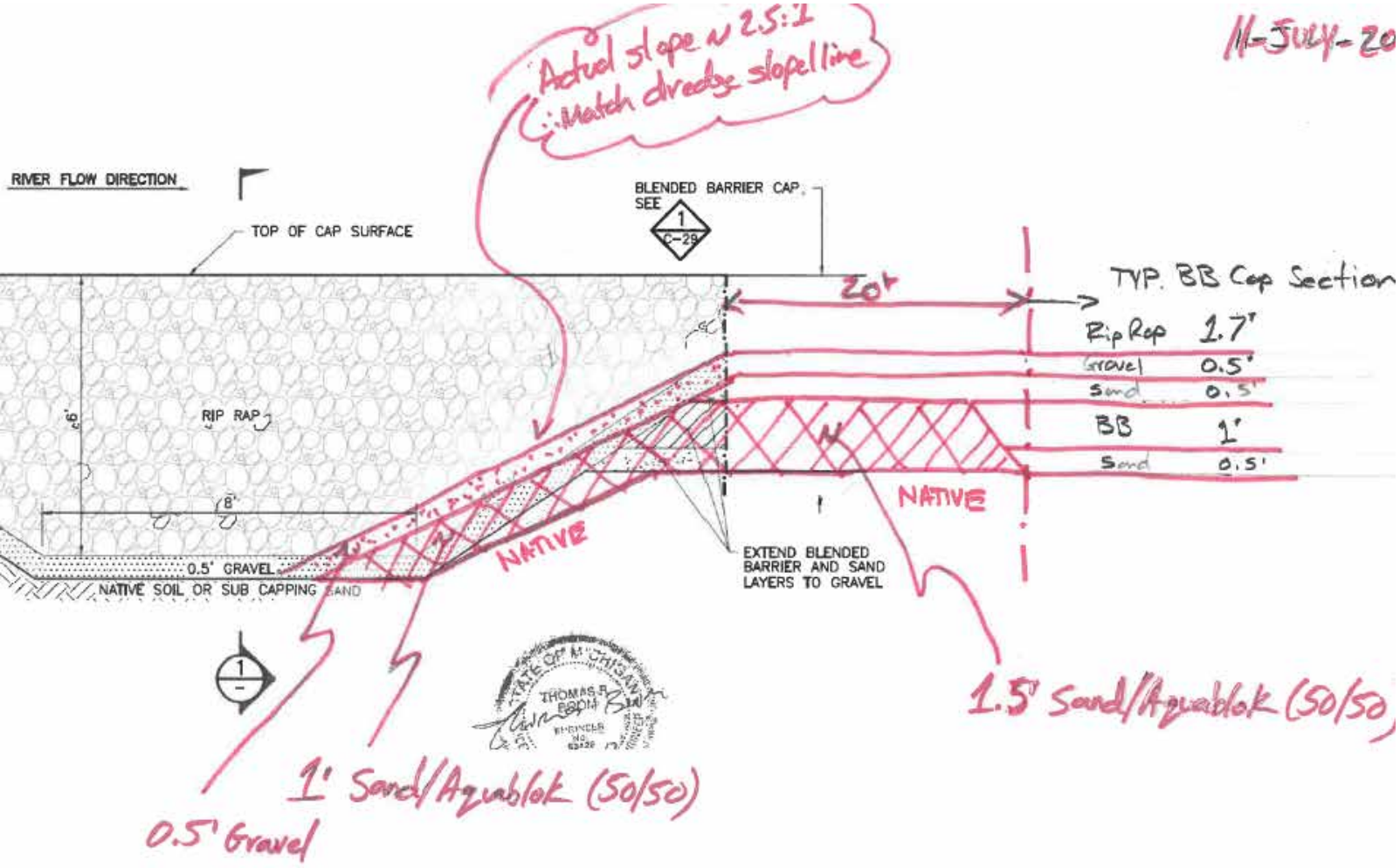
design changes during construction



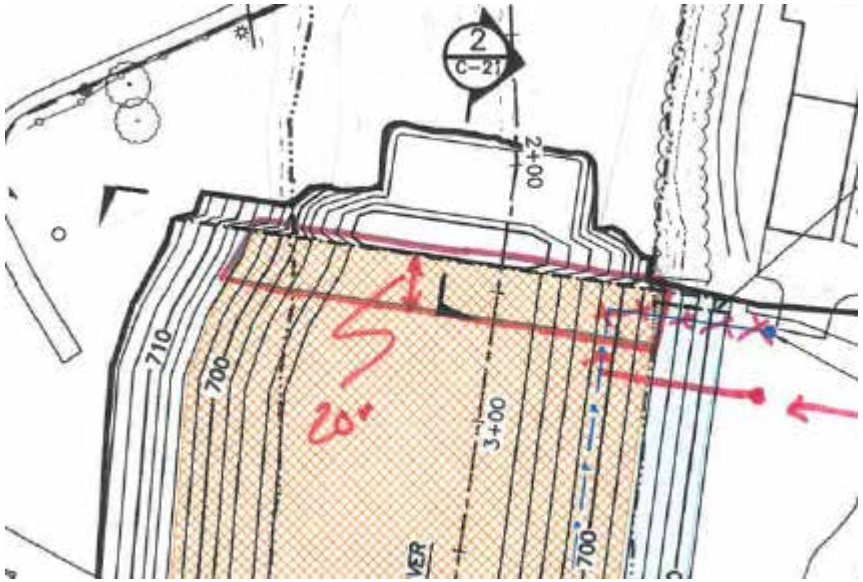
pedestrian bridge removal and replacement

storm outfall design

modification to transition areas

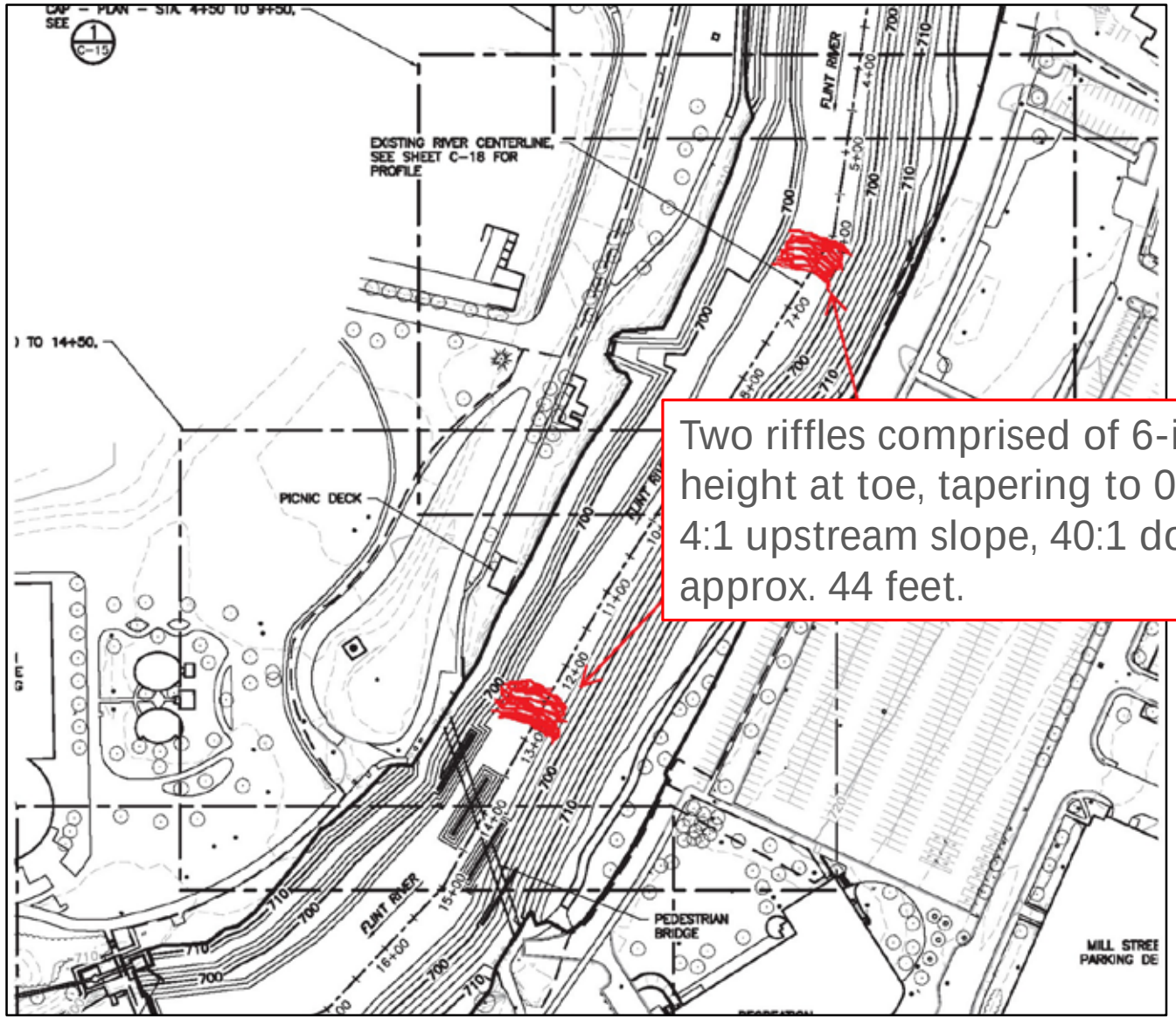


profile – upstream tie-in modifications



plan view – upstream tie-in

Newberry riffles



Two riffles comprised of 6-inch minus material, 12-inch height at toe, tapering to 0-inch toward channel center; 4:1 upstream slope, 40:1 downstream slope. Total length approx. 44 feet.

construction camera

before

after

tboom@barr.com

RESEARCH ARTICLE

WILEY

Designing and implementing an urban river remediation

Tom Boom[1] | Mike Ellis[1] | Don Richard[2]

overall project objectives

1. address direct contact exposure pathway for MGP-related impacts
2. meet compliance criteria for groundwater venting to the river
3. restore riverbanks and infrastructure compatible with future dam scenarios

existing bathymetry

- EXISTING ELEVATION: 692 AND BELOW
- EXISTING ELEVATION: 692 TO 694
- EXISTING ELEVATION: 694 TO 696
- EXISTING ELEVATION: 696 TO 698
- EXISTING ELEVATION: 698 TO 700
- EXISTING ELEVATION: 700 TO 702
- EXISTING ELEVATION: 702 TO 704
- EXISTING ELEVATION: 704 TO 706
- EXISTING ELEVATION: 706 TO 708
- EXISTING ELEVATION: 708 TO 710
- EXISTING ELEVATION: 710 TO 712
- EXISTING ELEVATION: 712 TO 714
- EXISTING ELEVATION: 714 TO 716
- EXISTING ELEVATION: 716 AND ABOVE