Design Tools For Upgrading Underground Infrastructure in a Congested Urban Environment

February 4, 2020

Northeast Ohio Regional Sewer District

PROJECT CLEAN LAKE
25-year Combined Sewer Overflow control program

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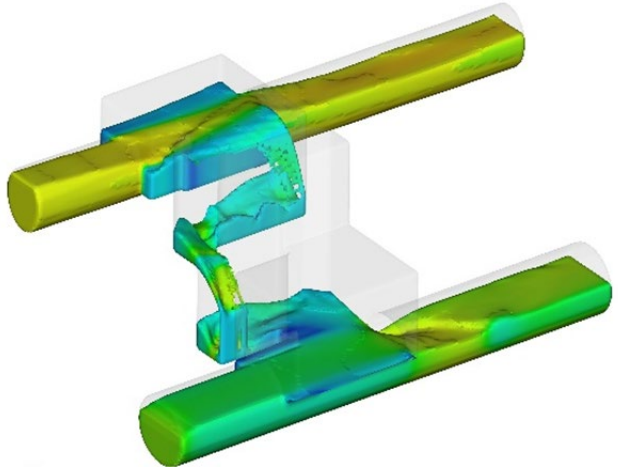
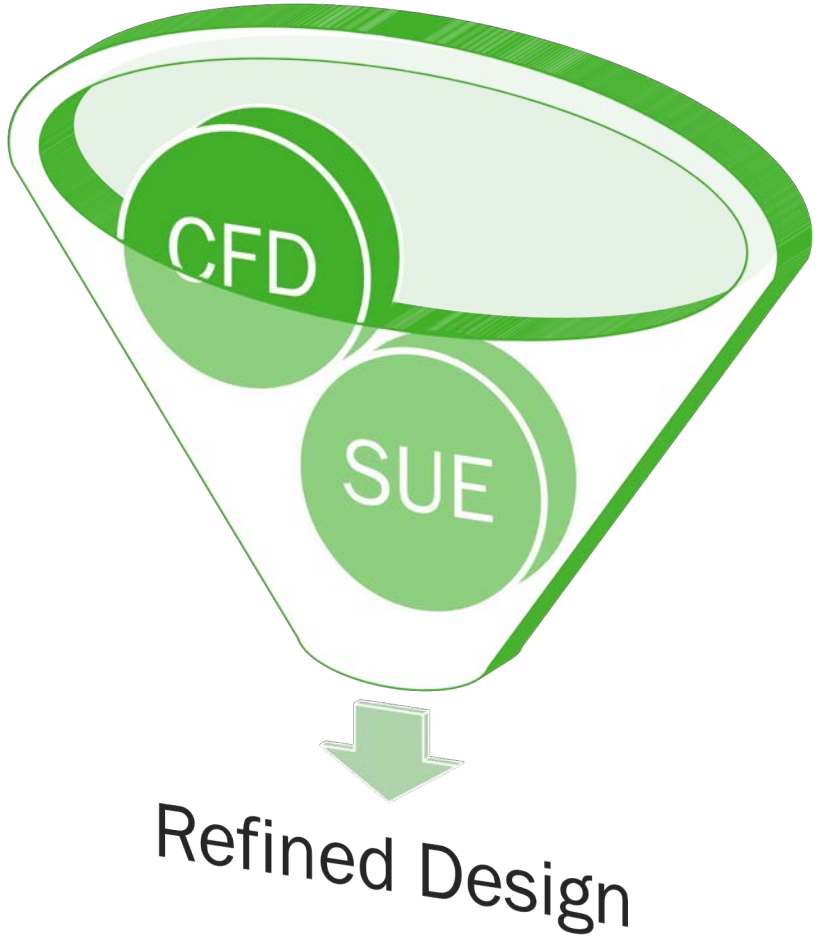
WADE TRIM

MOTT MACDONALD

Multiple design tools enhanced the design of underground hydraulic structures for a new relief sewer system in an urban environment

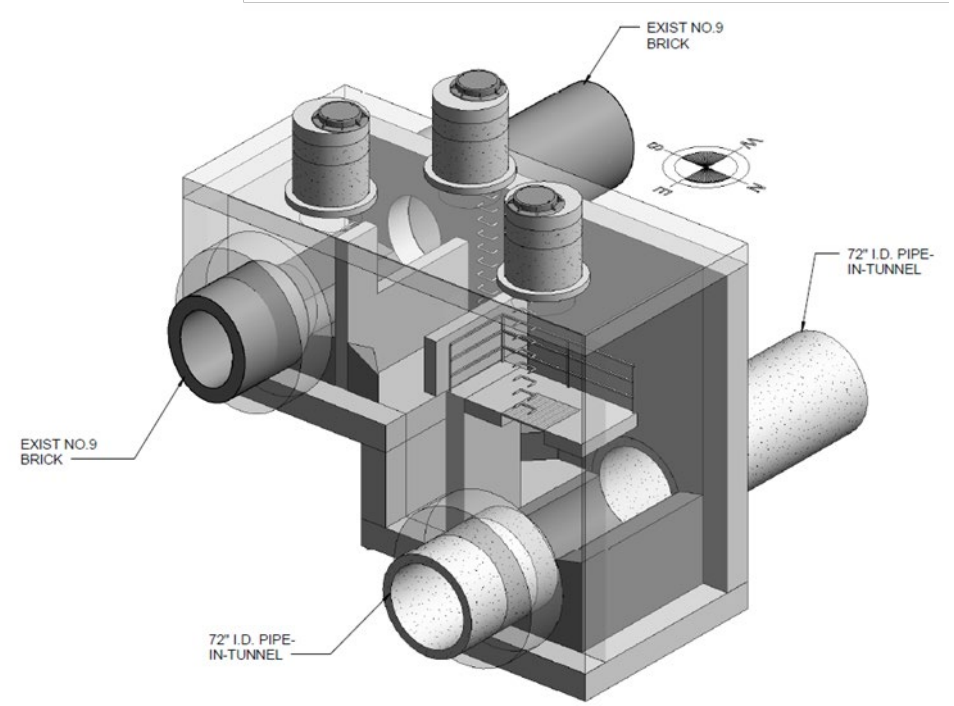
This presentation focuses on Computational Fluid Dynamics (CFD) and enhanced field reconnaissance using a detailed Subsurface Utility Engineering (SUE) program

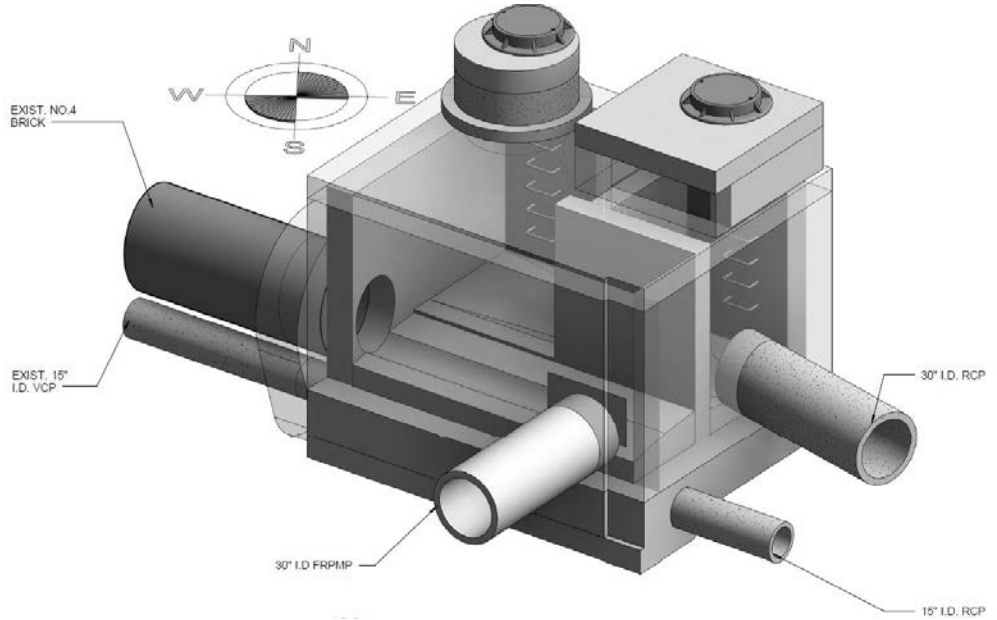




Agenda

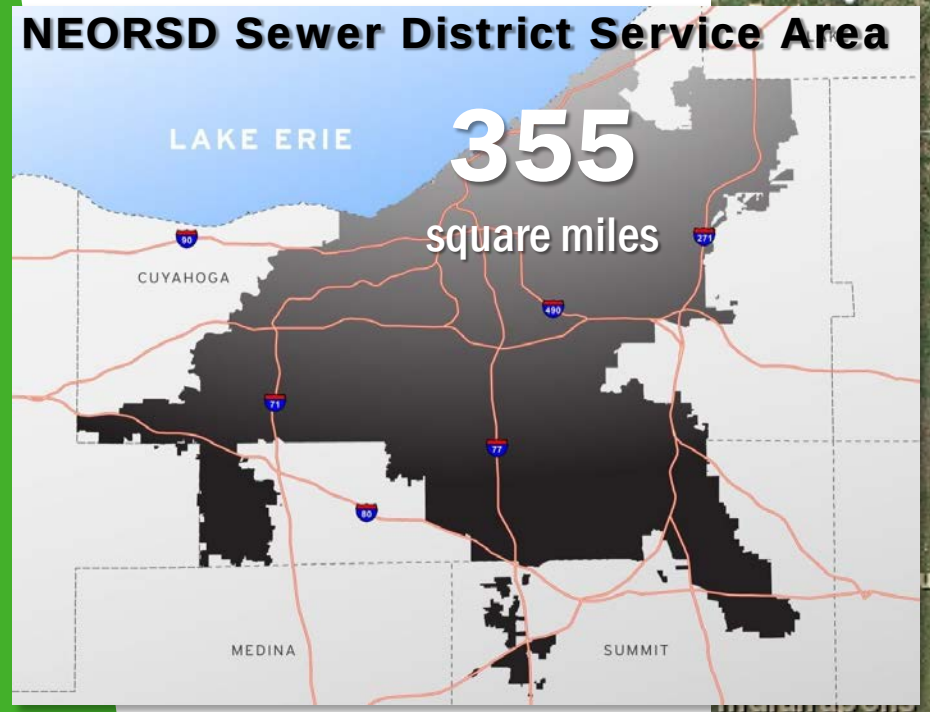
- Project Overview
- Design
  - Diversion Structure R1-D1
    - Hydraulic Analysis & CFD
    - SUE
  - Diversion Structure R6-D1
    - SUE
    - Utility Owner Coordination
- Construction
- Conclusions





Project Context

Northeast Ohio Regional Sewer District



Serves:
- 62 municipalities
- >1M residents

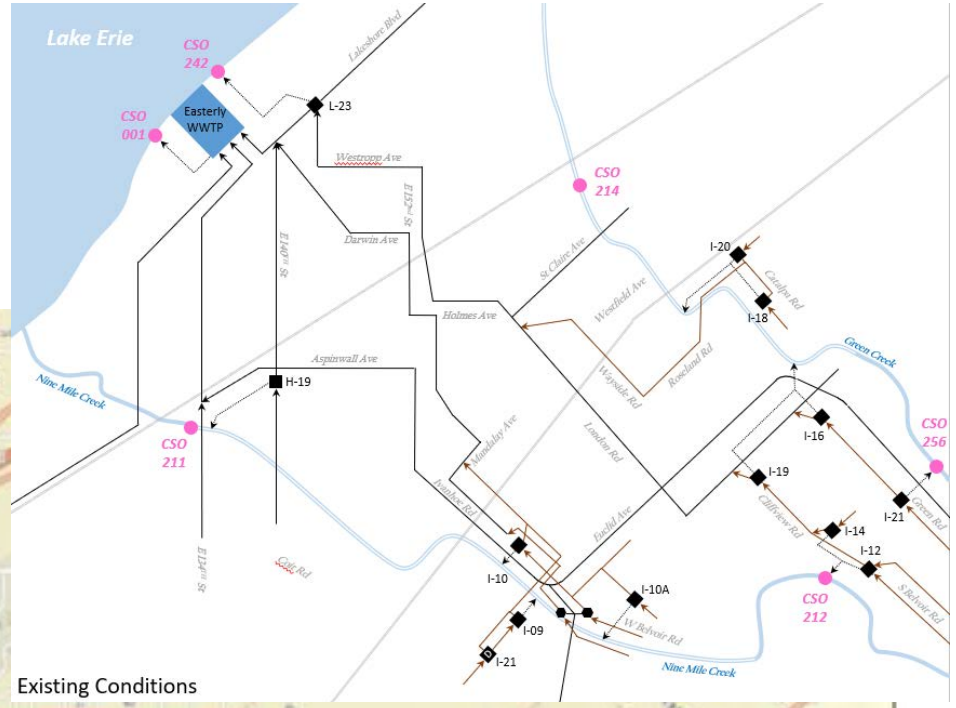
Maintains & Operates:
- Interceptor Sewers
- 3 WWTPs

Consent decree
- 25-yr, $3.6B program
- 4B gallons/yr CSO reduction
  - Tunnels
  - Plant improvements
  - Increased system conveyance capacity

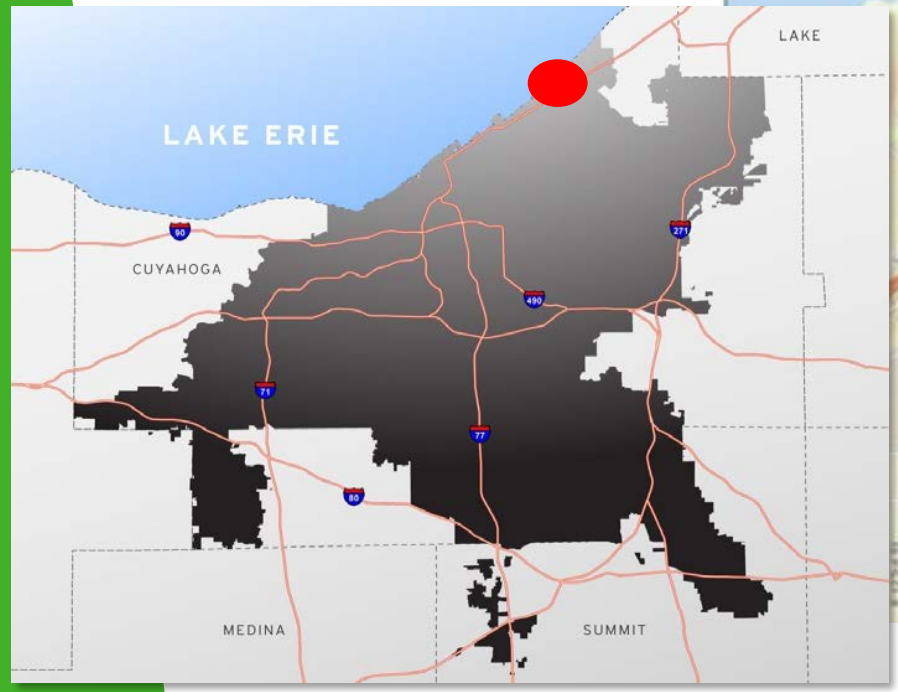
PROJECT CLEAN LAKE
GREAT LAKE • GREAT FUTURE

Project Overview

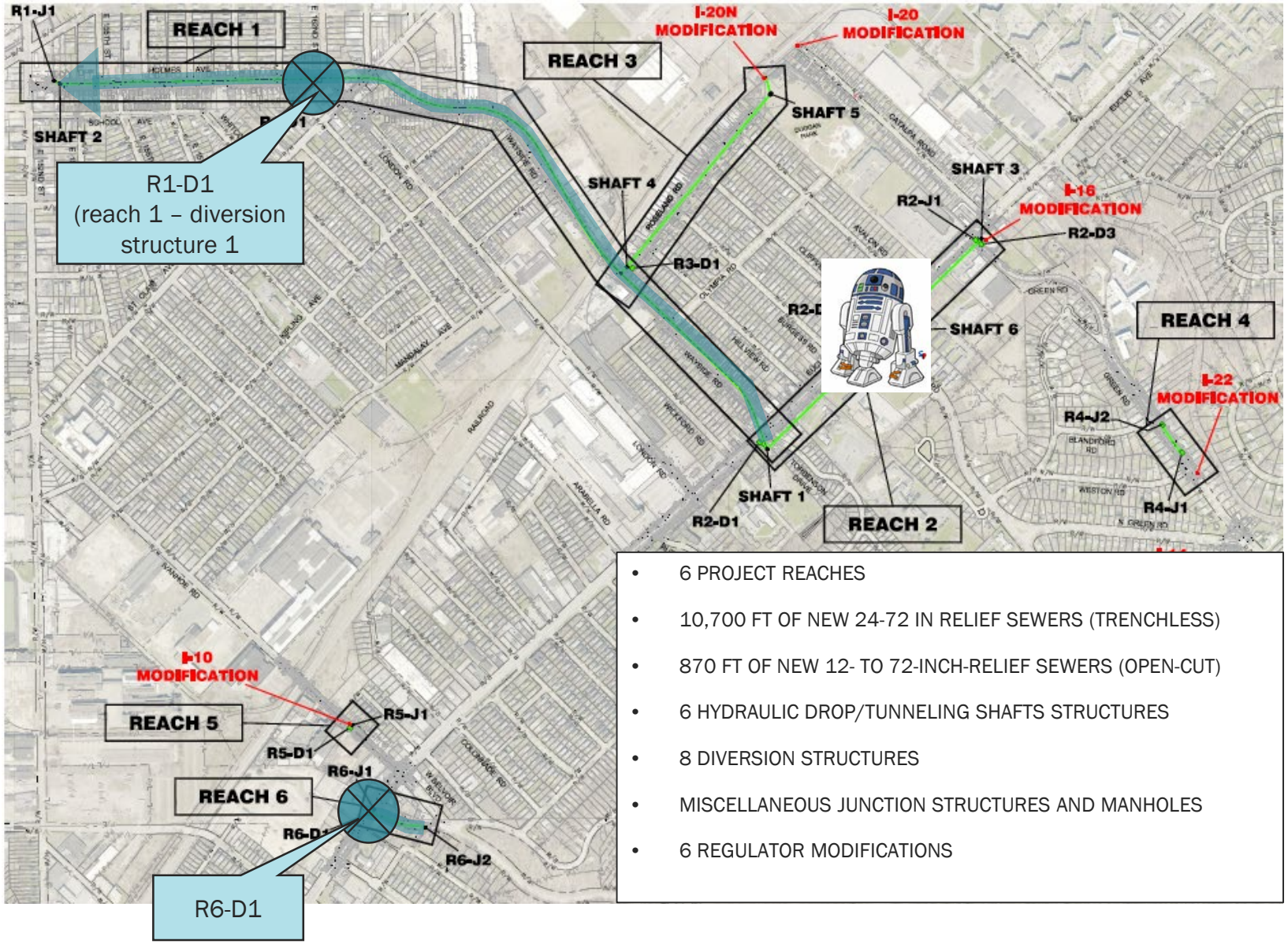
- London Road Relief Sewers Project (LNDN)
  - Control CSOs
  - Reduce Surcharging



Existing Conditions



Project Overview



- 6 PROJECT REACHES
- 10,700 FT OF NEW 24-72 IN RELIEF SEWERS (TRENCHLESS)
- 870 FT OF NEW 12- TO 72-INCH-RELIEF SEWERS (OPEN-CUT)
- 6 HYDRAULIC DROP/TUNNELING SHAFTS STRUCTURES
- 8 DIVERSION STRUCTURES
- MISCELLANEOUS JUNCTION STRUCTURES AND MANHOLES
- 6 REGULATOR MODIFICATIONS

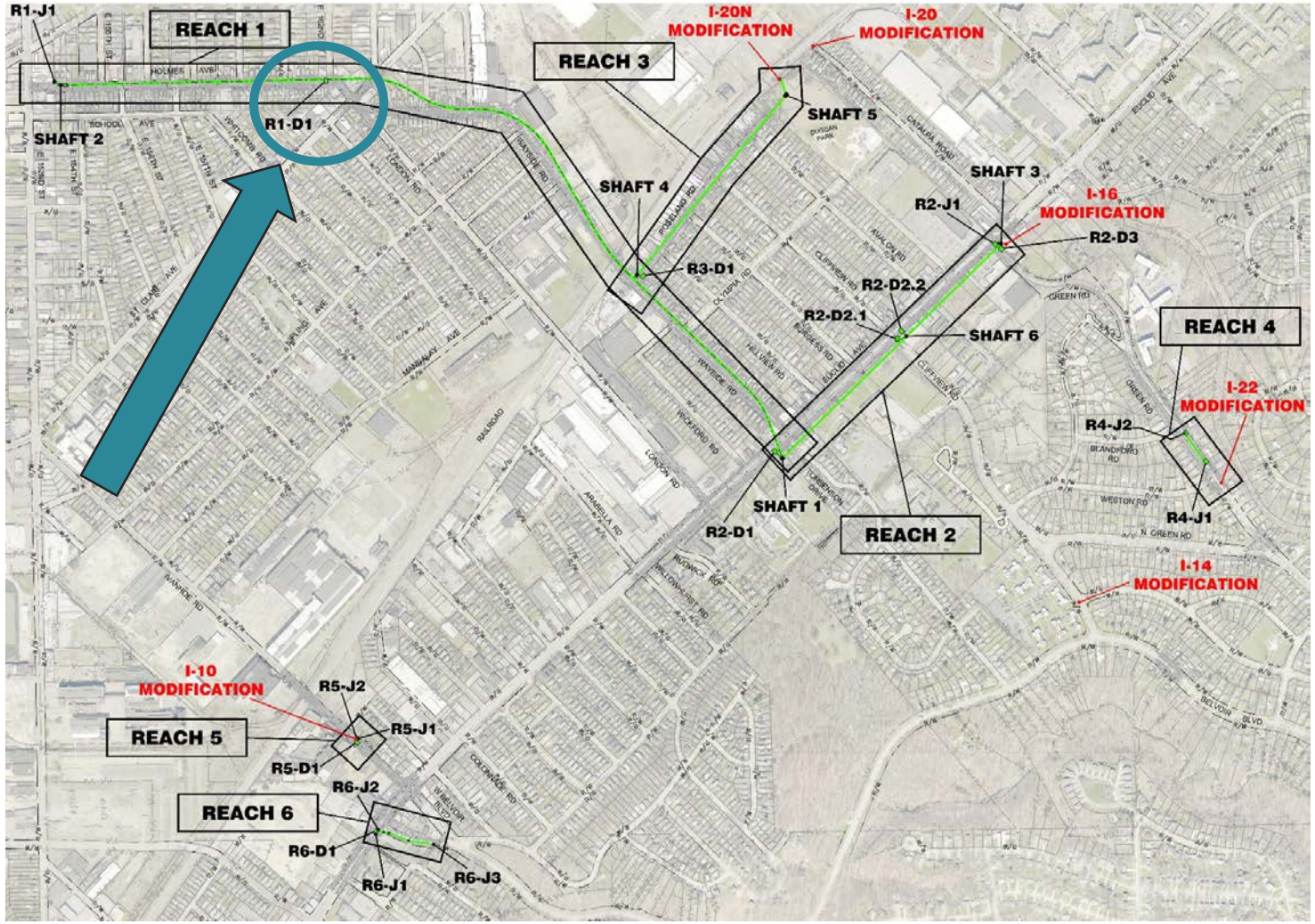
Project Schedule & Current Status

- Design
  - Started: December 2016
  - Completed: March 2018
- Construction
  - Started: July 2018
  - Scheduled Completion: July 2020
  - $40M CV

Overall Design Process

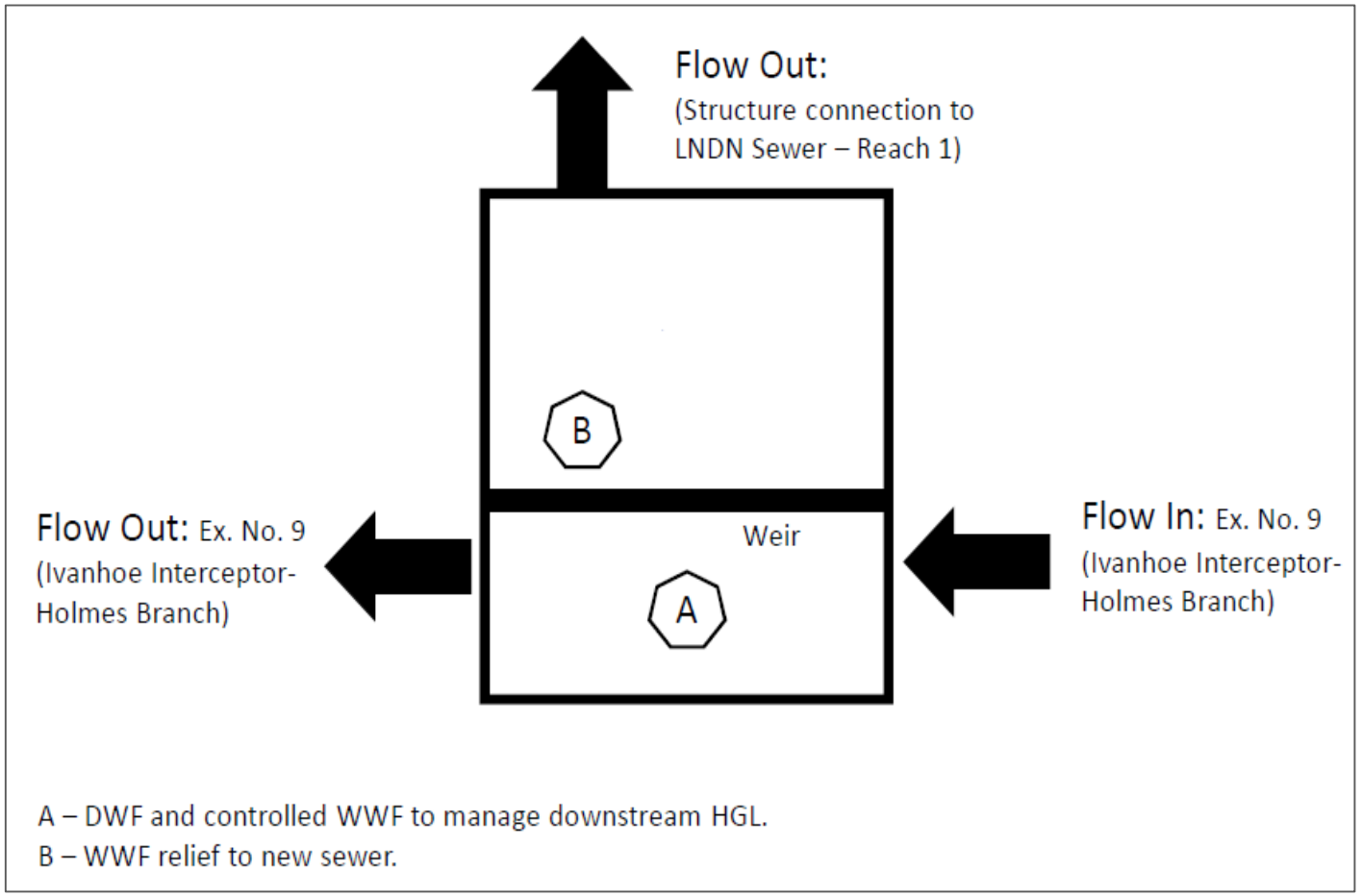
- Establish alignment and locate near surface hydraulic structures
  - Hydraulic analysis
  - Anticipated construction methods
  - Geotechnical considerations
  - Existing underground utility impacts
  - Community impacts
- Balance hydraulic performance with construction risk
- Selectively deploy CFD and SUE design enhancement tools
  - When to use?
  - In which order?
  - Why use them at all?

Diversion Structure R1-D1



- Purpose of Structure
- Location Evaluation
- CFD
- SUE

Diversion Structure R1-D1



No. 9 Egg shaped sewer (52”W x 66”H)

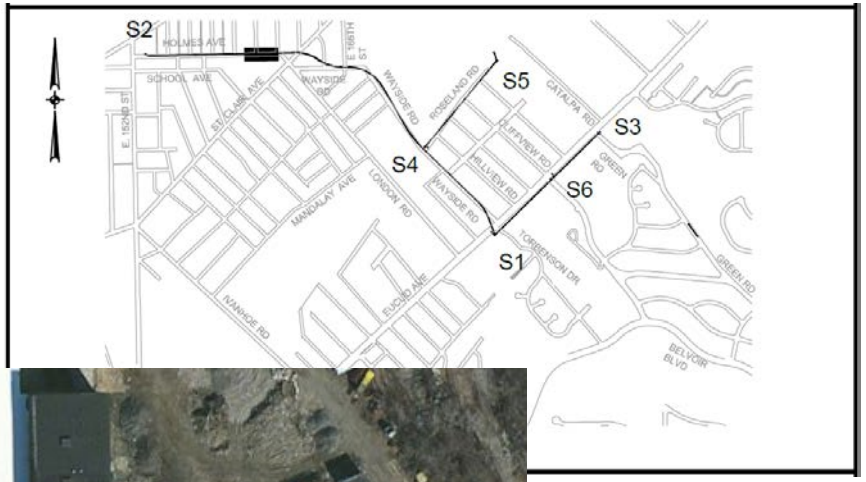
Structure Purpose:

- Relieve flow from existing interceptor

How achieved:

- Utilize the full conveyance capacity of the existing combined sewer
- Divert excess wet weather flows to relief sewer
- Dissipate energy due to elevation difference

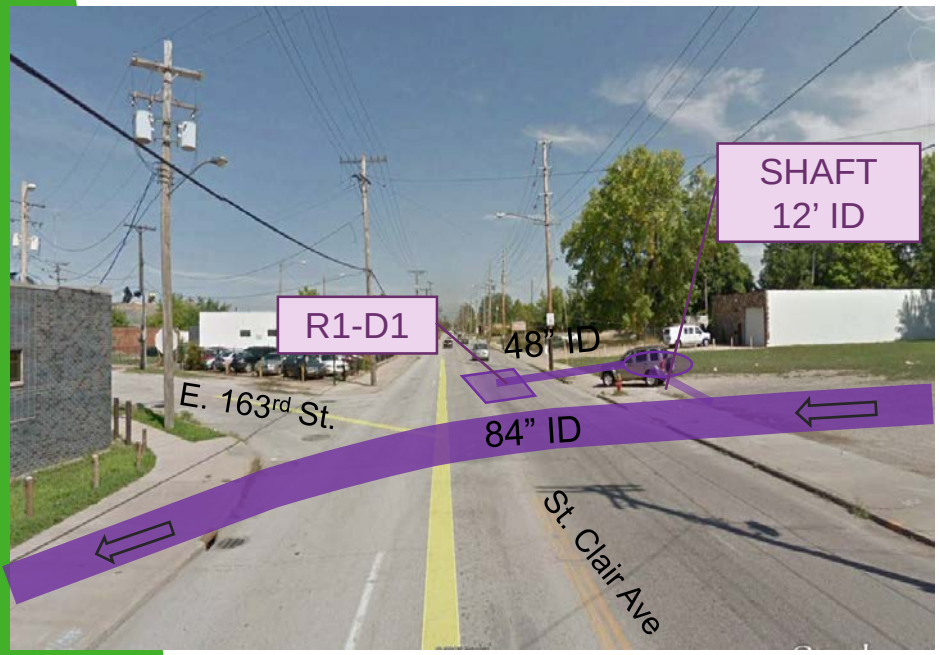
R1-D1 Location Evaluation



- Hydraulic analysis
- Anticipated construction methods
- Geotechnical conditions
- Existing underground utility impacts
- Community impacts

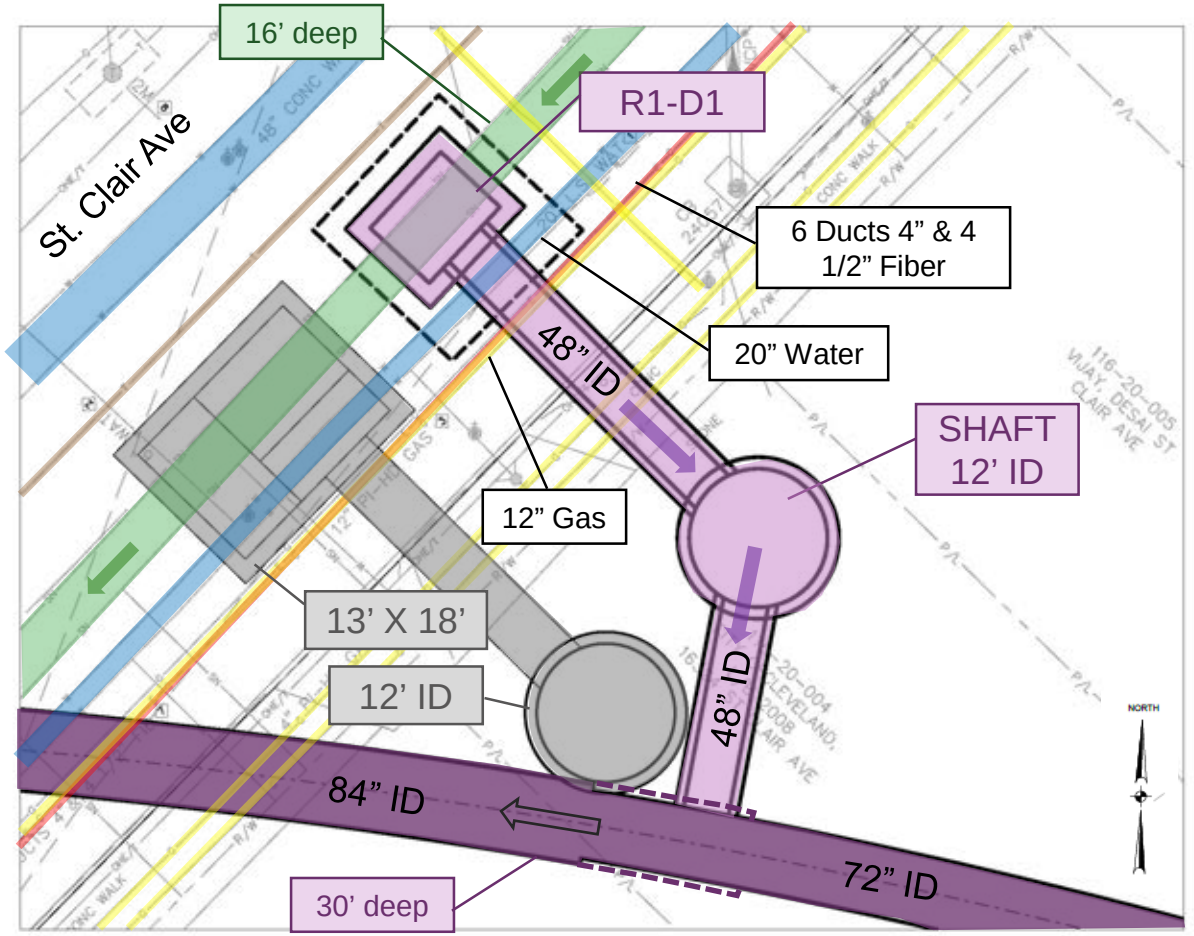
R1-D1 Site – Location #1 Utilities

- 20” water main
- Electric ductbank
- Telephone ductbank
- Gas lines



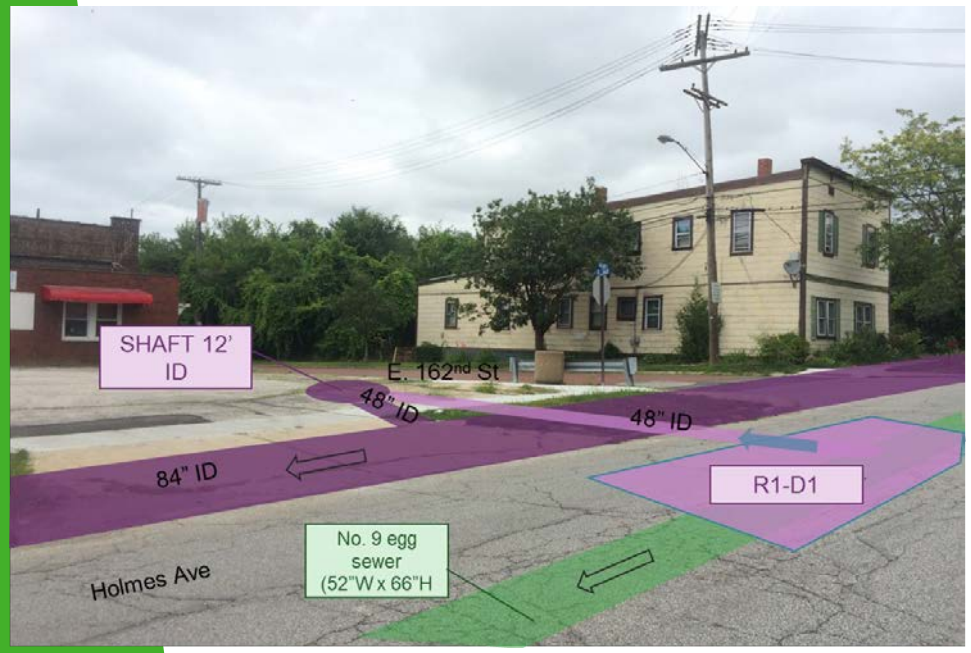
LEGEND

- PROPOSED SEWER
- SEWER
- WATER
- GAS
- TELEPHONE
- ELECTRIC



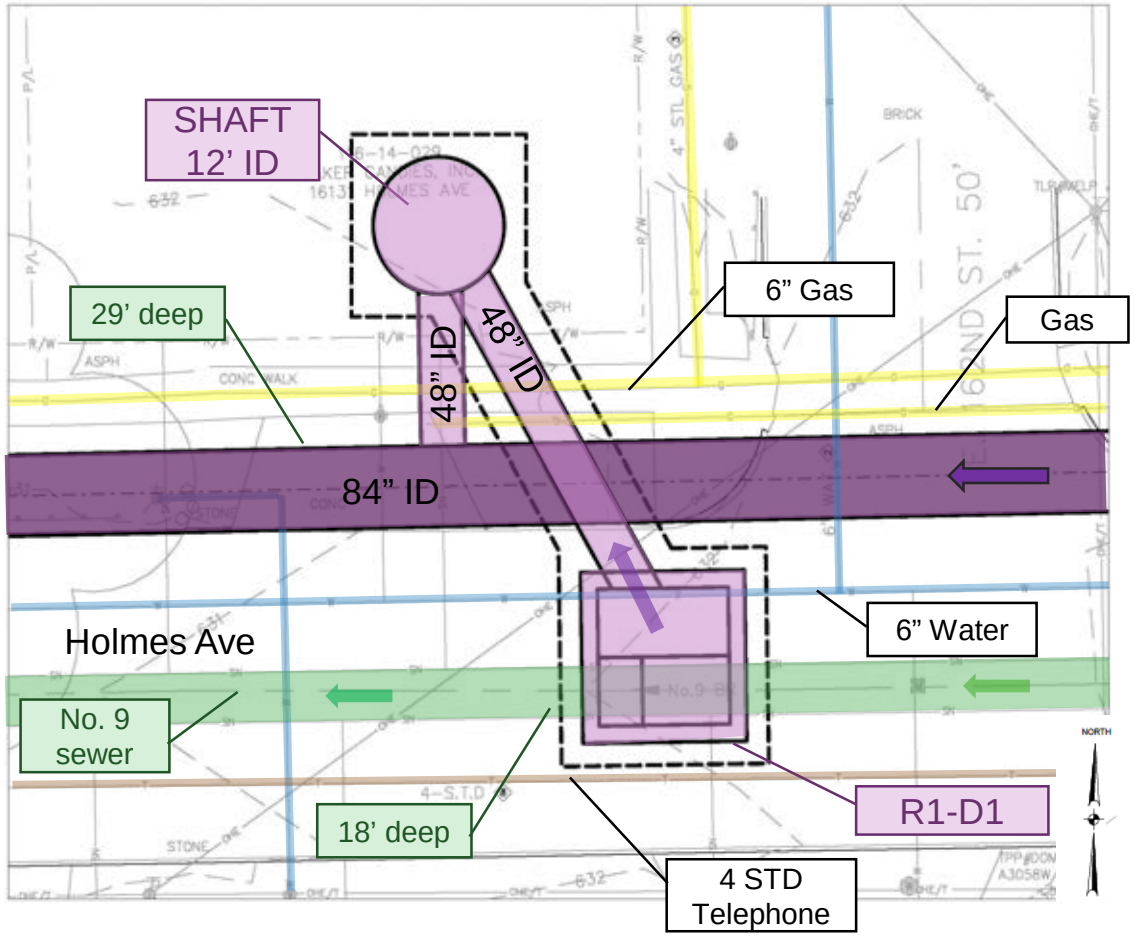
R1-D1 Site – Location #2 Utilities

- 6” water main
- Telephone ductbank
- Gas lines

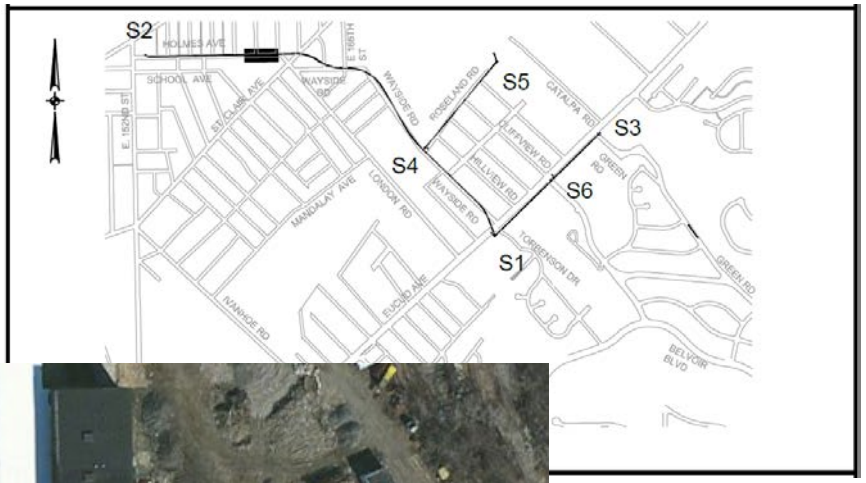


LEGEND

- PROPOSED SEWER
- SEWER
- WATER
- GAS
- TELEPHONE



R1-D1 Location Evaluation



1

- Optimal hydraulics
- Most utility conflicts

2

- Acceptable hydraulics
- Manageable utility conflicts

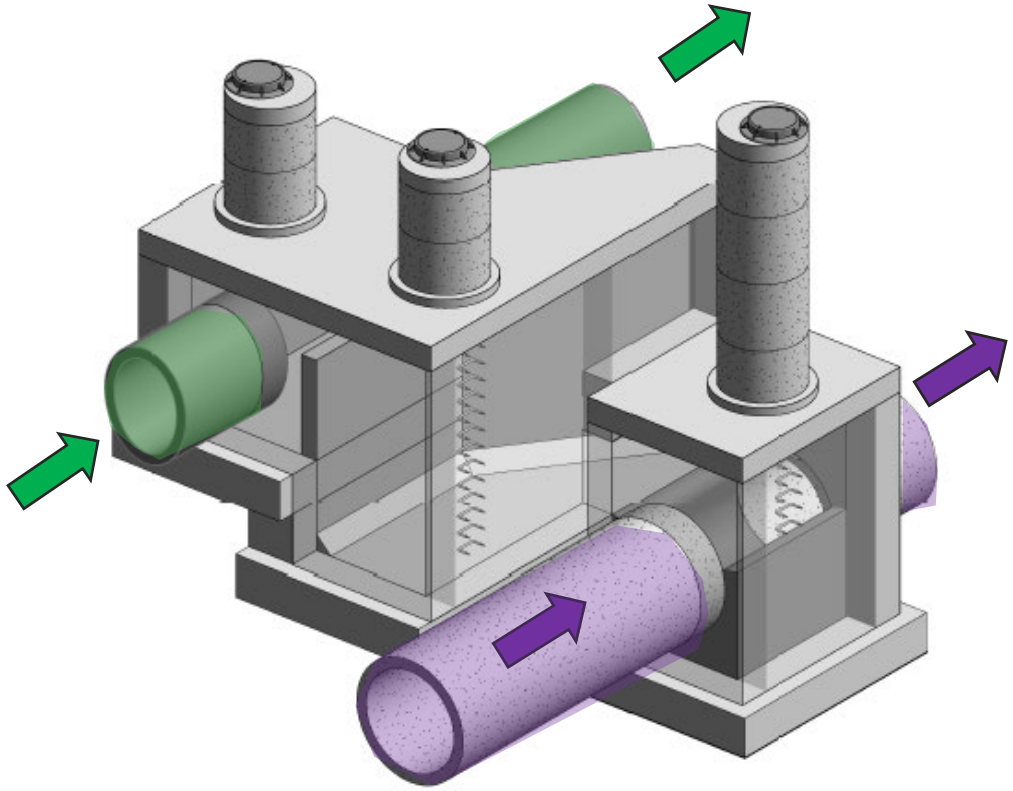
3

- Least hydraulic benefit
- Least utility conflicts

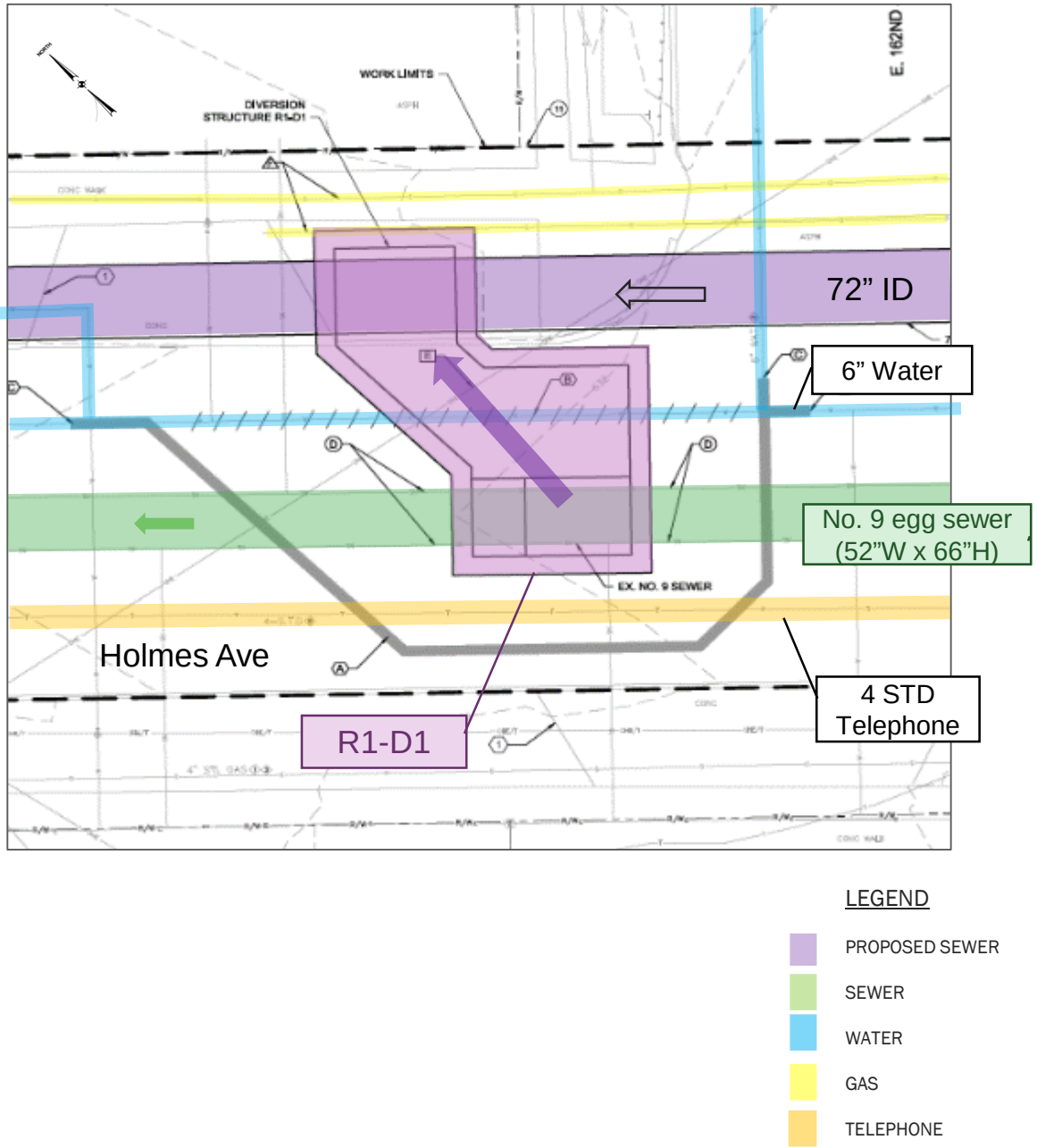
Diversion Structure R1-D1

Advance design to 60%, then use additional tools to refine

- CFD modeling
- SUE



R1-D1 ISO



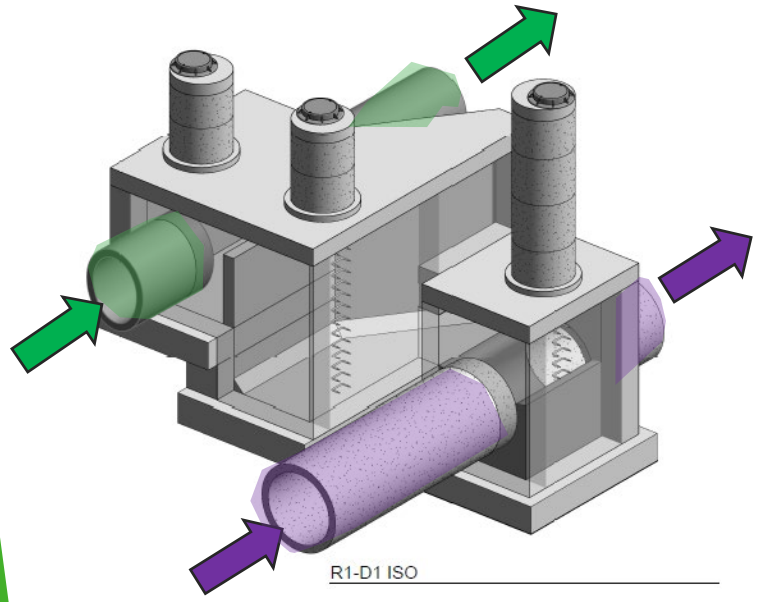
CFD Modeling Workflow

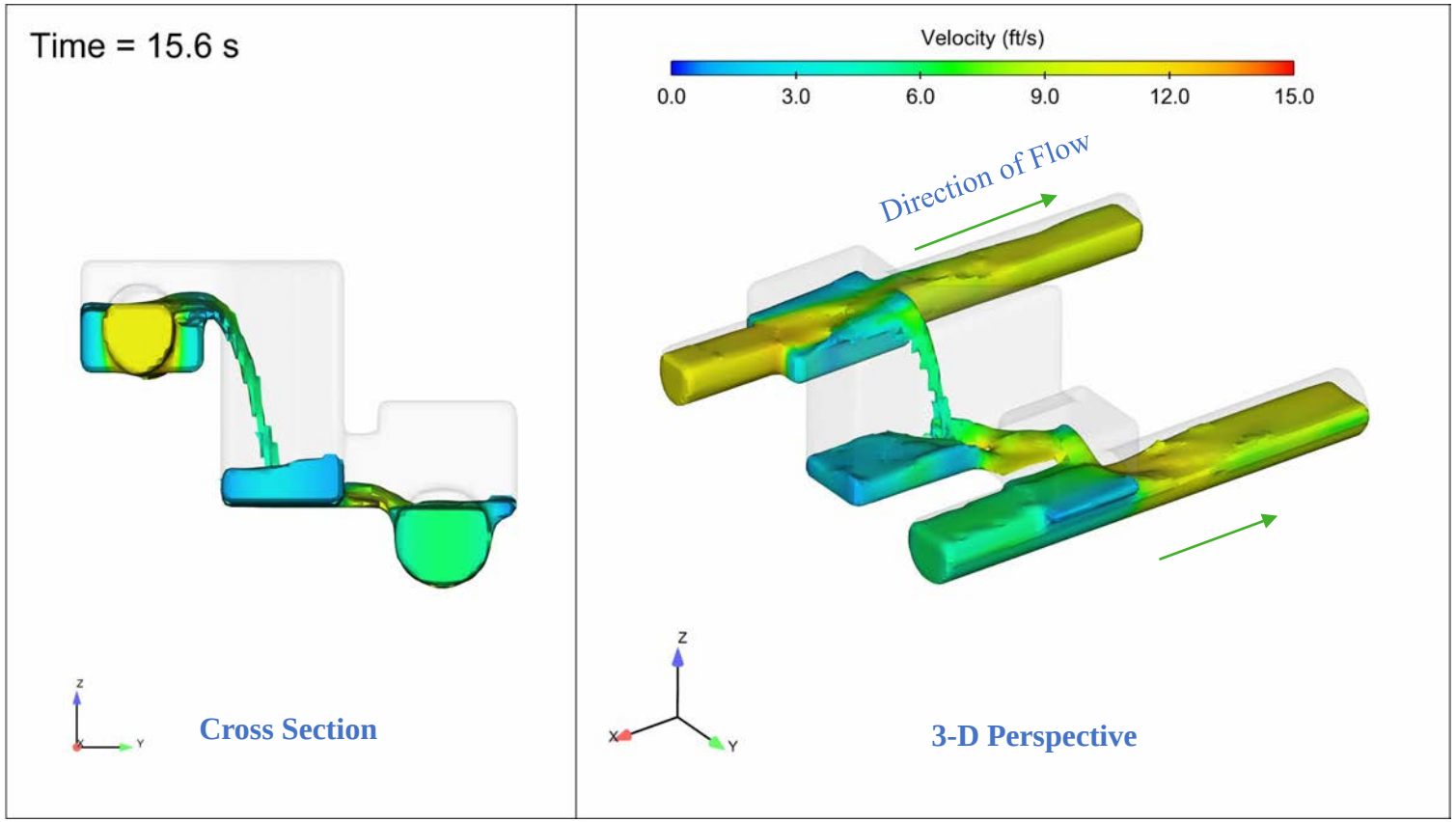
- Develop 3D model representing structure geometry
  - Autodesk REVIT
- Export 3D model as Stereolithography (STL) file for import into FLOW-3D
- Develop coarse mesh model, define boundary and initial conditions
- Evaluate the sensitivity of the numerical methods
- Refine mesh for additional accuracy and verification of solution convergence

Diversion Structure R1-D1 Refinement Through CFD

Alt 1 - Large chamber with side spill weir (60% design)

- Stagnant area after drop due to momentum over weir
- Large footprint

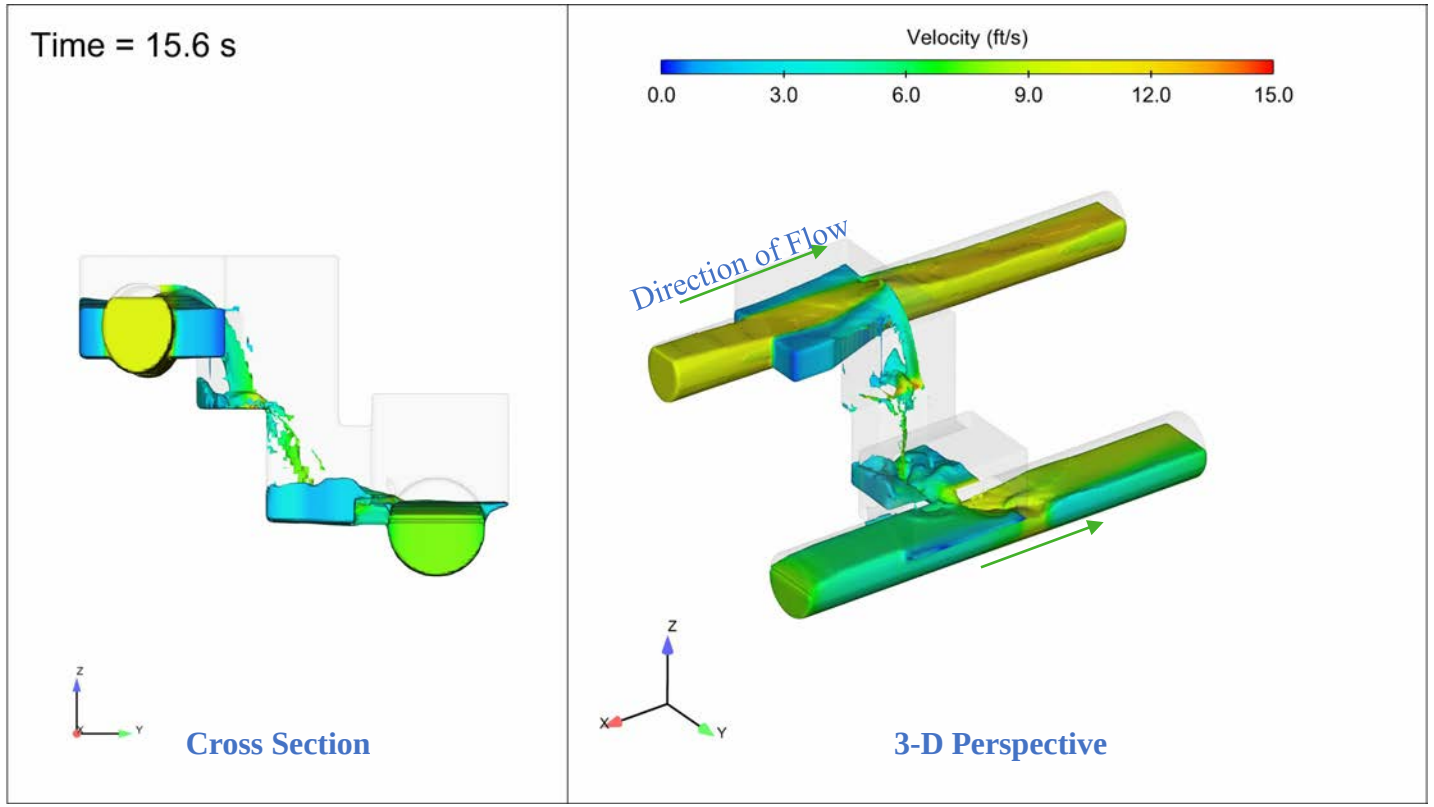




Diversion Structure R1-D1 Refinement Through CFD

Alt 2 - Decreased chamber length with intermediate step

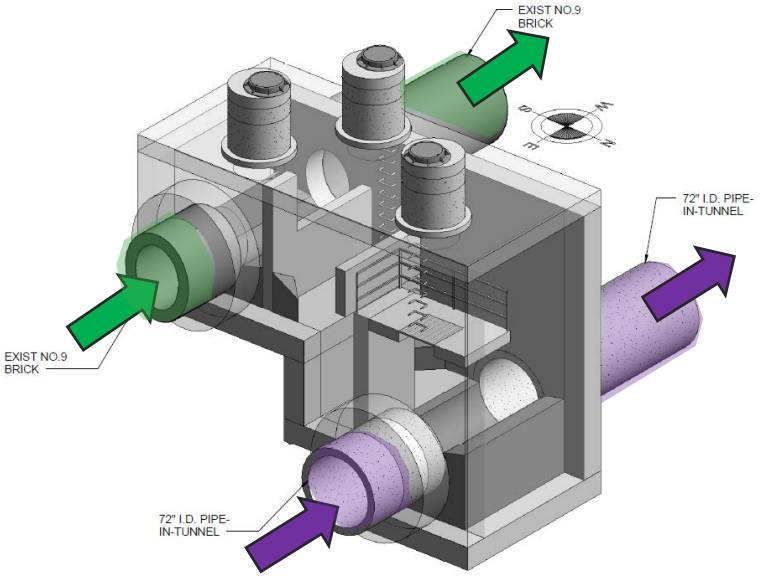
- High turbulence on step, unsteady flow
- Improved energy dissipation and outlet hydraulics

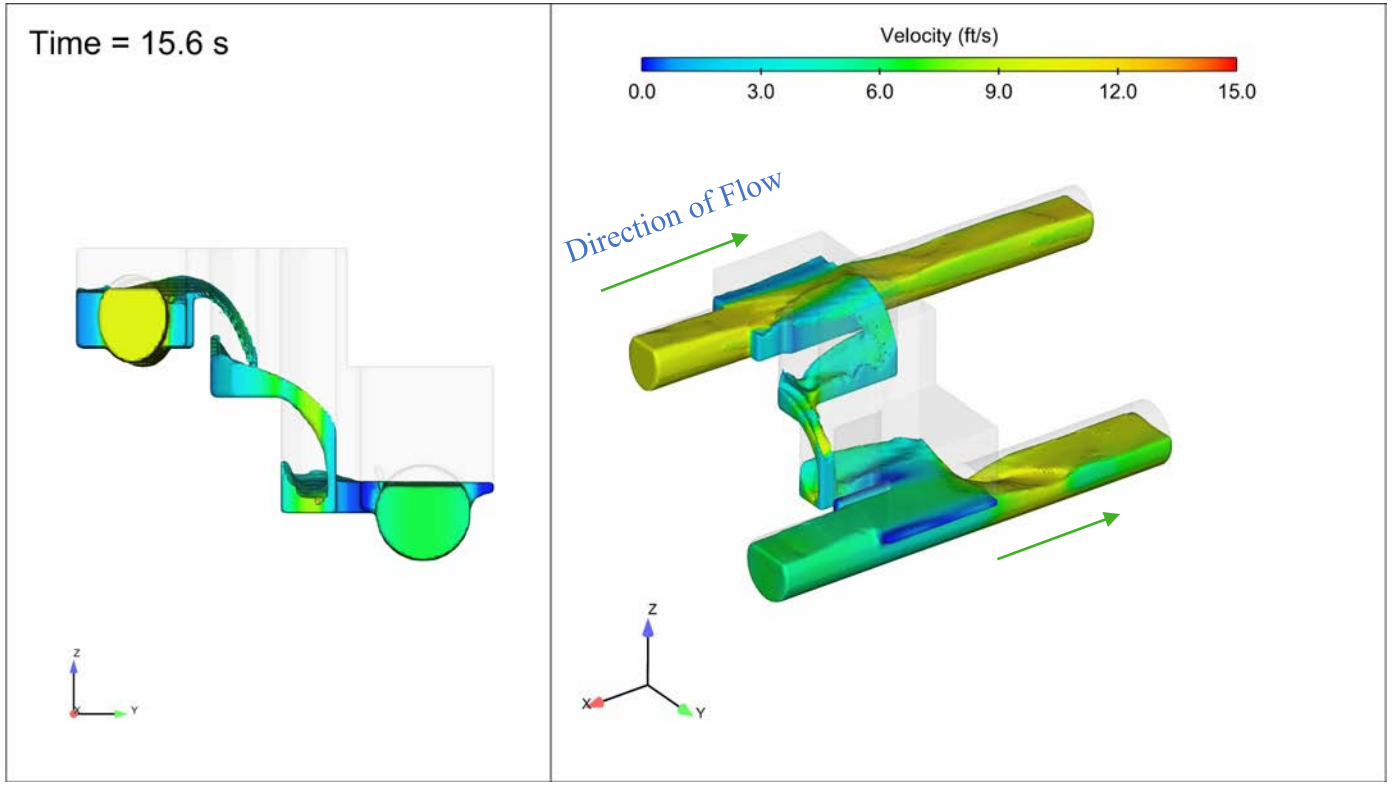


Diversion Structure R1-D1 Refinement Through CFD

Alt 3 - Decreased chamber length, stepped with dividing walls

- Steady flow through structure
- Improved energy dissipation and outlet hydraulics





Cross Section

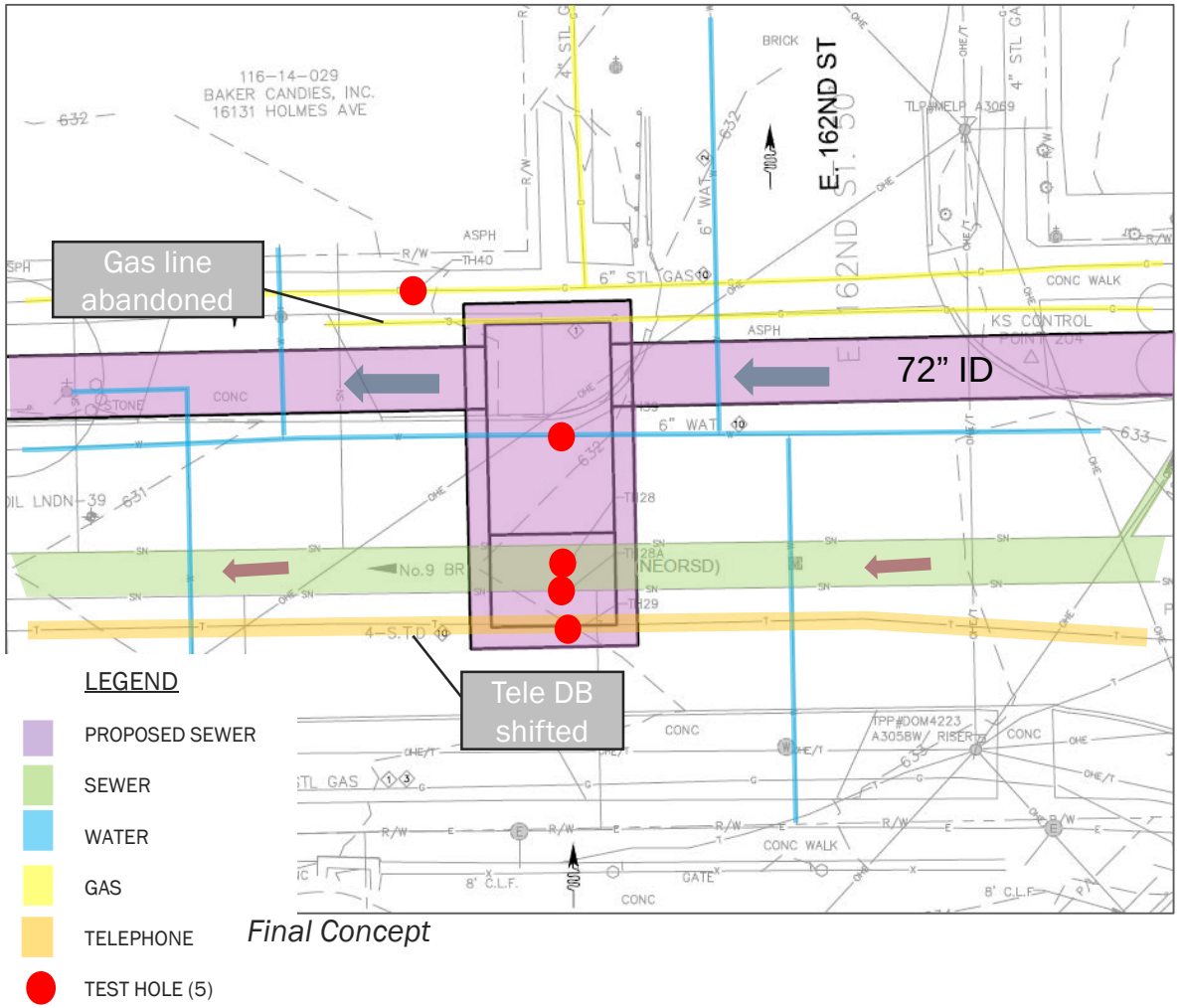
3-D Perspective

SUE Approach

- ASCE Standard 38-02 “Standard Guideline for the Collection and Depiction of Existing Subsurface Utility Data”
- Progression of detail:
  - Level D: records research
  - Level C: above ground survey
  - Level B: utility designation
  - Level A: test hole/pot holing

Diversion Structure R1-D1 SUE

- 5 Level A test holes performed
  - Located top and sides of existing sewers
  - Confirmed underground utility locations
- Coordinated with utility companies

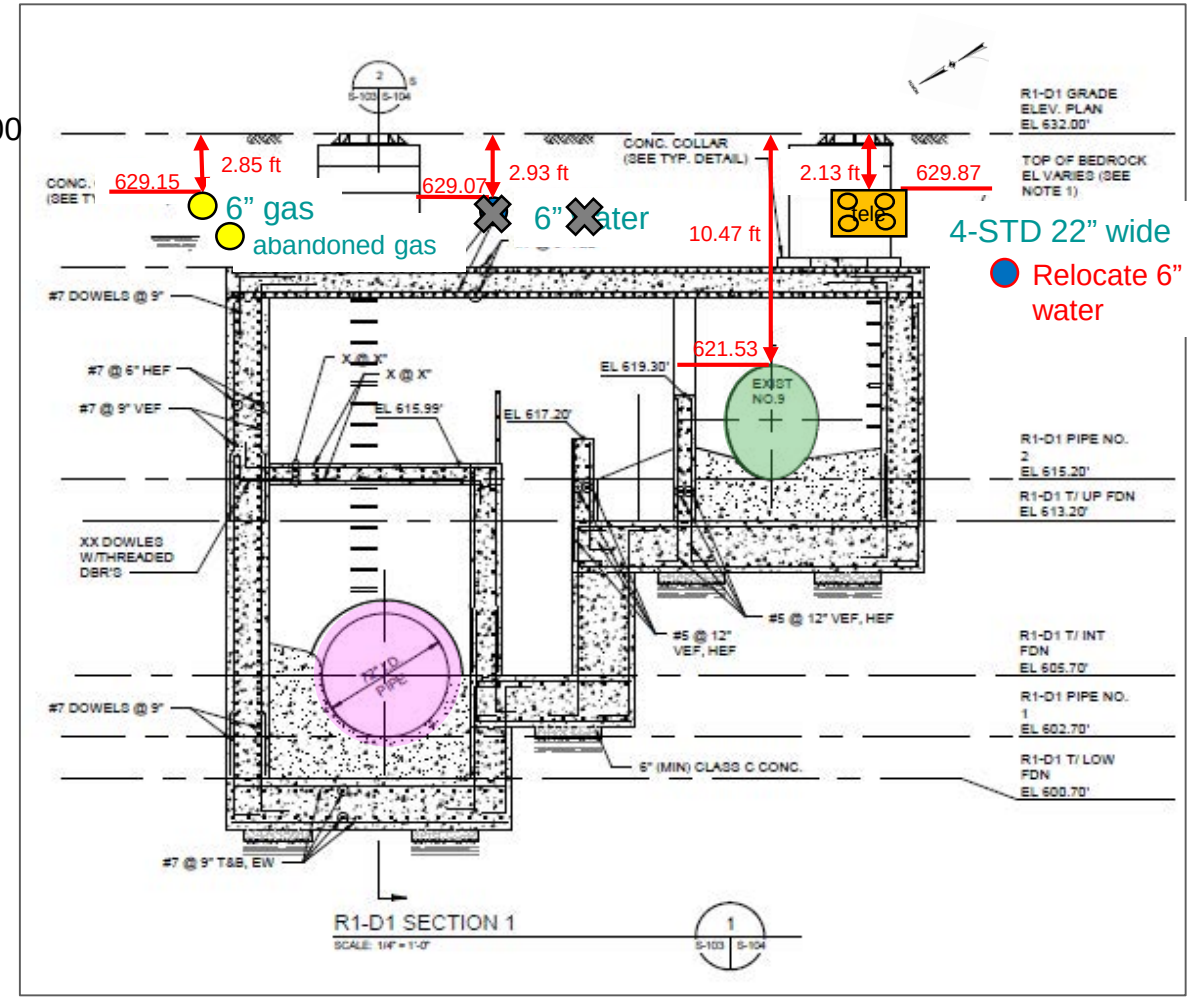


Final Concept

Diversion Structure R1-D1 SUE

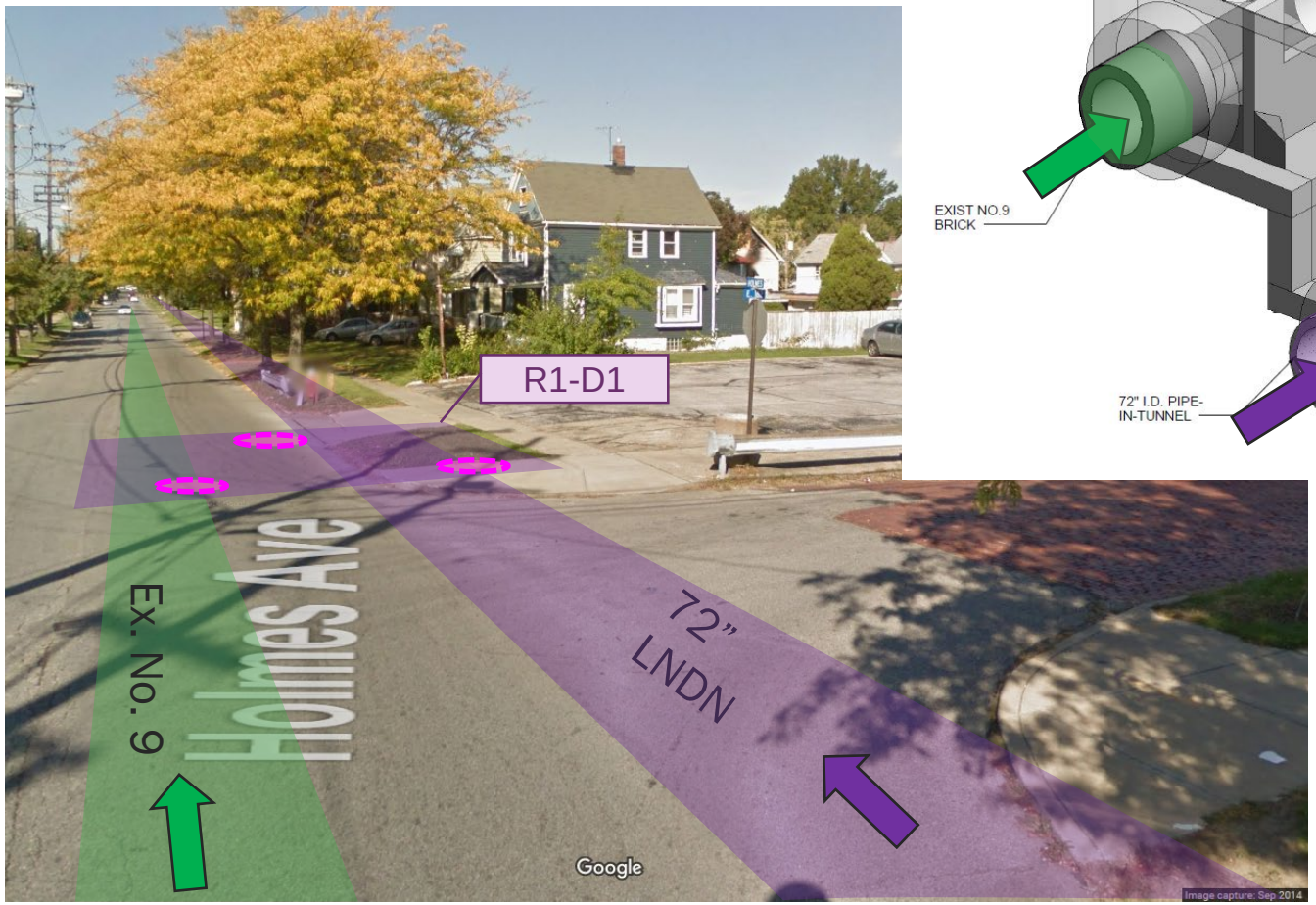
Results:

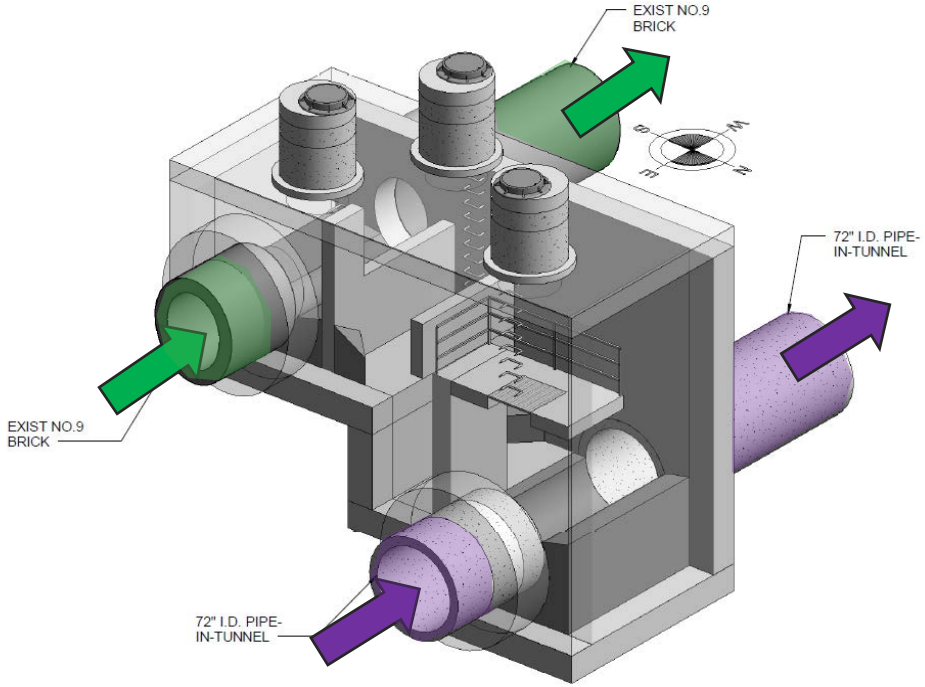
- Unknown gas line was confirmed as abandoned, remove during construction
- Telephone ductbank located, different than record drawings
  - Lowered structure roof
  - Relocated structure riser



R1-D1 Structure Final Configuration

Compact shape
Refined hydraulics
Minimized utility conflicts





LEGEND

PROPOSED SEWER

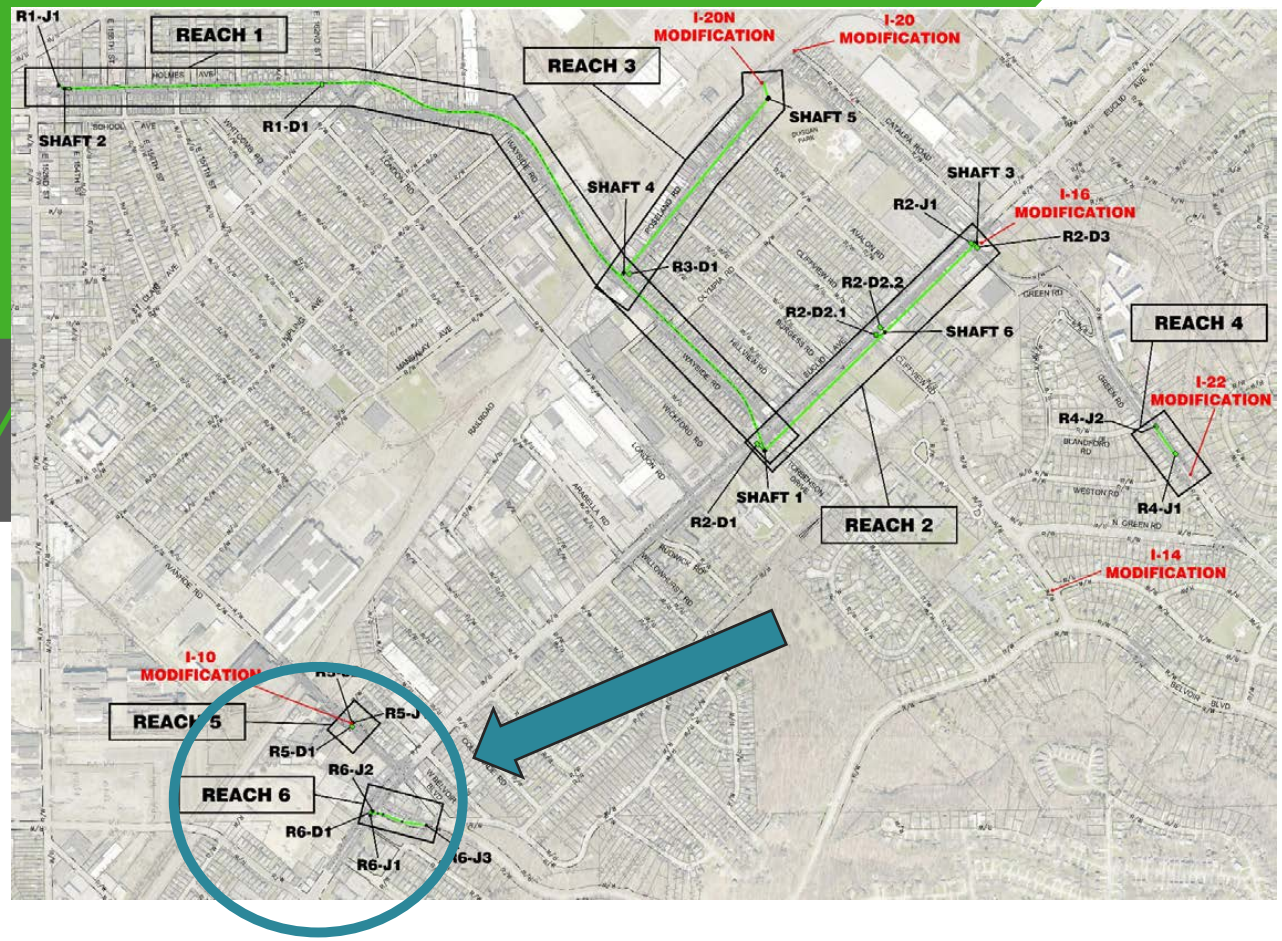
EXISTING SEWER (

PROPOSED ACCESS
OPENING

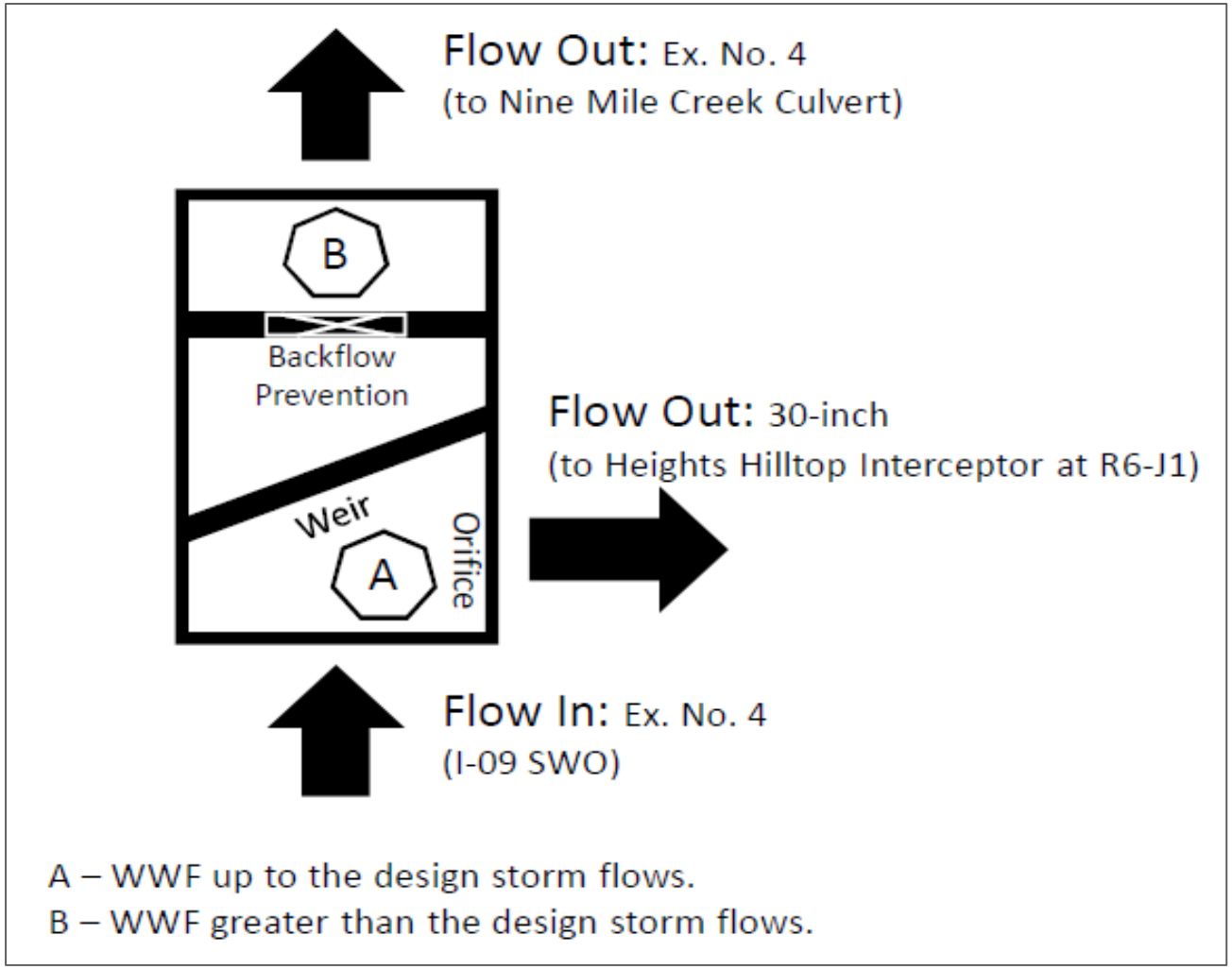
Diversion Structure R6-D1

Design Refinement

- SUE
- Utility Owner Coordination



Diversion Structure R6-D1



No. 4 egg shaped sewer (39”H x 30”W)

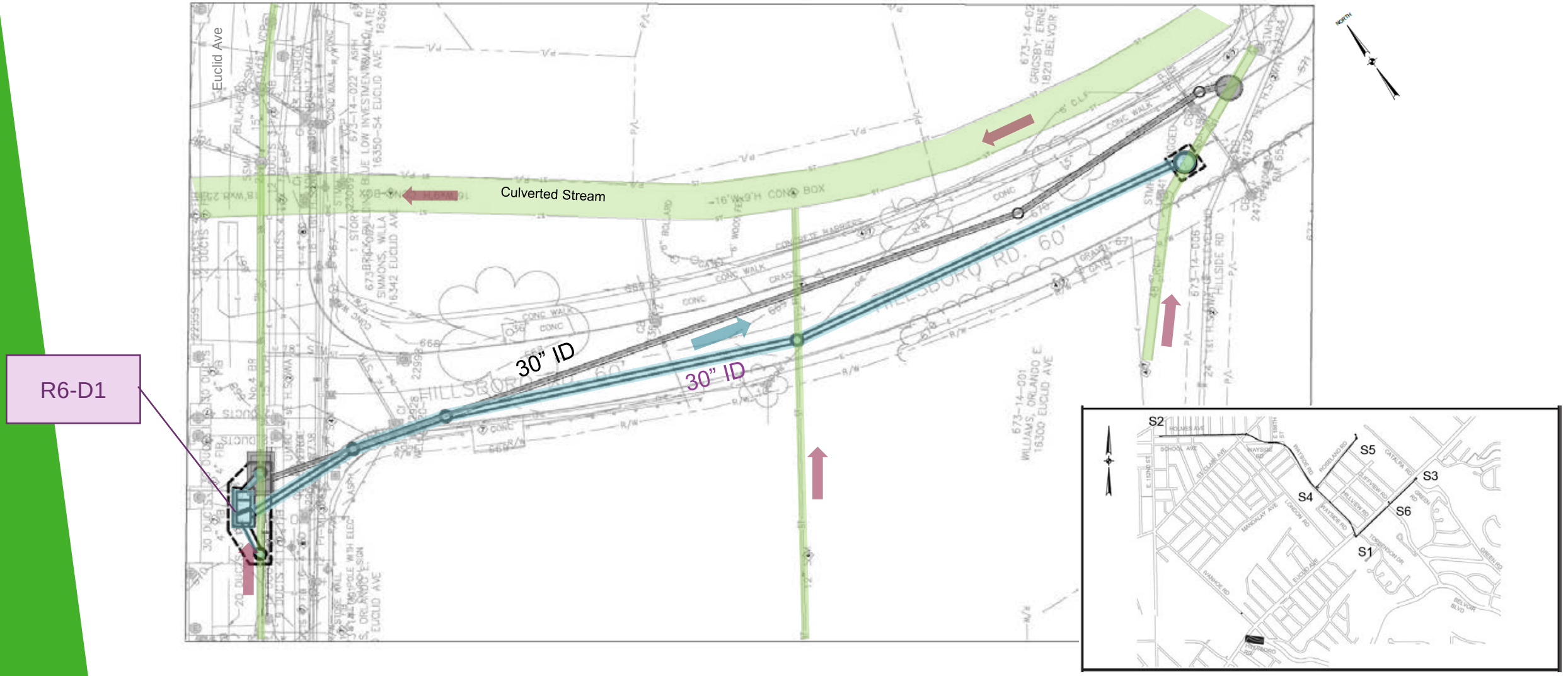
Structure purpose:

- Reduce CSO overflows to Nine Mile Creek

How achieved:

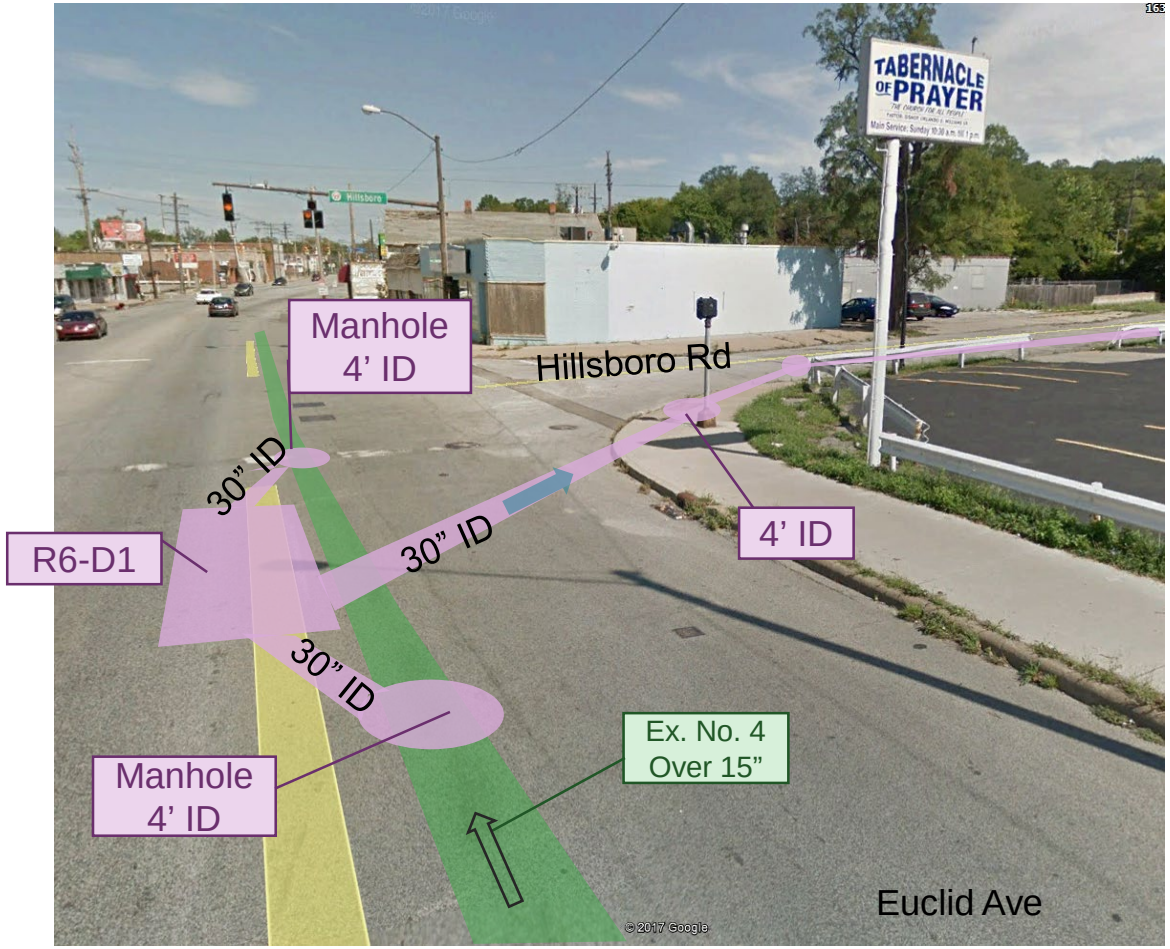
- Divert excess wet weather flows to new relief sewer
- Use conveyance capacity of nearby existing combined system (HHI)

Diversion Structure R6-D1



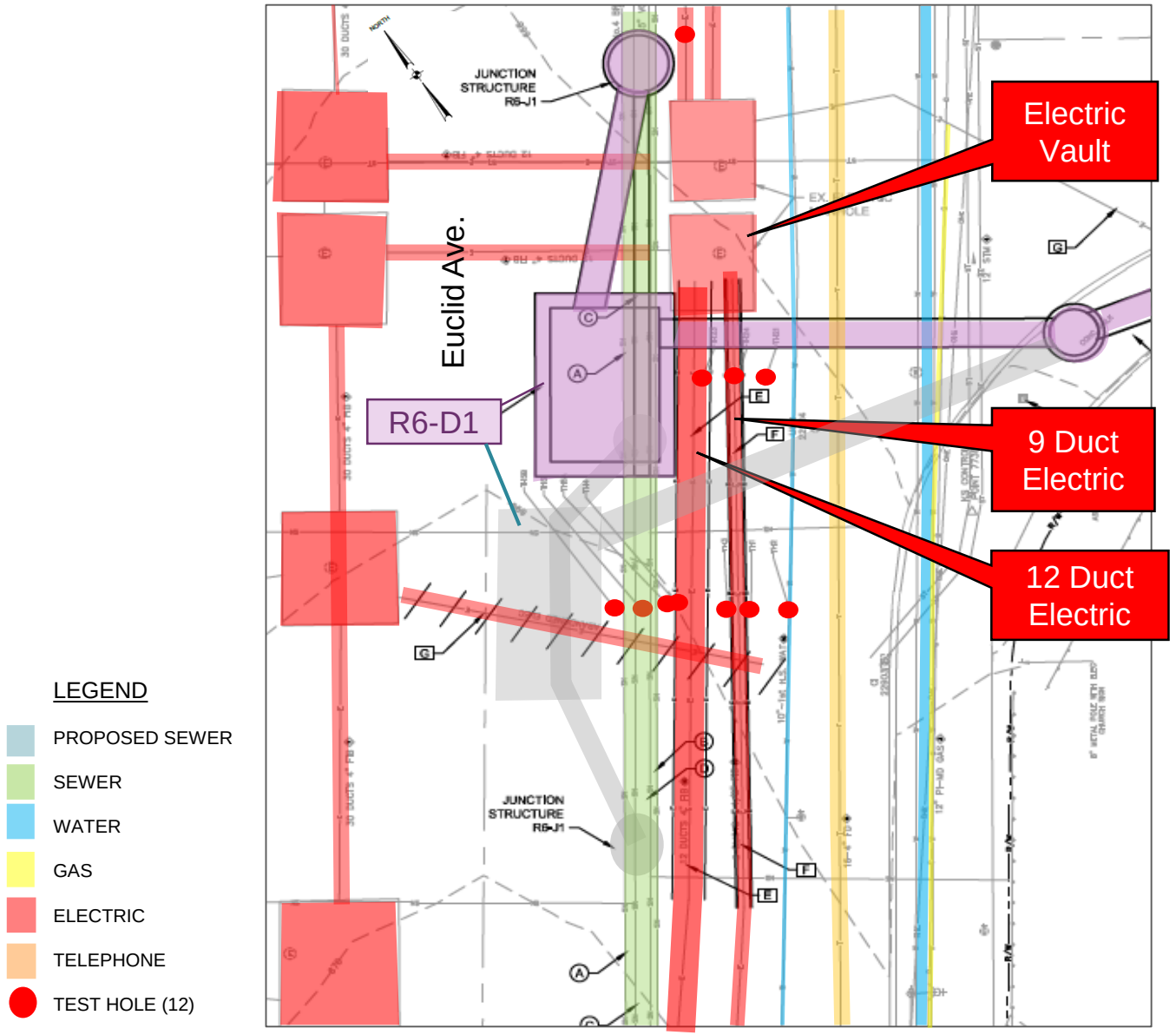
Diversion Structure R6-D1 SUE

- 12 Level A test holes performed in two rounds
  - Located top and sides of existing sewers
  - Confirmed underground utility locations
- Coordinated with utility companies
  - Electric Company - CEI



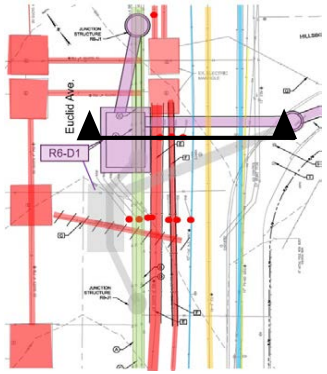
Diversion Structure R6-D1 SUE

- Round 1: 7 test holes
  - Horizontal and vertical conflicts with electric ductbanks
- Round 2: 5 test holes
  - Reduced vertical conflict

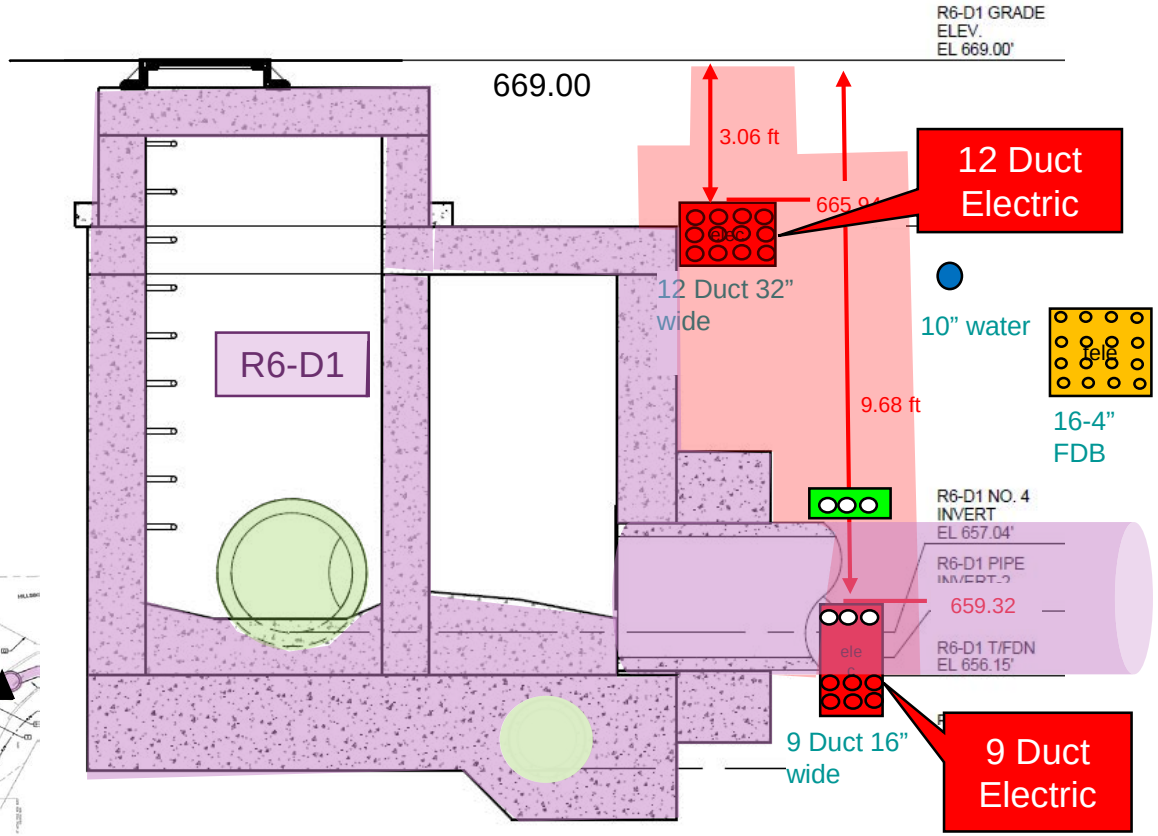


Diversion Structure R6-D1 Electric Utility Coordination

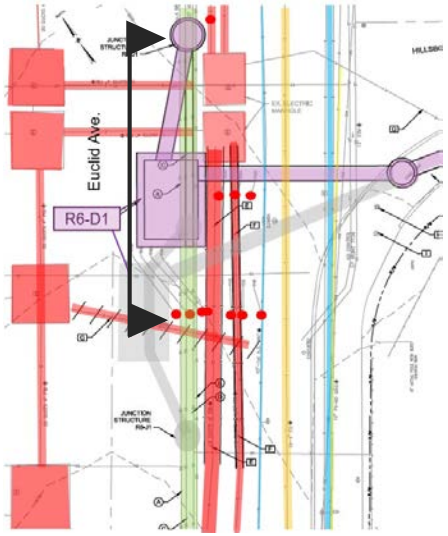
- 12 Duct system
  - Can be relocated horizontally
- 9 duct system
  - Top 3 ducts are vacant, can relocate vertically



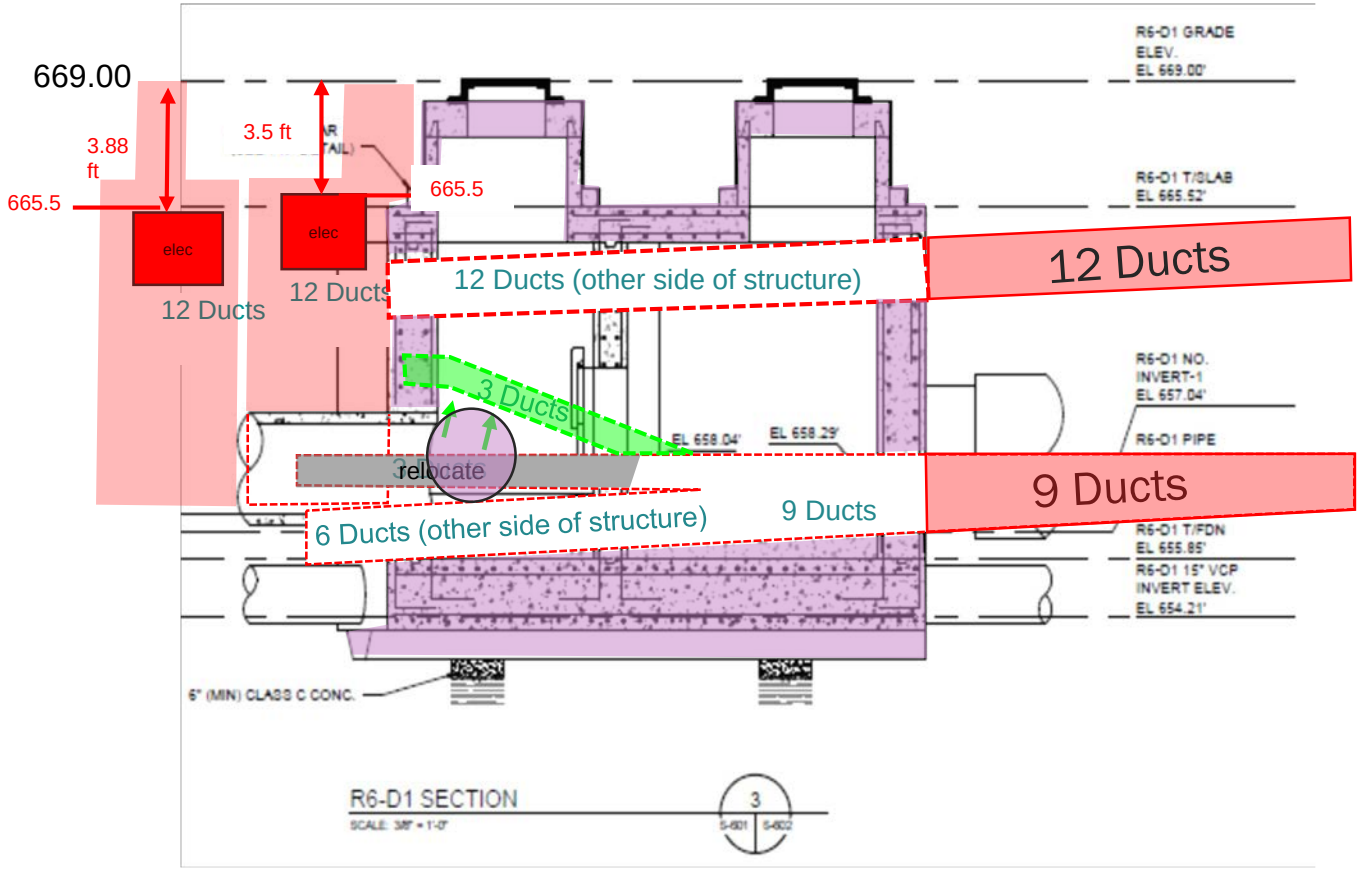
R6-D1 Plan



R6-D1 Electric Ductbank Locations



R6-D1 Plan



R6-D1 Results of SUE and Utility Coordination

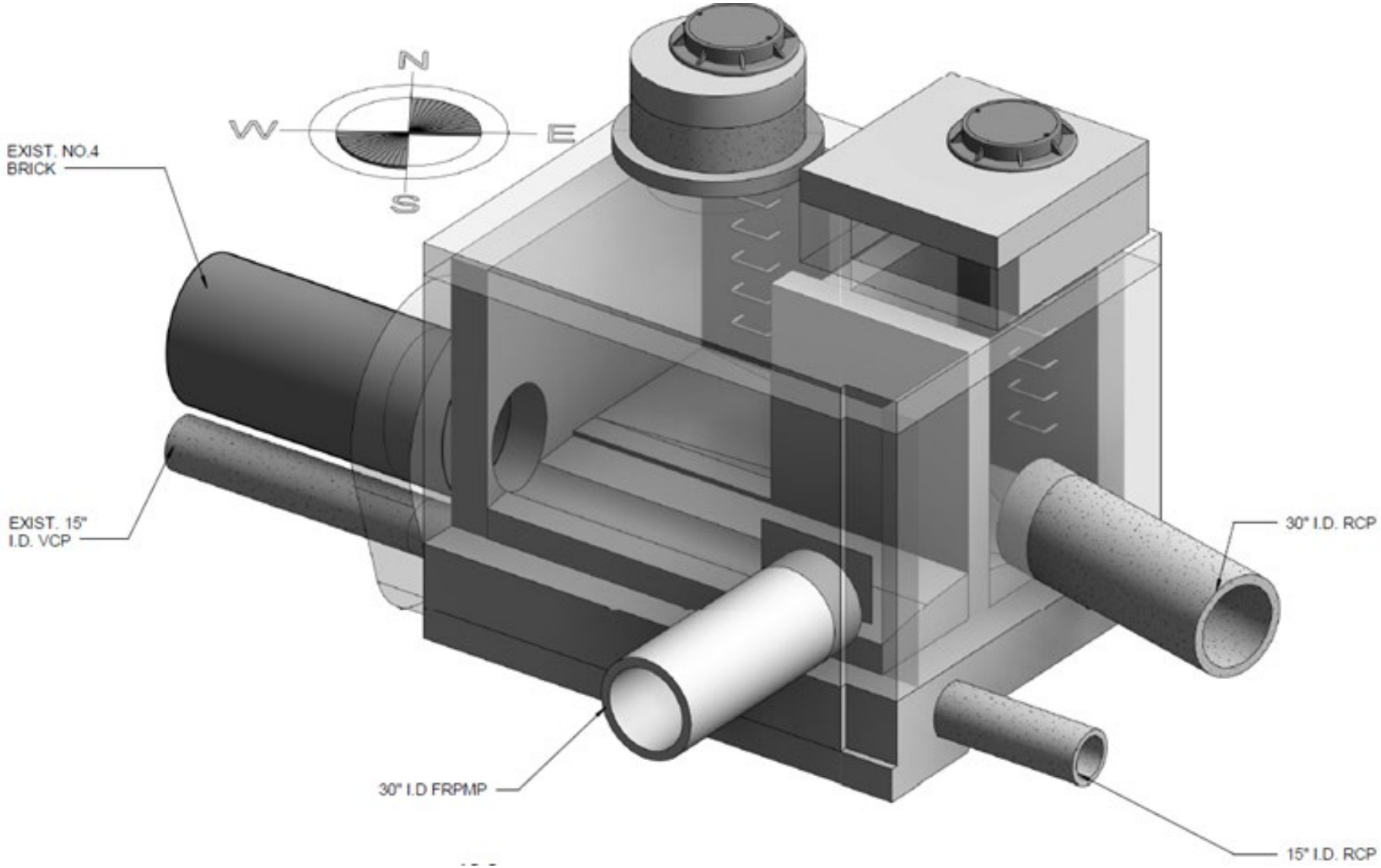
SUE

- Confirmed horizontal and vertical locations of utilities
  - 1st round – revise layout
  - 2nd round – viable

Utility coordination

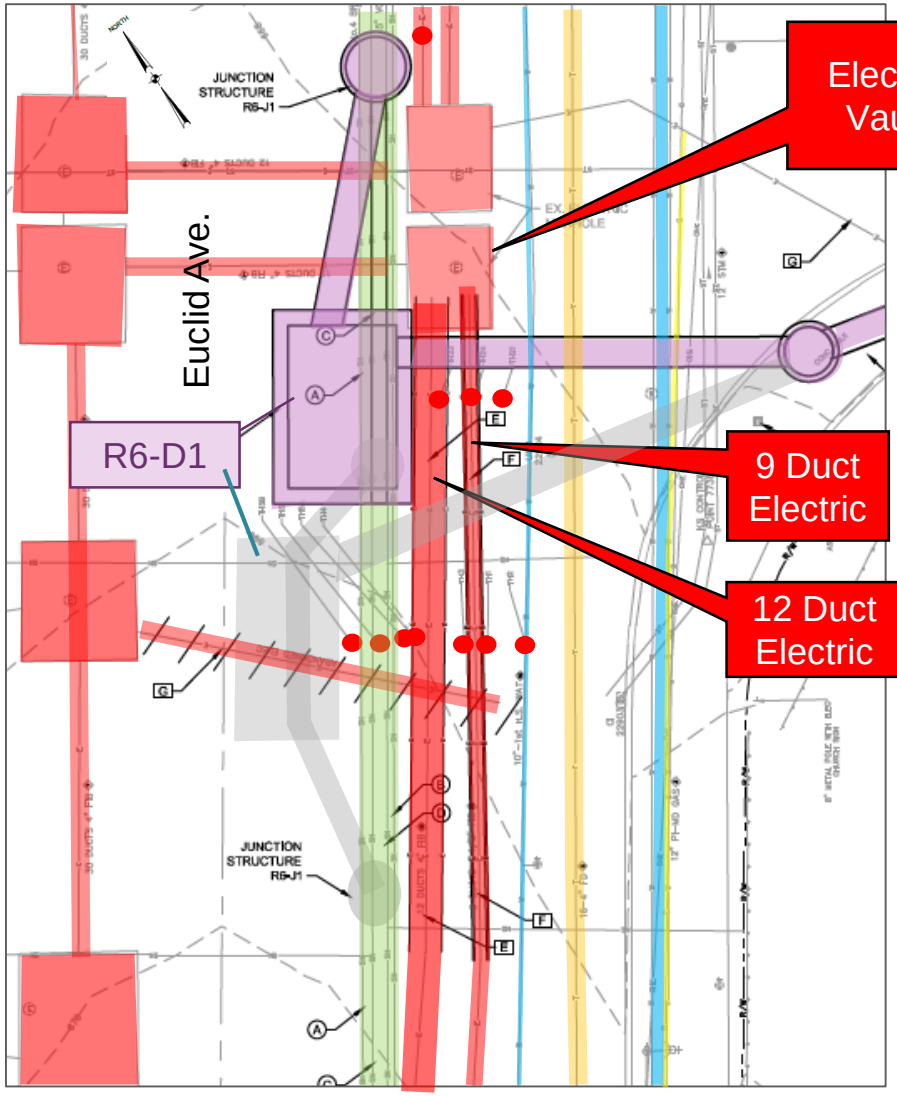
- Corroborated SUE information
  (from MH inspections & records)
- Confirmed vacant ducts
- Allowed R6-D1 Structure to be cast against existing Electric Vault
- Estimated relocation costs

R6-D1 Final Configuration



R6-D1 Plan

Construction?



Electric Vault

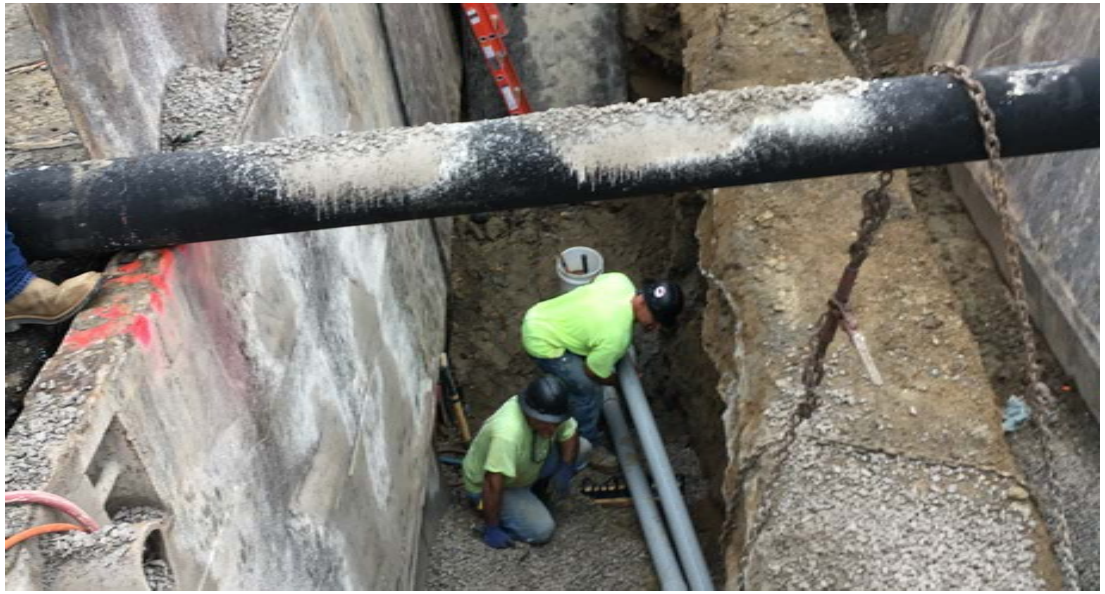
9 Duct Electric

12 Duct Electric

LEGEND

- PROPOSED SEWER
- SEWER
- WATER
- GAS
- ELECTRIC
- TELEPHONE
- TEST HOLE (12)

Pipe Installation & Duct Bank Relocation

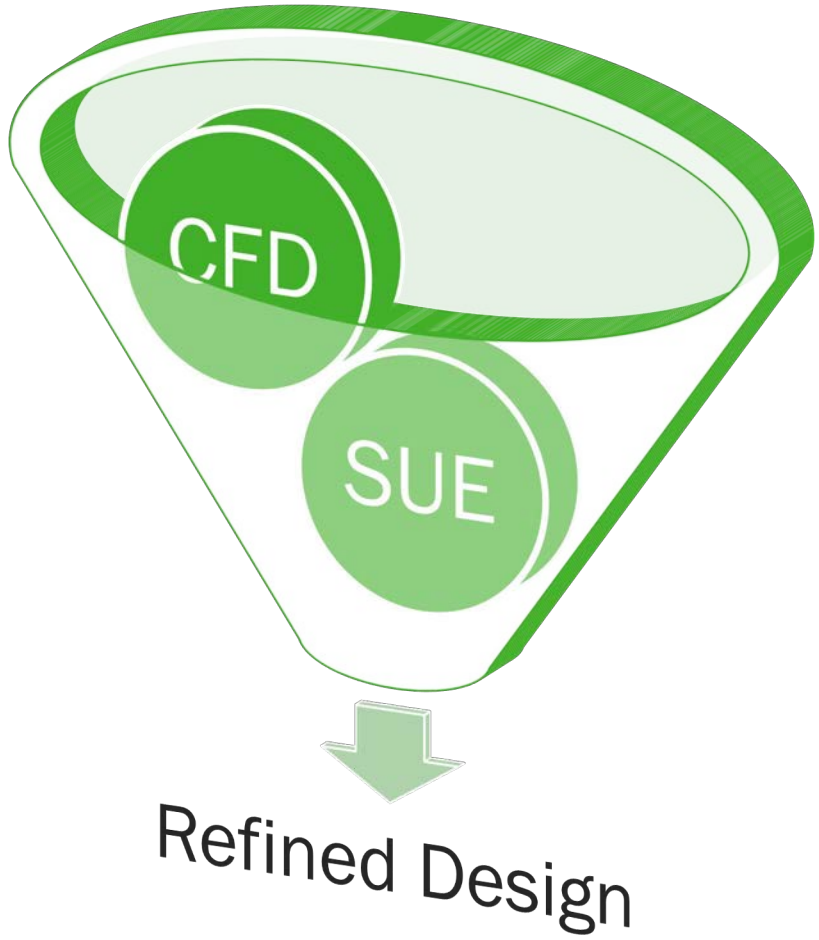



ROAD CLOSED
TRAFFIC


312C
CAT

Conclusions

- Designs can be enhanced by selectively using targeted tools
- Use tools at appropriate times
  - Collection system modeling
  - CFD modeling
  - SUE
  - Coordination with utility owner(s)
- Additional cost during design yields reduced risk and cost during construction



Thank you!

Questions?

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216.363.0300 office
216.317.6662 cell

Additional reference slides not presented follow this one.


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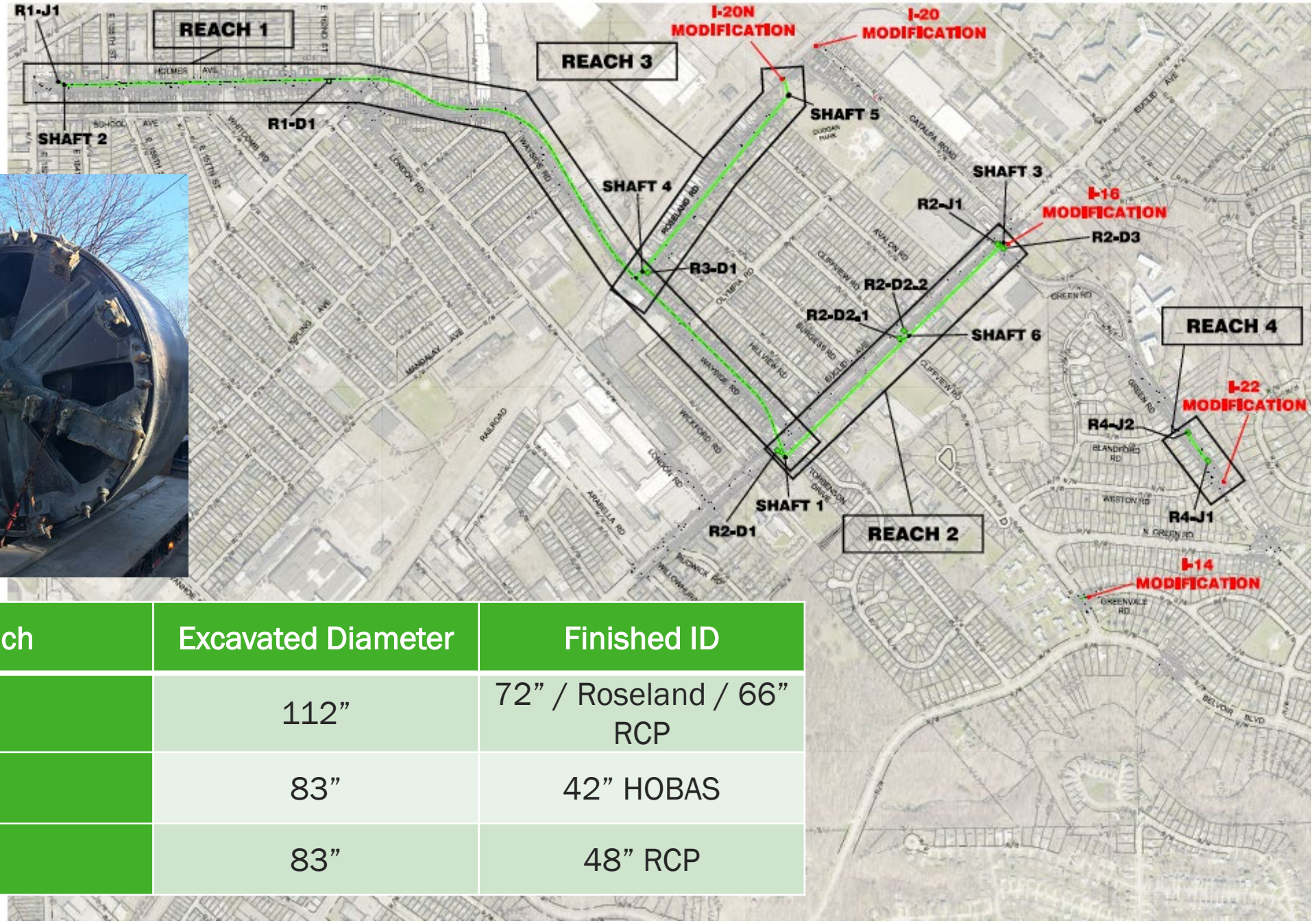


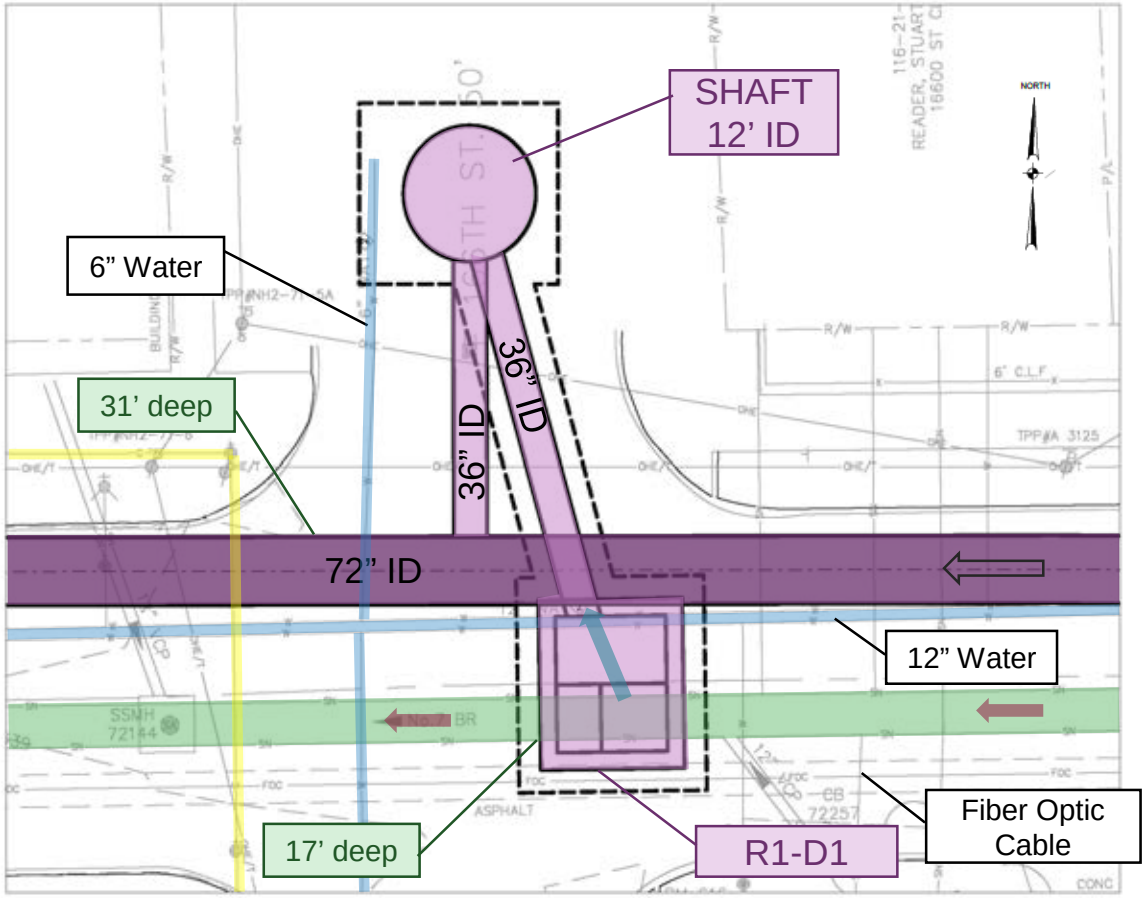
Reach	Excavated Diameter	Finished ID
1	112”	72” / Roseland / 66” RCP
2	83”	42” HOBAS
3	83”	48” RCP

R1-D1 Site – Location #3 Utilities

- 6” water main
- Telephone ductbank
- Gas lines

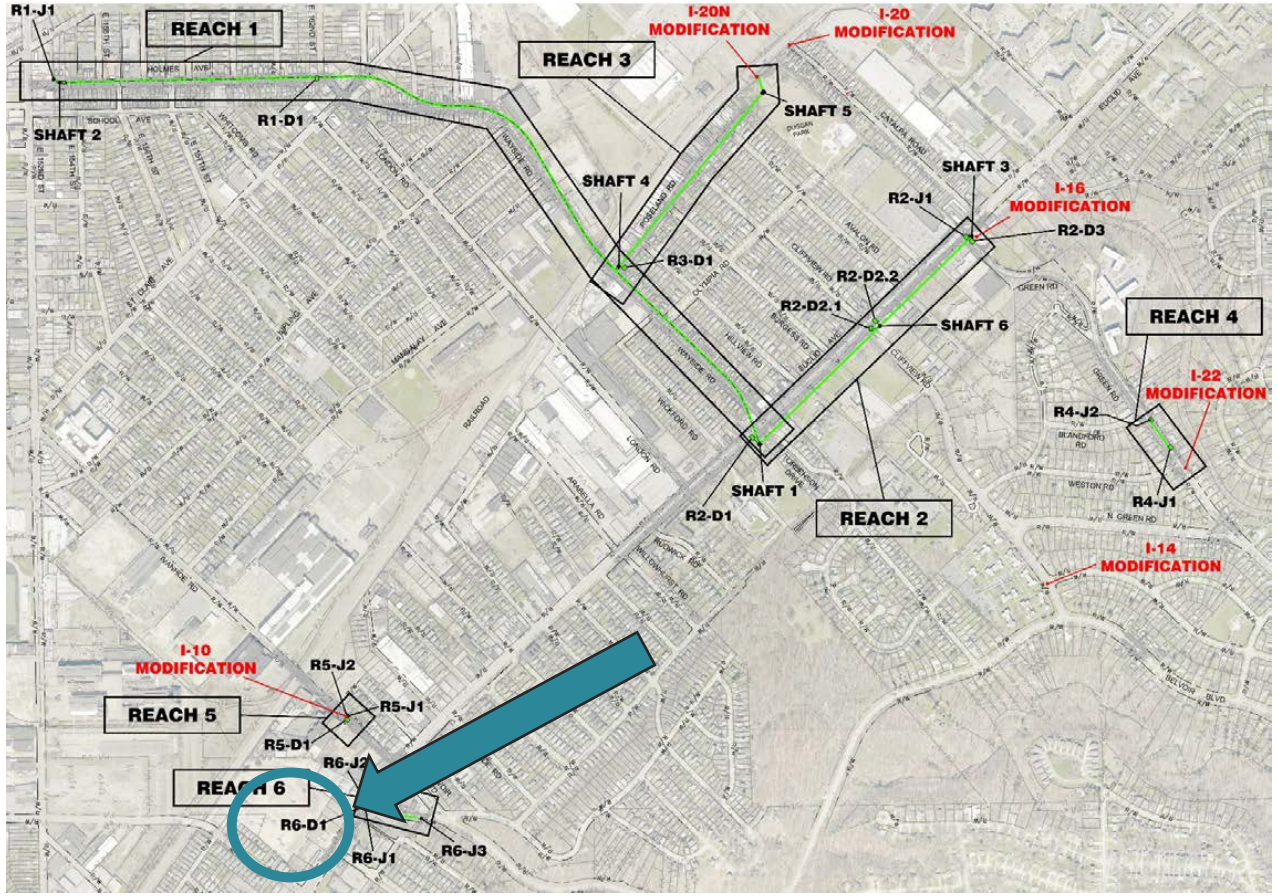
LEGEND

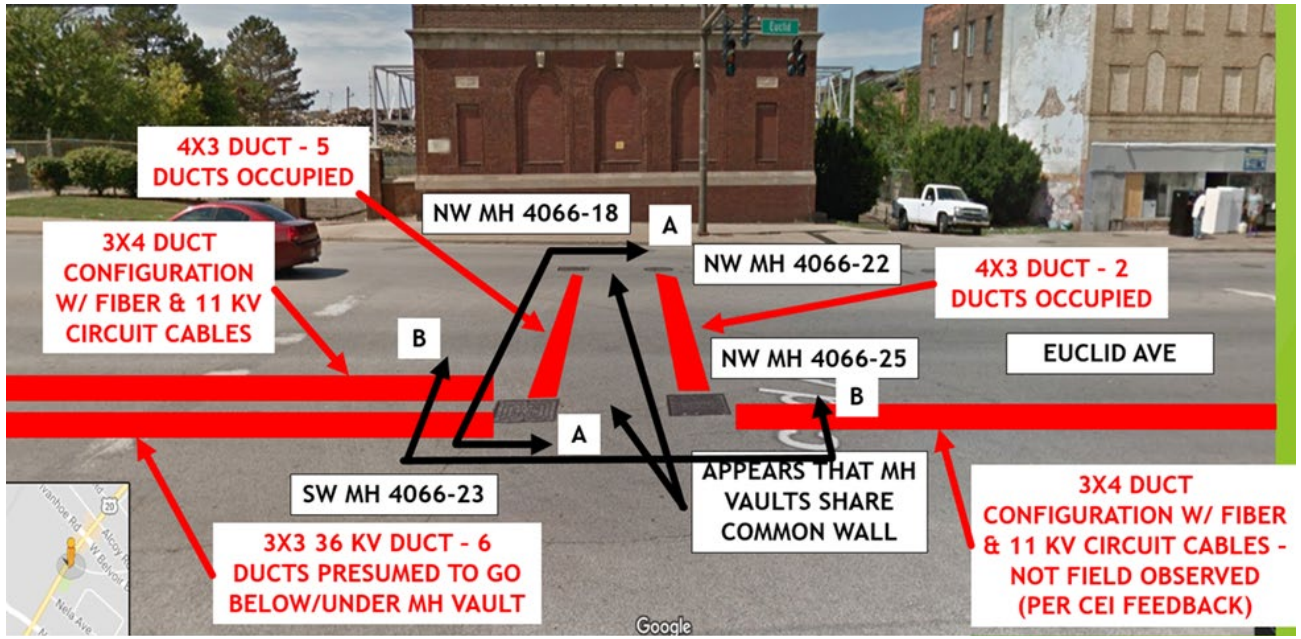
- PROPOSED SEWEI
- SEWER
- WATER
- GAS
- TELEPHONE



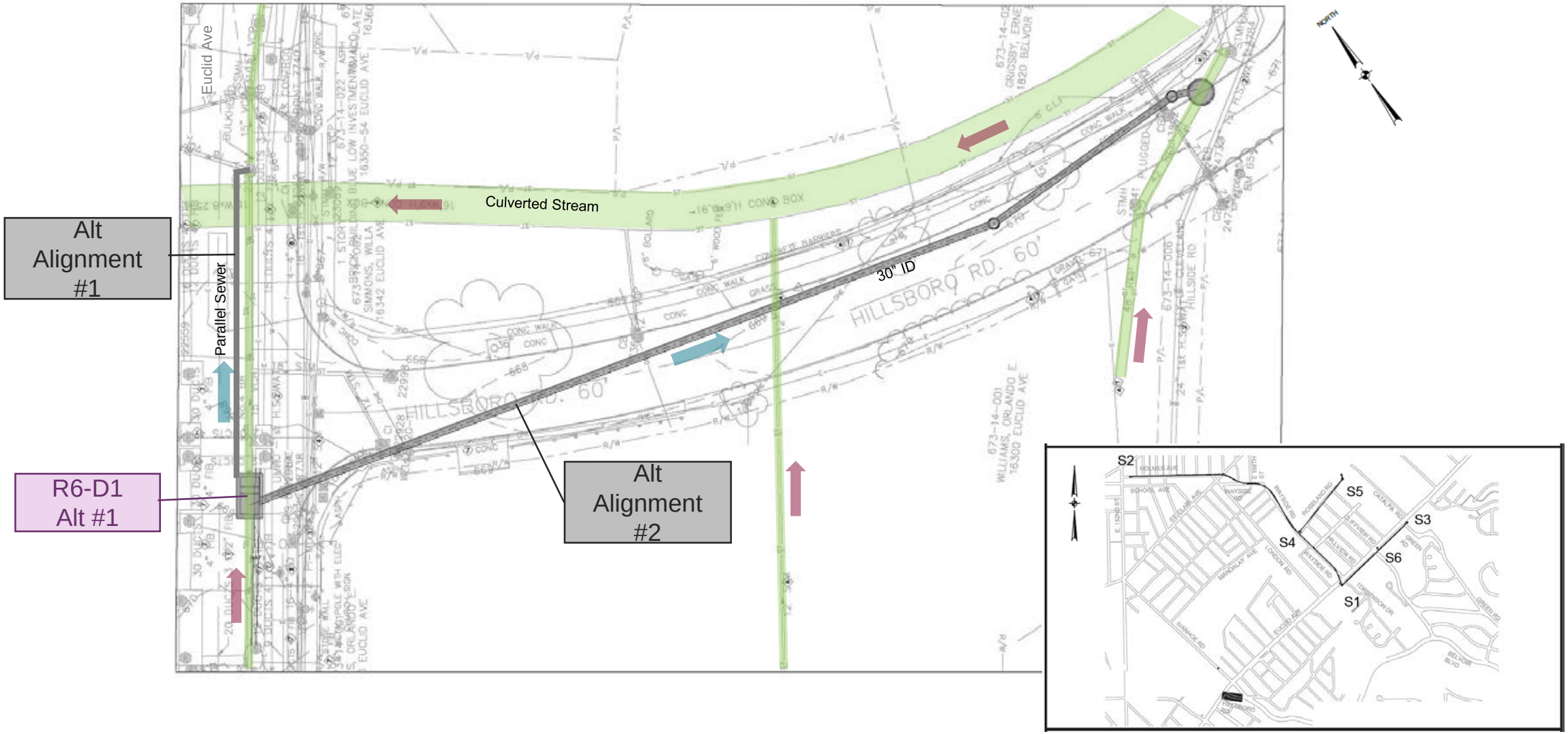
Diversion Structure R6-D1

- Purpose of Structure
- Sewer Alignment/ Connectivity
- SUE
- Utility Owner Coordination




4X3 DUCT - 5 DUCTS OCCUPIED
NW MH 4066-18
A
3X4 DUCT CONFIGURATION W/ FIBER & 11 KV CIRCUIT CABLES
NW MH 4066-22
4X3 DUCT - 2 DUCTS OCCUPIED
B
NW MH 4066-25
EUCLID AVE
B
A
APPEARS THAT MH VAULTS SHARE COMMON WALL
SW MH 4066-23
3X4 DUCT CONFIGURATION W/ FIBER & 11 KV CIRCUIT CABLES - NOT FIELD OBSERVED (PER CEI FEEDBACK)
3X3 36 KV DUCT - 6 DUCTS PRESUMED TO GO BELOW/UNDER MH VAULT
Google

Diversion Structure R6-D1



Exiting R6-D1 and conveying WWF down Hillsboro

Hobas (R6-D1 to R6-M1)

RCP (downstream of R6-M1)