Tunneling to Meet the Speed of Economic Development

The Blacklick Creek Sanitary Interceptor Sewer (BCSIS) from Design into Construction

August 16, 2017

Cities Conference



DEPARTMENT OF PUBLIC UTILITIES Presenters:

Nick Domenick, PE – City of Columbus Mike Keller, PE - EMH&T

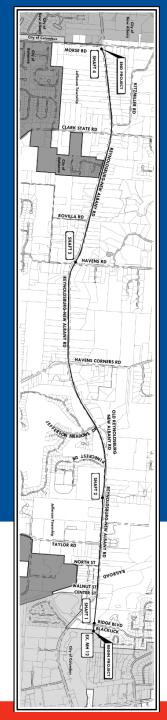
AGENDA

1. Project Background

- 2. Key Design Constraints and Final Design Components
- 3. Construction

4. Current Project Status





Perspective – Where we are....



Purpose

Need for Investment/Project

Multi-Jurisdictional

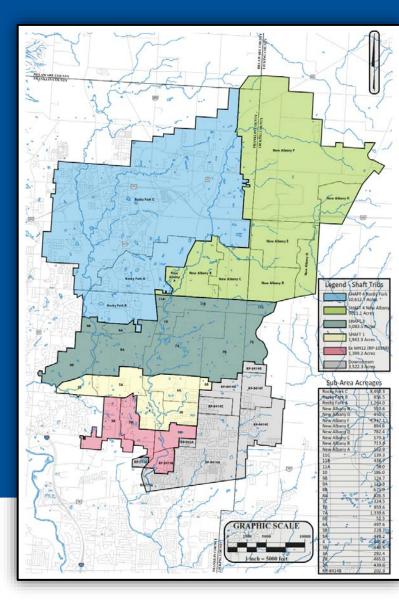
 Agreement between Columbus & Local Communities (JWSD and New Albany)

Support Comprehensive Plans for Jefferson Township, New Albany and City of Columbus within the Blacklick Tributary Area

Service Area

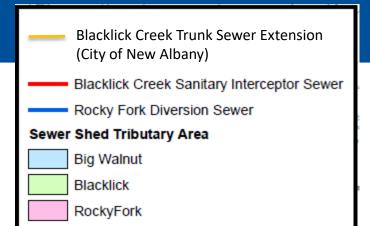
- 28,000 Acre Tributary Area
 - Blacklick Creek Sewershed (17,200 Ac)
 - Rocky Fork Sewershed (10,600 Ac)

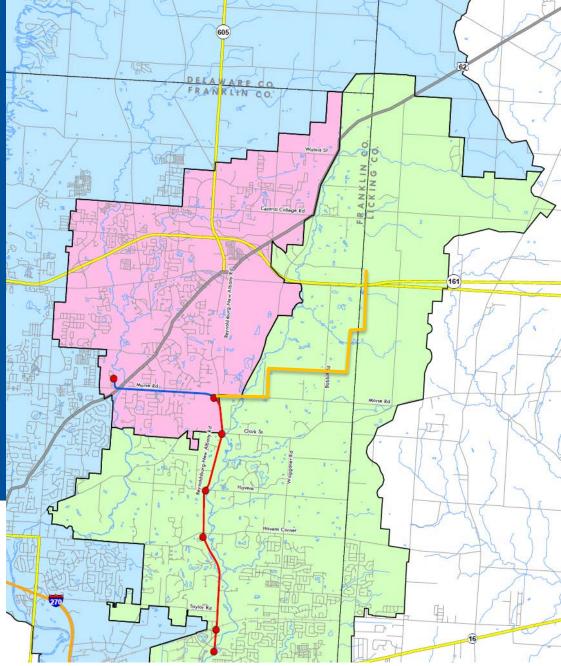




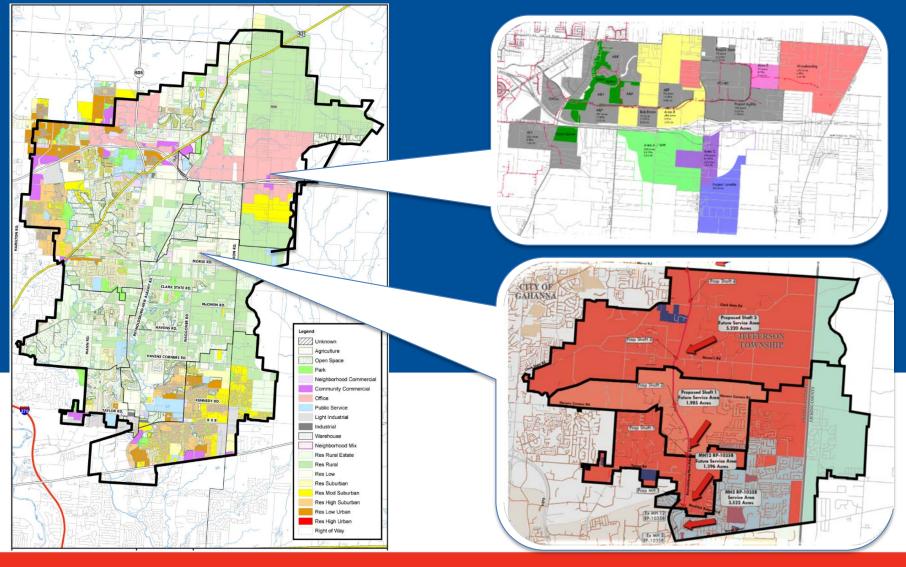
Operational Flexibility

- Service
 - Blacklick Sewershed
 - BCSIS
 - BCTS
 - Rocky Fork Diversion
 - Big Walnut
 Sewershed
 - Divert flow to support growth





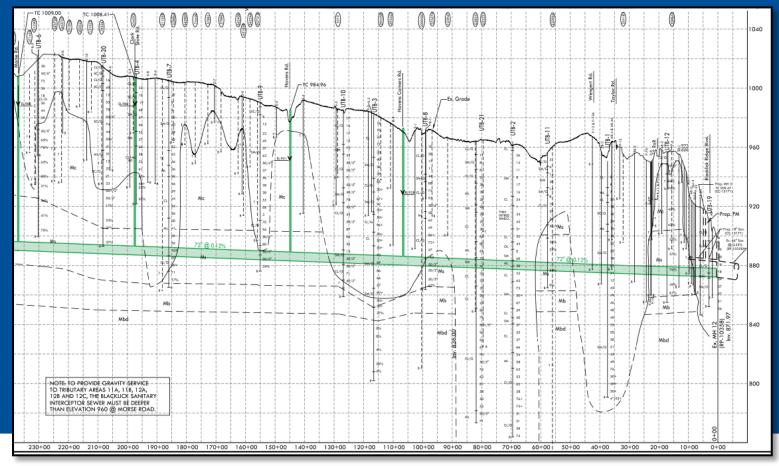
Master Planning, Contract Communities and Expansion Area



Goals at the Start of the Project (2007) vs. Final Design

	2007	Final Design/Current		
Service Area	22,000 Acres (original concept was to intercept less than 50% of Rocky Fork tributary area)	Up to 28,000 Acres (opportunity to take 100% of Rocky Fork to free up capacity in Big Walnut Service Area)		
Sewer Length	23,020 linear feet	23,020 linear feet		
Sewer Size	66-inch	120-inch		
# of Shaft Connections	6 (3 for JWSD, 1 for NA, 2 launch/connection MH)	5 (2 for JWSD, 1 for NA, 2 launch/connection MH)		
Estimated Construction Cost	\$64,000,000	\$110,000,000		
Rocky Fork Diversion (future)	Pump Station/Force Main	Gravity Option		

Key Design Considerations





The first key was organizing a Team...for the design investment

- Extensive Geological/Subsurface Investigation
- Hydrogeological (Groundwater) Investigation
- Coordination with Stakeholders
- Value Engineering and Technical Reviews
- Complex Design













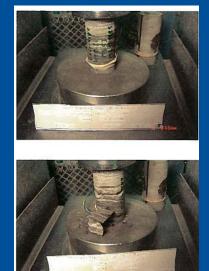
What are our Design Constraints?

- Schedule City had commitment to contract communities
- Subsurface Conditions
 - Geology Understand "complex" subsurface within glaciated till plain; Bedrock Lithology and Buried Valleys
 - Hydrogeology Protection of Groundwater and Private Wells
- Alignment
 - Land Acquisition
 - Serviceability Contracted Connection Points for New Albany and Jefferson Water and Sewer District
- Constructability/Risk Management Microtunnel, TBM, EPBM, shafts,
- Impacts to Area Maintenance of traffic, construction area aesthetics,...
- Cost



Geotechnical Investigation

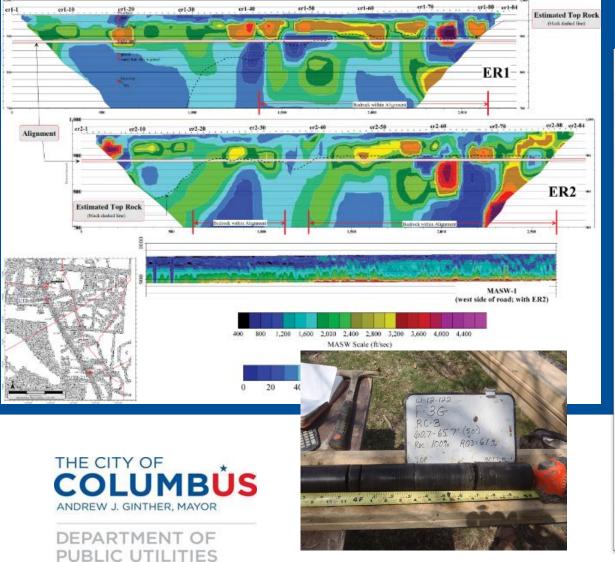
- Number of Borings
 - Phase 1- drilled 23
 - Phase 2- drilled 84
 - 107 total borings
- Vertical ft drilled = 12,025 ft/2.34 miles
- 42 Monitoring Wells total
- 12 soil to rock transitions
- 907 Total Tests 522 Soil Tests + 385 Rock tests

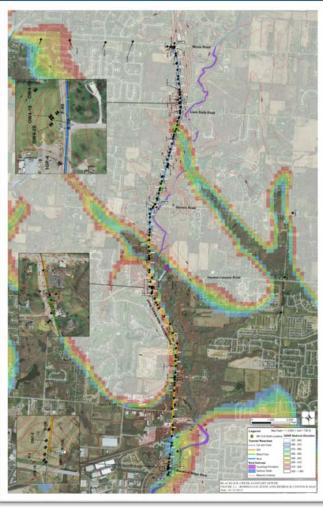


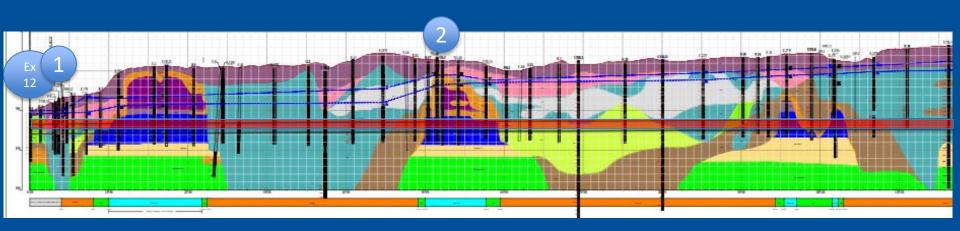


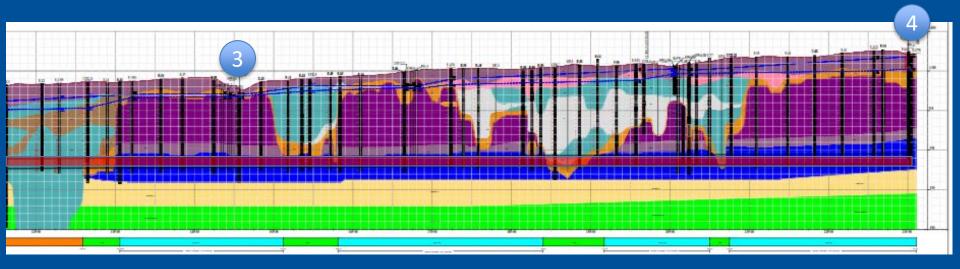


Geology of Project Corridor







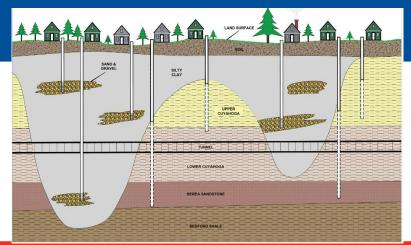


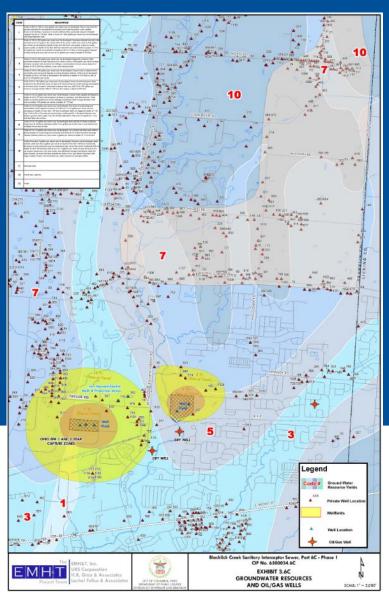


DEPARTMENT OF PUBLIC UTILITIES Subsurface Conditions Bedrock (3 Bedrock Units) Soil (7 Soil Units) Transitional Material (1 Unit) All defined in the GBR

Hydrogeology of Project Corridor

- Protection of Groundwater was a major driver in the design of the project...
 - Approx. 240 Wells within ¼ Mile
 - Approx. 610 Wells within ½ Mile
- At Public Meeting residents expressed concern on impacts on wells
- Specifications limit impact to groundwater for shaft and tunnel construction
 - Maximum Groundwater drawdown limit
 - Heading Inflow/Shaft Inflow Limits (in GBR)
- Defined in the Specifications and GBR
 - Hydrogeologic Report in Appendix of GDR





Hydrogeology of Project Corridor

WELL SURVEY – DEFINE CURRENT CONDITIONS

- Wells within ¼ Mile of Shafts & 600 feet of Tunnel
- Measured Static Water Levels
- Measured Drawdown & Pumping Rate
- Basic Water-Quality Parameters

Documentation of Baseline Conditions

- Well Log Search Spring 2014
- Door-To-Door Residential Well Survey Summer 2014
- Residential Well Performance & Water-Quality Testing Summer 2014
- Compile Residential Well Database Fall 2014

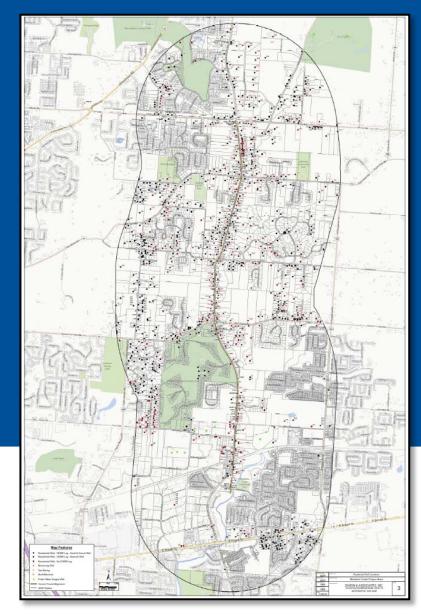
Pre-Construction Water-Level Monitoring

- Establish Monitoring Network March 2016
- Begin Routine Monitoring April 2016
- Routine Water-Level Monitoring of Observation Wells 2012-2016

Water-Level Monitoring During Construction

- Continue Routine Water-Level Monitoring
- Evaluate Trends in Water-Level Data
- Investigate Significant Changes in Water Levels





During Construction Phase Well Monitoring and Action Plans

Construction Management Team and Contractor will monitor:

- Existing Monitoring Wells (installed during design)
- Additional Monitoring Wells Installed by Contractor
- Selected Water Wells from Survey

Contract Specification– Temporary Water Supply Allowance

- Specification Written to Provide Protection to Local Residents
- Prescribes process to follow
- \$750,000 Allowance in Bid Form B4
- CMT Manages Activities (not the Contractor)

Apparent or Observed Impacts to Private Wells Each Situation is Unique... Defined Well Impact Response Plan

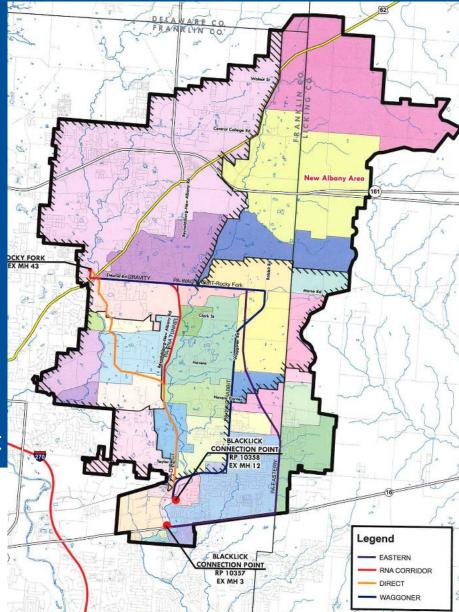




Horizontal Alignment

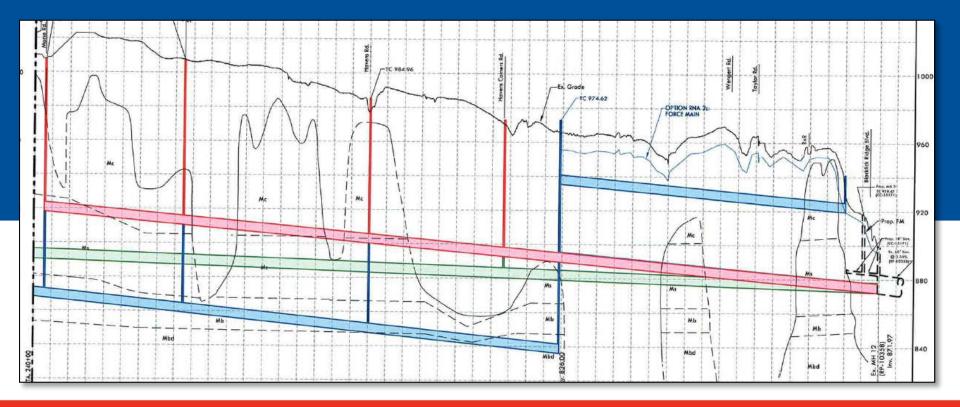
- Alignment Evaluation
 - Corridor Analysis
 - Subsurface Conditions
 - Gravity vs Pump Station
- Future Connections
 - Rocky Fork
 - City of New Albany
 - Jefferson Water and Sewer District





Vertical Alignment

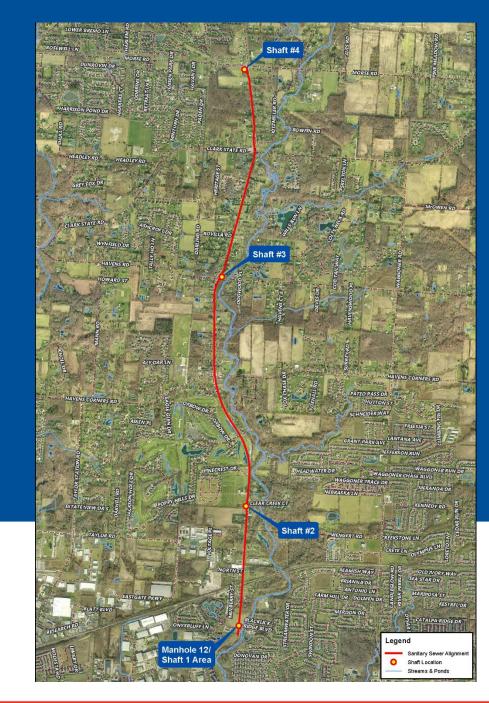
- Gravity Sewer Control Points
 - 66" BCSIS Section 5
 - Future 54" Rocky Fork Connection
- Preferred Geology/Hydrogeology



Final Alignment

- Generally follows
 Reynoldsburg New Albany
 Road
- Launch Site (Shaft 1) at Blacklick Ridge Boulevard
- Intermediate Shafts 2 & 3
- Terminus (Shaft 4) Morse Road
- Gravity at 0.052% Slope





Value Engineering and Business Case Evaluation

Business Case Evaluation

- 1. Tunnel Construction Method
- 2. Tunnel Sizing
- 3. Corrosion Protection
- 4. Dewatering/Shaft Construction
- <u>Examples of Value Engineering</u> <u>Recommendations</u>
 - 1. Minimize number of shafts
 - 2. Contractor to determine size of tunnel
 - 3. Reduce Slope
 - 4. Fiber reinforcement of segments
 - 5. Reconcile Cost with independent estimator



Shaft Location

• Four (4) Project Access Shafts, Three (3) Drop Shafts, and Two (2) Connection MHs

ACCESS SHAFTS

- Shaft 1 / Main Project Site North of Blacklick Ridge Blvd (Launch) Geology - Soil; Depth – Approximately 45'
- Shaft 2 Near Clear Creek Court (Tree Farm) Geology – Soil Transition Material/Bedrock; Depth – Approximately 95'
- Shaft 3 Reynoldsburg-New Albany Rd & Havens Road Geology – Soil Transition Material/Bedrock; Depth – Approximately 100'
- Shaft 4 Reynoldsburg-New Albany Rd & Morse Road (Retrieval) Geology - Soil Transition Material/Bedrock; Depth – Approximately 145'



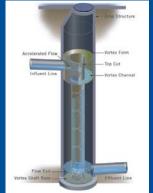
Shaft Construction Methods

- Performance Specifications
- Minimum Excavated Diameter Provided
- Finished Riser Diameter
 - 8' (nominal) for Shafts 1, 2, and 3
- Shaft 4 has baffled drops as per dimensions provided on plans (S-8)
- Drill and Blast allowed by not required (Specification 02305)
- DEWATERING PROHIBITED (WATERTIGHT CONSTRUCTION REQUIRED) AT...
 - SHAFTS 3 AND 4
 - TRANSITIONAL MATERIAL AND ROCK ON SHAFT 2



Drop Connections for Future Sewer Extensions

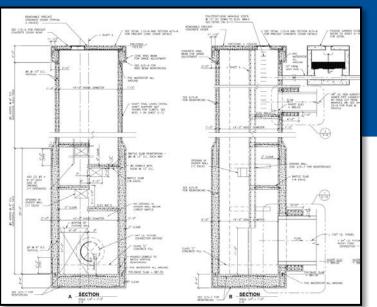


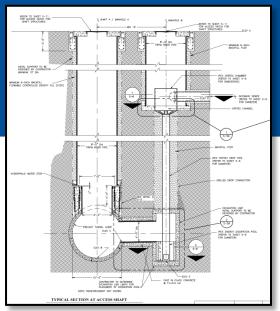












Sewer Sizing

- How we evaluated size of Excavation/Tunneling?
 - Hydraulics
 - Ventilation
 - Efficiencies
 - Project Duration/Progress Rate Impacts
 - Cost Impacts
 - TBM
 - Segments
 - Risk Impacts
 - Boulders
- Final Design (Bid) Allowed for 10' 12' finished tunnel ID
- Range of Size for Alternatives included 5.5' 14'

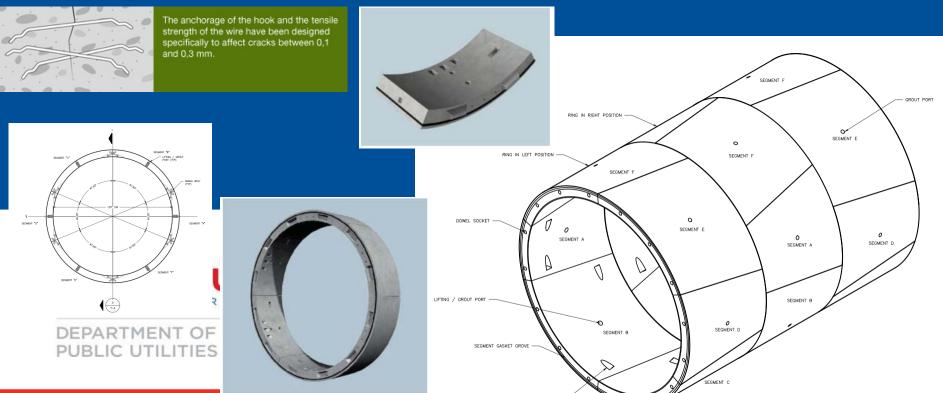




Segment Design



- Structural requirements for all load cases
- Use of steel fibers for construction handling and enhanced long-term performance, reduces rebar requirement
- Corrosion inhibiting admixtures and sacrificial cover concrete



RADIAL BOLT POCKE

Segment Design



- Steel Fibers American Iron and Steel Requirements
- Precast concrete with gaskets and guide rods
- (6) segment = 1 ring



Tunnel Design





Finished Concrete Segmented Tunnel



Tunnel Construction Methods

• Earth Pressure Balance Machine (EPBM) prescribed for the project

- Control face in soil and mixed face zones
- Suits the types of soils and rock at tunnel face
- Limit groundwater inflow
 - Groundwater in open mode excavation will be closely monitored in rock and excessive inflow will require closed mode operation

• Design Team Ruled Out...

- Multiple TBMs to deal with varying subsurface conditions
- Slurry TBM
 - limited site access along route for slurry handling
 - Total length of tunnel





Tunnel Construction Conditions

- Potential Gassy Operation
 - Base bid shall include 120 shift hours of downtime due to gas in the tunnel and/or shafts
- Cobbles and Boulders
 - Shall be expected to occur in group, lenses, and individually with all soft ground (SG) and mixed face (MF) tunnel reaches
 - Quantities baselined in Geotechnical Baseline Report
- Muck Removal
 - Limited onsite storage available at launch site
 - Haul routes identified in Maintenance of Traffic (MOT)
 - Ohio EPA approval is required for offsite disposal location





Tunnel Construction Schedule

Project Duration

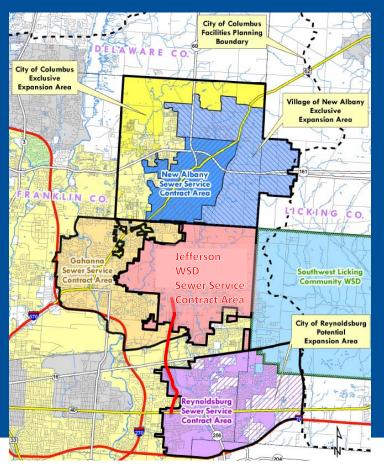
- 48 Months (1,540 days per CMS Item 108.03, Milestones)
- Tunneling activities observed as critical path
- Sizing of tunnel allows for California Switch/Improved Support Activity
- 24-hour activity allowed with some limitation
- Preparation
 - Milestone No. 2 Downstream Sewer Tail Tunnel (470 days)
 - 400 Feet \pm sewer for use as Tail Tunnel
 - Milestone No. 3 TBM Startup and 500' Initial Mining (560 days)





Final Design Features

- Sewer Service Contract Area
- Geology (Mixed Shale & Glacial Soil Deposits)
 & Hydrogeology
- Length: 23,020 Feet
- Depth: 40-140 Feet
- Finished Diameter: 10-12 Feet
- Earth Pressure Balance (EPB) Tunnel Boring Machine (TBM) w/Precast Segmental Lining
- Shafts and Drop Structures
- Construction Cost: \$108,974,000





Other Facilities- Tunnel Launch Site

Shaft 1 / Main Project Site - North of Blacklick Ridge Blvd

- Main Project Site Location
- Daily Operations
- Columbus/Design Team coordinated with Jefferson Township on screening and other site considerations



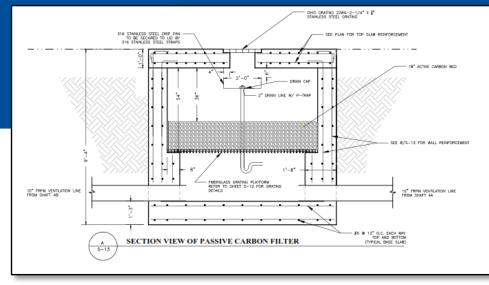
Other Facilities - Odor Control

- Air Quality Control Facility
 - Shaft 1
- Passive Carbon Filter
 - Shaft 4









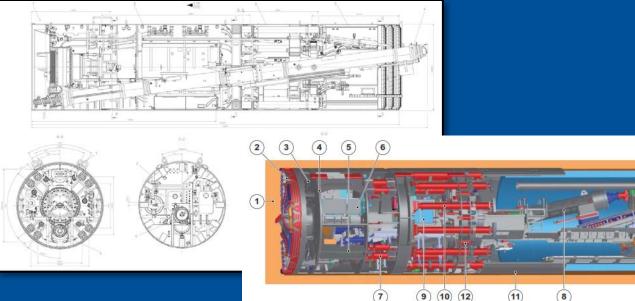
Construction Schedule

- Construction Start May 2016
- Completion of CMT Offices 90 days
- TBM Startup and Initial Mining 560 days
- Substantial Completion 1450 days
- Construction Completed July 2020

15040 F 15050 F 15050 h 15070 F	Activity Name	Ca						
15050 F 15060 h 15070 F		Float	Orginal	Activity % Complete	Start	Frish	2018 2017 2018 2019 2020 2021 2022	
15050 F 15060 h 15070 F			Duration				AMJUASONGJEMAMJUASONGJEMAMJUASONGJEMA, JUASONGJEMAMJUASONGJEMAMJUASONGJEMA	
15060 h 15070 F	Form & Install Construction Joints (MH12)	-25	5	0%	(3-Mar-20	09-Mar-20	Form & Instal Construction Joints (MH12)	
15070 F	Form & Install MH Riser Support Ring (MH12)	-25	5	0%	10-Mar-20	16-Mar-20	Form & Install MH Riser Support Ring (MH12)	
	Install 96" Dia MH Riser & 48" Pipe Stu (MH12)	-25	5	0%	17-Mar-20	23-Mar-20	Instal 56" Dia MH Riser & 48" Pipe Stu (MH12)	
	Form & Install MH Top Ring (MH12)	-25	5	0%	24-Mar-20	30-Mar-20	Form & Instal MH Top Fling (MH12)	
	Cure Period (MH12)	-25	5	0%	31-Mar-20	06-Apr-20	Cure Period (MH12)	
	Remove 66" Buikhd Connect 18" Swr (MH12)	-25	5	0%	07-Apr-20	13-Apr-20	Remove 66" Bukhd Connect 18" Swr (MH12)	
	Instal Procest MH Cover With Hatch (MH12)	-25	5	0%	14-Apr-20	20-Apr-20	Instal Presast MH Cover With Hatch (MH12)	
	Restare MH-12	-25	5	0%	21-Apr-20	27-Apr-20	Restore MH-12	
	Seed MH-12	-25	5	0%	28-Apr-20	04-May-20	Seed MH-12	
Tunneling -25 770			16-Jun-16A	10-346-10	10-Jus-19, Turnoling			
	nufacturing		129		16-Jun-16A	05-Jan-17A	 06-Jan-17A, TBM Manufacturing 	
	TBM Design		15	100%	16-Jun-16A	08-Jul-16A	TEM Design	
	TBM Manufacturing		60	100%	11-Jul-16 A	03-Oct-16A	TBM Manufacturing	
	TBM Pre-Assembly		10	100%	04-Oct-16A	21-Oct-16A	TBM Pre-Assembly	
51040 1	TBM Internal Commissioning		15	100%	24-Oct-16 A	09-Nov-18-A	TBM Internal Commissioning	
	TBM Factory Testing and Acceptance		2	100%	10-Nov-16.A	11-Nov-16 A	1 TBM Factory Testing and Acceptance	
	TBM Disassembly and Pack		11	100%	16-Nov-16.A	01-Dec-16 A	6A TEM Disassembly and Pack	
51060 1	TBM Shipment		23	100%	01-Dec-16A	05-Jan-17A	 TBM Shipment 	
Segment	t Manufacturing	87	443		18-Aug-16-A	07-May-18	O7-May-18, Segment Manufacturing	
52010 A	Mould Manufacturing and Delivery		73	100%	18-Aug-16 A	16-Dec-16 A	Mould Manufacturing and Delivery	
52090A /	Apply for AIS Waiver		0	100%	07-Sep-16A		 Apply for A3S Wakeer 	
52100A V	Waiting on EPA for AIS Waiver		25	100%	07-Sep-16.A	15-Nov-18-A	Walting on EPA for AIS Walver	
52020 0	Demonstration Ring		5	100%	10-Oct-16A	14-Oct-16A	Demonstration Ring	
52000 F	Prepare Final Drawings		16	100%	10-Nov-16.A	02-Dec-16A	Prepare Final Denvings	
52030 N	Manufacture and Deliver 1000 Segments (1000 Total)	4	50	37%	28-Feb-17A	06-Jun-17	Manufacture and Deliver 1000 Segments (1000 Total), Manufacture and Deliver 1000 Segments (1000 Total)	
52040 1	Manufacture and Deliver 1000 Segments (2000 Total)	4	50	0%	07-Jun-17	16-Aup-17	Manufacture and Deliver 1000 Segments (2000 Total)	
52050 N	Manufacture and Deliver 1000 Segments (3000 Total)	35	50	0%	17-Aug-17	28-Oct-17	Manufacture and Deliver 1000 Segments (3000 Total)	
52060 1	Manufacture and Deliver 1000 Segments (4000 Total)	63	50	0%	27-Oct-17	09-Jan-18	Manufacture and Deliver 1000 Segments (4000 Total)	
52070 M	Manufacture and Deliver 1000 Segments (5000 Total)	87	50	0%	10-Jan-18	20-Mar-18	Manufacture and Deliver 1000 Segments (5000 Total)	
52080 N	Manufacture and Deliver Remaining Segments (5670 Total)	87	34	0%	21-Mar-18	07-May-18	Manufacture and Deliver Remaining Segments (5670 Total)	
Tunnel P	Production	-25	648		11-Nov-16 A	19-Jul-19	19-Jul-19, Turnel Production	
50020 5	Setup Turnel Support Equipment		30	100%	11-Nov-16 A	24-Feb-17.A	Setup Turnel Support Equipment	
	Prep Portal For TBM Launch		15	100%	16-Dec-16.A	07-Feb-17A	Prop Potal For TBM Launch	
50060 F	Receive TBM Equipment		10	100%	05-Jan-17A	13-Jan-17A	Receive TBM Equipment	
50030 5	Surface TBM Mechanical Assembly		5	100%	05-Jan-17A	27-Feb-17A		
50000 5	Setup Shaft For TBM Assembly		20	100%	09-Jan-17A	27-Jan-17A	Setup Shaft For TBM Assembly	
50070 F	Pre-Build Tunnel Switches Above Ground	-21	12	30%	09-Jan-17A	12-May-17	Pre-Build Tunnel Switches Above Ground, Pre-Build Tunnel Switches Above Ground	
50460A P	Pre-Assemble TBM Gantries		4	100%	16-Jan-17A	20-Jan-17A	Pre-Assemble TBM Ganties	
50040 8	Below Ground TBM Mechanical Assembly		19	100%	27-Feb-17 A	24-Mar-17 A	A Below Ground TBM Mechanical Assembly	
	Below Ground TBM Electrical Assembly		19	100%	27-Feb-17A	24-Mar-17.A		
50081 1	TBM Assembly Complete		1	100%	27-Mar-17 A	27-Mar-17A		
	Test TBM		10	100%	28-Mar-17 A		Test TDM	
50100 L	Laurch TBM		0	100%		12-Apr-17A	Lauch TBM	
	Tunnel First 400' - Sta 4+00 to Sta 8+00	-25	14	50%	18-Apr-17-A	05-May-17	Turnel First 400' - Sta 4+00 to Sta 8+00, Turnel First 400' - Sta 4+00 to Sta 8+00	
50140	Cutter Head Re-Dress 1	-25	2	0%	08-May-17	09-May-17	Cutter Head Re-Dress 1	
			-					



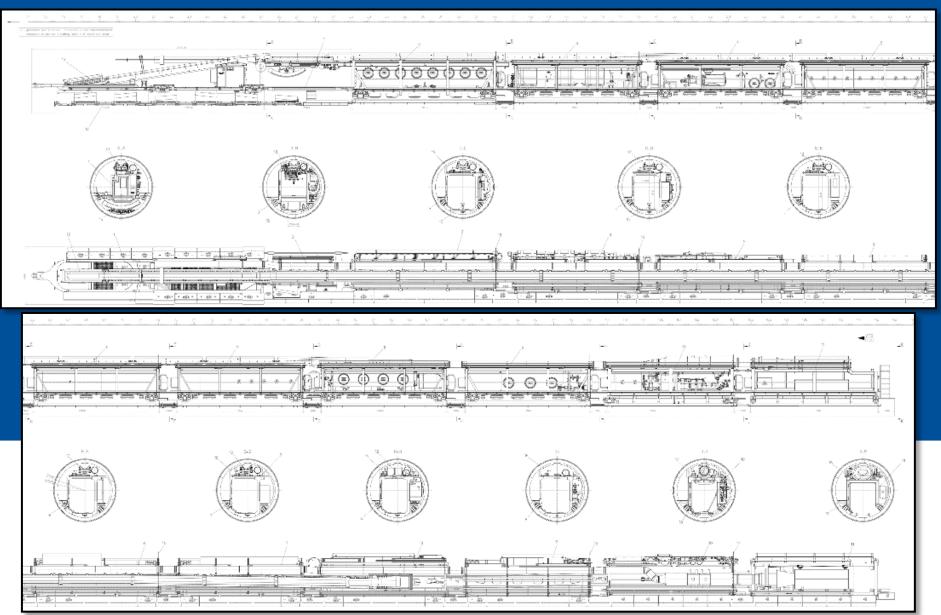
Construction – From Submittals to Field Construction



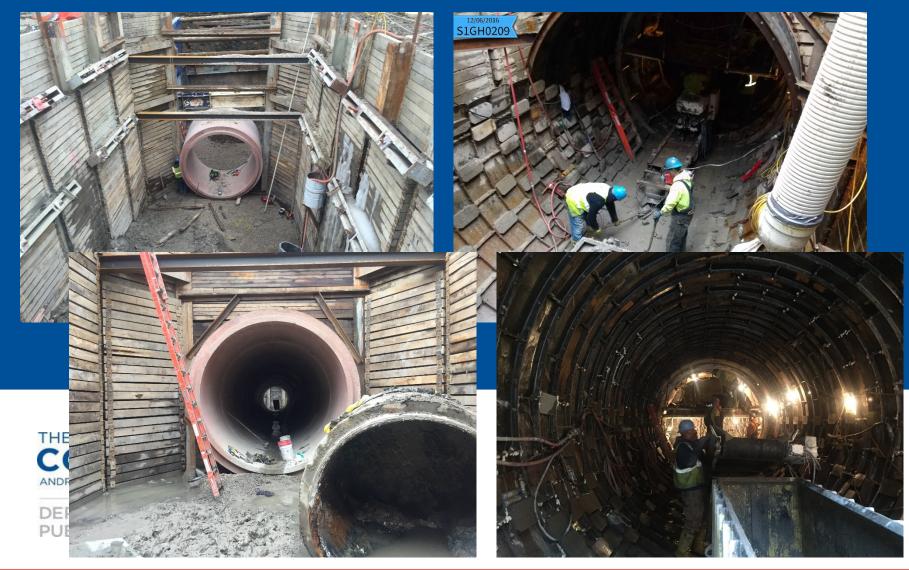




TBM Submittal



Tail Tunnel Construction



















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Shaft 1 with push rings installed for TBM launch

Tunelvortriebstechnik



Shaft 1 with top half of push rings removed





Segment Delivery and Storage



Tunneling Activity Progress









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Muck being dumped in the muck pond



Tunnel muck being removed from Shaft 1





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Tunnel segments being lowered into Shaft 1



Drilling Shaft 3B.



Inside of MH 3B where the connection from MH3C enters.

J

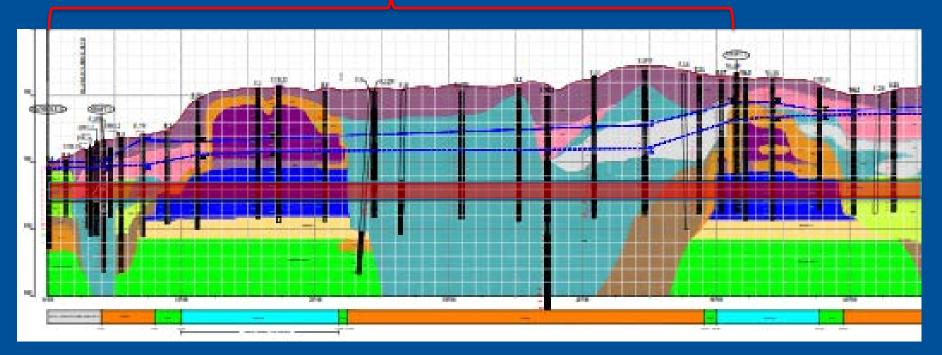






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Start of drilling of MH 2B





View in the tunnel with utilities and air piping shown.



Utility Extension Work in Tunnel

Questions





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