THE UNDERGROUND UTILITIES EVENT
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Houston's Upper Brays Tunnel Liner Removal A True Trenchless Project

Presented by

Mary Bac, P.E. – City of Houston

Datta Shirodkar, P.E. – Boyer Inc

CONTRACTORS
ENGINEERS
INVENTORS

Overview

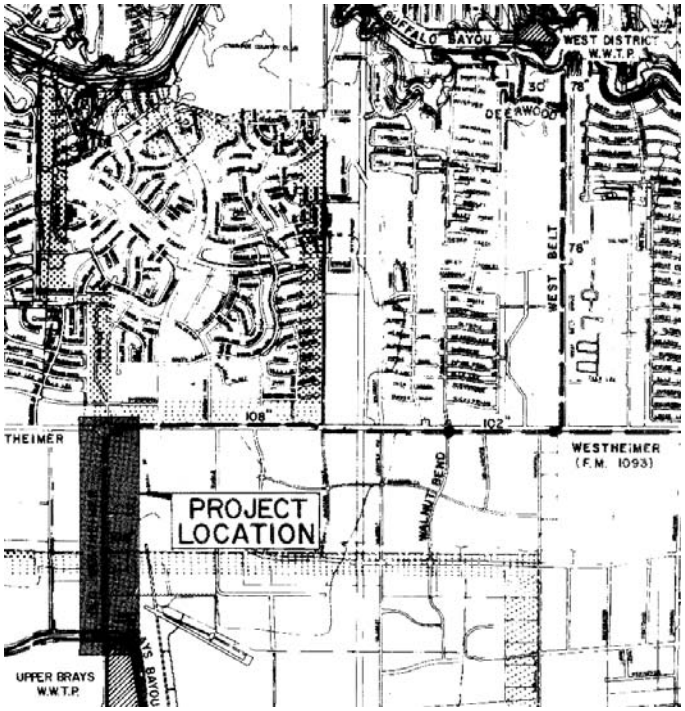
- History & Background
- Investigation & Inspection
- Project Scope of Work
- Anticipated Challenges
- Pre-Planning & Safety
- Construction Overview

Upper Brays Tunnel History

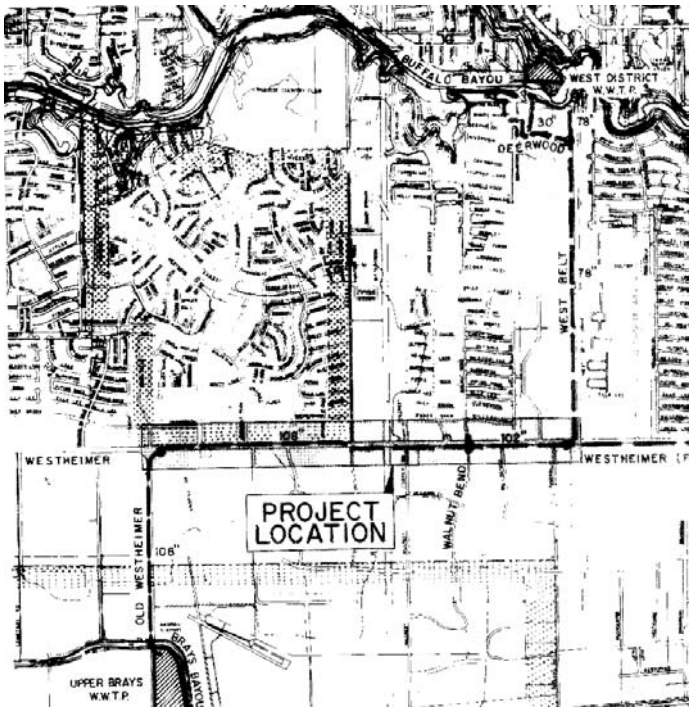
- 108-inch tunnel approximately 60 feet deep installed from 1988 to 1990
- Part of West District Diversion project
- Location: Tunnel runs west from the junction box at W. Sam Houston Parkway S. and Westheimer Road and turns south at West Houston Center Boulevard
- Designed by Pate Engineers and constructed by National Projects, Inc.
- MRC sewer with corrosion protection consisting of concrete with limestone aggregate and 6mm HDPE liner (Schlegal Lining)

Tunnel Contracts - Vicinity Maps

West District Diversion Contract No. 1



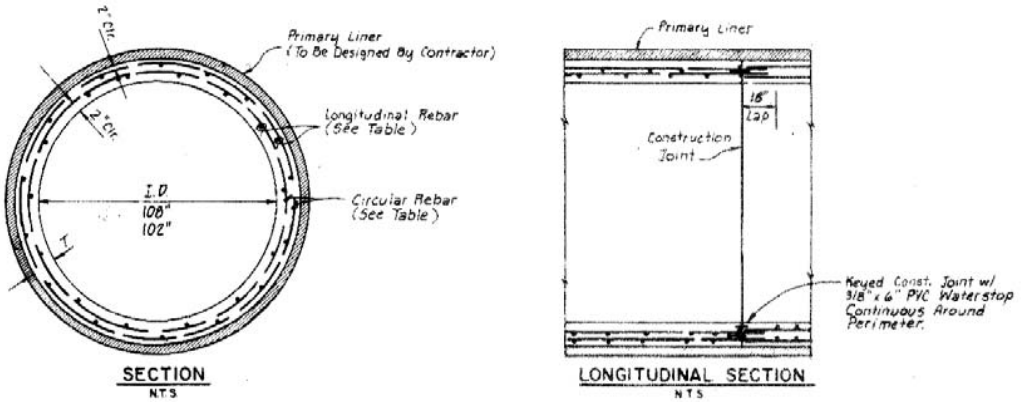
West District Diversion Contract No. 2



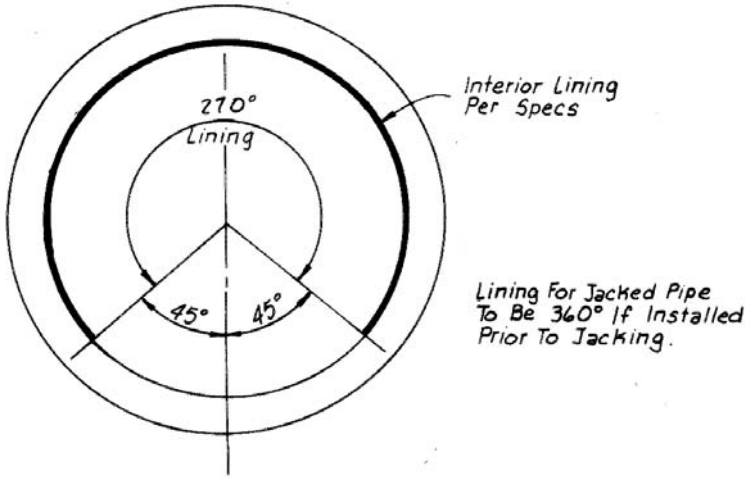
Tunnel Contracts - Specifications

- RCP or MRC sewer with corrosion protection, consisting of concrete with limestone aggregate and a PVC or HDPE liner
- Liner: PVC liner integrally cast into the concrete (Ameron T-Lock or equal) or an HDPE liner mechanically fastened to the concrete (Schlegel Lining or equal)
- HDPE Liner: 6mm thick white sheet anchored at the bottom edges (5 o'clock and 7 o'clock positions) and crown of the pipe with bolts and HDPE batten strips.
- Stainless Steel Anchoring Rings: Upstream and downstream of each manhole, and every 100 feet along sewer. Three anchoring rings 12-inches apart at upstream and downstream of each structure and beginning and end of each segment.

Tunnel Contracts - Details



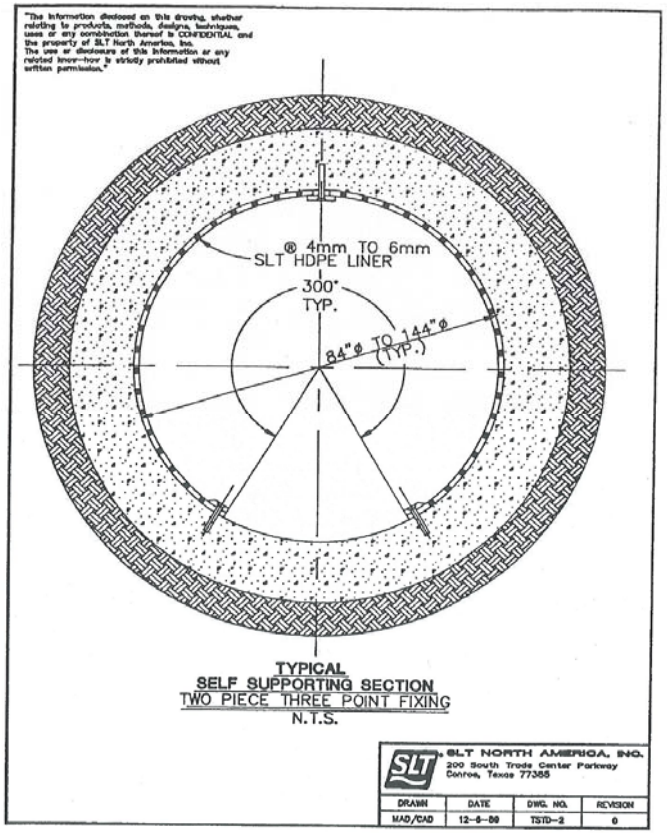
MONOLITHIC REINFORCED CONCRETE
(MRC) SEWER IN LINED TUNNEL
N.T.S.



INTERIOR LINING DETAIL
N.T.S.

Schlegal Lining

- Self-Supporting HDPE Liner
- Anchoring: Steel batten strips and HDPE batten strips
- Fasteners: Stainless Steel Type 304 bolts
- Spacers at bottom of liner for drainage to relieve back water pressure
- Schlegal submittal shows 4mm liner (City objected) with no anchoring rings between manholes (no objection by City noted)



Schlegal Lining (cont'd)

- 26 installations word-wide and 15 installations in U.S., 14 of which were installed in the City of Houston (the other was in Austin)
- Liner was installed by SLT North America (Schlegal) and Environmental Protection Systems
- Most of the City installations were part of the Northside Relief Sewer System.
- 1991 video inspection showed 54% of approximately 64,000 feet of HDPE liner installed in Northside Sewer Relief Tunnel (NSRT) had failed, 4% had major deformations and 42% had minor deformations (Allen & Bishop, 1994)
- 1991 Upper Brays Tunnel showed little deformation, but the system was not in operation at that time (Allen & Bishop, 1994)

Tunnel Liner Investigation

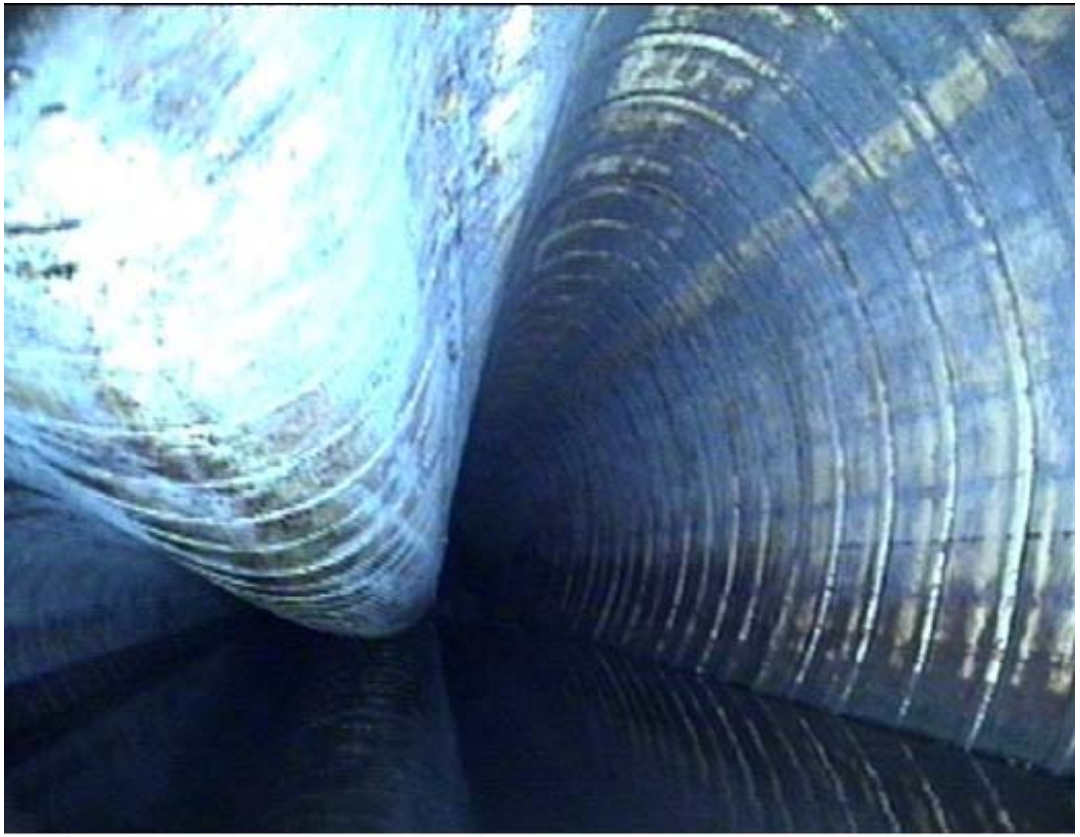
- Tunnel Liner Investigation Reports: Prepared by Turner Collie & Braden (TC&B) in 1992 for NSRT and 1994 for Upper Brays Tunnel, Horspen Gulley and Smith Road Systems
- TC&B report (Allen & Bishop, 1994) indicated primary cause of failure was the method of attachment of the liner to the pipe
- Schlegel Lining submittal indicates lining system is self-supporting, so a design for static water pressure was not needed, since there is a space between the pipe and liner that allows for water to drain through weep holes at the bottom edges.

Tunnel Liner Investigation (cont'd)

- Schlegal calculations did not consider the possibility of flow level being above the bottom edges for a prolonged period
- With flow levels above the bottom edges, static water pressure would not be relieved leading to potential liner failure
- TC&B also reported that imperfections impacting circular shape of sewer could result in non-uniform support of liner
- TC&B recommended that the liner be removed from all tunnels and for the tunnels to be inspected every 10 years.

Sewer Inspection

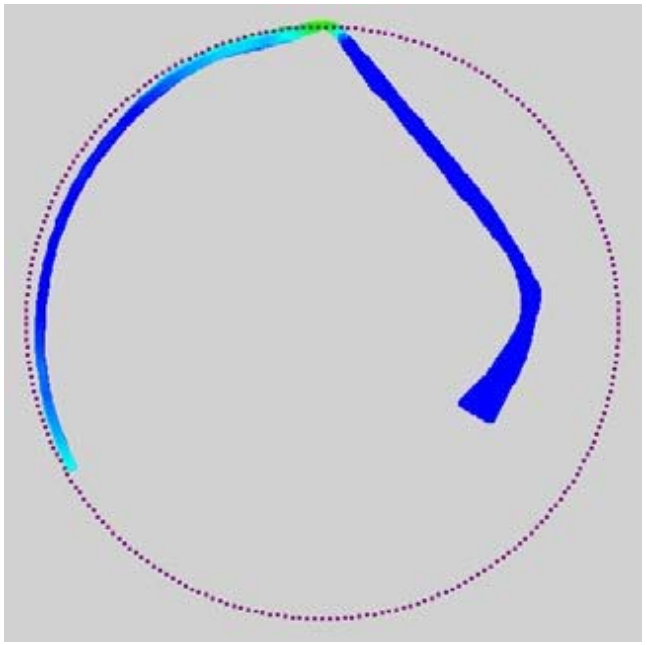
- RedZone Robotics sewer inspection performed in 2013 by CleanServe
- Liner failure observed in multiple locations
- Some liner completely detached from crown of pipe
- Equipment unable to pass in multiple areas
- Inspection was abandoned 365 feet downstream of manhole UBU01007 due to high water level
- No inspection performed from UBU01007 to the lift station due to high water level



Sewer Inspection (cont'd)

UBU01013 - UBU01012

Cross Section



Sewer Inspection (cont'd)

UBU01011 – UBU01010

UBU01009 – UBU01008

Sewer Inspection (cont'd)

Gas Summary

Upstream MH	Downstream MH	Average Concentration of H^2S (ppm)	Maximum Concentration of H^2S (ppm)	Average Temperature (degrees F)	Maximum Temperature (degrees F)
UBU01013	UBU01012	7.3	9.0	94	96
UBU01012	UBU01011	6.4	8.0	88	90
UBU01011	UBU01010	7.4	8.0	88	88

Flow Summary

Upstream MH	Downstream MH	Flow Height
UBU01013	UBU01012	20%
UBU01012	UBU01011	20%
UBU01011	UBU01010	30%
UBU01010	UBU01009	30%
UBU01009	UBU01008	30%
UBU01008	UBU01007	30%
UBU01007	UBU01006	30%

Sewer Inspection (cont'd)

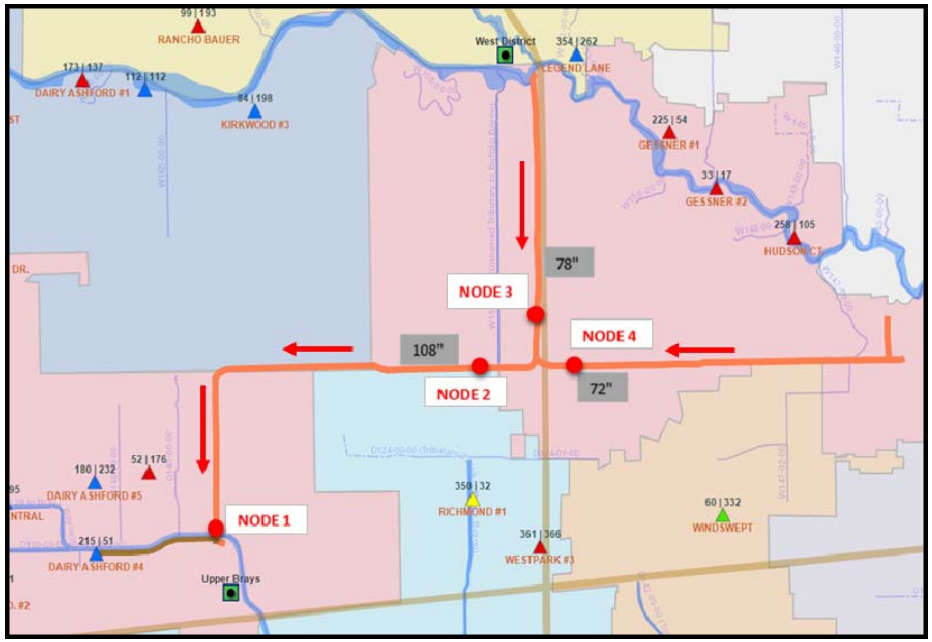
		RedZone Inspection - Sediment Summary				1991 Man Entry Inspection - Sediment Summary		
Upstream MH	**Downstream MH**	**Inspected Length (ft)**	**Average Sediment Depth (inches)**	**Sediment Volume (CY)**	**RedZone Recommendation**	**Inspected Length (ft)**	**Sediment Depth (inches)**	**Sediment Volume (CY)**
UBU01013	UBU01012	616	0.0	0.0	No cleaning	980	0	
UBU01012	UBU01011	1759	3.4	38.6	No cleaning	1800	0	
UBU01011	UBU01010	432	3.2	8.7	No cleaning	1570	0	
UBU01010	UBU01009	1315	1.9	12.3	Light cleaning from 1161.5 ft to 1179.8 ft	1285	0	
UBU01009	UBU01008	1760	1.3	9.3	No cleaning	1725	0	
UBU01008	UBU01007	1245	4.2	38.0	No cleaning	1215	0	
UBU01007	UBU01006	365	14.1	65.8	Light cleaning	990	3"-6" over 215 feet upstream of MH 006	7.4
UBU01006	UBU01005	1285				1285	8-18" sand and mud over most of the segment	133.9
UBU01005	UBU01004	810				810	0	0
UBU01004	UBU01003	1090				1090	3"-6" soft mud over 200 feet	3.7
UBU01003	UBU01002	1780				1780	6-26" over entire segment	378.6
UBU01002	UBU01001	1340				1340	24" soft mud over 70 feet downstream of MH 002	27.3

Debris Estimate

Engineer's Debris Estimate			
Sewer Lines	Debris (CY)	Debris (Wet Ton) 1.5 Tons/CY	Source
UBU01013 to UBU01006	173	260	Redzone Inspection
UBU01006 to UBU01001	544	816	1996 Man Entry Inspection
Total Estimated Debris (Wet Tons)		1076	

Flow Data

	108 Inch Line	108 Inch Line	78 Inch Line	72 Inch Line	Remarks
	Node 1	Node 2	Node 3	Node 4	
Wet Weather 2hr Peak Flow, MGD	97.92	84.25	56.65	30.62	Design Rain (2Y6H) Event has been used to calculate Wet Weather Peak; 10.5 MGD Flow has been diverted from West District to Upper Brays during this period.
Peak Hour Dry Weather Flow, MGD	11.26	7.88	3.92	3.96	No flow has been diverted from West District to Upper Brays during Dry Weather Model Run.
Average Daily Flow, MGD	7.68	5.77	2.33	3.44	No flow has been diverted from West District to Upper Brays during Dry Weather Model Run.
Minimum Flow, MGD	3.26	3.00	0.95	2.05	No flow has been diverted from West District to Upper Brays during Dry Weather Model Run.



Upper Brays Tunnel Liner Removal Project

- Timeline
  - Bidset preparation: January 2016 to February 2016
  - Advertisement: 02/19/16 & 02/26/16
  - Pre-bid Meeting: 03/02/16
  - Bid Opening: 03/24/16
  - Notice to Proceed: 07/13/16
- Estimated Construction Cost: $12 million
- Contract Duration: 730 days

Scope of Work

- Removal of approximately 16,000 linear feet of liner from the 108” Upper Brays tunnel starting at the Westheimer West Belt junction box and ending at the bypass shaft at the Upper Brays Lift Station
- Disposal of approximately 0.5 million pounds of HDPE Liner
- Flow Control: Total and/or partial diversion/bypass pumping of existing wastewater flows (dependent on the Contractor’s means and methods)
- Traffic Control (TxDOT right of way on Westheimer)
- Removal & Disposal of debris
- Post liner removal laser inspection, sonar inspection and condition assessment via robotics

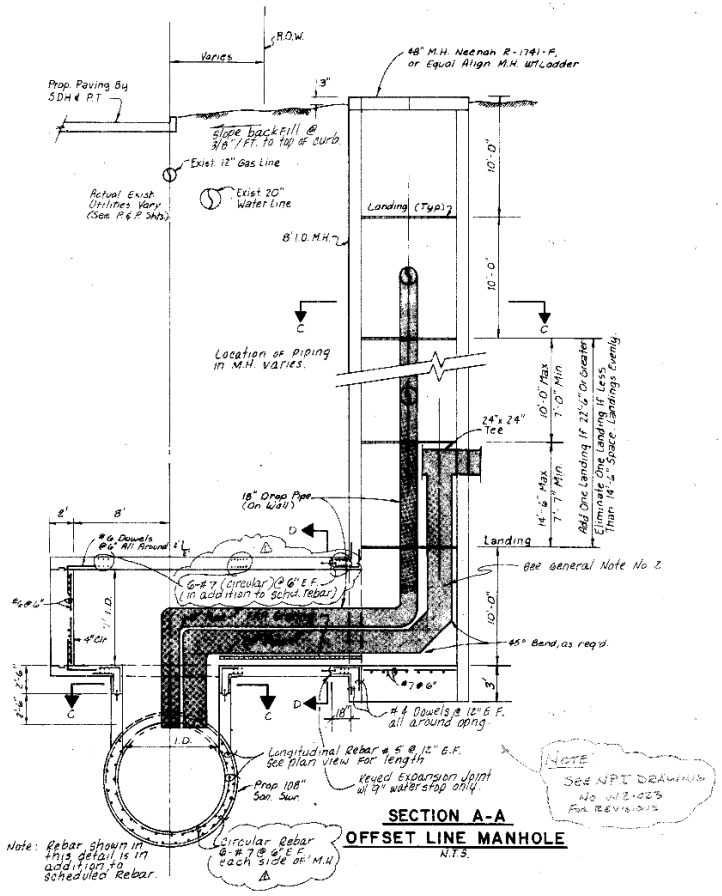
Scope of Work - Continued

- Modification/Removal/Installation of drops inside existing Manholes
- Removal of existing Grating & Ladders
- Installation of Safety nets in lieu of existing ladders & grating
- Construction of a Permanent Diversion Structure in place of an existing Manhole

Vicinity Map

Anticipated Challenges

- Safety
- Traffic Control
- Flow Control
- Limited Access
  - Diversion Structure at Treatment Plant
  - Junction Box at Beltway/Westheimer
  - 11 manholes (2 offset, 1 buried, 5 in or near street) over 1,000 feet apart
- Complaints



Bid Results

Bidder	Bid Amount
Boyer, Inc.	$8,876,300.00
PM Construction & Rehab, LLC	$11,811,326.60
Oscar Renda Contracting, Inc.	$12,178,000.00
Kenny Construction Company	$13,141,465.00
S.J. Louis Construction of Texas, Ltd.	$22,368,100.00

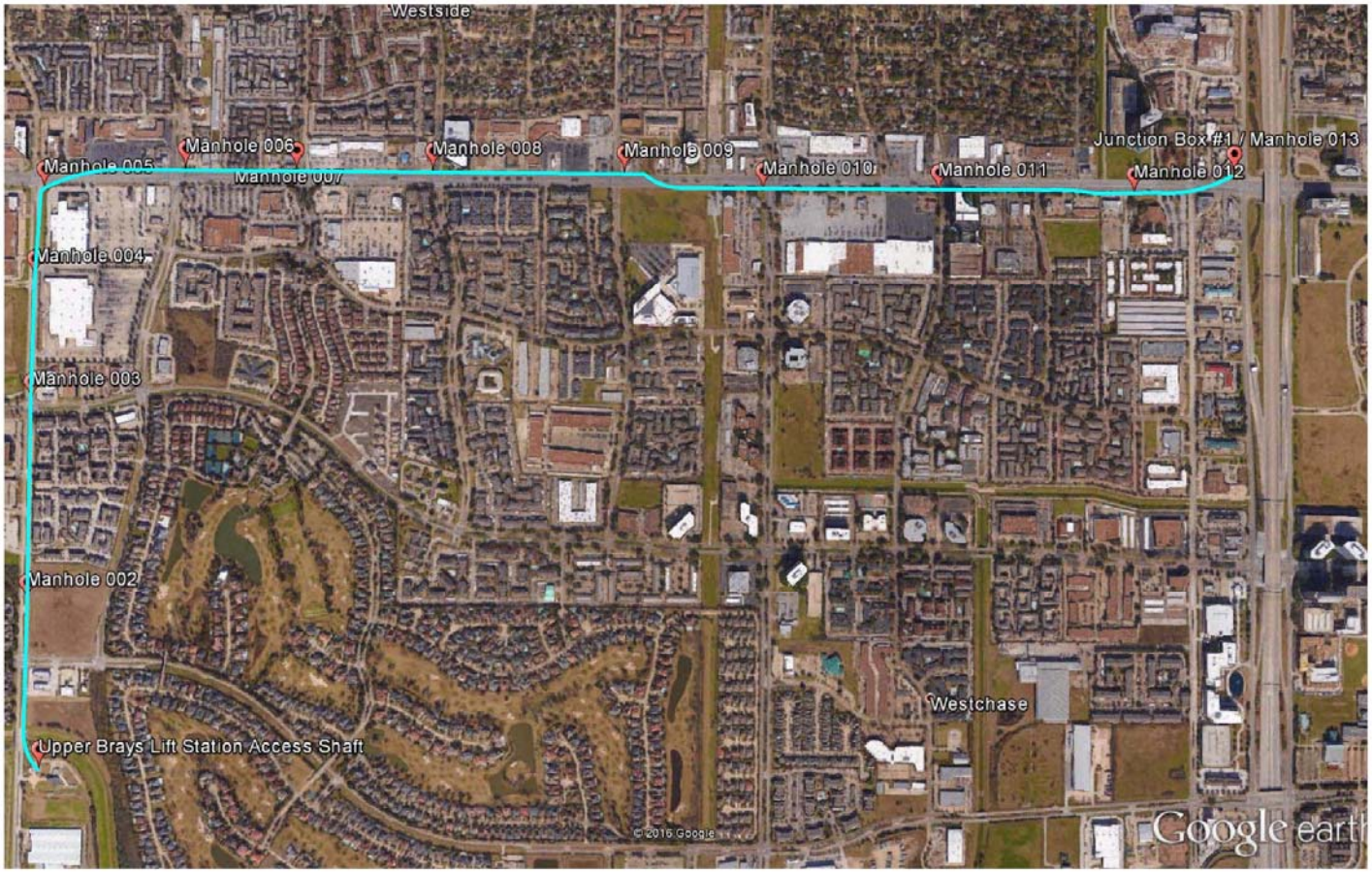
PRE-PLANNING & SAFETY

- Tunnel Layout & Location
- Safety
  - Ingress/Egress
  - Transportation inside the tunnel
  - Ventilation
  - Communication
- Custom Fabrication
- Avoid/reduce/eliminate citizens complaints
- Cause minimum disruption

CONSTRUCTION OVERVIEW

- Flow Control
- Cleaning ,Debris Removal & Disposal
- Liner Removal & Disposal
- Laser Scanning & CCTV
- Construction of Permanent Diversion Structure

TUNNEL LAYOUT & LOCATION



INGRESS & EGRESS

- 20’ dia. Access shaft at Upper Brays LS
- Crane & Man Basket
- Landing at the bottom of access shaft
- Ladder to get to the invert of the tunnel

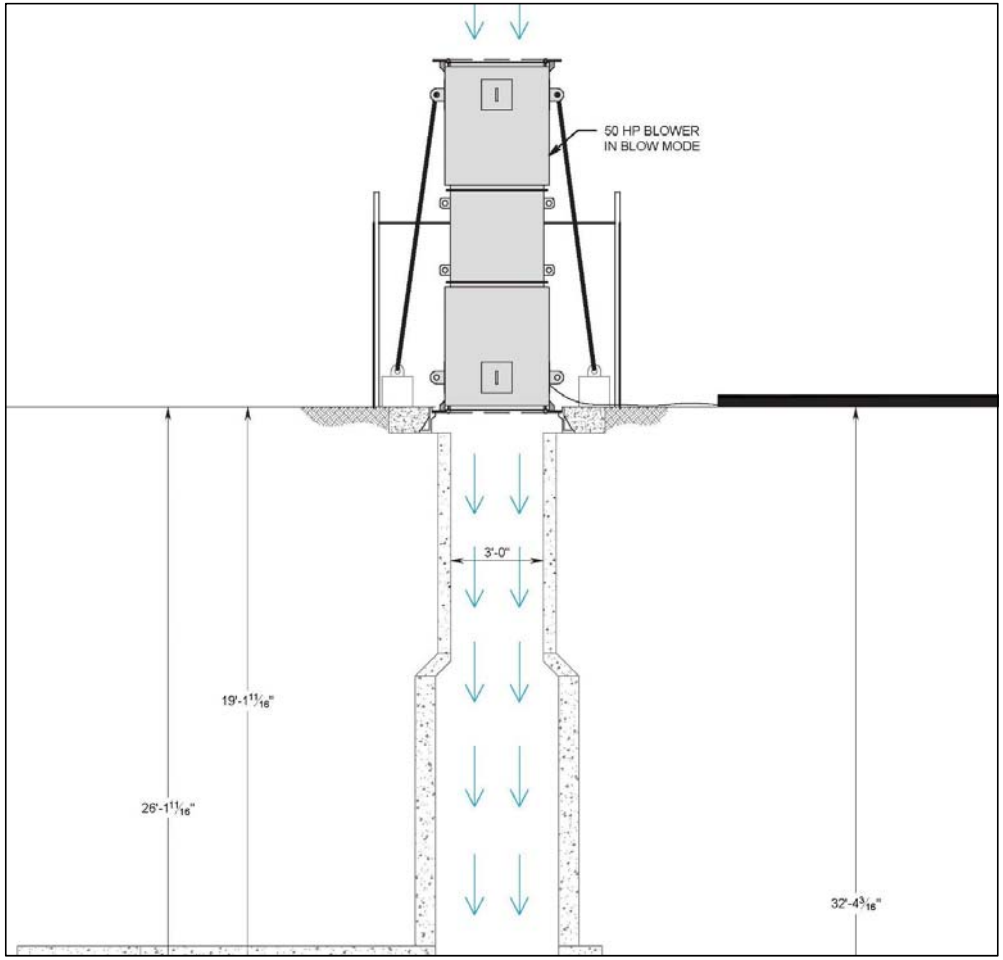
LOWERING CREW INSIDE THE ACCESS SHAFT

TRANSPORTATION INSIDE THE TUNNEL

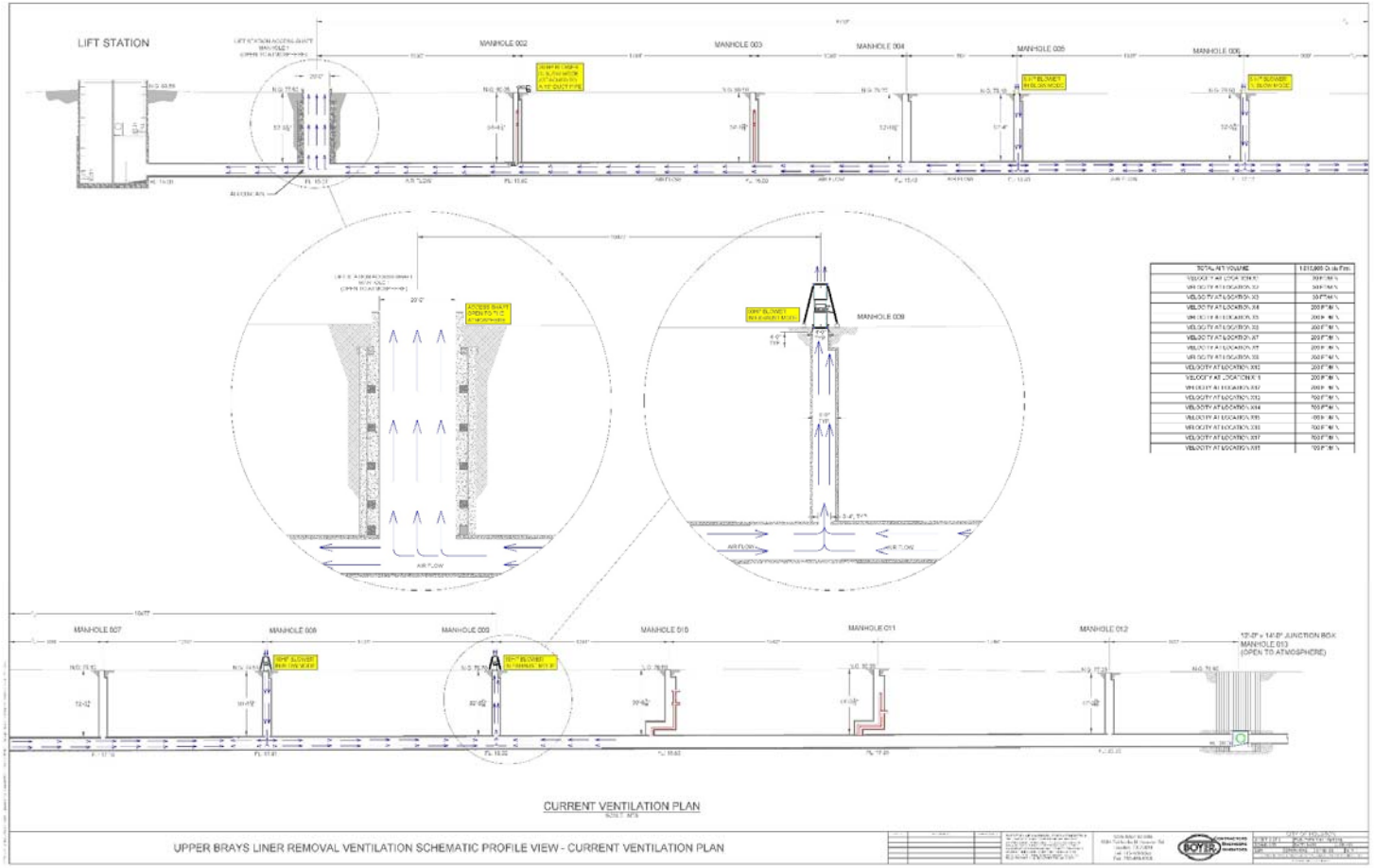
- Bob Cat Skid Steer
- Custom Fabricated Cart
  - Budgeted Cost – Kia Reo
  - Actual Cost – BMW 328i (Fully Loaded)

VENTILATION

- Most Important aspect of Safety
- Move 1,000000 Cubic feet of air
- Minimum 200 CFM Per Person
- Minimum air velocity – 30 ft./min
- Combination of 2-5HP ,1-50HP ,1-40-HP, 2-20 HP Blowers
- Blowers Operating in Blow & Suction mode
- Ventilated Tunnel 3 miles long , 108” in diameter , 65 ft. below ground
- Air Velocities up to 400 ft./min



VENTILATION PLAN – PROFILE VIEW



20 HP BlOWER IN BLOW MODE

40 HP BLOWER IN EXHAUST MODE

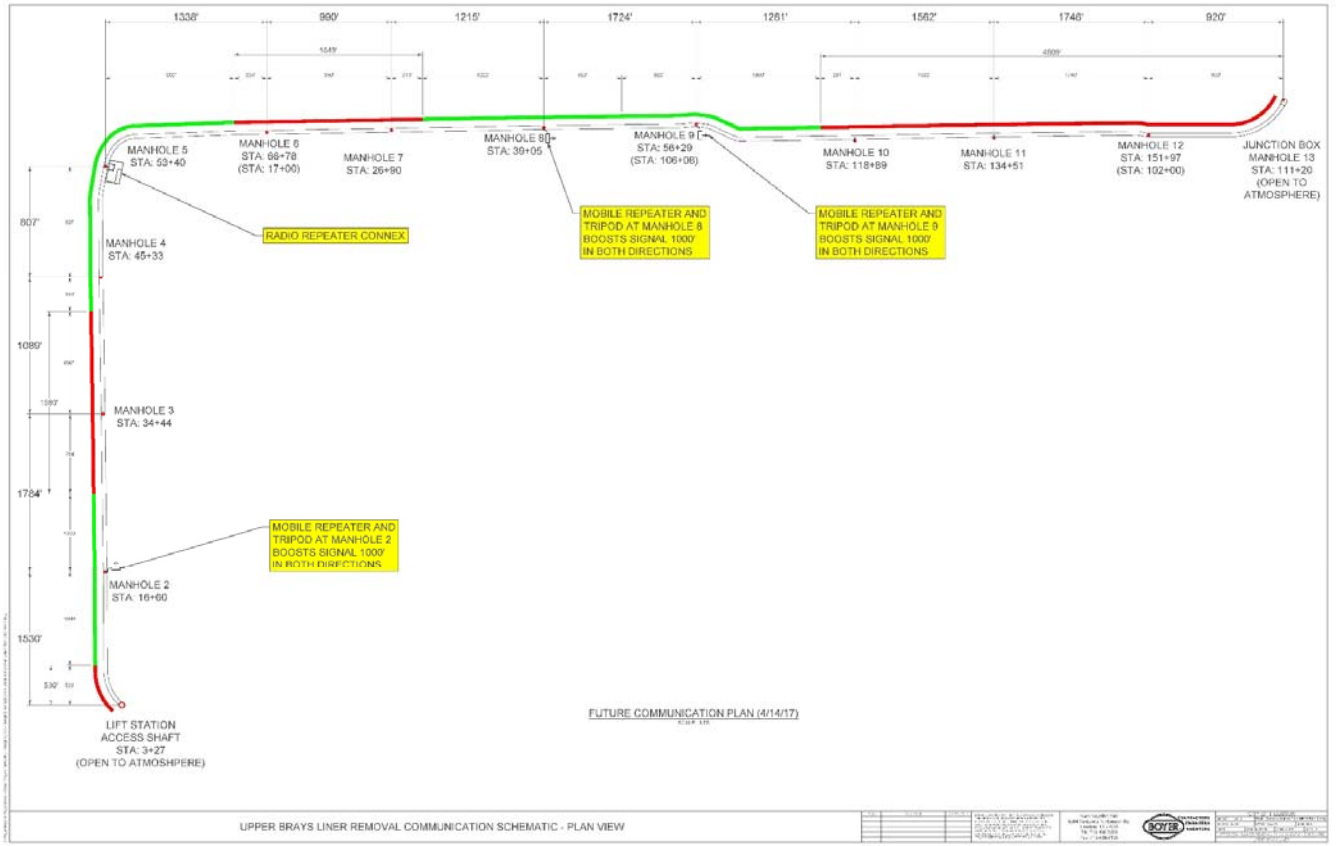
40 HP BLOWER IN EXHAUST MODE

COMMUNICATION

- Main Repeater Station
- 4 Mobile Repeater stations
- Digital Radios
- Seamless Communication inside the 3 mile tunnel & above ground

COMMUNCATION - MAIN REPEATER

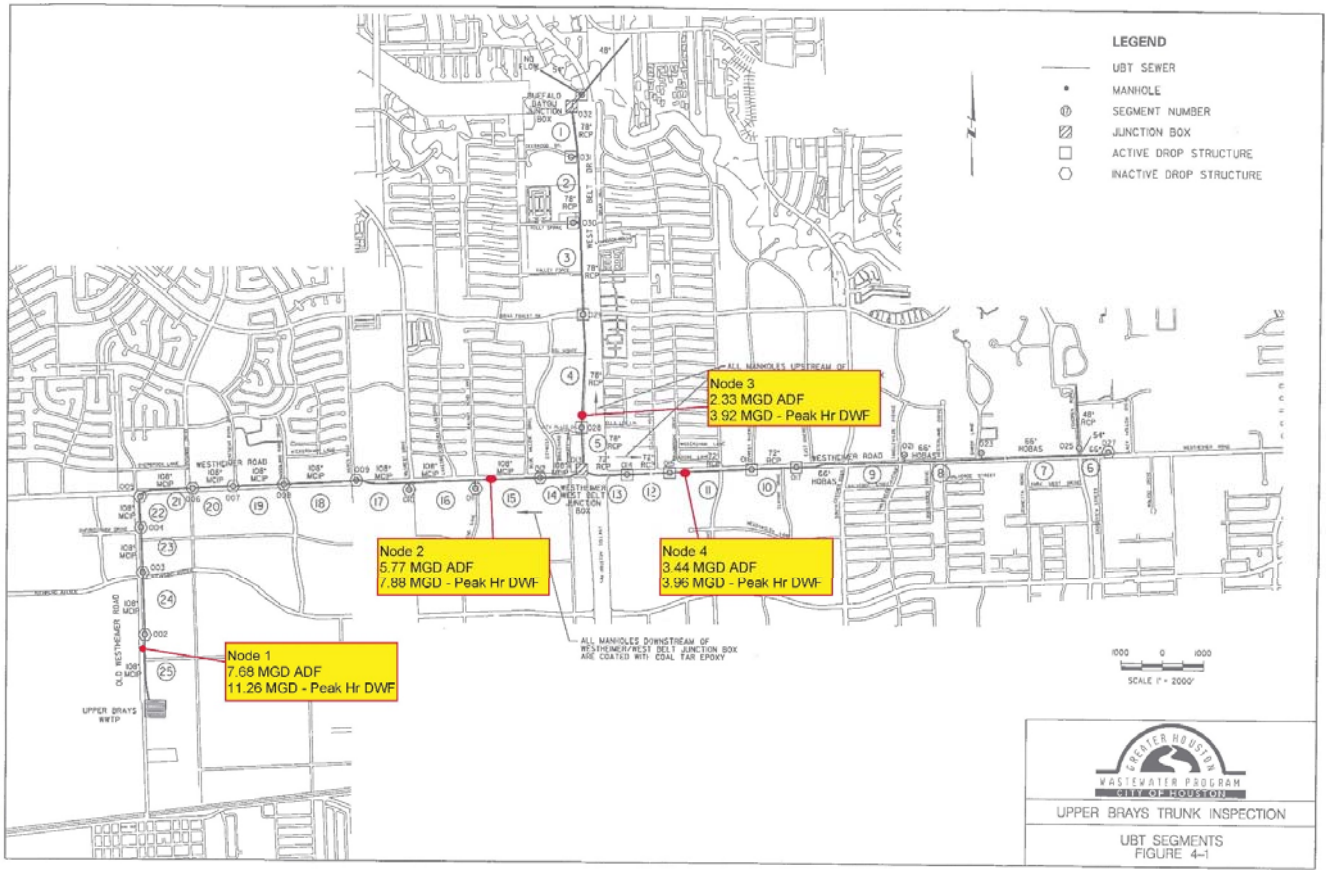
COMMUNICATION SCHEMATIC



CUSTOM EQUIPMENT & FABRICATION

- Tower Crane
- Bob-Cat Skid Steer
- Debris Screen/Catch bar
- Debris cleaning bucket
- Debris Disposal Bucket
- Transportation Cart
- Batten Strip Removal attachment

FLOW CONTROL/DIVERSION



FLOW CONTROL/DIVERSION

Install Diversion weir

- Excavate 30’Lx30’Wx50’D Shaft
- Saw Cut 28”T reinforced concrete slab
- Laser Scan Inside of the existing JB
- Design , Fabricate & Install a diversion weir with 36” Pneumatic Knife Gate Valve

DIVERSION WEIR OPERATION

- Open Knife Gate Valve everyday at 6.30 am and Close at 5.00 pm
- Store flow in 72” & 78” Pipes Upstream
- Coordinate with WWOP’s to shut off Lift Stations everyday
- Divert Flow inside the 108” Tunnel

CLEANING , DEBRIS REMOVAL & DISPOSAL

- Total 600 TN of Sewer Debris
- Granular Sand
- Skid Steer with Custom Fabricated cleaning Bucket
- Custom Fabricated Disposal Bucket

CUSTOM DISPOSAL BUCKET

CUSTOM DISPOSAL BUCKET

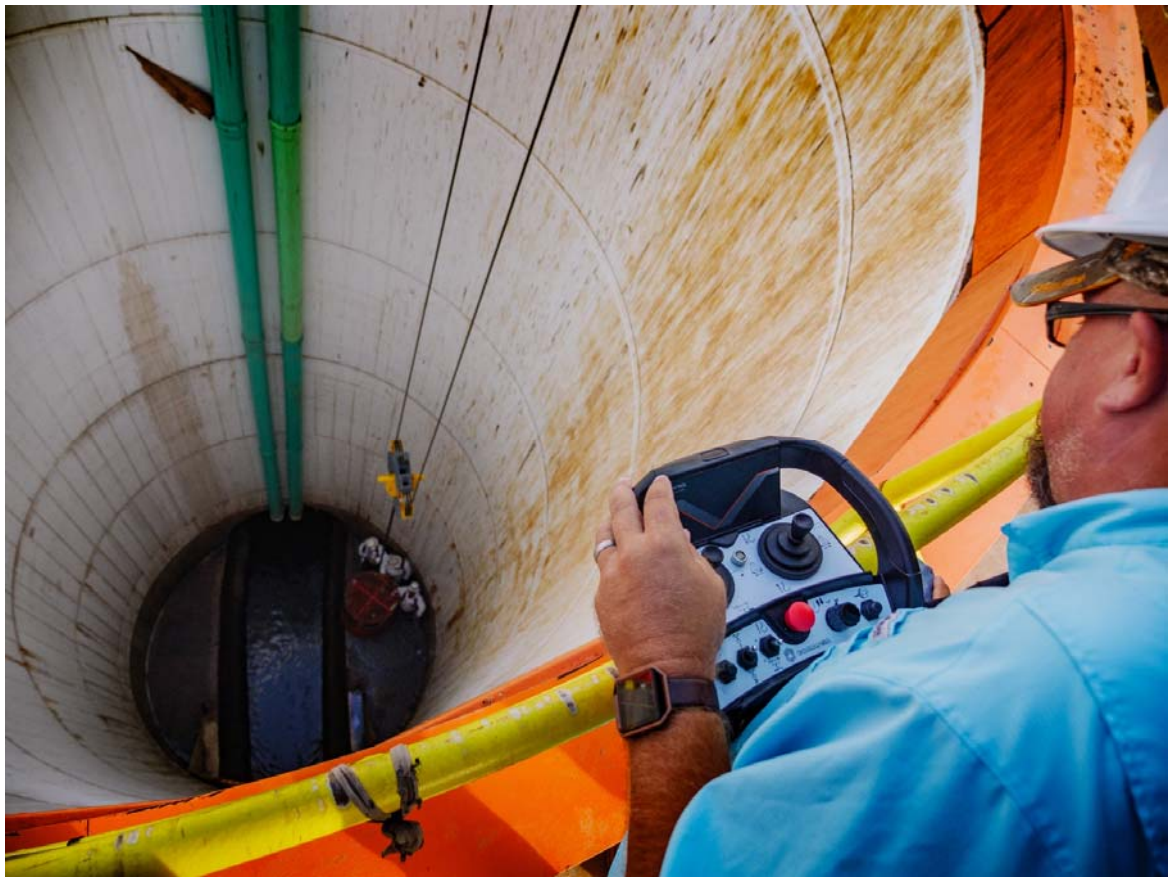
READY FOR A WALK ??

LINER REMOVAL & DISPOSAL

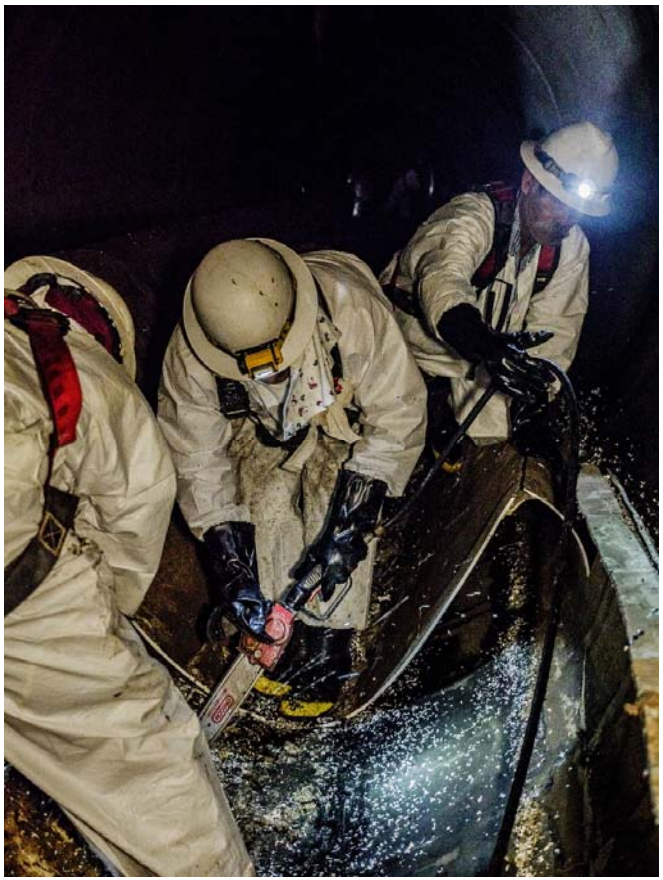
- HDPE Liner – 0.25’ thick
- Cut into strips – 3ft. Wx10-12ft. L using pneumatic bucket chain saws
- Floated & drug inside the Tunnel using Skid steer
- Washed using bleach & muriatic acid
- Bundled together after cutting using 3ftx3ft panels
- 0.5 Million pounds recycled – Environmentally friendly
- Batten Strips removed using Skid Steer & Custom attachment

LINER REMOVAL & DISPOSAL

LOWERING CREW USING REMOTE CONTROLLED TOWER CRANE



CUTTING LINER USING PNEUMATIC CHAIN SAWS



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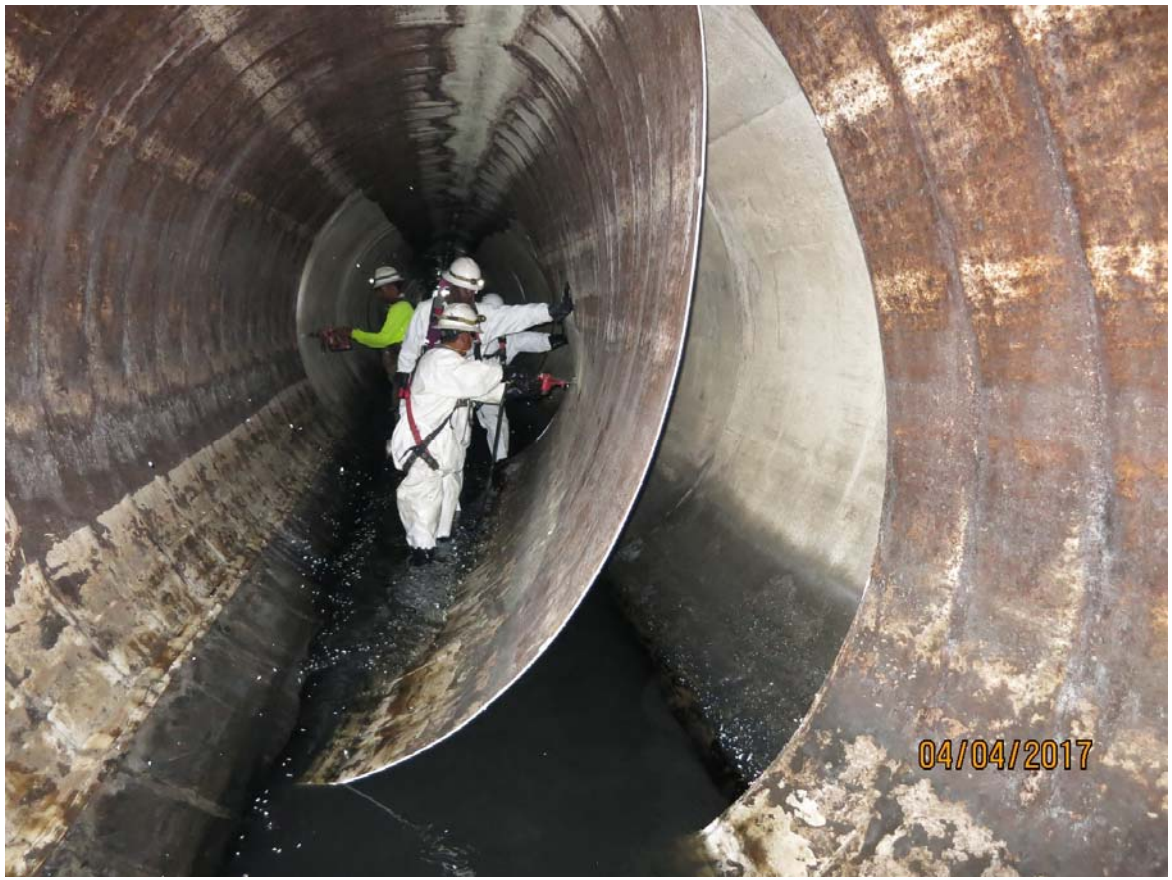


CUTTING LINER USING PNEUMATIC CHAIN SAWS

LINER CUT IN PANELS

TUNNEL AFTER REMOVING LINER

TUNNEL AFTER REMOVING LINER

SCHLAGEL LINER SCARPYARD?

CLEANER THAN YOUR KITCHEN TABLE !!

READY TO MAKE SOME CHAIRS

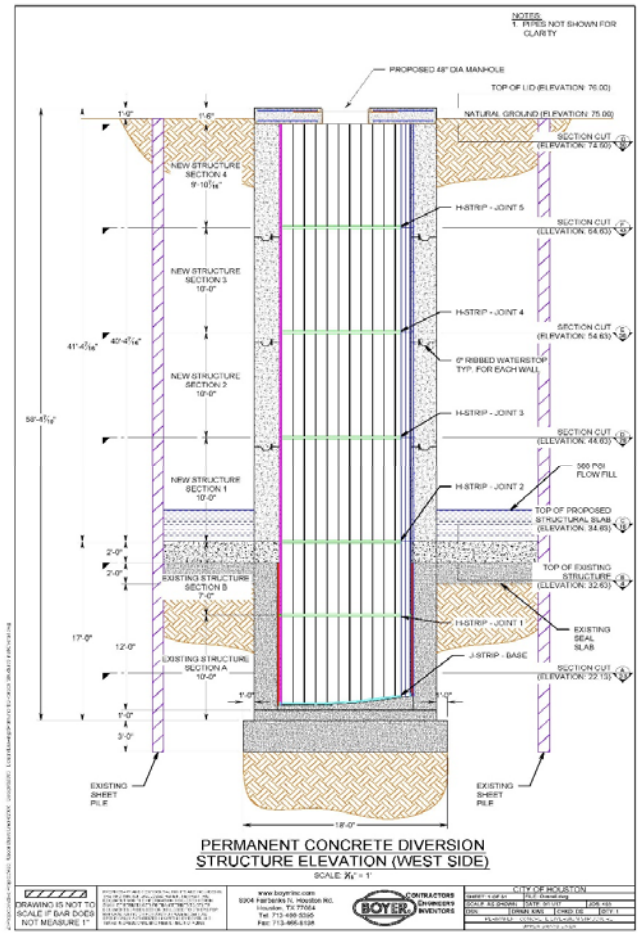
LASER SCANNING & CCTV

- Specified – Red-zone Robotics
- Proposed – Laser Scanning & CCTV
- True As-Built showing the horizontal & vertical deflections in the tunnel & elevation of the tunnel invert at any point
- Information can be used on a future Rehabilitation Project

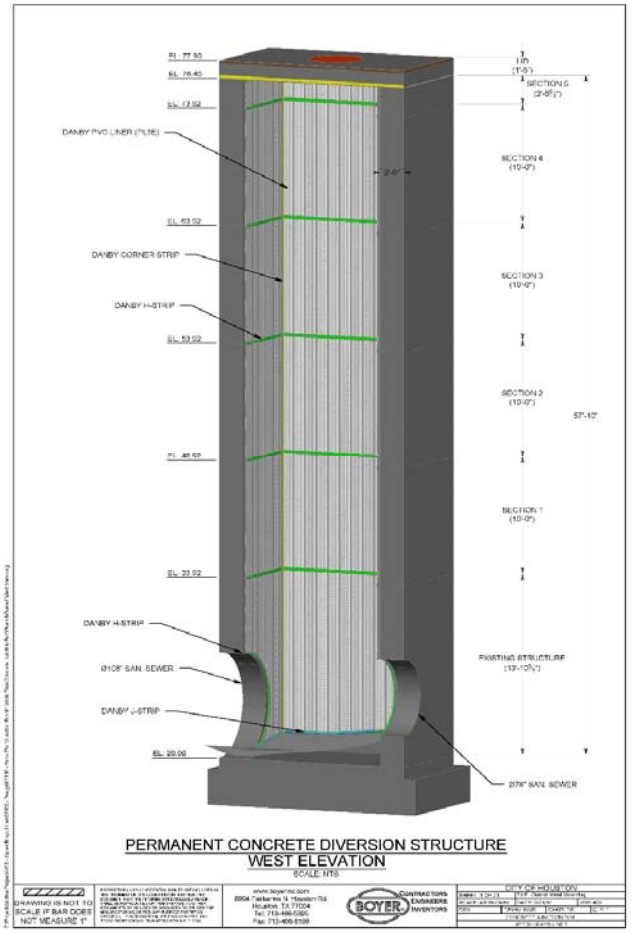
PERMANENT DIVERSION STRUCTURE

- Change Order within the allocated budget
- Upgrade to the Upper Brays system
- Future access & flow Diversion during rehab & inspection
- Built on top of existing 12’Wx15’L Junction box
- 12’Wx15’Lx50’D with 2’T reinforced walls
- Lined with Corrosion Protection Danby PVC Liner
- 316 SS Guide Rails in the corner for future diversion weir
- Removable Pre-Cast Lids with in-built 48” MH Ring & Cover

PERMANENT DIVERSION STRUCTURE



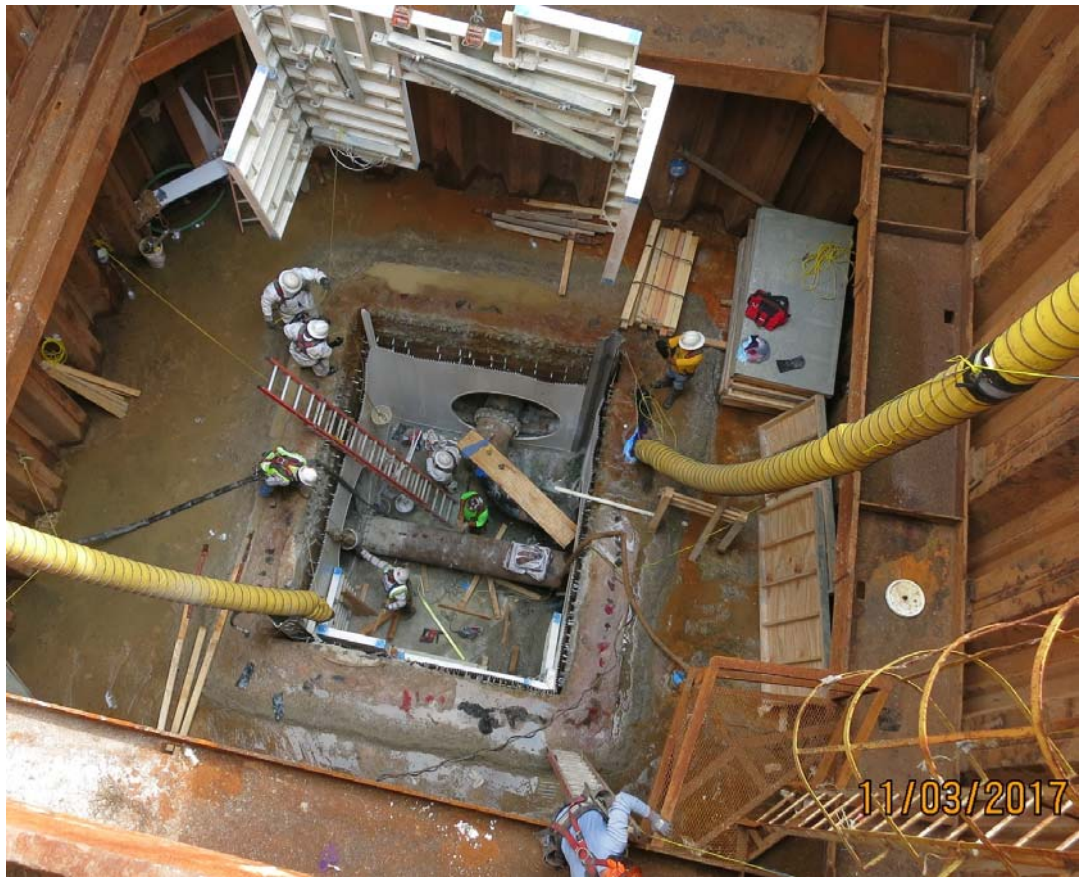
PERMANENT CONCRETE DIVERSION STRUCTURE ELEVATION (WEST SIDE)
SCALE: 3/16" = 1'



PERMANENT CONCRETE DIVERSION STRUCTURE
WEST ELEVATION
SCALE: NTS

STRUCTURAL SLAB INSTALLATION

INSTALLATION OF DANBY PVC LINER



FIRST 10 FT POUR

LAST 10 FT POUR

FINISHED STRUCTURE

SETTING REMOVABLE PRECAST LID

HIGHLIGHTS

- Project located on Major Thoroughfare
- Very minimal to no complaints
- True Trenchless project
- Ventilated entire Tunnel : 3 Miles , 108” Dia , 65 ft. Below Ground
- Communication throughout entire Tunnel
- Project Completed 9 months ahead of schedule
- Project Completed within budget with upgrades to the UB System
- Re-Cycled 0.5 M lbs. of HDPE Liner

KEY PLAYERS

- JASON IKEN – Sr. Assistant Director (ex) , COH
- SHANNON DUNE – Sr. Assistant Director , COH
- MARY BAC – Engineer of Record , COH
- DAVID TAJADOD – Construction Manager , COH
- BRAD WINKLER – Construction Manager , Weston Solutions
- BRIAN CAMPBELL- Senior Project Manager , COH
- SIDNEY BOMER – Operations Manager , COH
- SHEMAN IRISH – Site Inspector
- MARK BOYER – President , Boyer Inc.
- KEVIN TREADWELL – Superintendent , Boyer Inc.

Any questions ?