San Antonio Water System

APPENDIX A
GEOTECHNICAL BASELINE REPORT

SubTerra Inc.®

Central Water Integration Project (CWIP) Segment 5-1
San Antonio, TX

GEOTECHNICAL BASELINE REPORT

Prepared For

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Geotechnical Baseline Report

1 Introduction

This report is the Geotechnical Baseline report (GBR) for the Central Water Integration Project (CWIP), Segment 5-1, located in San Antonio, Texas. The report describes and summarizes the geological, geotechnical, geohydrological, and geomechanical data for those parts of the project that are specified to be constructed using tunneling.

The GBR is part of the Contract Documents and must be read in conjunction with the Conditions of Contract, Drawings and Specifications. The Conditions of Contract, Drawings and Specifications shall take precedence where a conflict exists between the GBR and these other Contract Documents.

1.1 Owner and Engineer

The following organizations have been involved in the design of this project:

- Owner: San Antonio Water System (SAWS)
- System Designer: Tetra Tech, Inc.
- Tunnel Engineer: SubTerra, Inc.
- Geotechnical Engineer: Arias GEOPROFESSIONALS

1.2 Scope and Purpose

This GBR has been prepared using the ASCE publication Geotechnical Baseline Reports for Construction: Suggested Guidelines[1] and in accordance with the City of San Antonio's codified requirements. The primary purpose of this GBR is to establish a contractual statement of the geotechnical conditions expected to be encountered during underground construction. These baseline conditions serve as the basis for evaluating actual geotechnical conditions and for determining conditions that might qualify as differing site conditions under the provisions of this contract. This report is a contractual baseline, not necessarily geotechnical fact, and constitutes a means of equitably and unambiguously apportioning the risk of underground construction.

1.3 Contents

The GBR is divided into four sections. Section 2 contains the Project Description, which is further detailed in Section 01010 of the Bid Documents and on the Project Drawings. Section 3 describes the anticipated site conditions, and Section 4 describes the construction considerations and baseline conditions.

2 Project Description

CWIP Segment 5-1 is the beginning of the final segment of a Regional Water Supply project which will transmit water from Burleson County to San Antonio. Segment 5-1 connects from a water treatment facility that will be constructed at the Terminus Site just south of Las Lomas Elementary School (located off Hardy Oak Boulevard) to a location just south of Loop 1604 and west of Voigt Drive in San Antonio. CWIP Segment 5-1 involves installing approximately 10,500

[1] Geotechnical Baseline Reports for Construction, Suggested Guidelines. Prepared by The Technical committee on Geotechnical Reports of the Underground Technical research Council, ASCE, R. J. Essex editor, 2007.

feet of 54-in steel pipe water main along this alignment and includes three trenchless Reaches and one open cut Reach as shown on Drawings GBR-101 to GBR-111and described below:

1. Terminus Shaft (STA 204+30 to STA 204+70). The Access Shaft for Reach 1.
2. Reach 1 (STA 157+52 to STA 204+30) is planned as a minimum 8-ft diameter mined tunnel and will be mined from the Terminus Shaft to a recovery shaft just south of Sonterra in the north bound lanes of Sigma Road.
3. Sonterra Shaft (STA 157+27 to STA 157+52). The Recovery Shaft for Reach 1.
4. Reach 2 (STA 141+89 to STA 157+27) is planned as an open cut segment that will be excavated from the recovery shaft just south of Sonterra in the north bound lanes of Sigma Road to the 1604 Frontage Road where it will connect to the recovery shaft for Reach 3.
5. Sigma Shaft (STA 141+62 to 141+89). The Recovery Shaft for Reach 3.
6. Reach 3 (STA 105+92 to STA 141+62) is planned as a minimum 8-ft diameter mined tunnel and will be completed from the SE corner of the Cornerstone Church parking lot (Stone Oak Parkway and Loop 1604) to a recovery shaft at Sigma Road.
7. Cornerstone Shaft (STA 105+52 to STA 105+92). The Access Shaft for Reaches 3 and 4.
8. Reach 4 (STA 100+58 to STA 105+54) is planned as a pipe jacked under crossing of Loop 1604 (a TXDOT under crossing) connecting from the shaft in the Cornerstone Church parking lot to a location just west of Voigt Drive. The 54-in pipeline will connect to an existing 48-in water main at this location.
9. Voigt Drive Shaft (STA 100+43 to STA 100+58). The Recovery Shaft for Reach 4.

This project includes:

1. Constructing temporary shafts required for tunnel access and installation of water main components. Five temporary shafts are indicated on the Geotechnical Baseline Plan and Profile Drawings:

   (1) Terminus Shaft: The main tunnel shaft at Terminus will be nominally 45-ft deep and either:

   - Circular (nominally 30-ft diameter) supported by back grouted, ring stiffened liner plate, or
   - Rectangular, nominally 30-ft to 40-ft long by 20-ft to 30-ft wide supported by mesh reinforced shotcrete and patterned, cementitious grouted rock bolts.

   (2) Sigma Road Shafts: The TBM recovery shafts on Sigma Road will be nominally 40-ft deep, rectangular, nominally 20 to 25-ft long by 15-ft wide supported by mesh reinforced shotcrete and patterned, resin or cementitious grouted rock bolts or alternate shoring method (see Specification 02360). The Sigma shaft at Sigma and Loop 1604 could be used for access for pipe installation and grouting.

   (3) Cornerstone Shaft: The main shaft at Cornerstone will be rectangular, nominally 90-ft deep and 25 to 40-ft long by 20 to 25-ft wide supported by mesh reinforced shotcrete and patterned, resin or cementitious grouted rock bolts. This configuration is dictated by the need to provide access for two independent tunneling operations, one mining towards Sigma Road (Reach 3) and one mining beneath Loop 1604 (Reach 4). One construction scenario involves:

- Initially constructing the shaft to a nominal depth of 40-ft to provide access for constructing the Reach 4, Loop 1604 under crossing using pipe jacking methods.
- Once casing installation in Reach 4 was complete, the shaft would be mined to full depth ready for mining the Reach 3 Tunnel.

Other scenarios are possible and the Contractor will determine the shape, size and sequence that best meets his means and methods.

(4) Voigt Drive Shaft: The recovery shaft on the south side of Loop 1604 will be nominally 30-ft deep, rectangular, nominally 15-ft long by 10-ft wide supported by mesh reinforced shotcrete and patterned, resin or cementitious grouted rock bolts or alternate shoring method (see Specification 02360).

2. Dewatering and ground improvement (if required), probe hole drilling, excavating and primary lining the Reach 1, Reach 3, and Reach 4 tunnels noted above within existing easements. Pipe installation and testing, backfilling around the pipe, installation of structures and all other work required to complete the CWIP Segment 5-1 Tunnel segments.
3. Dewatering and ground improvement (if required), excavation and ground support, pipe installation and testing, backfilling around and above pipe, and all other work required to complete Reach 2, within existing easements, by open cut trenching.
4. Installation of structures, valves, transitions and other water main components and constructing permanent access in the shafts as detailed on the Project Drawings and in accordance with the Project Specifications.
5. Connecting upstream and downstream ends to the existing water lines.
6. Site restoration and cleanup.

A complete list of sequential construction tasks is provided in Section 01010 of the Contract Documents.

3 Site Description and Ground Conditions

Tunnel Reaches will be constructed at depths varying from 20-ft to 90-ft deep as shown on GBR Drawings GBR-102 to GBR-111. Reach 1 starts at the Terminus site in a nominal 45-ft deep shaft and runs south under open ground (GBR-102 and 103) until reaching the soccer field in the Ronald Reagan High School (GBR-103). The tunnel traverses beneath the soccer field and an infiltration basin (GBR-104), past the High School property boundary and continues south beneath parking areas (GBR-105) and under Sonterra Boulevard to a recovery shaft in the northbound lanes of Sigma Road (GBR-106). The Drawings and Traffic Control Plans indicate that the northbound lanes of Sigma Road will be closed during CWIP Segment 5-1 construction.

Reach 2 is an open cut section that continues the pipeline to the south, in the Sigma road easement, ending at the Recovery Shaft for Reach 3 located just north of Loop 1604 (GBR-107)

Reach 3 starts at the Cornerstone Church site in a nominal 90-ft deep shaft (GBR-111) and runs east in an easement on the north side of the Loop 1604 frontage road. The easement is very narrow, as shown on the Drawings, and requires that the Reach 3 TBM navigate several 1,000-ft radius curves. Reach 3 reaches a low point under Dry Creek (GBR-109), passing under a congested utility corridor, including sewer, gas, storm water, fiber optic, overhead power lines, street signs, etc. (GBR-108) and connects to its recovery shaft on Sigma road (GBR-107).

The tunnel Reaches will be completed in Edwards Formation Limestone which is known to contain near horizontally bedded, limestone bedrock, abundant chert seams, clay and sandy clay and clay filled voids, karst features and open voids. Additional geologic details are provided in the paragraphs below.

3.1 *Geologic and Hydrologic Setting*

3.1.1 Geology

Data regarding rock conditions along the proposed tunnel alignment are contained in several Geotechnical Reports prepared by Arias Geoprofessionals (Arias, 2018(a)[2], 2018(b)[3]) which are included with the Bid Documents. These reports contain:

1. A description of the site investigation program.
2. Core logs and core photographs
3. Soils data
4. Rock quality data.
5. Groundwater data.
6. Laboratory test data.

The project Geotechnical reports indicate that the site is underlain by a relatively thin surficial layer of soil derived from the underlying weathered limestone. Limestone bedrock, characterized by a seismic velocity ranging from 2,800 to 5,000 ft/sec[4], underlies this thin soil layer to a depth of from 10-to-15 ft.

Project tunnels will be excavated with their crown a minimum of 10-ft below this horizon in Edwards Formation limestone and dolomitic limestone. Arias (2018(a)) provides the following general description for this Formation:

> *The Edwards Formation is Cretaceous age limestone consisting of relatively soft to extremely hard limestone, dolomitic limestone and dolomite. The limestone is typically described as vuggy, honeycombed and porous, having solution cavities and voids (karst), as well as nodules and lenticular layers of very hard chert. The voids are often infilled with red clay and brecciated limestone. The dolomite and dolomitic limestone of the Edwards is typically softer and when exposed to weathering may take on a soil-like consistency.*

Arias Geo-Professionals cored and logged fifteen exploration boreholes along the CWIP Tunnel alignment summarizing the intact rock properties in Table 3 of their summary report, part of which is reproduced below as Table 1 of this report.

[2] Arias Geoprofessionals, 2018(a). Geotechnical Data Report, SAWS Central Water Integration Project, Segment 5-1, 54-inch Pipeline, Terminus Site to Loop 1604, San Antonio, TX. Prepared for Tetra Tech, Inc., July, 2018.

[3] Arias Geoprofessionals, 2018(b). Karst Feature Data Report, SAWS Central Water Integration Pipeline (CWIP) Project, Tunnel Segment, San Antonio, TX. Prepared for Tetra Tech, Inc., April, 2018

[4] Collier Consulting, Inc., 2018. Geophysical Interpretation Report, Geophysical Assessment of the proposed SAWS Tunnel Location, San Antonio, TX. Prepared for Kiewit Infrastruture South Co., January, 19, 2018.

Table 1: Summary Intact Rock Properties (after Arias, 2018(a))

		Segment 5-1	Reach 1	Reach 2	Reach 3	Reach 4
UCS (psi)	**Max**	16,946	16,946	11,412	10,253	8,801
	Min	1,361	1,748	3,096	1,361	2,243
	Avg	6,787	7,122	6,411	5,391	6,328
BTS (psi)	**Max**	5,576				
	Min	1,028				
	Avg	2,786				
E (psi)	**Max**	6.64E+06	6.64E+06	3.20E+06	2.61E+06	3.16E+06
	Min	7.35E+04	7.35E+04	1.93E+05	3.68E+05	5.03E+05
	Avg	1.68E+06	1.79E+06	1.54E+06	1.37E+06	1.71E+06

Where:

UCS - Unconfined Compressive Strength, psi

BTS Brazilian Tensile Strength, psi

E - Rock Modulus, psi

Max - Maximum value

Min - Minimum value

Avg - Average value

3.1.2 Hydrology

Arias notes that…

> ”*Groundwater was not encountered in the borings at the time of drilling. Notes of drilling fluid losses are included on the boring logs and may be indicative of strata capable of transmitting groundwater.*
>
> *Packer testing was conducted in four borings for the purpose of investigating hydraulic conductivity of the rock stratum.*
>
> *In general, packer test results indicated areas of very low to no permeability, and zones of very high permeability. It is suspected that the upper permeability values on the order of 10^{-4} cm/sec are likely representative of the limits of the packer test assembly. Actual permeability rates in the porous vuggy limestone may be higher than that indicated from the packer test data.”*

The expected or baseline conditions include a dry excavation, above the regional groundwater table, which may experience significant infiltration during heavy rain events.

3.1.3 Faulting

Kiewit Infrastructure South (Decker, 2017[5]) located two faults placing one just south of Borehole TU-2 and one at Borehole TU-5. Arias reports the presence of a fault located in the middle of Reach 1 of unknown width and with a reported throw of 260-ft. A summary of their fault related evaluations is provided on pages 6 and 7 of the GDR (Arias, 2018(a)):

[5] Decker, 2017. Preliminary Geotechnical Review and Ground Support- SAWS Central Water Integration Project. Memorandum to Tony O’Donnel dated October 2017.

1. USGS Interactive Map indicates two geologic faults. One geologic fault runs between borings TU-3 and TU-4, and another runs just north of boring TU-6.
2. Edwards Aquifer Map shows two geologic faults. The geologic faults are located near borings TU-2 and TU-5.
3. Collins Map indicates one geologic fault close to boring TU-4.

Collier Consulting, Inc. (Collier, 2018) subsequently conducted a geophysical study which identified the possible location of a nominally 400-ft wide fault zone located between Boreholes TU-3 and TU-4.

Baseline conditions will therefore include encountering fault zones throughout the alignment ranging from several tens of feet to 400-ft in width.

3.1.4 Karst Features and Caves

Karst features and open caves are located throughout this area of San Antonio and shallow karst features have been observed in road excavations near the project site (Decker, 2017) as well as in areas either side of the alignment (SWCA, 2017[6]).

Collier Consulting, Inc. (Collier, 2018) identified nineteen (19) potential karst features along the alignment based on their analysis of a series of Resistivity and Seismic surveys. Seventeen (17) of these potential features were explored using rotary and pneumatic downhole hammer boring methods with CCTV logging of each completed drillhole (Arias, 2018(b)). The results indicate the presence of soft zones up to 15-ft thick in many of the feature holes but no caves or caverns were encountered. Many of the soft zones have been correlated with clay filled zones in the exploratory boreholes or with areas of zero RQD bedrock.

This work has been documented in a Karst Feature Data Report produced by Arias (Arias, 2018(b)) which is included with the Contract Documents. Summary information for the rotary bores detailed in Arias, 2018(b) has been reproduced on the attached plan and profile drawings.

Baseline conditions will include encountering soft zones and karst features throughout the alignments. Open features up to 3-ft in diameter are allocated to the Contractor, as they are not considered significant with regard to environmental criteria (see SWCA, 2017), while features larger than 3-ft will require special inspection and treatment.

Separate provisions, drawings, specifications and bid items have been developed for standby during special inspections and working though larger than 3-ft voids, if encountered.

3.2 Geological and Geotechnical Conditions for the Tunnel Reaches

As previously noted, the tunnel horizon for all reaches will be located in the Edwards Formation. Construction considerations are presented in Section 4 of this report.

3.2.1 Soils and Fill

Surficial soils consist primarily of topsoil overlying residual soils derived from the underlying limestone. Characteristics range from stiff to very stiff sandy lean and fat clays with gravel to dense to very dense silty clayey sand with gravel.

3.2.2 Edwards Formation

Beds of the Edwards Formation underlying this site consist of limestone, dolomitic limestone, layered nodular chert, dolomite along with soft clay and clayey sand filled zones . As noted

[6] SWCA, 2017. Vista Ridge Integration Program, Environmental Constraints Analysis. Report prepared for Black and Veatch, May, 2017.

above, the rock that makes up this formation varies from massive to thinly-bedded, fine grained, essentially crystalline and hard, to very coarse-grained and soft and tends to be vuggy and fractured with solution collapse zones that can contain voids and large caves.

3.2.2.1 Intact Rock Properties

Laboratory determined Edwards Formation limestone unconfined compressive strength ranged from 1,360 to 17,000 psi (see Tables 1 and 2). Unit dry weight ranges from 128 to 163 pcf.

Table 2: Summary of Segment 5-1, Intact Rock Properties (Arias, 2018(a))

Boring Number.	Depth	Density	UCS[7] Unconfined Compressive Strength	BTS Brazilian Tensile Strength	Punch Penetration[8]		Cerchar Abrasivity
					Spherical	Conical	
	(ft)	(pcf)	(psi)	(psi)	Kips/in	Kips/in	(1/10 mm)[9]
TU-1	12	144	4,693				
TU-1	21	162	6,040				
TU-1	33.3			2,524			0.31
TU-1	34-36	151	1,748				
TU-1	41	143	14,518	2,781			
TU-1	52	154	9,076				
TU-2	10	140	6,025				
TU-2	25	163	6,242				
TU-2	36	160	10,560				
TU-2	39	155	9,416				
TU-2	45	149	3,342				
TU-2	49	153	11,479				
TU-2	56	163	11,497				
TU-2	66			3,352			
TU-2	68						1.13
TU-2	84	163	6,170				
TU-3	17	153	11,523				
TU-3	23						2.75

[7] ASTM-7012-10. Standard Test Method for Compressive Strength and Elastic Moduli of Intact Rock Core Specimens under Varying States of Stress and Temperatures.

[8] Dollinger and Handewith, 2000. Correlations Between Punch Test Results and Rock Physical Properties. Pacific Rocks 2000, Girard, Liebman, Breeds and Doe (editors).

[9] West, G., 1989. Technical Note: Rock Abrasiveness Testing for Tunneling. International Journal Rock Mechanics, Vol 26, N0.2, pp 151-160, 1989.

Table 2: Summary of Segment 5-1, Intact Rock Properties (Arias, 2018(a))

Boring Number.	Depth	Density	UCS[7] Unconfined Compressive Strength	BTS Brazilian Tensile Strength	Punch Penetration[8]		Cerchar Abrasivity
					Spherical	Conical	
	(ft)	(pcf)	(psi)	(psi)	Kips/in	Kips/in	(1/10 mm)[9]
TU-3	38.75	165	11,647				
TU-3	40						0.45
TU-3	41 to 42	165	6,615	3,734	328	91	
TU-3	66	156	6,493				
TU-4	17.5	154	6,922				
TU-4	33			2,361			0.37
TU-4	34				314	72	
TU-4	34.5	140	4,224				
TU-4	52	163	10,188				
TU-5	24	162	6,716				
TU-5	30	160	8,923				
TU-5	39.5			2,027			
TU-5	52	158	3,891				
TU-5	53			2,746			
TU-6	19	131	3,096				
TU-6	26.5						0.45
TU-6	28 to 29			2,595	336	60	
TU-6	32	157	5,670				
TU-6	35	164	9,414				
TU-6	46	169	11,412				
TU-6	60.5	157	9,619				
TU-7	13	149	5,027				
TU-7	22	136	4,481				
TU-7	30.5			1,985	221	64	
TU-7	35						0.45
TU-7	44	153	4,058				
TU-8	23	130	1,560				
TU-8	30	148	1,361				

Table 2: Summary of Segment 5-1, Intact Rock Properties (Arias, 2018(a))

Boring Number.	Depth	Density	UCS[7] Unconfined Compressive Strength	BTS Brazilian Tensile Strength	Punch Penetration[8]		Cerchar Abrasivity
					Spherical	Conical	
	(ft)	(pcf)	(psi)	(psi)	Kips/in	Kips/in	(1/10 mm)[9]
TU-8	35			5,576			2.37
TU-9	17	157	6,656				
TU-9	18	158	10,253				2.36
TU-9	29	147	5,959				
TU-9	33				124	24	
TU-9	37			2,722			0.34
TU-9	43	140	5.568				
TU-9	44	154	9,502				
TU-9	57	143	7,719				
TU-10	25			1,028			
TU-10	27.5	128	2,243				
TU-10	28.5				261	43	
TU-10	43.3	147	5,829				
TU-10	70.8	155	7,101				
TU-11	12	150	5,489				
TU-11	14.5						2.53
TU-11	16	148	6,132				
TU-11	22	142	8,694				
TU-11	27	155	8,801				0.49
B13	9	161	6,615				
B13	15	163	6,095				
B13	19	155	4,500				
B13	22	147	4,331				
B13	31.5	157	7,507				
B13	41.5	151	9,095				
B13	58	161	5,229				
TU12	2	159	3,004				
TU12	10	161	10,567				

Table 2: Summary of Segment 5-1, Intact Rock Properties (Arias, 2018(a))							
Boring Number.	Depth	Density	UCS[7] Unconfined Compressive Strength	BTS Brazilian Tensile Strength	Punch Penetration[8]		Cerchar Abrasivity
					Spherical	Conical	
	(ft)	(pcf)	(psi)	(psi)	Kips/in	Kips/in	(1/10 mm)[9]
TU12	25	148	16,946				
TU12	30	156	4,210				
TU12	35	141	1,831				
TU12	55	152	2,036				
TU13	15	150	3,498				
TU14	20	160	3,910				
TU14	28	138	4,666				

3.3 *Rock Mass Characteristics for the Tunnel Reaches*

Rock mass characteristics of consequence to tunnel excavation and ground support include UCS, BTS, and rock mass quality. Tables 1 and 2 have previously summarized the intact rock properties for the Edwards Formation that will be encountered during tunneling. This section of the GBR assesses the effect of structural discontinuities on the overall characteristics of the rock mass with regard to ground support design and excavation.

Table 3 summarizes the ranges in two field-determined indices, core recovery and Rock Quality Designation (RQD), that contribute to Rock Mass Quality, and the range in Rock Mass Rating (RMR) estimated for each of the Reaches.

Table 3: Summary Field Determined RQD and Core Recovery Data and Estimated RMR									
	REC (%)			RQD (%)			RMR		
	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max
Reach 1	0	74	100	0	38	100	25	52	89
Reach 2	0	58	100	0	40	100	NA	NA	NA
Reach 3	14	53	100	0	32	97	25	44	74
Reach 4	78	96	100	20	55	100	26	62	76

Where:

REC - Rock Core Recovery, %
RQD - Rock Quality Designation, %
RMR - Rock Mass Rating
Max - Maximum value
Min - Minimum value

Ave - Average value

Detailed RQD and Core recovery data are provided in the referenced Geotechnical Data Report(s).

4 Construction Considerations and Baseline Conditions

This section of the GBR summarizes the main construction elements that will be influenced by site-specific geotechnical conditions, states baselines for construction elements and guides the Contractor to sections of the report where additional baseline data can be found.

4.1 Dewatering

Excavation dewatering is a risk allocated to the Contractor and it is the Owner's intent that the Contractor be responsible for managing all water encountered.

Excavations are located above the regional groundwater table and are expected to be dry, as previously noted. However, it is important to understand that groundwater elevations will vary throughout the year and that the tunnel may encounter water bearing karst features at other locations than those already shown on the Boring Logs.

It is essential the Contractor select Means and Methods that are compatible with the anticipated range in ground and groundwater conditions.

4.2 Trench Construction

Trench excavations will be designed by a Professional Engineer registered in the State of Texas in accordance with local, state, and federal requirements and in accordance with the Project Specifications.

It is emphasized that heavy duty "rock ripping" excavating equipment and rock saws will be required for excavating in the Edwards Formation Limestone bedrock that will be encountered.

The Contractor should expect to encounter karst voids during trenching. Voids up to 3-ft in diameter and less than 18 cubic feet in volume do not require mitigation and are allocated to the Contractor. That is the Contractor shall include the costs for backfilling and excavating through voids with a volume less than 18 cubic feet in their bid.

All voids greater than 18 cubic feet in volume will be mitigated and the Contractor will be reimbursed at the unit rates included in Specification 01510. As one category of void is allocated to the Contractor and all other categories of void are compensable, a baseline for voids is not needed and has not been set.

This GBR has been prepared primarily for reference by the Tunnel Contractor with regard to planning and estimating the costs to excavate and primary line or case reaches that must be constructed using trenchless methods.

4.3 Shaft Construction

The Contractor's Professional Engineer (PE) will design the primary ground support for the access shafts and the Owner's Engineer, through the submittal process, will review their designs. The Contractor will utilize the geotechnical data contained in Section 3 as design input.

The Terminus Shaft will be excavated through nominally 3-ft of soil (clay, clayey sand with limestone fragments) into the limestone of the Edwards Formation. The Contractor will size the Terminus Shaft to:

- Act as the access shaft for tunnel construction of Reach 1 and installation and grouting of the Transmission Main carrier pipe in Reach 1.
- Allow installation of a permanent vault and vault access from the surface that will be used by SAWS for operations and maintenance, as shown on the Drawings.
- Allow installation and backfill/grouting of the Transmission Main carrier pipe required to connect the tunnel carrier pipe to the carrier pipe-installed from the Treatment Plant.

The Cornerstone Shaft will be excavated through asphalt pavement and nominally 2-ft of soil (clayey sand with limestone fragments) into the limestone of the Edwards Formation. The Contractor will size the Cornerstone Shaft to:

- Act as the access shaft for tunnel construction of Reach 4 and installation and grouting of the Transmission Main carrier pipe in Reach 4.
- Act as the access shaft for tunnel construction of Reach 3 and installation and grouting of the Transmission Main carrier pipe in Reach 3.
- Allow installation of a permanent vault and vault access from the surface that will be used by SAWS for operations and maintenance, as shown on the Drawings.
- Allow installation and backfill/grouting of the Transmission Main carrier pipe required to connect the tunnel carrier pipe in Reach 4 to the tunnel carrier pipe in Reach 3.

The Sonterra and Sigma Road Exit Shafts will be excavated through asphalt paving and 2-ft of fill or soil into the limestone of the Edwards Formation. The Contractor will size these shafts to:

- Act as the exit shafts for Reaches 1 and 3 and installation and backfilling /grouting of the Transmission Main carrier pipes required to connect to Reach 2.
- Allow installation of a permanent vault and vault access from the surface that will be used by SAWS for operations and maintenance, as shown on the Drawings.

The Voigt Road Shaft will be excavated through about 3-ft of soil into the Edwards Formation Limestone. The Contractor will size the Voigt Road shaft to:

- Act as the exit shaft for a pipe jacked, tunnel constructed beneath Loop 1604 and its frontage roads.
- Allow access for the installation and backfilling/grouting of the Transmission Main connecting from the carrier pipe in Reach 4 to the 48-in water line.

4.3.1 Shaft Excavation and Ground Support

Shaft excavation methodology and primary ground support is a Contractor option. However, it is anticipated that the Contractor will use back-grouted, ring-stiffened liner plates in circular shafts and patterned rock bolts with mesh or steel fiber reinforced shotcrete in square or rectangular section shafts. Requirements are provided in Specification Section 02360.

Note that each shaft liner installed by the Contractor is considered temporary and is not intended to become part of the final structure.

Excavation and primary ground support will be designed using the data provided in Section 3 of this report and the following criteria:

1. A minimum horizontal ground pressure of 55 psf per foot of depth.

The Contractor is responsible for means, methods and safety and should incorporate higher loads if deemed necessary to meet the objectives associated with those responsibilities.

The Contractor should expect to encounter karsts (voids) during shaft construction. Voids up to 3-ft in diameter and less than 18 cubic feet in volume do not require mitigation and are allocated to the Contractor. That is the Contractor will include the costs for grouting and excavating through voids with a volume less than 18 cubic feet in their bid.

All voids greater than 18 cubic feet in volume will be mitigated and the Contractor will be reimbursed at the unit rates included in Specification 01510.

As one category of void is allocated to the Contractor and all other categories of void are compensable, a baseline for voids is not needed and has not been set.

4.3.2 Groundwater Inflows

If care is taken to prevent surface water from entering the excavation shaft, construction in the Limestone Formations should be relatively dry. Nevertheless, be prepared to handle groundwater in the unlikely event that it is encountered. The baseline groundwater inflow quantity has therefore been set at 50 gpm in any Shaft. This quantity does not include inflows via man made penetrations or poorly sealed areas.

The contractor is responsible for minimizing and managing groundwater inflows encountered during shaft construction and for managing all inflow during and following construction.

4.3.3 Groundwater Handling and Removal

The Contractor will be responsible for all Groundwater Handling and Removal and related consequences.

4.4 Trenchless Construction

Trenchless construction methods will be used to construct three Reaches using Tunnel Boring Machines or a Rock Boring Machine. Separate TBMs/RBMs are required for each Reach so that the construction of each Reach can be completed in the fastest time possible.

Reach 1 Terminus to Sonterra Shaft will be excavated through nominally 4,700 LF of Edwards Formation Limestone.

Reach 3 Cornerstone to Sigma Shaft will be excavated through nominally 3,570 Lf of Edwards Formation Limestone.

Reach 4 Cornerstone to Voigt Shaft will be pipe jacked through nominally 500 LF of Edwards Formation Limestone.

4.4.1 Baseline Rock and Soil Conditions

The following baseline rock and soft ground conditions are set for each tunneled reach in the Edwards Limestone:

Reach 1 Baseline Conditions: The Contractor will encounter Edwards Formation limestone bedrock with UCS up to 17,000 psi averaging 8,000 psi and with RQDs ranging from 0% to 100% averaging 40%. Soft zones containing clay and sandy clay will also be encountered along with fault zones ranging from 20-ft to 400-ft wide characterized by low RQD bedrock and soft clay filled voids. Open karst features and voids will also be encountered.

Reach 3 Baseline Conditions: The Contractor will encounter Edwards Formation limestone with UCS up to 15,000 psi averaging 8,000 psi and with RQDs ranging from 0% to 100% averaging 40%. Soft zones containing clay and sandy clay will also be encountered along with fault zones ranging from 20-ft to 40-ft wide characterized by low RQD bedrock and soft clay filled voids. Open karst features and voids will also be encountered. This reach is particularly susceptible to groundwater infiltration to the tunnel as a result of rain storms as the approximate center of the alignment is located 20-ft below Dry Creek in a zone of 0% RQD bedrock.

Reach 4 Baseline Conditions: The Contractor will encounter Edwards Formation limestone with UCS up to 15,000 psi averaging 8,000 psi and with RQDs ranging from 0% to 100% averaging 60%. Soft zones containing clay and sandy clay will also be encountered along with zones ranging from 20-ft to 40-ft wide characterized by low RQD bedrock and soft, clay filled voids. Open karst features and voids will also be encountered.

4.4.2 Voids

Voids will be encountered in all Tunnel Reaches. Voids up to 3-ft in diameter and less than 18 cubic feet in volume do not require mitigation and are allocated to the Contractor. That is the Contractor will include the costs for grouting and mining through voids with a volume less than 18 cubic feet in their bid.

All voids greater than 18 cubic feet in volume will be mitigated and the Contractor will be reimbursed at the unit rates included in Specification 01510.

As one category of void is allocated to the Contractor and all other categories of void are compensable, a baseline for voids is not needed and has not been set.

4.4.3 Rock Abrasivity

Cerchar Abrasivity Index (CAI) testing, conducted for Edwards Formation limestone, indicates a range between CAI = 0.14 to 2.75. A baseline of CAI ranging from 0.3 to 2.75, averaging 1.5 has been set for this project. The Contractor will also encounter bands of chert up to 1-ft thick with a CAI up to 5.5.

4.4.4 Excavation of Tunnel Reaches

Tunnel reaches will be excavated using a Tunnel Boring Machine (TBM) or a Rock Boring Machine conforming to the project specifications. It is anticipated that Contractors will use pipe jacking as a means of advancing the RBM/TBM through Reach 4 and a TBM pushing off of a primary liner for Reaches 1 and 3. The actual selection of means, methods, and tunneling equipment is a Contractor responsibility.

Karsts (voids) will be encountered during tunnel construction and provisions have been included in the Contract Specifications (Specification 02300 and Specification 01510) for mitigation should mitigation be required.

4.4.4.1 Tunnel Excavation and Primary Lining installed using a conventional TBM (Reaches 1 and 3).

Tunnel construction by two-pass method with man entry. The construction method involves excavation using a TBM jacking or propelled off of the Primary Lining and/or propelled by grippers that react off of the tunnel sidewalls.

Primary Lining. These methods of excavation and lining are permitted depending on CONTRACTOR's selection:

1. Circular steel ribs with hard wood lagging.
2. Circular steel ribs with steel channel lagging.
3. Steel Liner Plate.
4. Ring Stiffened Liner Plate (circular ribs with steel liner plate).

4.4.4.2 Tunnel Excavation and Primary Lining installed by Pipe Jacking (Reach 4).

Tunnel construction by two-pass method with or without man entry. The construction methods involve jacking pipe following a rock boring machine (RBM), or a tunnel boring machine (TBM), with the jack-pipe serving only as the primary lining or casing.

CONTRACTOR must use welded steel pipe as the primary liner or casing.

4.4.4.3 Closure

As noted above, excavation and primary ground support will be designed by the Contractor using the data provided in this report and requirements provided elsewhere in the Project Manual including Specification 02300.

The Contractor will utilize the geotechnical data contained in Section 3 for Tunnel Design.

The Contractor is responsible for means, methods and safety and should utilize more conservative criteria if deemed necessary to meet the objectives associated with these responsibilities.

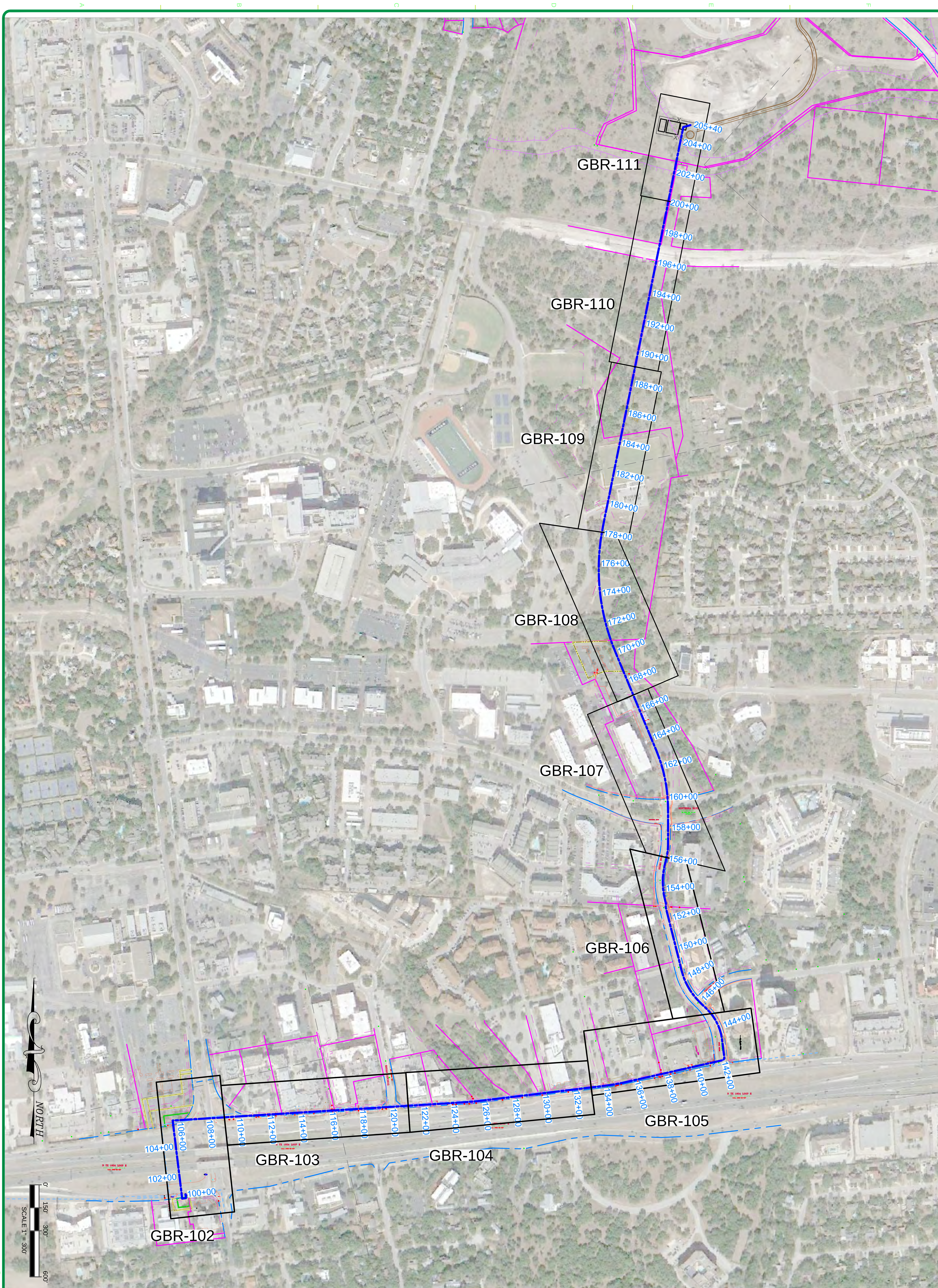
4.4.5 Groundwater Inflow to Tunnels

If care is taken to prevent surface water from entering the excavation from surface shafts or from other man made penetrations, tunneling conditions in the Limestone Formations should be relatively dry. Nevertheless, be prepared to handle groundwater in the unlikely event that it is encountered while tunneling. The baseline groundwater inflow quantity has therefore been set at 50 gpm in Reaches 1 and 4 and at 100 gpm in Reach 3. This value is set as a baseline quantity that may occur at any one or a combination of many locations throughout each tunnel reach. It does not include inflow via the shafts or other man made penetrations. The Contractor is responsible for sealing and cutting off all potential sources associated with surface penetrations, including the shafts that are a part of this project.

5 Disclaimer

The provision of a baseline in the contract is not a guaranty, representation, nor a warranty or indication, express or implied, that the baseline conditions will, in fact and actually, be encountered; rather, the baseline is primarily intended to define, for contractual purposes, those conditions which, if determined to be more adverse than defined, may result in an equitable adjustment of the contract price or time. The baseline is not a guaranty or warranty that the baseline conditions actually will be encountered in the performance of the work; nor may the contractor exclusively rely upon the baseline for the planning or performance of any aspect of its work, including without limitation the selection, design, or implementation of the means, methods, techniques, sequences and procedures of construction to be employed by the contractor, and safety precautions and programs incident thereto.

DRAWINGS



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TEXAS REGISTRATION NO. 97180
April 2018

FEATURE LOG LEGEND:

- USCS CLAYEY SAND
- LIMESTONE
- USCS LOW PLASTICITY CLAY
- VOID

BORING LOG LEGEND:

- USCS HIGH PLASTICITY CLAY
- LIMESTONE
- USCS CLAYEY GRAVEL
- VOID
- FILL MATERIAL
- WEATHERED LIMESTONE
- USCS CLAYEY SAND

Legend

- Permanent Easement
- Temporary Easement
- Pipeline
- Water
- Gas
- Sanitary Sewer
- Storm Drain
- OH Power
- UGND Power
- Communication

SAN ANTONIO WATER SYSTEM

CENTRAL WATER INTEGRATION PIPELINE
PROJECT TRANSMISSION PIPELINE

GBR-101

Site Plan Layout

MARK	DATE	DESCRIPTION	BY
	6-06-2018	Based on Files Received 06-06-2018	

PROJ: 200-09308-18001
DESN:
DRWN:
CHKD:

HORIZONTAL SCALE 1"=50'
VERTICAL SCALE 1"=10'

SAN ANTONIO WATER SYSTEM

SubTerra Inc.®
Texas Registration No. F-10568

TETRA TECH
Texas Registration No. F-3924
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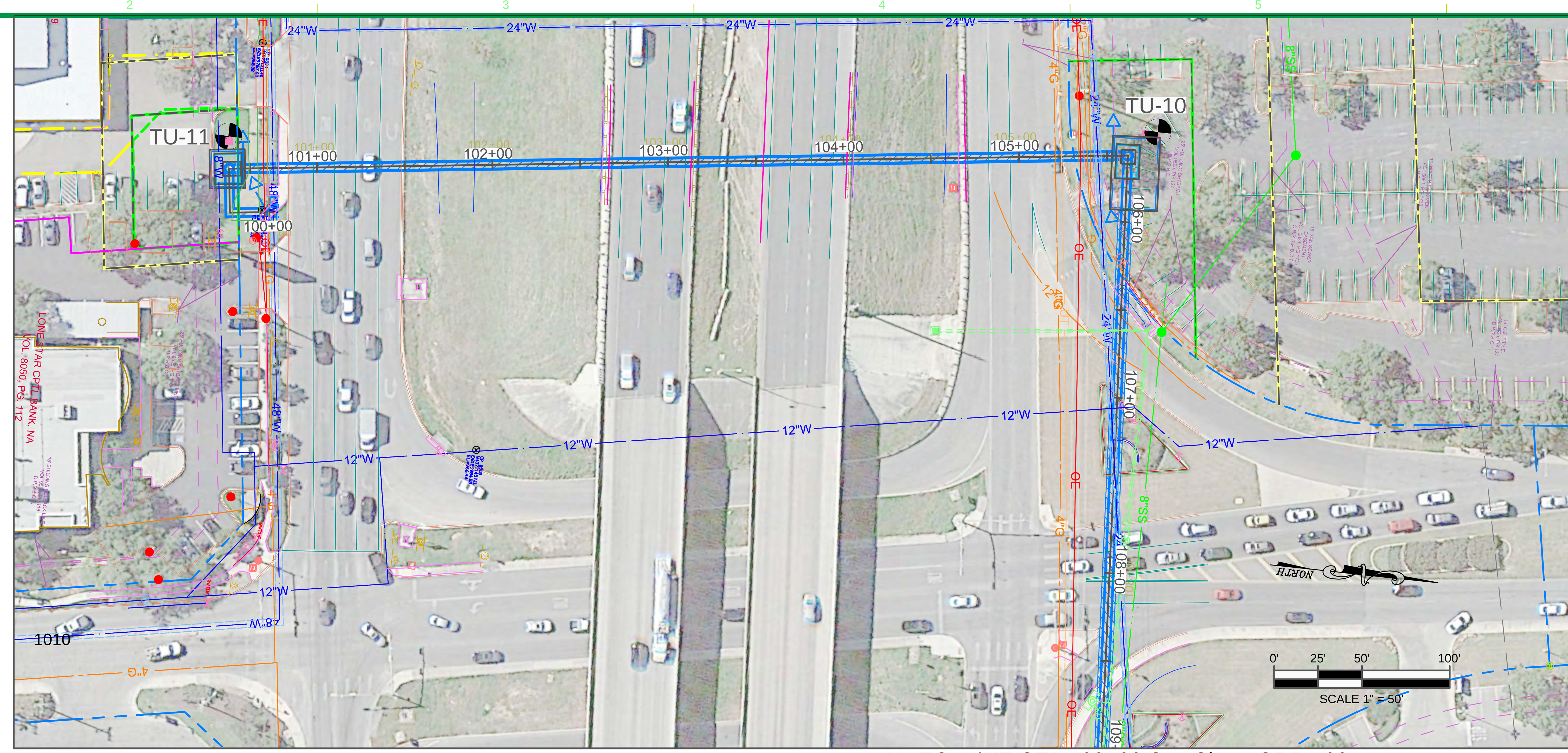
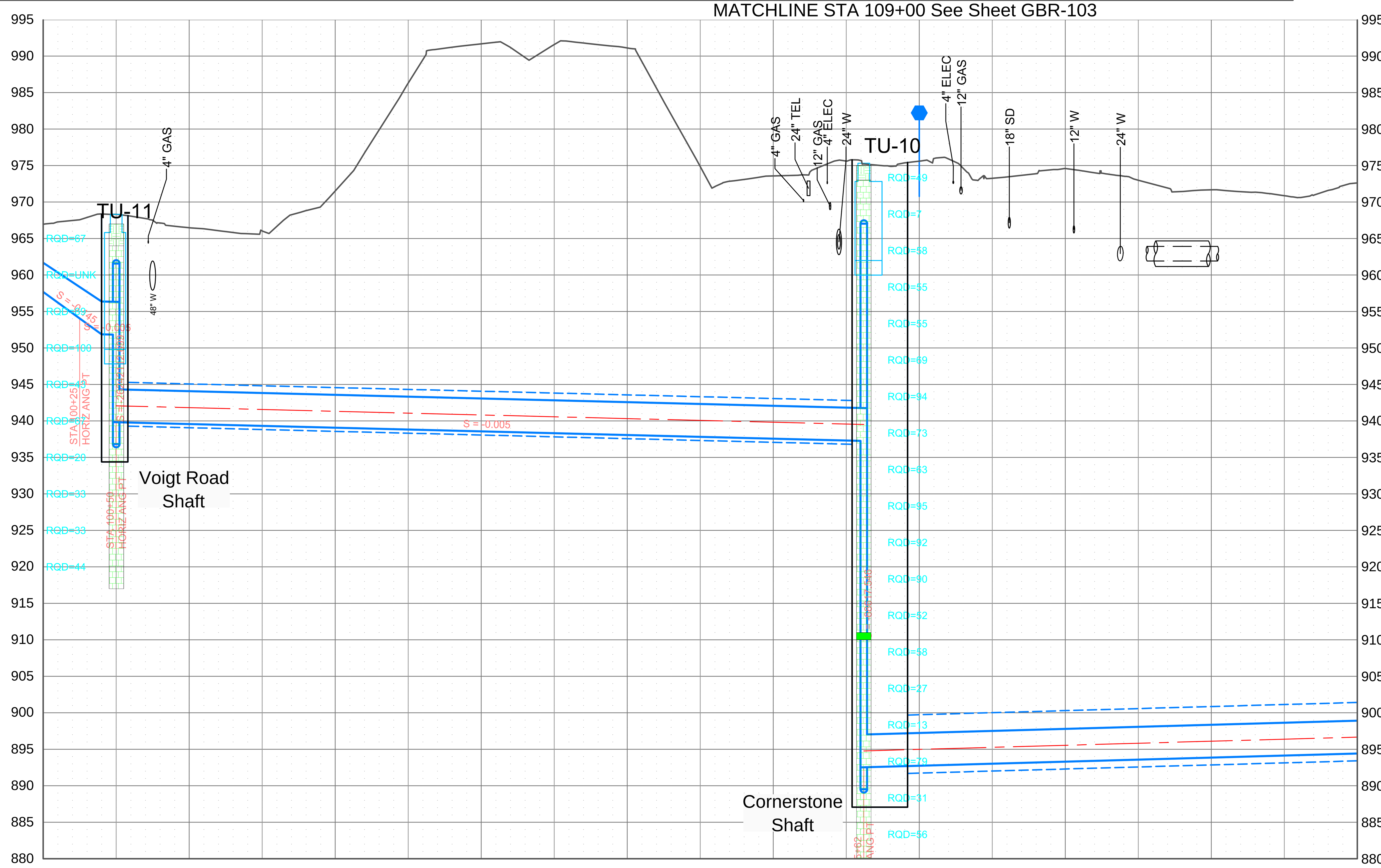
Ph (210) 299-7900 Fax (210) 226-8497

Bar measures 1 inch, otherwise drawing is not to scale



MATCHLINE STA 109+00 See Sheet GBR-103



Legend

Permanent Easement	Sanitary Sewer
Temporary Easement	Storm Drain
Pipeline	OH Power
Water	UGND Power
Gas	Communication

BORING LOG LEGEND:

- USCS HIGH PLASTICITY CLAY
- LIMESTONE
- USCS CLAYEY GRAVEL
- VOID
- FILL MATERIAL
- WEATHERED LIMESTONE
- USCS CLAYEY SAND

FEATURE LOG LEGEND:

- USCS CLAYEY SAND
- LIMESTONE
- USCS LOW PLASTICITY CLAY
- VOID

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SAN ANTONIO WATER SYSTEM
CENTRAL WATER INTEGRATION PIPELINE
PROJECT TRANSMISSION PIPELINE

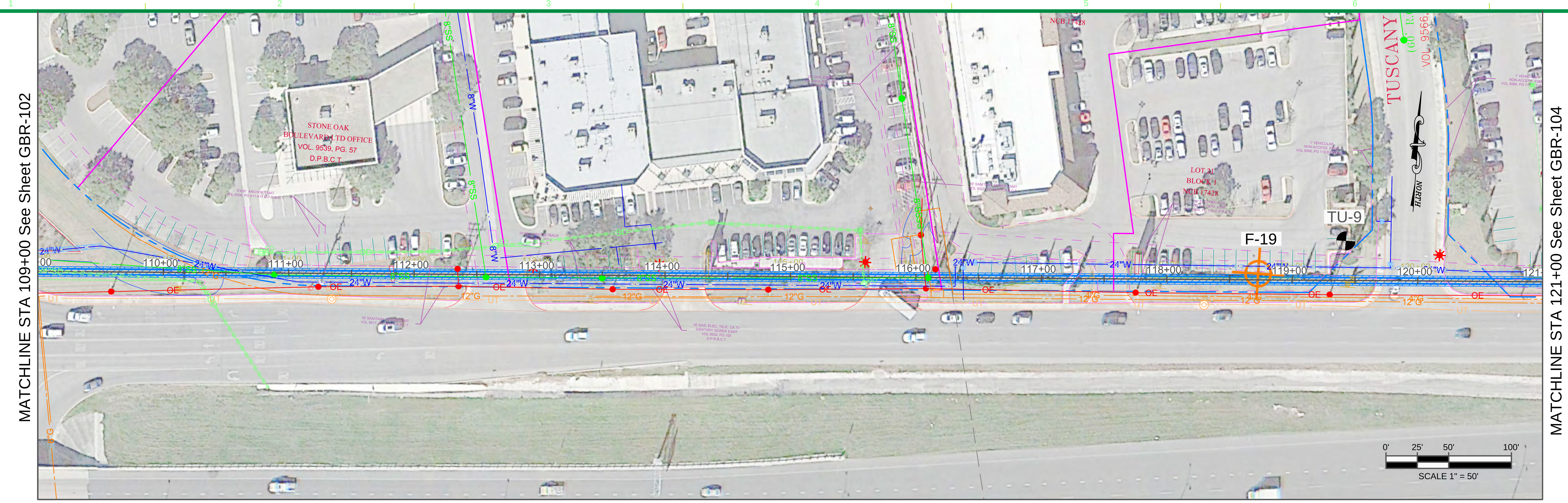
GBR-102

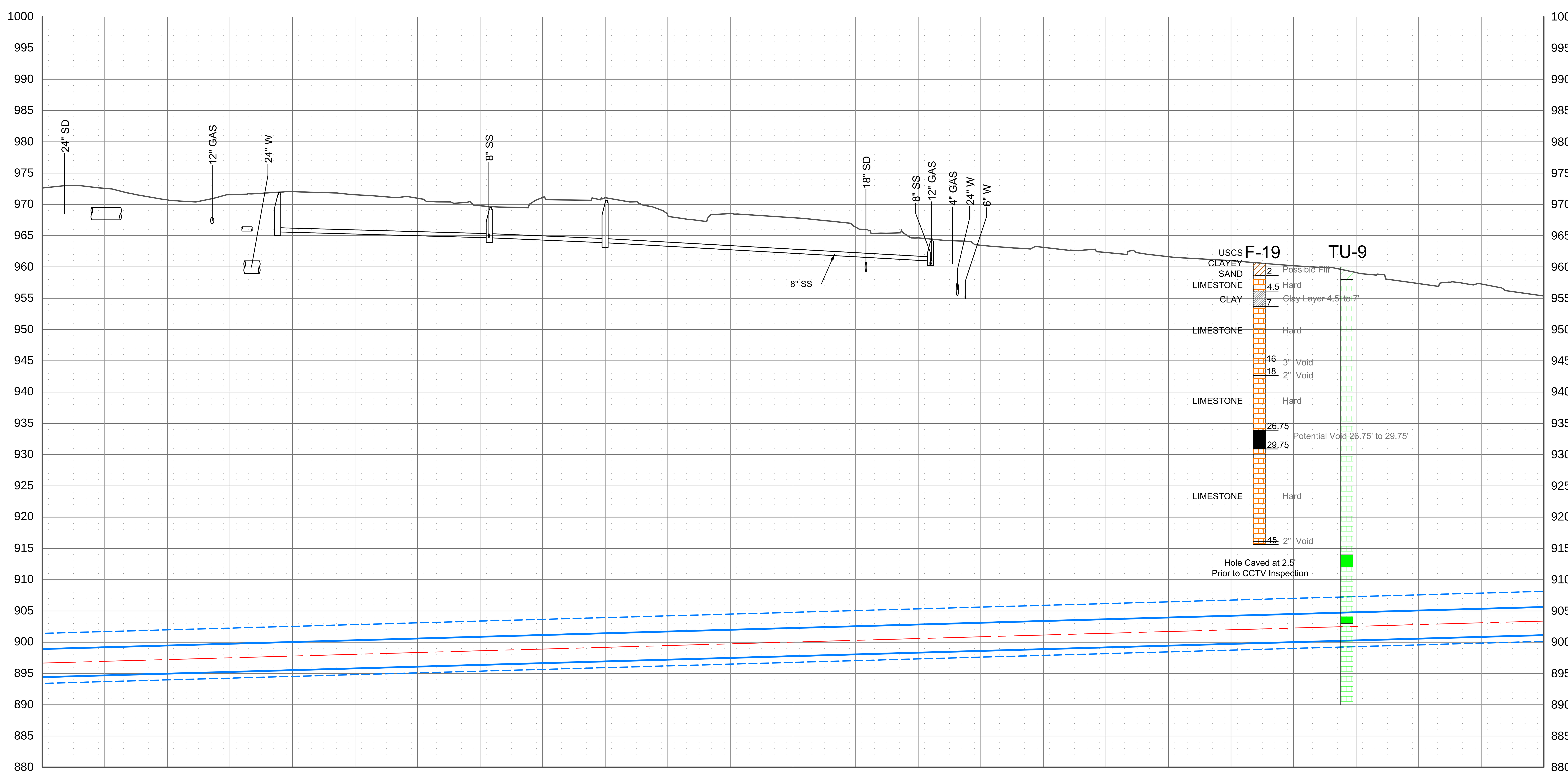
STA 100+00 to 109+00

PROJ: 200-09308-18001
DESN:
DRWN:
CHKD:

HORIZONTAL SCALE 1"=50'
VERTICAL SCALE 1"=10'

Bar measures 1 inch, otherwise drawing is not to scale





Legend

- Permanent Easement
- Temporary Easement
- Pipeline
- Water
- Gas
- Sanitary Sewer
- Storm Drain
- OH Power
- UGND Power
- Communication

BORING LOG LEGEND:

- USCS HIGH PLASTICITY CLAY
- LIMESTONE
- USCS CLAYEY GRAVEL
- VOID
- FILL MATERIAL
- WEATHERED LIMESTONE
- USCS CLAYEY SAND

FEATURE LOG LEGEND:

- USCS CLAYEY SAND
- LIMESTONE
- USCS LOW PLASTICITY CLAY
- VOID

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SAN ANTONIO WATER SYSTEM
CENTRAL WATER INTEGRATION PIPELINE
PROJECT TRANSMISSION PIPELINE

GBR-103

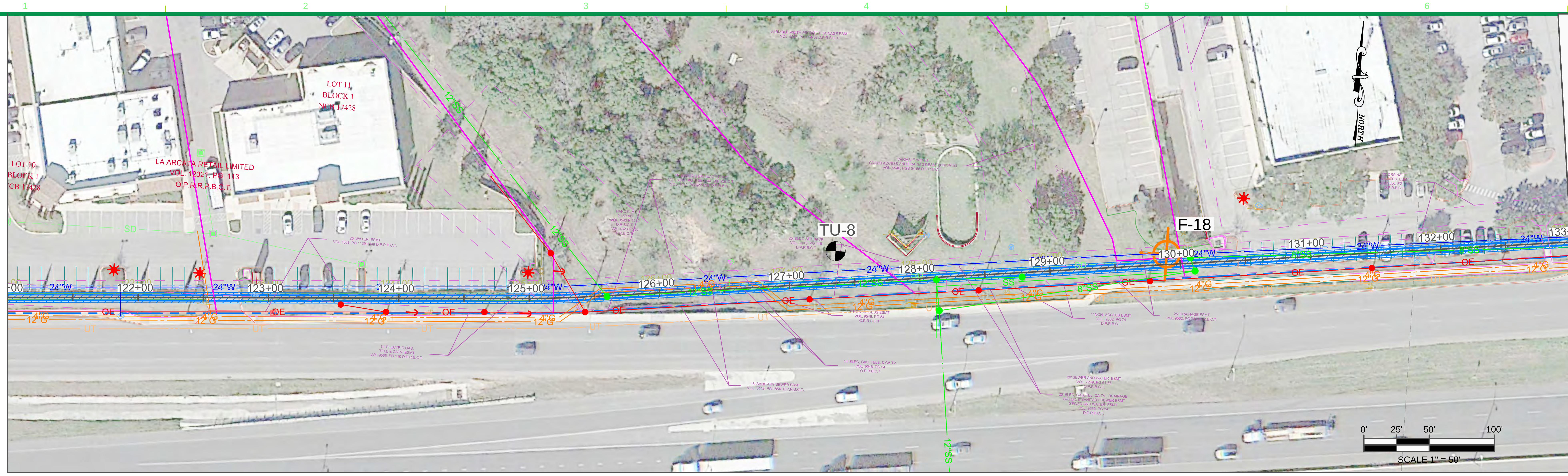
STA 109+00 to 121+00

PROJ: 200-09308-18001
DESN:
DRWN:
CHKD:

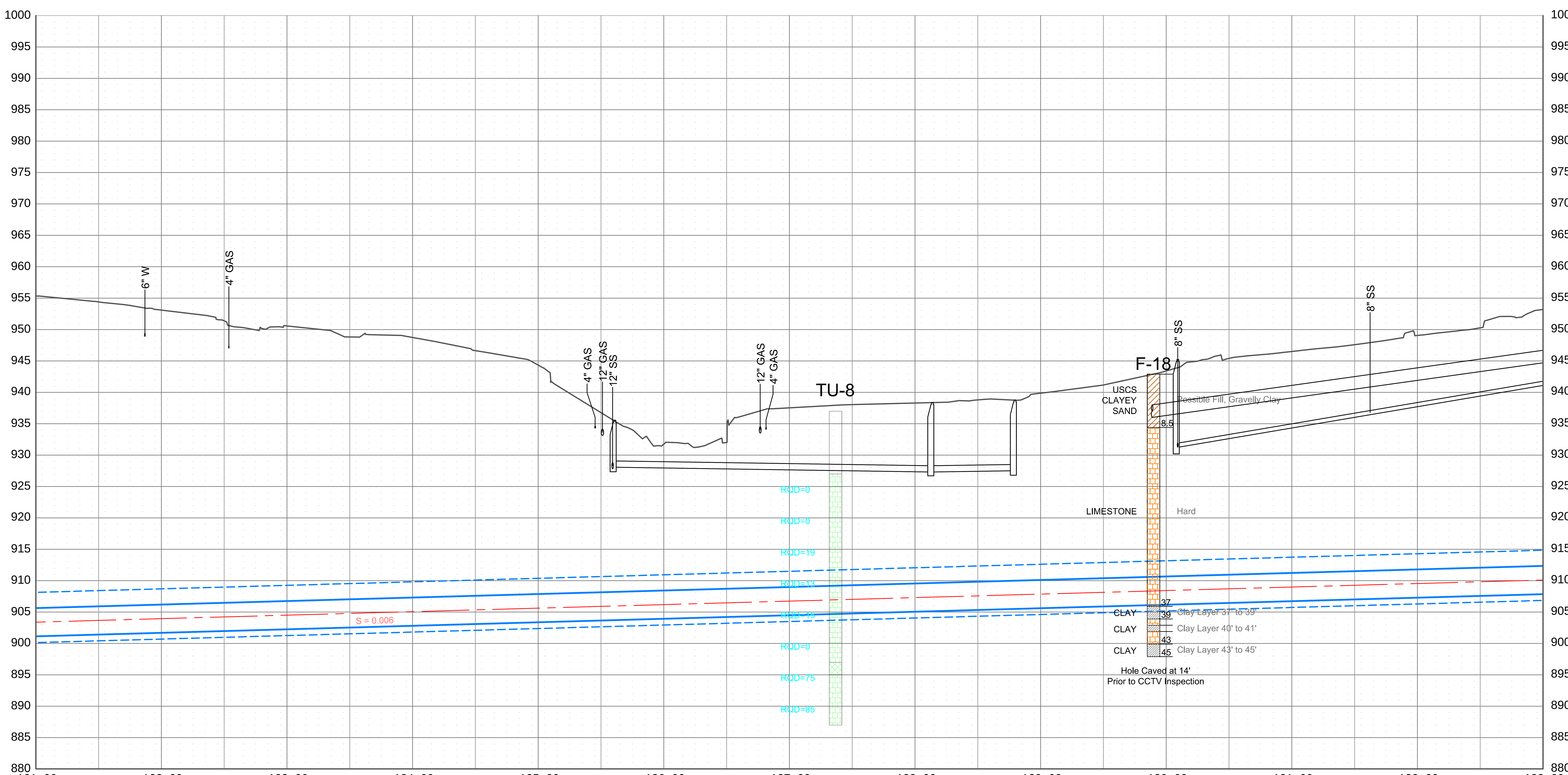
HORIZONTAL SCALE 1"=50'
VERTICAL SCALE 1"=10'

Bar measures 1 inch, otherwise drawing is not to scale

MATCHLINE STA 121+00 See Sheet GBR-103



MATCHLINE STA 133+00 See Sheet GBR-105



Legend

Permanent Easement	Sanitary Sewer
Temporary Easement	Storm Drain
Pipeline	OH Power
Water	UGND Power
Gas	Communication

BORING LOG LEGEND:

- USCS HIGH PLASTICITY CLAY
- LIMESTONE
- USCS CLAYEY GRAVEL
- VOID
- FILL MATERIAL
- WEATHERED LIMESTONE
- USCS CLAYEY SAND

FEATURE LOG LEGEND:

- USCS CLAYEY SAND
- LIMESTONE
- USCS LOW PLASTICITY CLAY
- VOID

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SAN ANTONIO WATER SYSTEM

CENTRAL WATER INTEGRATION PIPELINE PROJECT TRANSMISSION PIPELINE

GBR-104

STA 121+00 to 133+00

PROJ: 200-09308-18001
DESN:
DRWN:
CHKD:

HORIZONTAL SCALE 1"=50'

VERTICAL SCALE 1"=10'

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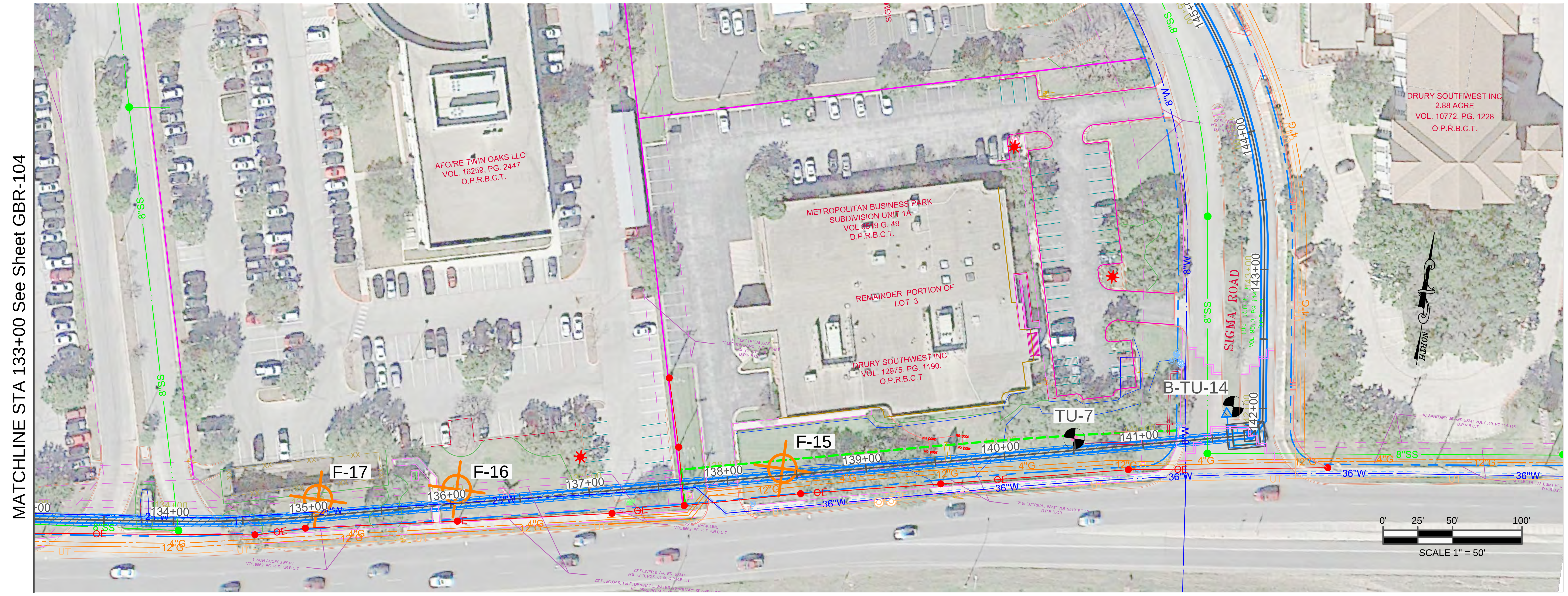
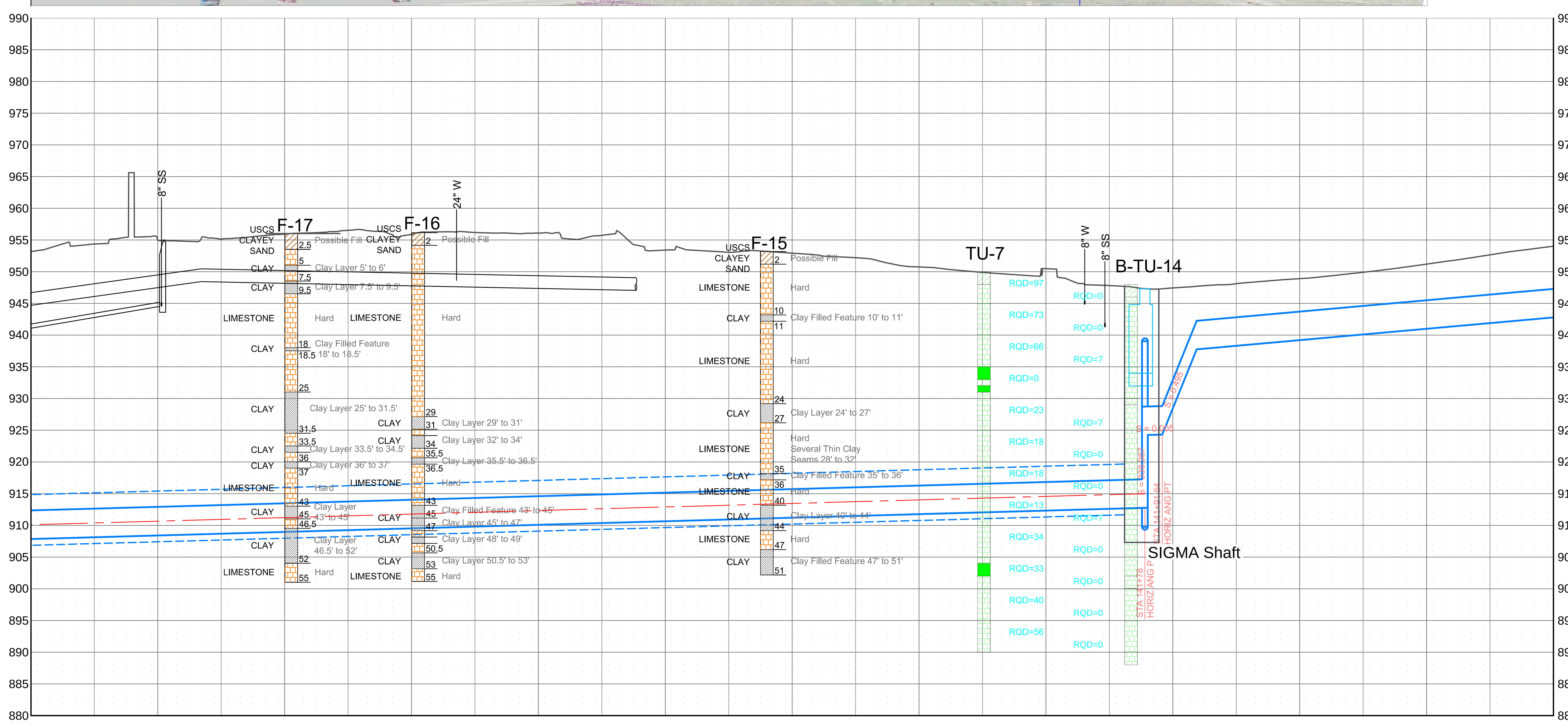
MATCHLINE STA 145+00 See Sheet GBR-106





Legend

Permanent Easement	Sanitary Sewer
Temporary Easement	Storm Drain
Pipeline	OH Power
Water	UGND Power
Gas	Communication

BORING LOG LEGEND:
- USCS HIGH PLASTICITY CLAY
- LIMESTONE
- USCS CLAYEY GRAVEL
- VOID
- FILL MATERIAL
- WEATHERED LIMESTONE
- USCS CLAYEY SAND

FEATURE LOG LEGEND:
- USCS CLAYEY SAND
- LIMESTONE
- USCS LOW PLASTICITY CLAY
- VOID

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SAN ANTONIO WATER SYSTEM
CENTRAL WATER INTEGRATION PIPELINE
PROJECT TRANSMISSION PIPELINE

GBR-105
STA 133+00 to 145+00

PROJ: 200-09308-18001
DESN:
DRWN:
CHKD:

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VERTICAL SCALE 1"=10'

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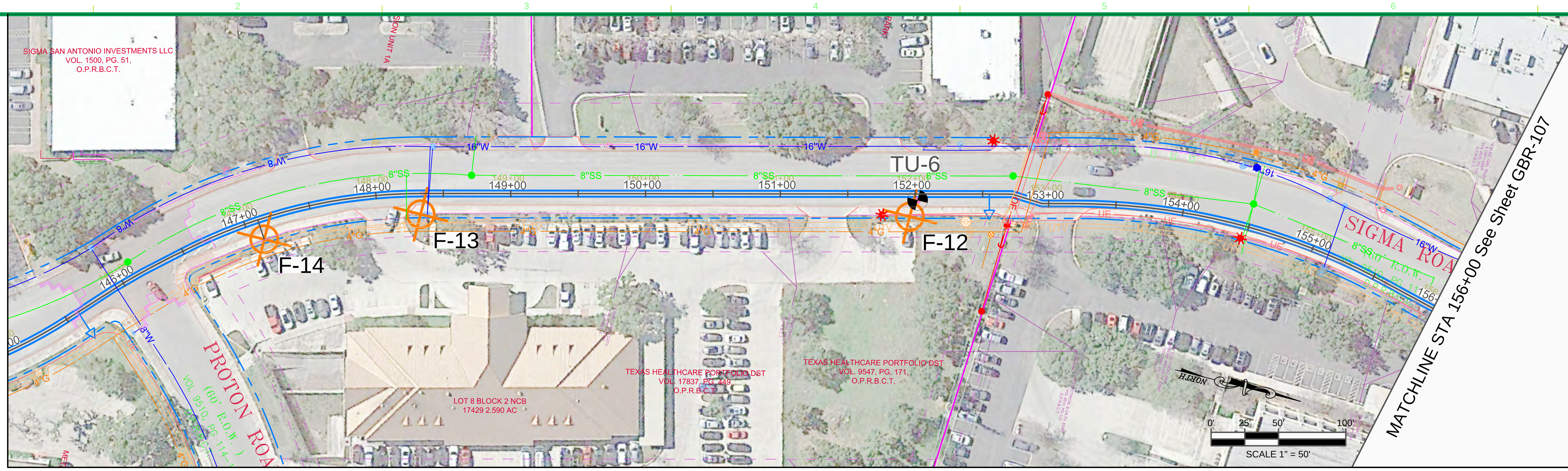

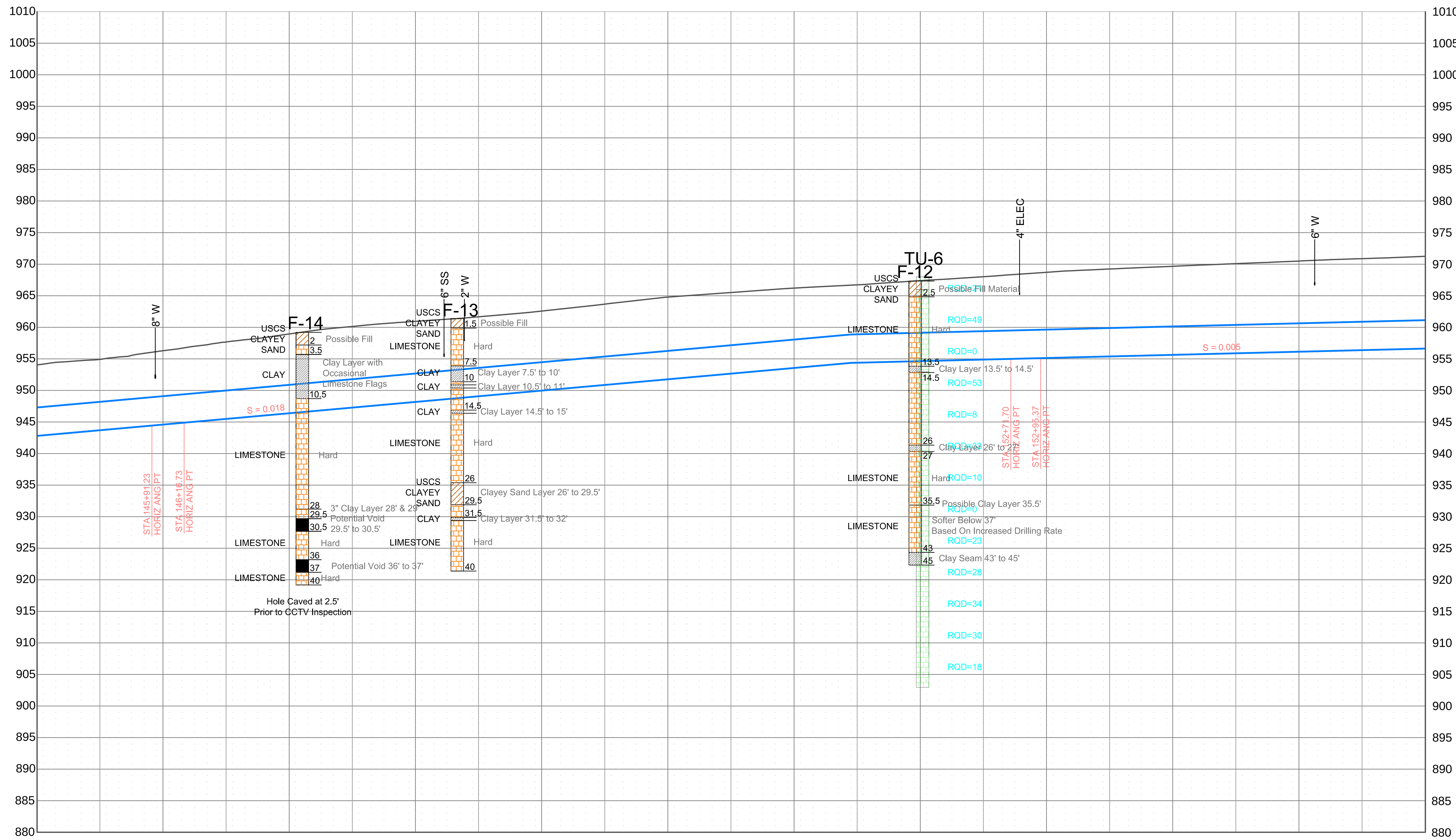

Legend

- Permanent Easement
- Temporary Easement
- Pipeline
- Water
- Gas
- Sanitary Sewer
- Storm Drain
- OH Power
- UGND Power
- Communication

BORING LOG LEGEND:

- USCS HIGH PLASTICITY CLAY
- LIMESTONE
- USCS CLAYEY GRAVEL
- VOID
- FILL MATERIAL
- WEATHERED LIMESTONE
- USCS CLAYEY SAND

FEATURE LOG LEGEND:

- USCS CLAYEY SAND
- LIMESTONE
- USCS LOW PLASTICITY CLAY
- VOID

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SAN ANTONIO WATER SYSTEM
CENTRAL WATER INTEGRATION PIPELINE PROJECT TRANSMISSION PIPELINE

GBR-106
STA 145+00 to 156+00

PROJ: 200-09308-18001
DESN:
DRWN:
CHKD:

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VERTICAL SCALE 1"=10'

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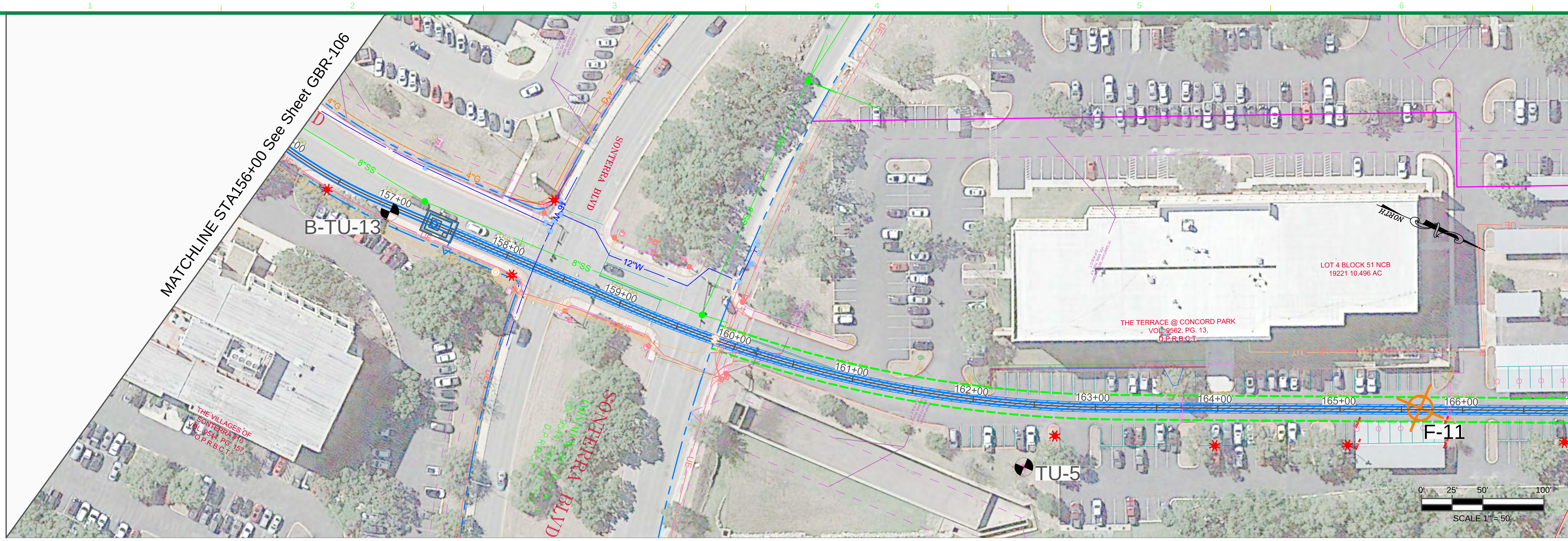

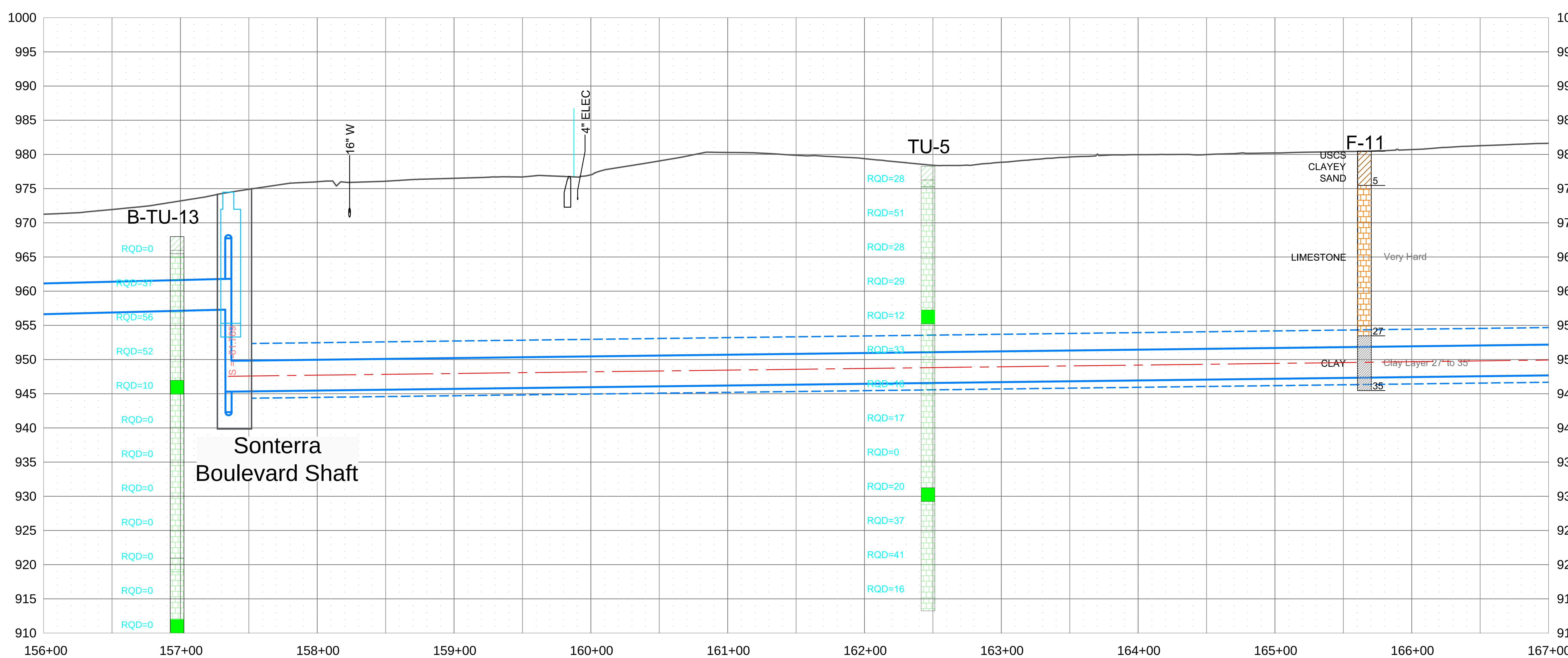

Legend

- Permanent Easement
- Temporary Easement
- Pipeline
- Water
- Gas
- Sanitary Sewer
- Storm Drain
- OH Power
- UGND Power
- Communication

BORING LOG LEGEND:

- USCS HIGH PLASTICITY CLAY
- LIMESTONE
- USCS CLAYEY GRAVEL
- VOID
- FILL MATERIAL
- WEATHERED LIMESTONE
- USCS CLAYEY SAND

FEATURE LOG LEGEND:

- LIMESTONE
- FILL
- SAND
- CLAY
- VOID

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SAN ANTONIO WATER SYSTEM
CENTRAL WATER INTEGRATION PIPELINE
PROJECT TRANSMISSION PIPELINE

GBR-107
STA 156+00 to 167+00

PROJ: 200-09308-18001
DESN:
DRWN:
CHKD:

HORIZONTAL SCALE 1"=50'
VERTICAL SCALE 1"=10'

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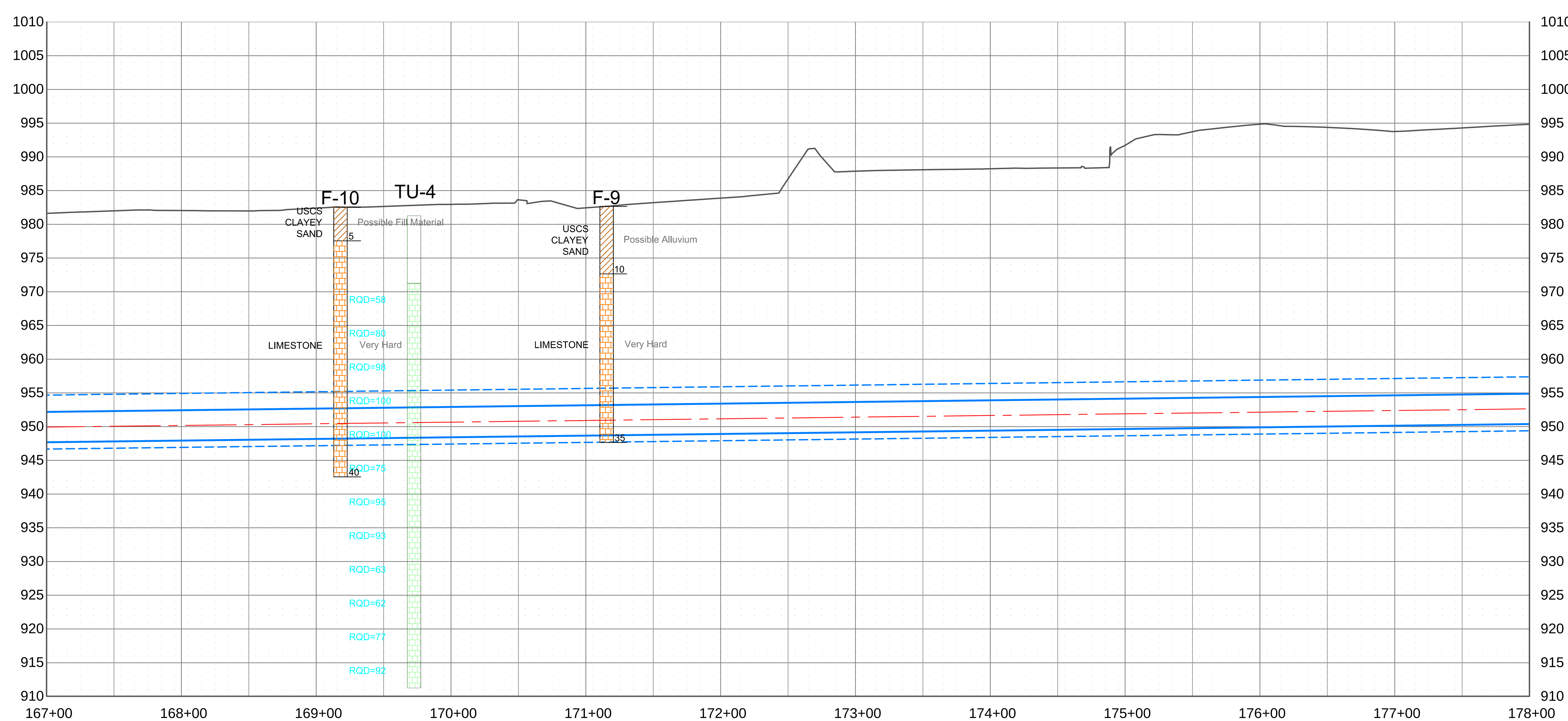

Legend

- Permanent Easement
- Temporary Easement
- Pipeline
- Water
- Gas
- Sanitary Sewer
- Storm Drain
- OH Power
- UGND Power
- Communication

BORING LOG LEGEND:

- USCS HIGH PLASTICITY CLAY
- LIMESTONE
- USCS CLAYEY GRAVEL
- VOID
- FILL MATERIAL
- WEATHERED LIMESTONE
- USCS CLAYEY SAND

FEATURE LOG LEGEND:

- USCS CLAYEY SAND
- LIMESTONE
- USCS LOW PLASTICITY CLAY
- VOID

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Texas Registration No. F-10568

SAN ANTONIO WATER SYSTEM

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SAN ANTONIO WATER SYSTEM
CENTRAL WATER INTEGRATION PIPELINE
PROJECT TRANSMISSION PIPELINE

GBR-108

STA 167+00 to 178+00

PROJ: 200-09308-18001
DESN:
DRWN:
CHKD:

HORIZONTAL SCALE 1"=50'
VERTICAL SCALE 1"=10'

Bar measures 1 inch, otherwise drawing is not to scale

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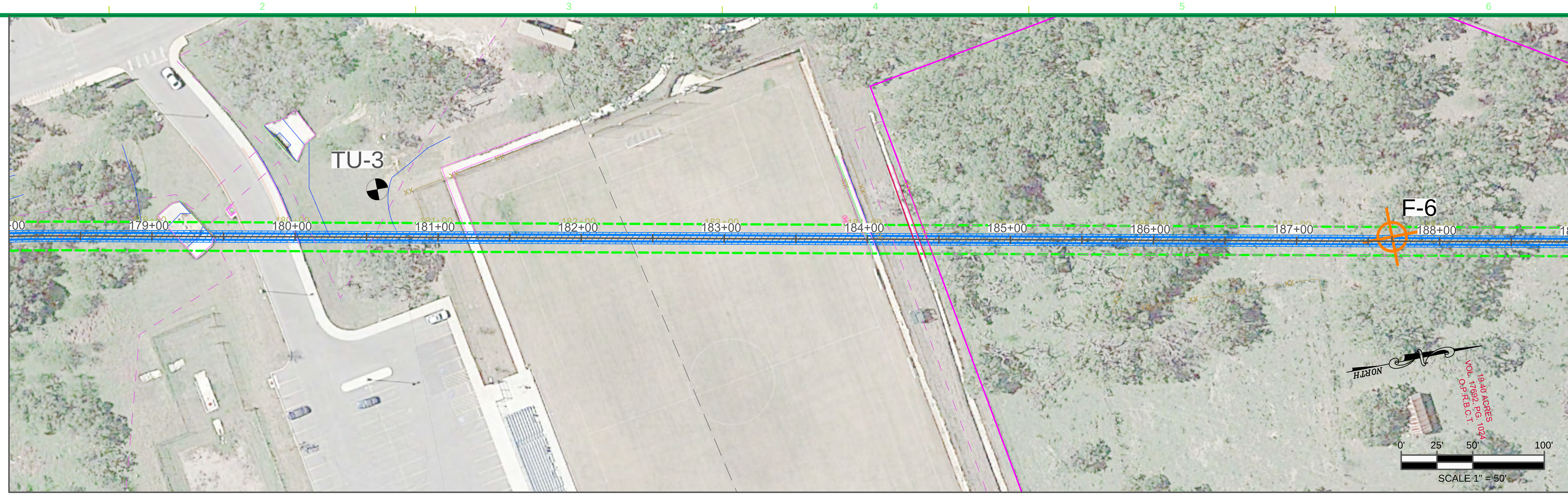
MATCHLINE STA178+00 See Sheet GBR-108



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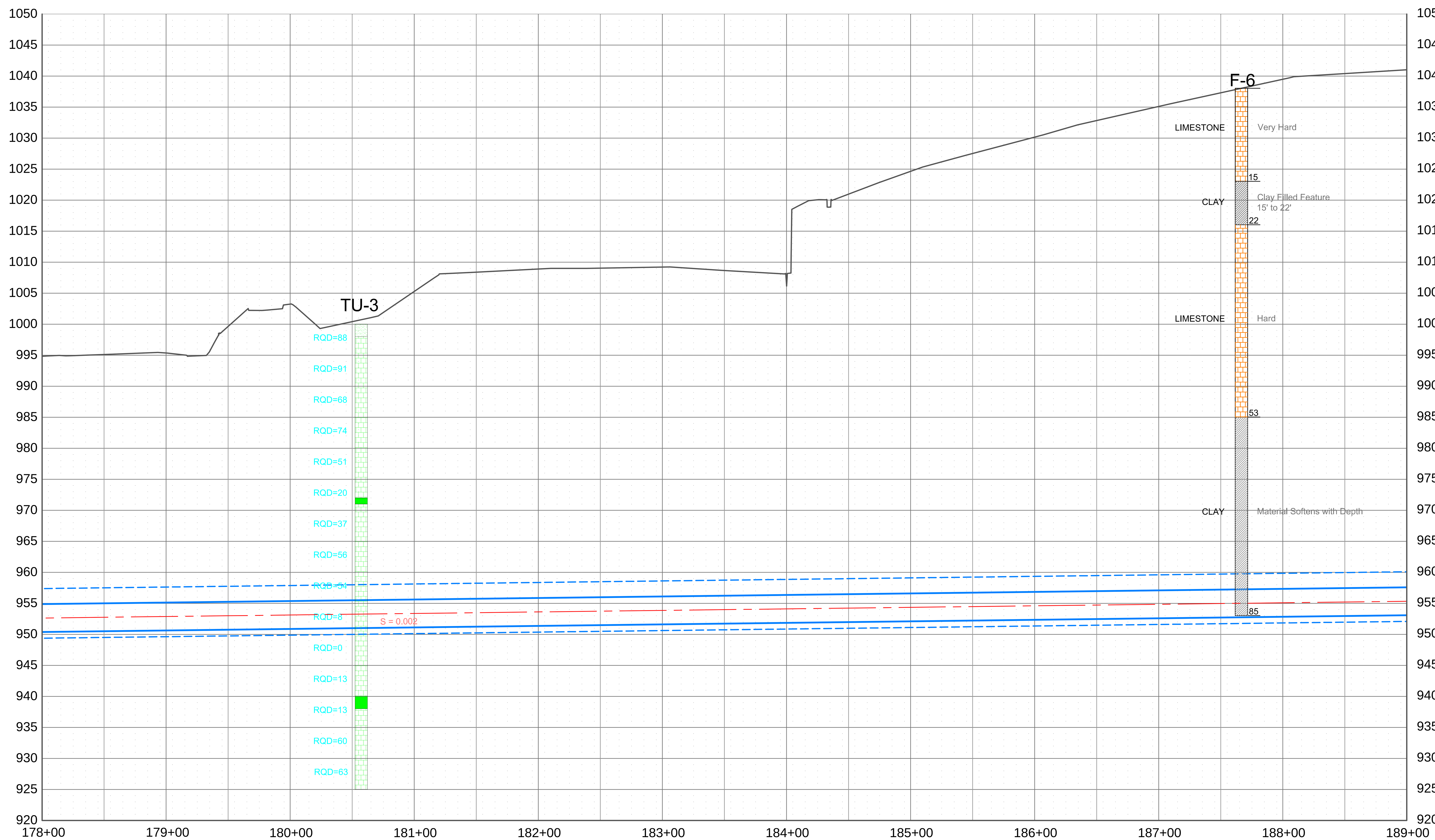

Legend

Permanent Easement
Temporary Easement
Pipeline
Water
Gas
Sanitary Sewer
Storm Drain
OH Power
UGND Power
Communication

BORING LOG LEGEND:

USCS HIGH PLASTICITY CLAY
LIMESTONE
USCS CLAYEY GRAVEL
VOID
FILL MATERIAL
WEATHERED LIMESTONE
USCS CLAYEY SAND

FEATURE LOG LEGEND:

USCS CLAYEY SAND
LIMESTONE
USCS LOW PLASTICITY CLAY
VOID

INCOMPLETE DOCUMENT
ISSUED FOR
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CHRISTOPHER D. BREEDS, P.E.
TEXAS REGISTRATION NO. 97180
April 2018

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SubTerra Inc.®
Texas Registration No. F-10568

SAN ANTONIO WATER SYSTEM

MARK	DATE	DESCRIPTION	BY
	6-06-2018	Based on Files Received 06-06-2018	

SAN ANTONIO WATER SYSTEM
CENTRAL WATER INTEGRATION PIPELINE
PROJECT TRANSMISSION PIPELINE

GBR-109

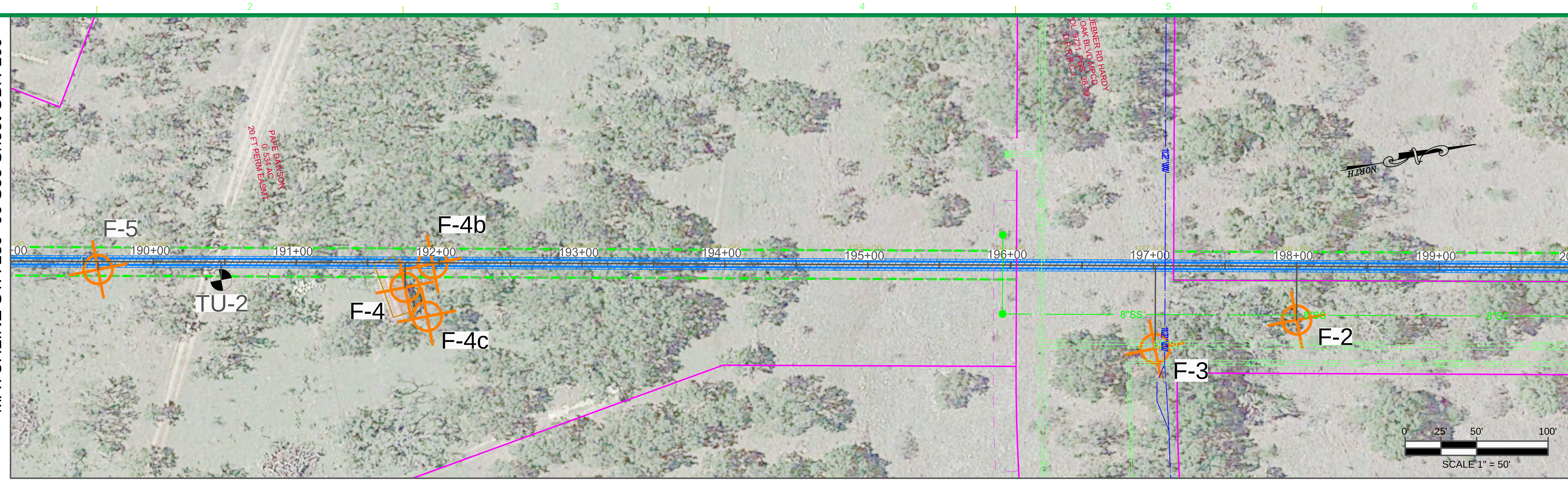
STA 178+00 to 189+00

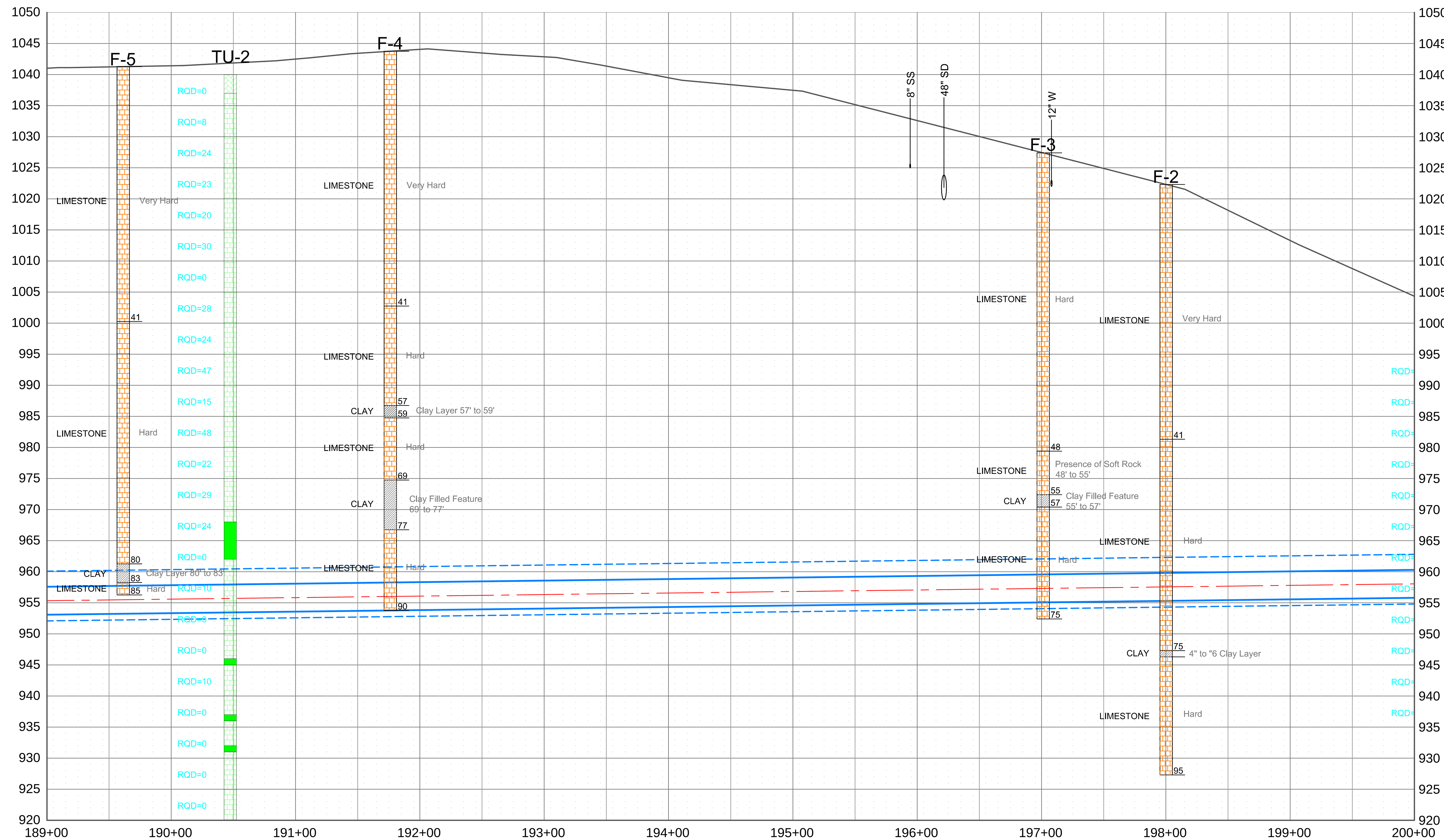
PROJ: 200-09308-18001
DESN:
DRWN:
CHKD:

HORIZONTAL SCALE
1"=50'

VERTICAL SCALE
1"=10'

Bar measures 1 inch, otherwise drawing is not to scale





Legend

Permanent Easement, Temporary Easement, Pipeline, Water, Gas, Sanitary Sewer, Storm Drain, OH Power, UGND Power, Communication

BORING LOG LEGEND:
USCS HIGH PLASTICITY CLAY
LIMESTONE
USCS CLAYEY GRAVEL
VOID
FILL MATERIAL
WEATHERED LIMESTONE
USCS CLAYEY SAND

FEATURE LOG LEGEND:
USCS CLAYEY SAND
LIMESTONE
USCS LOW PLASTICITY CLAY
VOID

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SAN ANTONIO WATER SYSTEM

MARK	DATE	DESCRIPTION	BY
	6-06-2018	Based on Files Received 06-06-2018	

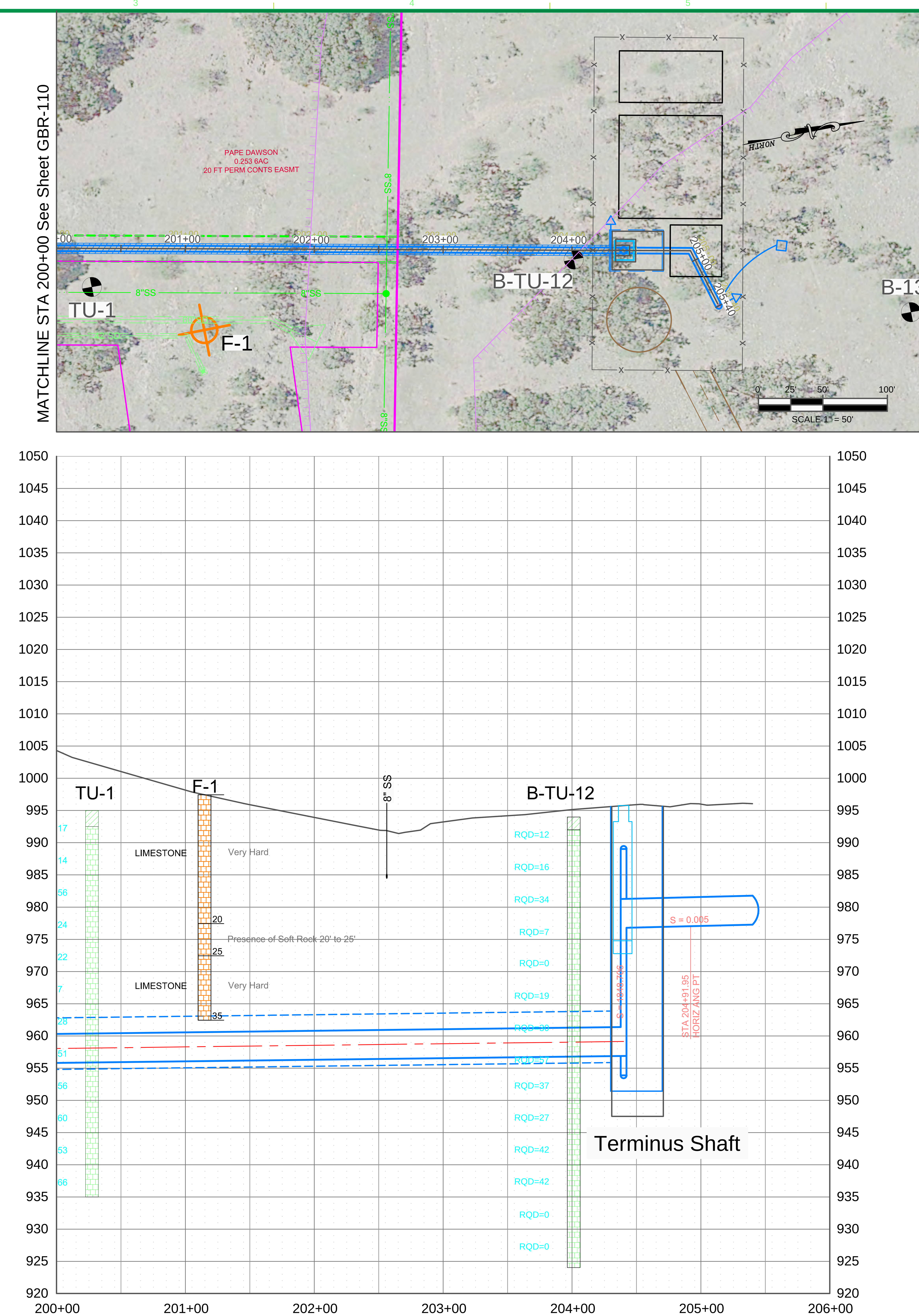
SAN ANTONIO WATER SYSTEM
CENTRAL WATER INTEGRATION PIPELINE PROJECT TRANSMISSION PIPELINE

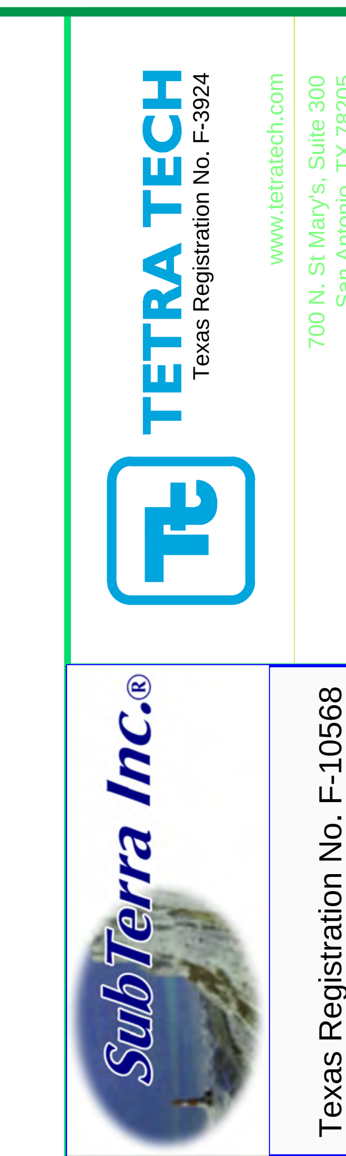
GBR-110
STA 189+00 to 200+00

PROJ: 200-09308-18001
DESN:
DRWN:
CHKD:

HORIZONTAL SCALE 1"=50'
VERTICAL SCALE 1"=10'

Bar measures 1 inch, otherwise drawing is not to scale





Legend

Permanent Easement; Temporary Easement; Pipeline; Water; Gas; Sanitary Sewer; Storm Drain; OH Power; UGND Power; Communication

BORING LOG LEGEND:

USCS HIGH PLASTICITY CLAY; LIMESTONE; USCS CLAYEY GRAVEL; VOID; FILL MATERIAL; WEATHERED LIMESTONE; USCS CLAYEY SAND

FEATURE LOG LEGEND:

USCS CLAYEY SAND; LIMESTONE; USCS LOW PLASTICITY CLAY; VOID

MARK	DATE	DESCRIPTION	BY
	6-06-2018	Based on Files Received 06-06-2018	

SAN ANTONIO WATER SYSTEM

CENTRAL WATER INTEGRATION PIPELINE PROJECT TRANSMISSION PIPELINE

GBR-111

200+00 to Terminus Site

PROJ: 200-09308-18001
DESN:
DRWN:
CHKD:

HORIZONTAL SCALE 1"=50'

VERTICAL SCALE 1"=10'

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