



Classen Steubing New Bore Alignment Project - RFCSP
Solicitation Number: CO-00552
Job No.: 21-4401

ADDENDUM 3
June 1, 2023

To Respondent of Record:

This addendum, applicable to project referenced above, is an amendment to the proposal, plans and specifications and as such will be a part of and included in the Contract Documents. Acknowledge receipt of this addendum by entering the addendum number and issue date on the space provided in submitted copies of the Respondent Questionnaire.

CHANGES TO SPECIFICATIONS

1. Remove Special Specification Section 01510: Karst Feature Management in its entirety and replace with the revised version provided in this addendum.
 - Under Section 3.01 E.5:
 - Revised language regarding calendar day allowance for construction delays associated with feature investigations
 - Under Section 3.02:
 - Added subsection 3.02 G: Special Instructions for Features Hit During Construction
 - Added subsection 3.02 H: Suitable Surveying Conditions

END OF ADDENDUM

This Addendum, including this 1 page, is thirteen (13) pages with attachments in its entirety.

Attachments:

Section 01510: Karst Feature Management (12 pages)



SECTION 01510

KARST FEATURE MANAGEMENT

PART 1 GENERAL

1.01 SUMMARY

- A. This item governs notification requirements, as well as the furnishing and installing of remediation measures, specified by the Engineer, for voids and karst features or caves discovered in bedrock during excavation activities on the Project. This item does not apply to excavations that occur below the water table or in unconsolidated earth material. It is intended to address features observed upon initial excavation or discrete discharge points that are discovered when trench backfill material is removed and/or shafts or tunnels are excavated.
- B. This section includes the work to clean-out (if required), fill, and seal geologic features (karst solution features) discovered during construction of the Project.
- C. The Contractor will be required to furnish all supplementary items necessary for their remediation/feature closure in accordance with approved Texas Commission on Environmental Quality (TCEQ) requirements.
- D. References
 - 1. Texas Commission on Environmental Quality (TCEQ) Water Pollution Abatement Plan (WPAP) and Sewage Collection System (SCS) regulations.
 - 2. Requirements of TCEQ WPAP and SCS project permits.
- E. Related Sections:
 - 1. Section 01300 Submittals
 - 2. Section 02240 Dewatering
 - 3. Section 02300 Tunnel Excavation and Primary Lining
 - 4. Section 02305 Health and Safety
 - 5. Section 02360 Tunnel Access Shafts
 - 6. Section 02420 Installation of Carrier Pipe in Tunnels
 - 7. Section 02430 Tunnel Grout
 - 8. Section 03330 Low Density Cellular Concrete (LDCC)

1.02 SUBMITTALS

- A. Void Remediation Plan (Tunnel Construction)
 - 1. Contractor shall submit a Void Remediation Plan, within 60 days of receiving NTP, that implements the remediation requirements contained in this specification. No excavation (shaft or tunnel) shall begin until the Contractor's Void Remediation Plan has been reviewed by the Engineer.

2. If a feature is encountered during construction of the shafts or tunnels, that requires remediation, the CONTRACTOR shall submit a work plan containing means, methods, and estimated materials quantities for inclusion with the Engineers Site Plan Correction. This submittal shall be coordinated with the Engineer and shall be provided within 24-hrs of the Engineers request. Work on remediating the feature shall not begin until the Engineer has completed a review of the Work Plan.
 3. A Void Remediation Plan submittal is not required for Open Cut Construction. Nevertheless, the Contractor shall comply with all other provisions of the Specification 01510 and the instructions of the Engineer.
- B. Excavation Safety System Plan or Trench Safety Plan. A separate safety plan is not required if the Safety Plan already submitted by the Contractor covers all the work anticipated for feature remediation.
- C. Material submittal requirements of this specification include:
1. Mine Foam: Mine Foam, Marifoam, or equivalent, subject to the approval of the Engineer.
 2. 3 x 5 hard rock: Source, type and gradation of rock.
 3. Sand/Cement/Bentonite grout: Mix design for Sand/Cement/Bentonite grout in accordance with Specification 02430 Tunnel and Shaft Grout.
 4. Low Slump Concrete: The mix design for Class C (see Specification 03300, Table 2 Concrete Classes) Concrete (3500 psi) shall have a maximum 3-inch slump. 2500 psi concrete mixtures allowed or required by the Texas Commission on Environmental Quality (TCEQ) will be accepted as an alternate on a case-by-case basis.
 5. Filter Fabric: Submittals as required by Specification 02200 Earthwork.

PART 2 PRODUCTS

2.01 MATERIALS

- A. General Requirements: Where the use of the following materials is required, such material shall conform to the requirements in the following paragraphs.
- B. 3 x 5 hard rock: Rocks shall be sound with a minimum of 3 inches in smallest dimension and 5 inches (125 mm) in largest dimension shall be used.
- C. Mine Foam: Mine Foam, Marifoam, or equivalent, subject to the approval of the Engineer.
- D. Sand/Cement/Bentonite grout shall meet the requirements of Specification 02430 Tunnel and Shaft Grout.
- E. Filter Fabric: This material shall meet the requirements for filter fabric as specified in Specification 02200 Earthwork.
- F. Low Slump Concrete: This concrete shall meet the requirements for Class C Concrete as specified in Specification 03300 Table 2. The concrete shall have a maximum 3-inch (75 mm) slump. 2500 psi concrete mixtures allowed or required by the TCEQ that meet Class D, Table 5 of the same specification will be accepted as an alternate on a case-by-case basis.
- G. Polypropylene Bags filled with pea gravel. Silt fence or erosion control log.

- H. Gravel Backfill: Gravel backfill shall meet requirements of Specification 02200 Earthwork for pipe bedding.

PART 3 EXECUTION

3.01 CONDITIONS

- A. The Engineer shall select and appoint a Geologist experienced in the observation and inspection of voids, caves, or karst features in the local area.
- B. All contractors conducting regulated activities, including site work and utilities, must keep copies of the submittal and approval letter of the applicable SCS and/or WPAP onsite.
- C. The Contractor shall observe all trench walls for this project located within the Edwards Aquifer Recharge Zone, accessible tunnel shafts, wet wells or tunnel excavations. Inspections must occur at least once daily during pre-trenching and excavation operations and prior to backfilling the trench or installing pipe in the tunnels.
- D. It is up to the Contractor to determine means and methods related to trench excavation. If the Contractor utilizes pre-trenching and a feature is discovered that results in a delay, the Contractor may be entitled to downtime associated with observation of voids. If the Contractor elects not to pre-trench the project and a feature is discovered while installing the pipe that results in a delay the Contractor is not entitled to claim downtime associated with observation of voids.
- E. If any caverns or features greater than four (4) feet in every direction are discovered during pre-trenching, excavation, tunneling, or other sitework activities, then all regulated activities near the feature (within 50 feet either direction of the feature) must be suspended immediately. Otherwise, Contractor may proceed with work to the proposed final depth at which point all regulated activities near the feature (within 50 feet either direction of the feature) will then be suspended immediately. The distance/area around the feature where construction must cease may be modified by the Engineer or the Engineer's Geologist after review of the site conditions.
 - 1. The Contractor must notify SAWS and Engineer immediately of the discovery of the feature including the location.
 - 2. Temporary BMPs shall be installed immediately to prevent sediment from entering the feature and must remain functional until the feature is remediated. Material that fell into the feature due to excavation or faulty BMPs, which prevents observation of and/or access to the feature must be removed by the Contractor prior to evaluation of the feature by the Engineer's Geologist and TCEQ personnel.
 - 3. The Engineer or Engineer's Geologist will visit the site and assess the feature in accordance with the Edwards Aquifer Guidance Manual RG-348, Table 5-1 and other criteria noted in this Specification. Upon visual inspection of the feature, excavation may continue under the professional judgment of the Engineer or Engineer's Geologist/Biologist. If remediation is required, the Engineer will notify the appropriate regional office of the Texas Commission on Environmental Quality (TCEQ) in writing within two (2) working days of the feature discovery. Engineer or Engineer's Geologist/Biologist will coordinate the visit with the Contractor. Any delays due to the Contractor not having the feature accessible upon Engineer's Geologist/Biologist's arrival will not be counted towards a downtime claim.

4. If determined by the Engineer's Geologist that the feature requires remediation under TCEQ guidance, the regulated activities within 50 feet may not proceed until the TCEQ Executive Director has reviewed and approved the methods proposed for disposition of the feature and protection of the Edwards Aquifer from any potentially adverse impacts to water quality while maintaining the structural integrity of the line where the utility line or other facility is involved.
 5. The construction schedule developed for this project included an allowance of 20 calendar days for possible construction delays associated with feature investigations under this specification. Time associated with feature remediation will only be charged against this allowance when the remediation time directly impacts the critical path of the construction schedule. Where features requiring remediation in the trench or tunnel are greater than four (4) feet in any direction, additional time will be added to the construction time period, if the 20 days allocated are exceeded, based on the size and complexity of the design required to remediate the feature.
- F. Each feature discovered during shaft installation or tunneling activity shall be remediated using a Work Plan prepared by the Contractor and reviewed by the Engineer and in accordance with Section 5 of the Edwards Aquifer Guidance Manual RG-348 and this Specification. Each feature discovered during trenching and/or open cut activities will be remediated using a Work Plan prepared by the Engineer.

3.02 PROCEDURES TO BE FOLLOWED UPON FEATURE DISCOVERY

- A. STOP ALL WORK IMMEDIATELY according to the conditions in 3.01 (E). Subsurface features encountered during construction will be evaluated by karst geologists. Owner's compliance inspector and Engineer shall be notified immediately in the event contractors, subcontractors, or others on the site encounter any subsurface features. Construction within 50 feet of, and up slope of, or alongside of, the feature opening shall cease immediately according to the conditions in 3.01 (E). Contractor shall immediately take measures to limit access to the feature to essential Contractor, SAWS, Engineer, Geologist, and TCEQ personnel. Contractor will not allow any other access to the feature without the authorization of SAWS or Engineer.
- B. Temporary BMPs will be installed to prevent sediment from entering the feature and must remain functional until the feature is remediated. Material that fell into the feature due to excavation or faulty BMPs, which prevents observation of the , feature must be removed prior to evaluation of the Engineer's Geologist and TCEQ personnel.
- C. For features discovered while trenching the features will be evaluated by the Engineer's Geologist to evaluate the possibility that the feature may contain endangered species habitat. If the features are too small to enter, the full extent of the features are visible, no apparent surface connections exists, and no air flow is observed, then the treatment method for abating the feature will be conducted by the engineering consultant in accordance with Texas Commission on Environmental Quality (TCEQ) rules and Edwards Aquifer Guidance Manual RG-348. The TCEQ and SAWS will be notified of the features, sketches, photographs, and descriptions of the features will be submitted to the TCEQ along with proposed treatment methods; upon written approval by the TCEQ, the feature treatment methods will be implemented. If the Engineer's Geologist determines that a feature may potentially contain endangered karst invertebrate habitat, the Engineer's Biologist will be notified. The Engineer's Biologist will initially determine if conditions in the feature might be favorable for occurrence of endangered species of concern. If it is the consensus of the Engineer's team that potentially favorable conditions are present, then a

biological collection survey will be conducted as soon as possible followed by a second biological collection survey not later than seven (7) days following the first to evaluate the presence or absence of endangered and species of concern.

- D. For tunnel activities, if no listed species of concern are determined to be present in an encountered feature, the Engineer will request, the Contractor to provide the Engineer for review a Void Remediation Work Plan that contains specific means and methods for remediating the feature along the construction zone in accordance with standard TCEQ accepted practices, as applicable for any particular feature. For trenching and open cut activities, if no listed species of concern are determined to be present in an encountered feature, the Engineer will issue to the Contractor a Void Remediation Work Plan that contains specific means and methods for remediating the feature along the construction zone in accordance with standard TCEQ accepted practices, as applicable for any particular feature. Construction activity may then resume upon completion of the provisions provided as part of the Void Remediation Work Plan.
- E. If listed species or species of concern are determined to be present within an encountered feature, closure and impact minimization instructions will be issued by the consensus of the environmental consultants to contractor(s) with follow-up notification to the US Fish and Wildlife Service. Upon completion or implementation of the minimization procedures, the work of the contractor will resume as normal.
- F. The Contractor shall construct the remediation measure(s) in accordance with the reviewed Void Remediation Work Plan. Anticipated measures shall be documented within the Contract Documents and pay items. The Contractor and Construction Inspector shall record material quantities of all completed remediation measures in accordance with the pay items in the Construction Inspector's daily progress report for each day that a specific remediation event is undertaken.
- G. Special instructions for features hit during construction: Contractor shall contact Owner and Engineer if feature is hit during construction. Engineer's environmental team is responsible for the following tasks. If the feature is humanly enterable, then conduct presence/absence surveys. If surveying an inaccessible feature encountered during construction, baiting must be conducted for a minimum of 14 days beginning when the baits are set and ending when the baits are removed. Baits must be checked at least six times during this period with no more than three days between visits (see below for methods). Data loggers must be installed during the entire two-week baiting period.
- H. Suitable surveying conditions: The entire cave should be searched when conditions in the cave are appropriate for finding the endangered karst invertebrates, generally avoiding temperature extremes and low humidity.

Surveys may be conducted any time of year as long as the weather conditions below are met (see suitable weather conditions). Ideally at least one survey should be conducted in the fall and one in the spring to observe species that may be more active or visible in one season or the other. For example, *Rhadine* beetles appear to be more abundant in the spring, indicating that fall surveys may not be as useful for these species (James Reddell, Texas Memorial Museum, pers. Comm. 2002). Also, a study by Weckerly (2010) assessed surveys conducted by the Balcones Canyonlands Preserve staff and found that *Texella* species were not detected in the fall and winter (however, there was not a statistically significant trend in seasonality of detection).

Suitable weather conditions include:

- Average weather (temperature and rainfall) for time of year (found at www.noaa.gov).
- Absence of recent, extensive, local flooding.

Surveying diligence and thoroughness: Since karst invertebrates are small, have low population sizes, and may have behaviors that make them difficult to find, such as retreating under rocks or into mesocavernous passages too small for humans, it is necessary to ensure that sufficient time and effort have been spent surveying. Before any endangered species are considered absent the following should be done:

- Search the void/cave thoroughly.
- Search times should be proportional to the size of the void/cave.
- Use a system of transects to ensure the entire cave is thoroughly searched.
- Search under all loose and easily movable rocks. Rocks should be moved with care to ensure species are not injured and should be returned to their original position immediately after examination.
- Search under clumps of dried, cracked sediment, which should also be moved with care and returned to their original position after examination.
- Search in crevices, on ceilings, and walls.
- Hand-sift samples of loose sediment and look on, and in, scat and dead animals.
- Search all habitat types, not only those that are believed to be the preferred habitat of the endangered karst invertebrates. Since habitat profiles are incomplete, this will provide information on habitat selection by these species.
- Record species abundance for listed and non-listed species and the microhabitat that they were found on/in.

3.03 REMEDIATION

- A. For voids/features discovered during construction activities related to tunnels, and/or shafts, the Contractor shall construct feature remediation in accordance with the Void Remediation Work Plan reviewed by the Engineer, and approved by the TCEQ
- B. For voids/features discovered during trenching activities, the Engineer shall provide the Contractor with a Void Remediation Plan, upon approval by the TCEQ.
- C. In all cases construction shall be conducted in such a manner as to provide the best protection of the Edwards Aquifer.
- D. Contractor shall not make changes to the remediation measures without first getting Engineer's written approval.
- E. Contractor must notify Engineer 24 hours in advance of beginning the sealing of any geologic feature.
- F. Contractor must provide Engineer or designated construction observer with opportunity to observe Contractor's implementation of approved remediation method prior to backfilling the trench or installing the pipe in a tunnel.
- G. Geologic features which are found during construction and approved for sealing by the

TCEQ must be shown and recorded on as-built drawings.

- H. Contractor must maintain access to the feature until such time as the Engineer, Geologist/Biologist, and the TCEQ Representative have had an opportunity to observe the feature(s).
- I. Contractor will be notified by the Engineer and/or Geologist when they will observe the feature.
- J. Contractor must provide safe access for the Engineer, Geologist/Biologist, and/or the TCEQ personnel to the feature.
- K. Trench excavation protection or Primary Ground Support, in the case of a Tunnel, must be provided at all times in accordance with the approved Trench Excavation Safety Plan or Tunneling Plan submitted by the contractor.

3.05 FEATURE REMEDIATION MEASURES

A. GENERAL

- 1. The Engineer or designated representative shall review the Contractor's Void Remediation Work Plan for compliance with the Edwards Aquifer Guidance Manual RG-348, provisions of this Specification and applicable provisions of the Construction Documents and Contractor submittals when developing remediation measure(s).

B. REMEDIATION MEASURES

- 1. Table 5-1 from the Edwards Aquifer Guidance Manual RG-348 provides the direction for evaluating and developing remediation measures for Sewer and Storm Drain Trenches.
- 2. The minimum protective standards in Table 5-1 shall also apply to underground construction in shafts and tunnels while treatment will be different and based primarily on the structural requirements for Primary Ground support. Drawing C.6 illustrates several treatments that were applied on a nearby SAWS project when karst features were encountered while tunneling and is provided for information only. Potential alternative treatments include:
 - a. Constructing a bulkhead to isolate the Tunnel Boring Machine (TBM) or heading and grouting the void to a sufficient distance above the tunnel crown to allow tunneling and installation of Primary Ground support to continue.
 - b. Installing additional ground support including beams and ring beams and filling above using lagging or mine foam, as appropriate based on the Contractor Engineer's design.
 - c. Sealing off smaller voids with Mine Foam to prevent loss of grout when back grouting liner plate or placing LDCC.

Table 5-1 Minimum Protective Standards for Sewer and Storm Drain Trenches
(from Edwards Aquifer Guidance Document 96.004, Effective 8/11/98)

Case	Description	Concern	Treatment	Notification/Approval
1	Sensitive feature is less than or equal to six (6) inches in all directions and is located above the embedment of the pipe. All rock within and surrounding the feature is sound.	Not environmental nor pipe integrity	No abatement required.	None required.
2	Sensitive feature is either larger than six (6) inches in at least one direction or is located within the level of the pipe embedment. No portion of the sensitive feature may intersect the plane of trench floor. All rock within and surrounding the feature is sound.	Environmental	The sensitive feature shall be filled with concrete. Gravel to "fist sized" rock or sacks of gravel may be placed in feature prior to placement of the concrete as long as a minimum of eighteen (18) inches of concrete is used to close the feature).	Requires notification and prior written approval from TCEQ.
3	Sensitive feature intersects the plane of the trench floor is less than four (4) feet in any direction. All rock within and surrounding the feature is sound.	Environmental	Sensitive feature shall be filled with concrete. Gravel to "fist sized" rock or sacks of gravel may be placed in feature prior to placement of concrete at least eighteen (18) inches of concrete is used to close the feature. The sewer line or storm sewer lines shall be concrete encased for width of the sensitive feature plus a minimum of five (5) feet on either end. The encasement shall provide a minimum of six (6) inches of concrete on all sides of the pipe and shall have a compression strength of at least two thousand five hundred (2,500) psi (28-day strength). The concrete may be steel reinforced.	Requires notification and prior written approval from TCEQ.
4	Sensitive feature intersects the plane of the trench floor and any opening in trench floor is greater than four (4) feet in any direction or the trench floor is unstable.	Environmental & Structural	Requires an engineered resolution at least as protective as Case 3 above. Additional protective measures, including rerouting of line, may be required.	Requires notification and prior written approval from TCEQ.

C. REPORTING

1. The Contractor shall provide written documentation to the Engineer and SAWS describing the void remediation measures taken on the Project. The information shall be included in the Construction Inspector's daily progress report. The report shall include, as a minimum, the following information:
 - a. Location (line stationing, distance from permanent structure, depth in trench from adjacent surface grade, geologic strata, etc.).
 - b. Physical dimensions of void and/or description of water flow recorded on the Contractor Void Description and Documentation Log Sheet.
 - c. Photographs, field notes, maps, sketches, and measurements.
 - d. Remediation action taken and status. Include a copy of the plan sheet showing the

location of the void and details for remediation measures.

- e. Actual agreed-upon quantities of materials used by Contractor in execution of remediation shall be included in the Construction Inspector's daily progress report.
 - f. Signature from the Contractor and Construction Inspector indicating agreement with the documented quantities and any delays associated with downtime for observation of the void.
2. The Engineer shall submit a site plan (Project As-Built Drawings) to SAWS showing features and/or anomalies that required remediation measures. The site plan shall show the location (approximate station) of the geological feature(s), Feature Number per the Contractor Void Description and Documentation Log Sheet and shall reference remediation measures from this specification. The corresponding detail(s) are to be included in the site plan. The remediation measures are included in Section 3.05 of this Specification. These measures include the potential for structural design requirements to span any void that is greater than 4 feet in any direction or based on the location of void in proximity to the pipe.

D. ENFORCEMENT

1. Failure to comply with this rule is a violation of LDC § 25-8-281 (D), Critical Environmental Features. Enforcement may be pursued.

PART 4 MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

- A. Measurement for feature remediation measures shall be made as follows:
1. Measurement of temporary feature protection (filter fabric, plywood planking, etc.) shall be for each occurrence.
 2. Measurement of sand/cement/bentonite grout shall be by the cubic yard of material in place.
 3. Measurement of pea gravel-filled polypropylene bags shall be by each. Minimum size is 1 cubic foot.
 4. Measurement of 3 to 5-inch rock shall be by the cubic yard (cubic meter) of rock placed.
 5. Measurement of filter fabric shall be by the square yard of filter fabric as needed to maintain specified clearance from edge of void.
 6. Measurement of low slump concrete material shall be by the cubic yard (cubic meter) of material in place.
 7. Measurement for provision of Special Trench Safety shall be per LinearFoot.
 8. Measurement for Downtime Associated with Observation of Voids shall be per Day. This pay item shall only apply in circumstances where the Contractor's operations have been halted and Contractor cannot continue work in another area of the project. Delay time will not be allocated for time that work on a feature remediation measure is in progress, only for time associated with observation and determination of remediation measures to be taken. Contractor must notify the SAWS Inspector within one hour of the beginning of the delay and document the time and cause of delay. Documentation shall also include explanation of why work could not continue. Work stoppage for one

hour or less shall not be cause for delay and will not be measured but shall be included in the unit price bid in the pipe pay items. Partial day delays shall be measured as fractions of a day calculated by half days. Delays over one hour and up to 4 hours will be counted at 0.5 DAY.

4.02 PAYMENT

- A. The work performed for "Temporary Feature Protection (Plywood Planking)" and "Pea Gravel-Filled Polypropylene Bags for Feature Remediation" will be paid for at the unit price bid per each occurrence. The unit price bid items shall include full compensation for all materials and all manipulations, labor, tools, equipment and incidentals necessary to complete the work.
- B. The work performed for "Low Slump Concrete" and "3 To 5 Inch Rock for Feature Remediation" will be paid for at the unit price bid per cubic yard. These unit bid price items shall include full compensation for all concrete, rock, curing, finishing, and for all labor, tools, materials, equipment and incidentals necessary to complete the work.
- C. The work performed for "Filter Fabric for Feature Remediation" will be paid for at the unit price bid per square yard. These unit bid price items shall include full compensation for all materials and all manipulations, labor, tools, equipment and incidentals necessary to complete the work.
- D. The work performed for "Special Trench Safety Associated with Observation of Voids" will be paid for at the unit price bid per linear foot. These unit bid price items shall include full compensation for all materials, supervision, mobilization, de-mobilization, and all manipulations, labor, tools, equipment and incidentals necessary to complete the work.
- E. The work performed for "Downtime Associated with Observation of Voids" will be paid for at the unit price bid per day for observations in trenches, in shafts, and in tunnels. These unit bid price items shall include full compensation for all materials, supervision, mobilization, de-mobilization, and all manipulations, labor, tools, equipment and incidentals necessary to complete the work.
- F. The work required to Construct Tunnel Bulkhead, and Grout from Underground to Fill Void will be paid for at the unit prices bid according to the units stated in the table below. These unit bid price items shall include full compensation for all materials, supervision, mobilization, de-mobilization, and all manipulations, labor, tools, equipment and incidentals necessary to complete the work.
- G. The work required for providing and placing mine foam shall be paid for at the unit price bid per cubic foot installed. Contractor shall demonstrate, before first use, the yield (in cubic feet) from packaged materials provided by the Foam supplier and quantities shall then be determined based on the number of packages used. The unit bid price item shall include full compensation for all materials, supervision, mobilization, de-mobilization, and all manipulations, labor, tools, equipment and incidentals necessary to complete the work.

4.03 PAYMENT

When included as a Contract Pay Item will be made under one of the following:

Pay Item No. 01510-A	Temporary Feature Protection (4-ft by 8-ft Plywood Sheet).	Each
Pay Item No. 01510-A(b)	Pea Gravel-Filled Polypropylene Bags (1-cu.ft) – in Trench	Each
Pay Item No. 01510-A(c)	Pea Gravel-Filled Polypropylene Bags (1-cu.ft) – Underground	Each
Pay Item No. 01510-B(a)	3 To 5 Inch Rock – in Trench	Cubic Yard
Pay Item No. 01510-B(b)	3 To 5 Inch Rock - Underground	Cubic Yard
Pay Item No. 01510-B(c)	Low Slump Concrete – in Trench	Cubic Yard
Pay Item No. 01510-B(d)	Low Slump Concrete - Underground	Cubic Yard
Pay Item No. 01510-C	Filter Fabric for Feature Remediation	Square Yard
Pay Item No. 01510-D	Special Trench Safety Associated with Observation of Feature	Linear Foot
Pay Item No. 01510-E(a)	Downtime Associated with Observation of Features in Trenches	Day
Pay Item No. 01510-E(b)	Downtime Associated with Observation of Features in Shafts	Day
Pay Item No. 01510-E(c)	Downtime Associated with Observation of Features in Tunnels	Day
Pay Item No. 01510-F(a)	Construct Tunnel Bulkhead	LS
Pay item No. 01510-F(b)	Grout from Underground to Fill Feature	Cubic Yard
Pay item No. 01510-G	Supply and Install Mine Foam (underground)	Cubic Foot
Pay item No. 01510-H	Install Structural Steel (underground)	LB

4.04 UNIT BID PRICES

The unit bid prices shall include full compensation necessary to complete the work described in Section 01510.

Notes:

- This Drawing provides examples regarding how the Bid Items in Specification 01510 were used to mitigate Karst Voids on other San Antonio Water System (SAWS) Projects.
- The Drawing is provided for Information Only. The Contractor is required to formulate their own plan and means and methods in accordance with Specification 01510.

2.2. Void / Feature No. 2 STA 115+13 Right Side

2.2.1. Summary and Mitigation

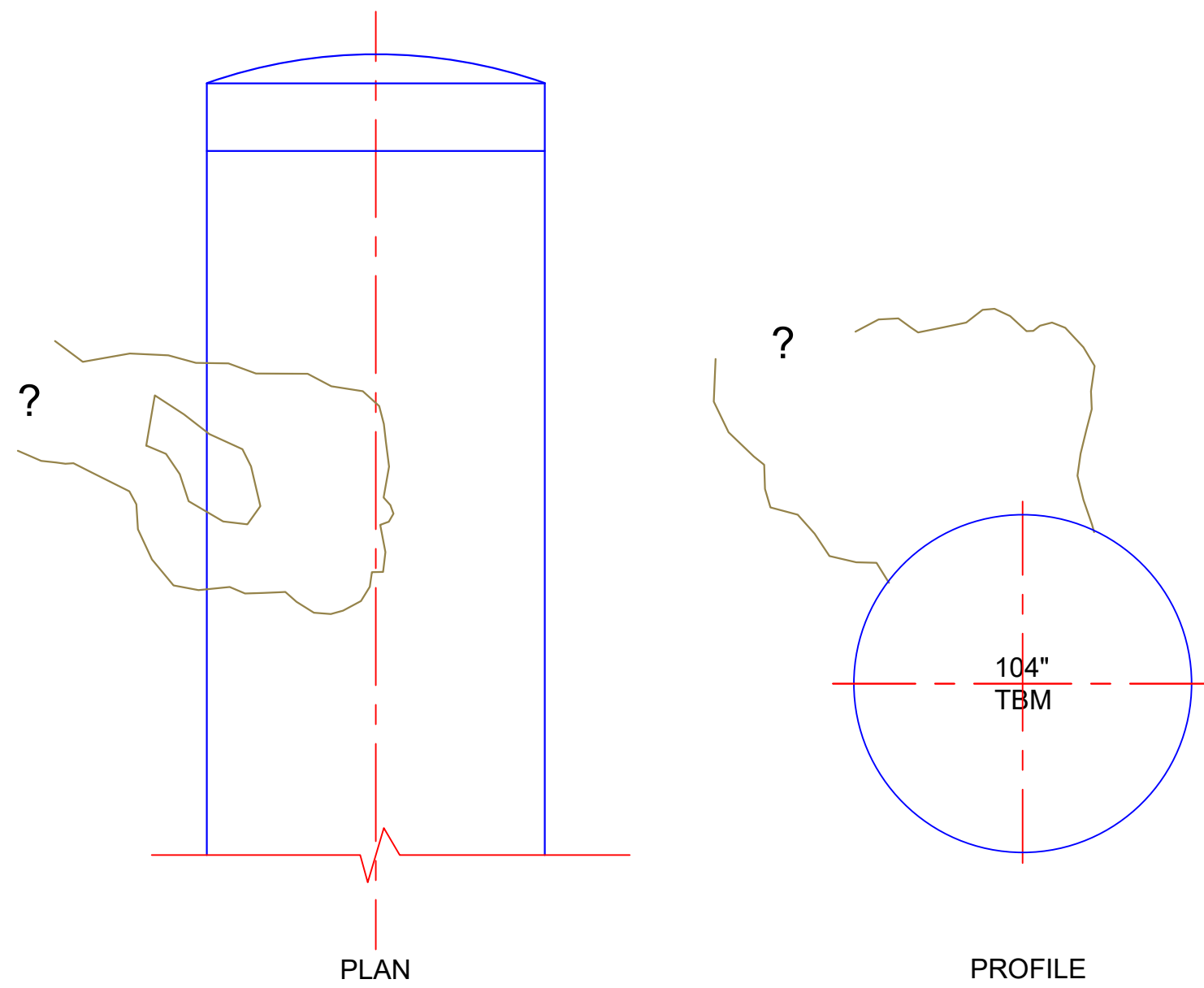
Void No. 2 was encountered in the roof on the right side of Reach 3 (looking East). The void measured 6-ft along the tunnel, extended 4-ft into the rib, and was approximately 15-ft high.

The Cave Biologist investigated Void No. 2 in September, 2019 and determined that this feature did not contain suitable habitat for any of the endangered karst invertebrates. The void was not of concern to tunnel stability and no mitigation was required.

2.2.2. Structural Assessment

This void was encountered in the right side of the tunnel and extended upward in an area that would not increase loading on the installed ground support. In addition, the Contractor filled Reach 3 with Low Density Cellular Concrete installed at a port pressure of 8 psi and proof drilled to above the lagging finding only grout or rock. We anticipate that the void would have been filled with grout and estimate that the fully encapsulated ground support has a safety factor greater than 4.0 as required by specification.

**Cornerstone Tunnel @ STA 115+13
Void Feature 2 & 3**



2.3. Void / Feature No. 3 STA 115+13 Above and Left

2.3.1. Summary and Mitigation

Void No. 3 was encountered in the roof on the left side of Reach 3 (looking East). The void measured 7-ft along the tunnel, extended from the tunnel center 5-ft into the rib, and was approximately 10-ft high.

The Cave Biologist investigated Void No. 3 in September, 2019 and determined that this feature did not contain suitable habitat for any of the endangered karst invertebrates. The void was not of concern to tunnel stability and no mitigation was required.

2.3.2. Structural Assessment

The ground and the area where the void contacted the tunnel roof were supported by W4x13-lbs per ft ribs and wood lagging. In addition, the Contractor has filled Reach 3 with Low Density Cellular Concrete installed at a port pressure of 8 psi and has proof drilled to above the lagging finding only grout or rock. This fully encapsulated ground support is estimated to have a safety factor greater than 4.0 as required by specification.

2.4. Void / Feature No. 4 STA 185+50 / 186+07 Above and Left

2.4.1. Summary and Mitigation

Void No. 4 was encountered above and in the left rib of Reach 1 (looking South). The void was approximately 20-ft long (parallel to the tunnel) extended 6 to 8-ft above the crown of the tunnel and approximately 12-ft into the left rib where it again extended upward an unknown distance.

The Contractor submitted an RFI on September 5, 2019 noting that the area represented a potential for significant rockfall and requesting that the void be immediately filled. The void was subsequently filled above the tunnel crown and into the left rib with mine foam. Steel sets were installed on 2.5-ft centers through the void area.

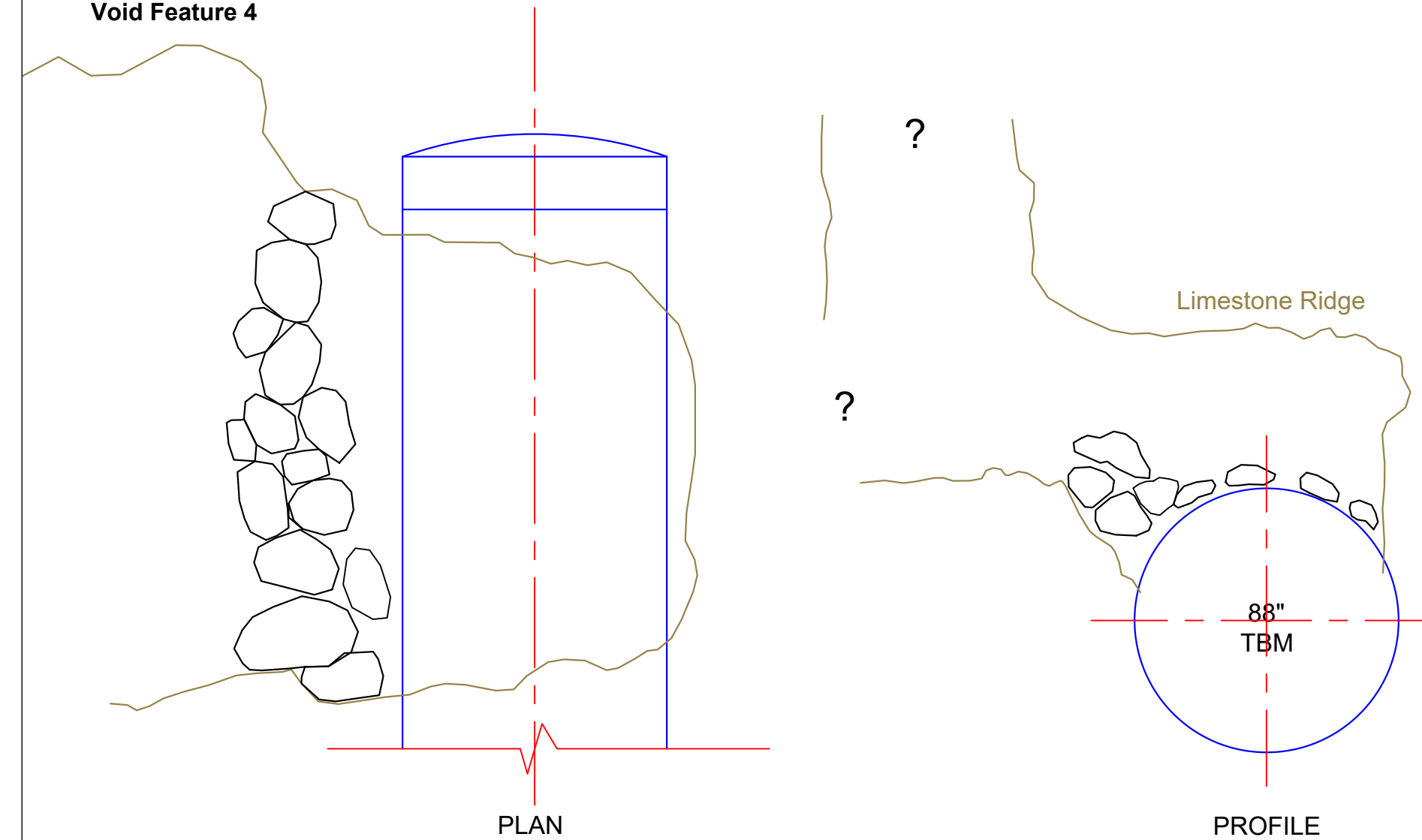
The Cave Biologist were not able to access this feature due to safety concerns, however, observations were made by Contractor and CM personnel and no signs of karst invertebrate habitat were observed.

2.4.2. Structural Assessment

The ground and the area where the void contacted the tunnel roof were supported by W4x13-lbs per ft ribs and wood lagging on 2.5-ft centers, effectively doubling the designed support in this area. In addition, the Contractor filled Reach 1 with Low Density Cellular Concrete installed at a port pressure of 5 psi and will proof drill to above the lagging mitigating any located voids by additional grouting. It is anticipated that areas of the void to at least 4-ft above the roof of the tunnel will be filled with grout.

This increased density, fully encapsulated ground support is estimated to have a safety factor greater than 4.0 as required by specification even when considering a possible increased height of loosened rock in excess of that actually encountered.

**Terminus Tunnel @ STA 185+80
Void Feature 4**



2.5. Void / Feature No. 5 STA 181+56 Above and Left

2.5.1. Summary and Mitigation

Void No. 5 was encountered above and in the left rib of Reach 1 (looking South). The feature was approximately 17-ft long (parallel to the tunnel), 10-ft wide and extended approximately 10-ft upward above an area in the left wall of the tunnel.

The Contractor installed 15 steel sets with wood lagging and steel channel on 2.5-ft centers through the area to improve stability.

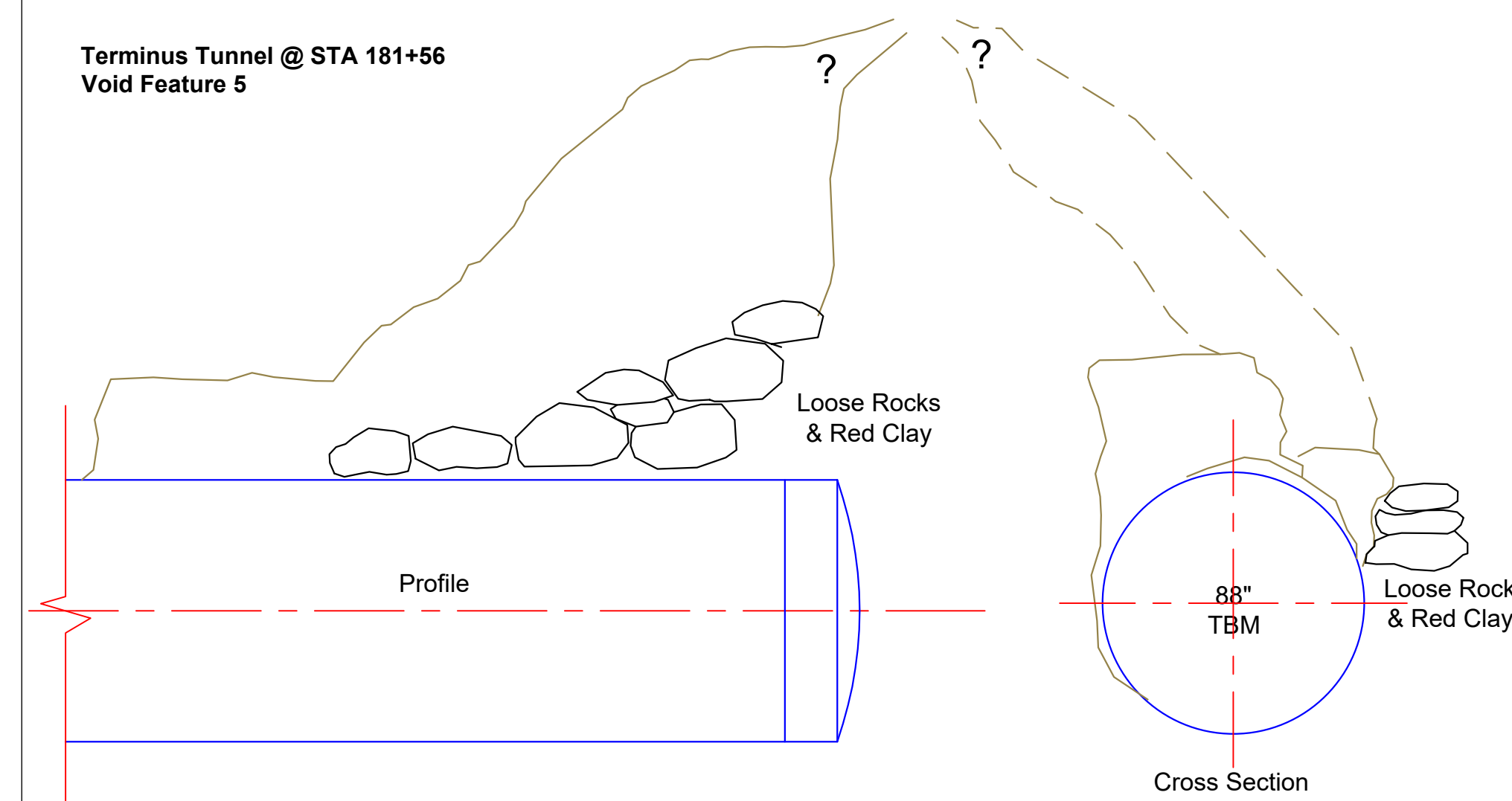
The Cave Biologist investigated Void No. 5 in November, 2019 and determined that this feature did not contain suitable habitat for any of the endangered karst invertebrates.

2.5.2. Structural Assessment

The ground and the area where the void contacted the tunnel roof were supported by W4x13-lbs per ft ribs and wood lagging on 2.5-ft centers, effectively doubling the designed support in this area. In addition, the Contractor will fill Reach 1 with Low Density Cellular Concrete installed at a port pressure of 5 psi and will proof drill to above the lagging mitigating any located voids by additional grouting. It is anticipated that areas of the void to at least 4-ft above the roof of the tunnel will be filled with grout.

This increased density, fully encapsulated ground support is estimated to have a safety factor greater than 4.0 as required by specification even when considering a possible increased height of loosened rock in excess of that actually encountered.

**Terminus Tunnel @ STA 181+56
Void Feature 5**



2.6. Void / Feature No. 6 STA 177+43

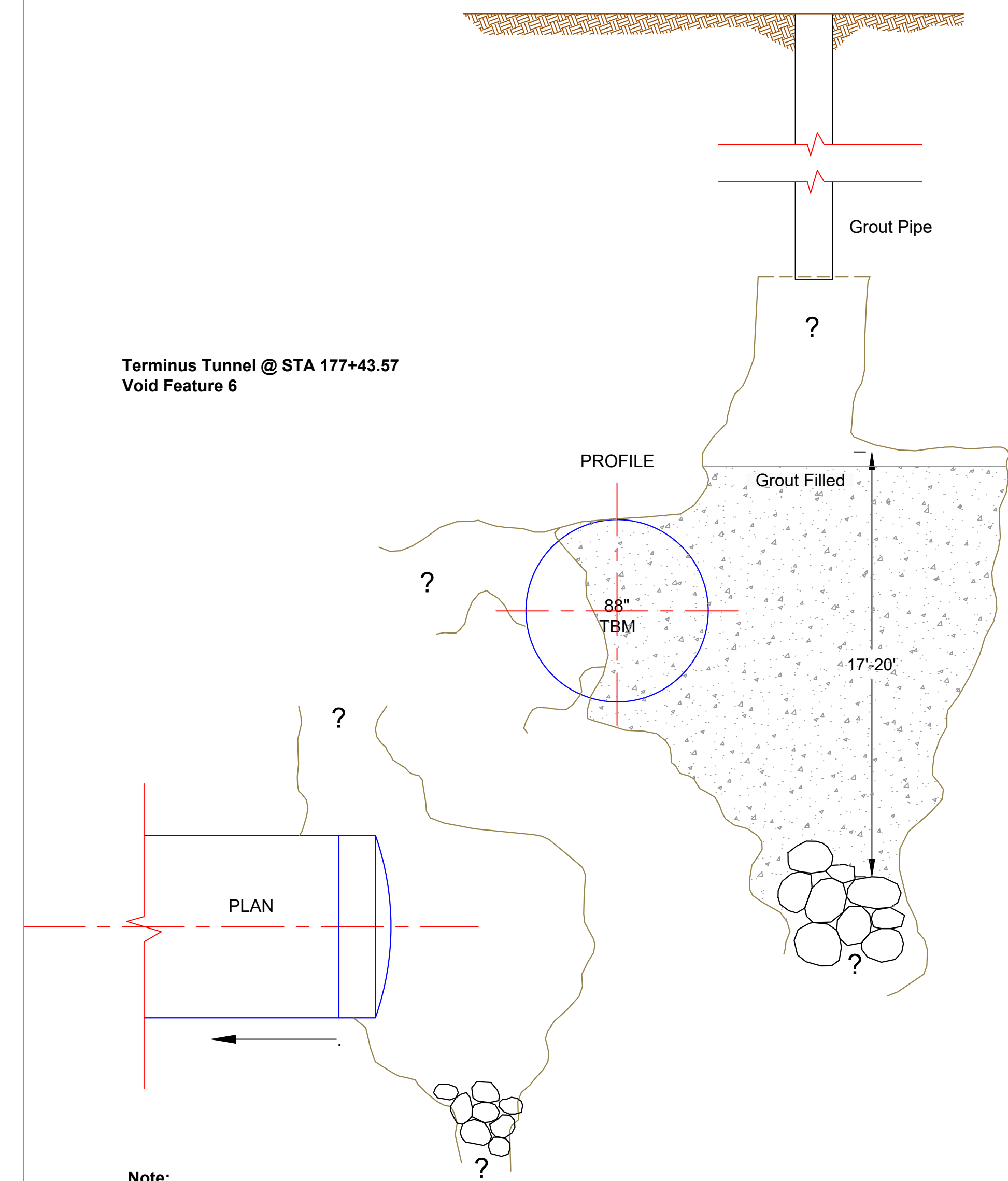
2.6.1. Summary and Mitigation

Void No. 6 was encountered on December 12, 2019 when the TBM entered an 8-10-ft wide, 15-20-ft tall karst feature. The TBM could not advance and, after consultation, it was determined that the best mitigation would be to drill a hole from surface and fill the feature with rock and concrete. There was no safe option to inspect the void.

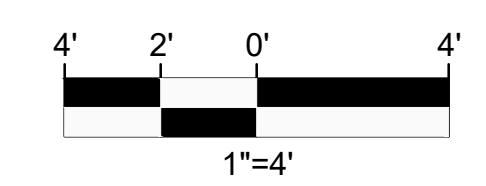
2.6.2. Structural Assessment

The Engineer reviewed the Geologist Report, the Contractor's proposed mitigation and Program Plan and observed the results of the rock fill and concrete placement after the TBM had mined through the filled section. The ground was supported by W4 x 13 steel sets placed on 5-ft centers through and either side of the filled void. The estimated safety factor for the ground support installed in the void area is greater than 4.0 as required by specification.

**Terminus Tunnel @ STA 177+43.57
Void Feature 6**



Note:
Tunnel Boring Machine Pulled Back and Bulkhead Constructed Across Tunnel



NO.	REVISION	DATE

INCOMPLETE DOCUMENT
ISSUED FOR
INTERIM REVIEW ONLY

NOT RELEASED FOR
REGULATORY APPROVAL,
PERMIT OR CONSTRUCTION

CHRISTOPHER D. BREEDS, P.E.
TEXAS REGISTRATION NO. 97180
APR 2022

PAPE-DAWSON
ENGINEERS

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SubTerra Inc.
SAN ANTONIO, TEXAS

Texas Registration No. F-10568

SAN ANTONIO WATER SYSTEM
BEXAR COUNTY, TEXAS
MUD CREEK SANITARY SEWER

Void Mitigation Sketches - CWIP 5-1 Tunnels

LEGEND

- = TBM
- = Loose Rock
- = Void Area

PROJECT

DESIGN

DRAWN

CHECKED

HORIZONTAL SCALE
1"=4'

VERTICAL SCALE
Same