Northern California Pipe Users Group
Twenty-First Annual Sharing Technologies Seminar

Berkeley, California
February 21, 2013

Dig that Creek or Tunnel that Creek? Case Study of Crossing San Tomas Aquino Creek with an Inverted Sewer Siphon in Santa Clara, California

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Falguni Amin, City of Santa Clara Public Works, Santa Clara, California

ABSTRACT: The Walsh Avenue Trunk Sewer project in Santa Clara, CA involved the construction of over 10,000 feet of 24 to 30-inch trunk sewer. The majority of the sewer was installed using traditional open cut construction methods. The trunk sewer crosses San Tomas Aquino Creek using an inverted siphon. The inverted siphon is a twin barrel siphon (15.2-inch each) with a 23.6-inch air jumper. The original design included open cut installation of the legs of the siphon with the creek being crossed using microtunneling. Two-thirds of the way through the design, the design was changed to open cutting the entire crossing. During construction, the Contractor requested to use auger boring to install the upstream and downstream legs of the siphon. Since one of the legs of the siphon is much steeper than typically constructed, this presented construction challenges which will be presented and discussed. The creek was crossed using open cut construction methods.

1. SETTING AND BACKGROUND

The City of Santa Clara is located on the south end of San Francisco Bay, adjacent to the cities of San Jose, Cupertino, and Sunnyvale, and has a population of about 118,000. Starting in the fall of 2014, the San Francisco 49ers will play football in their new stadium currently under construction in the City.

The City's wastewater collection system includes approximately 270 miles of sewer pipelines. The system conveys wastewater to the San Jose/Santa Clara Water Pollution Control Plant (SJ/SC WPCP), located north of Highway 237 in San Jose. In 2007 the City completed a Sanitary Sewer Capacity Assessment that identified the need for capacity improvements to the trunk sewer system to serve future growth and redevelopment. One of the key components of the recommended capacity improvement plan was construction of a major new west-to-east trunk sewer along Walsh Avenue. The Walsh Avenue sewer would divert a portion of the flow that would otherwise need to be conveyed north in existing, capacity-limited trunk sewers in Bowers Avenue and Great America Parkway to the City's Rabello and Northside Pump Stations, which pump the flow to the SJ/SC WPCP. Instead, up to about 4.5 MGD of peak wet weather flow (based on 10-year design storm) would be diverted to the Walsh Avenue Trunk Sewer and conveyed east through the City's Trimble Road trunk sewer to San Jose's interceptor pipelines in Zanker Road. The City initiated design of the Walsh Avenue project in 2008, construction started in August 2010, and the project went on-line in September 2011.

2. DESCRIPTION OF SAN TOMAS AQUINO CREEK

San Tomas Aquino Creek right-of way is 150 feet wide with a bike trail on one side and a maintenance road on the other. The creek channel is 21 feet deep and lined with concrete in the vicinity of Walsh Avenue. The creek flows south to north with office building development on both sides. The soil borings indicate lean clay with blow counts ranging from 13 to 30 blows per foot. The soil boring on the east side of the creek transitions from lean clay with sand to sandy clay at a depth near the bottom of the channel. The soil borings are attached at the end of this paper.

A new bike trail with retaining walls and footings was being constructed on the west side of the channel while the sewer project was under design. The retaining walls are decorated with cast-in-place artistic creek scenes. A 15-inch sewer and a 4-inch nitrogen pipe run parallel to the creek on the west side of the channel. The east side has the following buried utilities: 24-inch water, electrical duct bank, 8-inch water, and 18-inch storm drain. The west side has a line of trees ranging in size from 3 to 21 inches in diameter. The east side has trees that range in size from 18 to 22 inches in diameter in a small landscaped area. Photos of the creek are included at the end of the paper.

3. DESCRIPTION OF SIPHON

The sewer upstream of the inverted siphon is 30 inches in diameter, and the downstream sewer is 27 inches. The inverted siphon has two barrels with each barrel consisting of high density polyethylene (HDPE) DR 13.5 pipe with an outside diameter of 18 inches and an inside diameter of 15.2 inches. An air jumper was also part of the siphon. The air jumper is a 28-inch outside diameter, 23.6-inch inside diameter HDPE DR 13.5 pipe. Both the siphon inlet and outlet structures consist of t-lock lined precast concrete boxes on cast-in-place concrete bases.

4. DESIGN PHASE

The original plan identified the crossing as a trenchless crossing. The 30% design phase specified microtunneling for the entire crossing with the siphon up leg and down leg located inside the jacking and receiving shafts and extended as necessary with open cut construction. Permits were applied for from the California Department of Fish and Game (now California Department of Fish and Wildlife) and the Santa Clara Valley Water District. As the design evolved and easement negotiations with the private property owners moved forward, the design team and the City decided to evaluate the permittability of an open cut crossing. An open cut crossing would improve hydraulics by allowing the siphon to be less deep and allow the up leg and down leg to be straighter in their horizontal alignments and less steep in their vertical alignments. An open cut configuration would also allow future maintenance activities to be conducted more easily.

Discussions were held with the resource agencies, and permit applications were modified. Permits were obtained for an open cut crossing. Across the bottom of creek, the three pipes would be encased in concrete with the distance between the bottom of the creek and the top of the concrete encasement to be 5.5 feet. This distance was necessary to allow for the potential of a future creek project that would lower the bottom of the creek. A figure showing the "as bid" version of the creek crossing is attached.

5. BID PHASE

The project was released for bidding in 2010 and bids were opened on June 30, 2010. Seven bids were received. The low bidder was K.J. Woods Construction based in San Francisco. The bid item for the creek crossing ranged from about $400K to $1.3M.

6. CONSTRUCTION PHASE

Through a series of modified and re-modified proposals, the Contractor received approval to implement a no cost change order to install both legs of the siphon using traditional auger boring equipment. The main incentive to use a trenchless construction method was to avoid the recently constructed trail including the decorated retaining wall on the west side of the channel. Since the trenchless subcontractor would already be mobilized for the west side, the east side was added to avoid deep (25-foot) trenching on a slope.

Since the east side was now to be tunneled, the design team took this opportunity to align the pipe so as to tunnel under the trees and straighten the leg, thus improving hydraulics and increasing the ease with which the siphon could be cleaned. A figure showing the final alignment is attached.

The tunneling on the west side of the channel included 42- and 36-inch diameter steel casings. The length of the casings was 49 feet and vertical angle was 24.5 degrees. The steel casings were tunneled from a jacking shaft at the top of the channel.

The tunneling on the east side consisted of one 54-inch diameter steel casing. The length of the casing was 134.5 feet and vertical angle was 4.8 degrees. Similar to the other side, the steel casing was tunneled from a jacking shaft at the top of the channel.

After the tunneling was completed, the 18-inch OD HDPE siphon pipes were fused and pulled down through the 54-inch casing, across the open trench at the bottom of the channel, and up the steel casings on the west side. The 28-inch OD air jumper was inserted into the 54-inch steel casing on top of the two smaller pipes on the east side. On the west side, the 28-inch air jumper was pulled into the 36-inch casing. A condensate sump on the air jumper was installed, and the air jumper was fused together in the channel. A figure showing the Contractor's profile submittal and the configuration of the HDPE pipes inside the steel casings is attached.

After the HDPE pipes were installed, the reinforced concrete encasement was constructed. Later the open cut portion was backfilled, and the concrete channel lining was repaired. In order to allow construction activities to occur in the channel, the flow in the channel was diverted into a temporary pipe around/across the area. Photos of the construction phase are attached.

7. LESSONS LEARNED

The design team offers the following "lessons learned" from the San Tomas Aquino Creek crossing:

- When designing a creek crossing, take a mental step back and consider open cut construction. In some locations, it may be applicable.
- Always consider splitting the crossing into parts and using different construction methods for each part.
- In this situation, auger boring was used on a steep slope and should be considered in other similar situations.

ATTACHMENTS

The following items are attached:

- Photos.
- Cost information.
- As-Bid Drawing of Siphon
- Record Drawing of Siphon
- Drawing Produced by Contractor
- Soil Borings

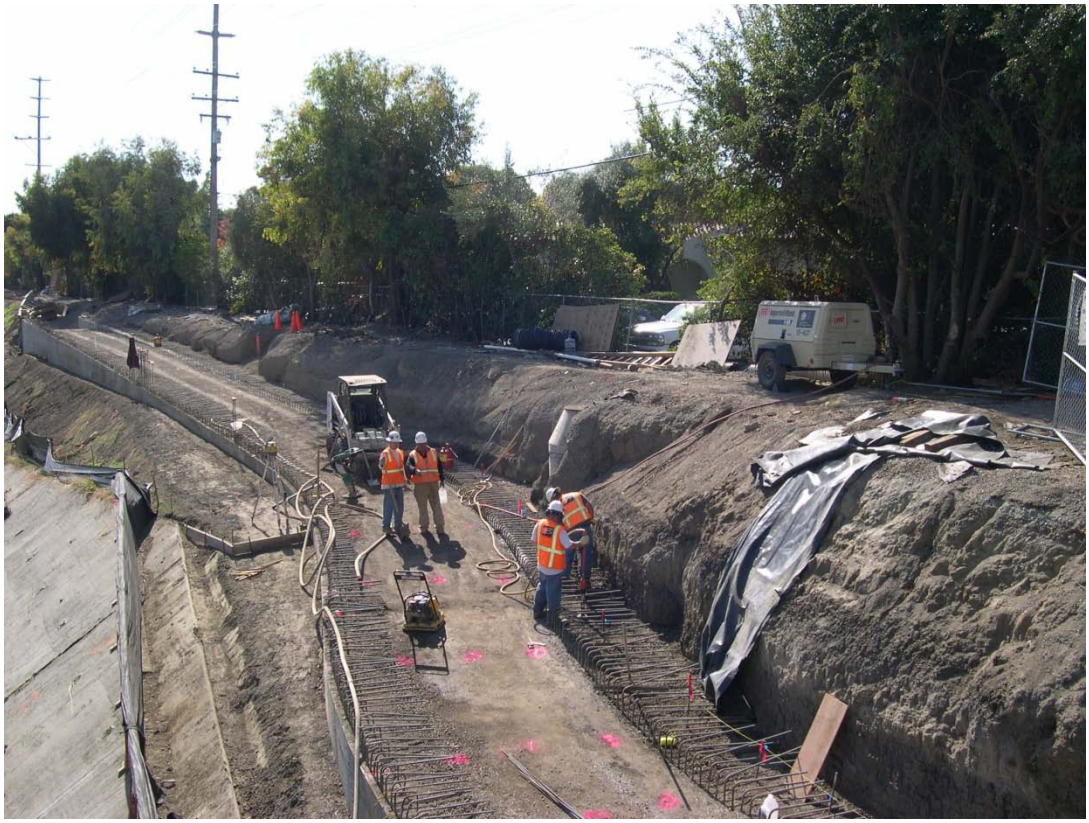


Photo 1. Trail being constructed during the design phase of the trunk sewer.

Photo 2. Crossing location for San Tomas Aquino Creek.

Photo 3. Trees on east side of creek.

Photo 4. Water in San Tomas Aquino Creek was diverted around construction site using temporary berms and a diversion pipeline (looking north).

Photo 5. Water from small dewatering pumps was pumped into settling tanks before discharging into the creek (looking south).

Photo 6. The creek diversion had different configurations during the project depending on the construction activities being performed.

Photo 7. Receiving shaft on west side of creek.


Photo 8. Steel casing with auger segment inside.

Photo 9. Steel casing showing “steering doors” or “steering flaps”.

Photo 10. Auger rig on west side of channel set with a 24.5 degree downward angle.

Photo 11. Auger rig pulled back ready to receive the next casing segment.

Photo 12. Auger rig was chained to the shoring to keep it from sliding down the slope.

Photo 13. Front of jacking shaft.

Photo 14. Steel casing with support struts to support HDPE pipe.

Photo 15.Restored creek looking south.

Photo 16. Restored creek looking north.

COST INFORMATION

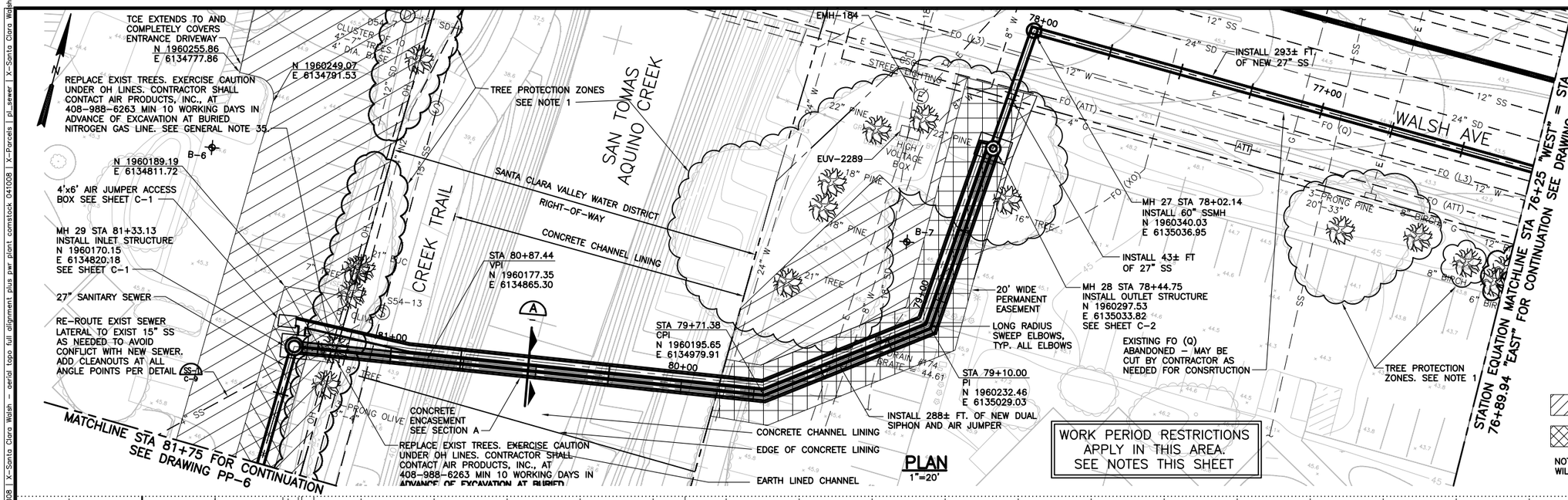
Bids were opened on June 30, 2010. Tabulations of various bid items are shown below.

Table 1. Comparison of the San Tomas Aquino Creek Crossing Bid Item

Item: San Tomas Aquino Creek Crossing	**Bid Amount (Lump Sum)**
Low Bidder	$916,325
Bidder #2	$750,000
Bidder #3	$395,000
Bidder #4	$480,000
Bidder #5	$725,000
Bidder #6	$600,000
Bidder #7	$1,300,000
Engineer's Estimate	$610,000

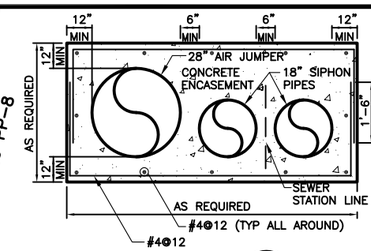
Table 2. Comparison of Various Trenchless Crossing Bid Items

	Caltrain Trenchless Crossing (Length = 200 ft) (per LF)	**San Tomas Expressway Trenchless Crossing (Length = 190 ft) (per LF)**	**UPRR Trenchless Crossing (Length = 86 ft) (per LF)**
Low Bidder	$900	$1,100	$1,300
Bidder #2	$1,200	$1,500	$2,000
Bidder #3	$1,950	$1,950	$2,250
Bidder #4	$1,696	$1,996	$2,196
Bidder #5	$1,440	$1,610	$1,885
Bidder #6	$950	$1,100	$1,400
Bidder #7	$1,050	$1,330	$1,167
Engineer's Estimate	$2,350	$2,661	$2,945
Note: These three crossings all had a 5/8-inch thick, 42-inch diameter steel casing installed using pilot tube guided auger boring (sometimes referred to as "pilot tube microtunneling"). Each bid item included a jacking shaft, receiving shaft, steel casing, and PVC sewer pipe.			



PLAN
1"=20'

WORK PERIOD RESTRICTIONS APPLY IN THIS AREA. SEE NOTES THIS SHEET



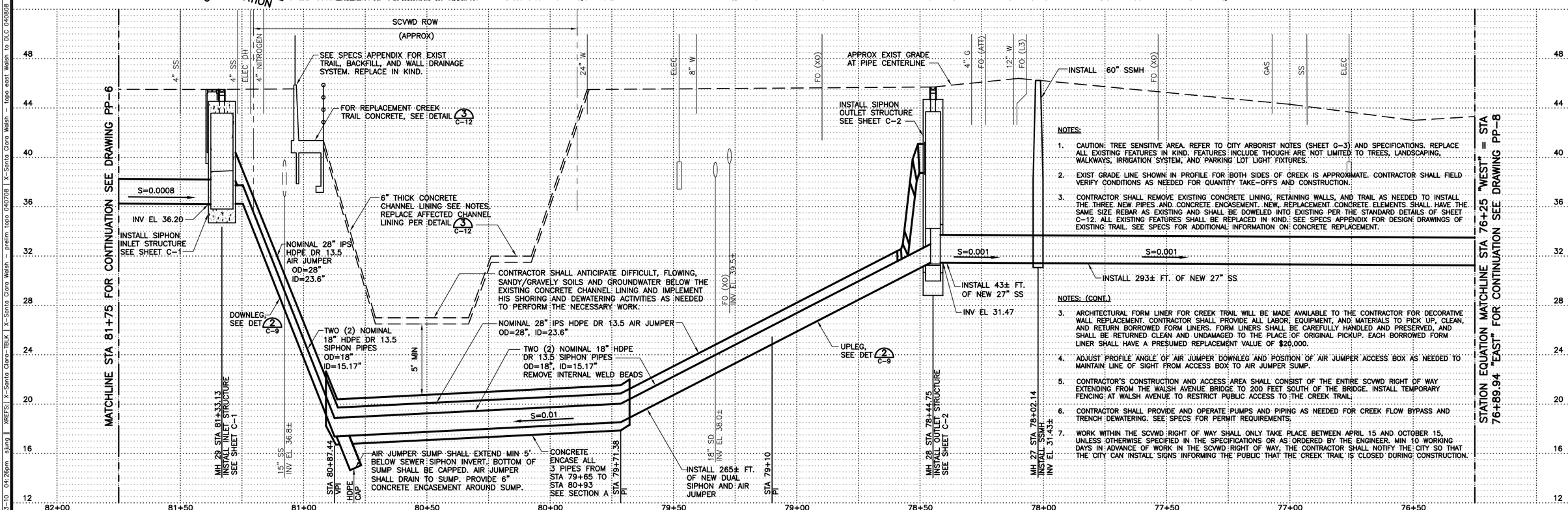
SECTION A
NTS

SECTION NOTES:
1. PIPES SHALL BE ONE (1) NOMINAL 28 INCH IPS HDPE DR 13.5 AND TWO (2) NOMINAL 18 INCH IPS HDPE DR 13.5
2. ALL REBAR SHALL HAVE 3" CONCRETE COVER (3" CLR).
3. BACKFILL WITH CLASS 2 AB.

TEMPORARY CONSTRUCTION EASEMENT

PERMANENT EASEMENT

NOTE: COORDINATES OF EASEMENT BOUNDARIES WILL BE PROVIDED DURING CONSTRUCTION



NOTES:

1. CAUTION: TREE SENSITIVE AREA. REFER TO CITY ARBORIST NOTES (SHEET G-3) AND SPECIFICATIONS. REPLACE ALL EXISTING FEATURES IN KIND. FEATURES INCLUDE THOUGH ARE NOT LIMITED TO TREES, LANDSCAPING, WALKWAYS, IRRIGATION SYSTEM, AND PARKING LOT LIGHT FIXTURES.
2. EXIST GRADE LINE SHOWN IN PROFILE FOR BOTH SIDES OF CREEK IS APPROXIMATE. CONTRACTOR SHALL FIELD VERIFY CONDITIONS AS NEEDED FOR QUANTITY TAKE-OFFS AND CONSTRUCTION.
3. CONTRACTOR SHALL REMOVE EXISTING CONCRETE LINING, RETAINING WALLS, AND TRAIL AS NEEDED TO INSTALL THE THREE NEW PIPES AND CONCRETE ENCASEMENT. NEW, REPLACEMENT CONCRETE ELEMENTS SHALL HAVE THE SAME SIZE REBAR AS EXISTING AND SHALL BE DOWELED INTO EXISTING PER THE STANDARD DETAILS OF SHEET C-12. ALL EXISTING FEATURES SHALL BE REPLACED IN KIND. SEE SPECS APPENDIX FOR DESIGN DRAWINGS OF EXISTING TRAIL. SEE SPECS FOR ADDITIONAL INFORMATION ON CONCRETE REPLACEMENT.

NOTES: (CONT.)

3. ARCHITECTURAL FORM LINER FOR CREEK TRAIL WILL BE MADE AVAILABLE TO THE CONTRACTOR FOR DECORATIVE WALL REPLACEMENT. CONTRACTOR SHALL PROVIDE ALL LABOR, EQUIPMENT, AND MATERIALS TO PICK UP, CLEAN, AND RETURN BORROWED FORM LINERS. FORM LINERS SHALL BE CAREFULLY HANDLED AND PRESERVED, AND SHALL BE RETURNED CLEAN AND UNDAMAGED TO THE PLACE OF ORIGINAL PICKUP. EACH BORROWED FORM LINER SHALL HAVE A PRESUMED REPLACEMENT VALUE OF $20,000.
4. ADJUST PROFILE ANGLE OF AIR JUMPER DOWNLEG AND POSITION OF AIR JUMPER ACCESS BOX AS NEEDED TO MAINTAIN LINE OF SIGHT FROM ACCESS BOX TO AIR JUMPER SUMP.
5. CONTRACTOR'S CONSTRUCTION AND ACCESS AREA SHALL CONSIST OF THE ENTIRE SCVWD RIGHT OF WAY EXTENDING FROM THE WALSH AVENUE BRIDGE TO 200 FEET SOUTH OF THE BRIDGE. INSTALL TEMPORARY FENCING AT WALSH AVENUE TO RESTRICT PUBLIC ACCESS TO THE CREEK TRAIL.
6. CONTRACTOR SHALL PROVIDE AND OPERATE PUMPS AND PIPING AS NEEDED FOR CREEK FLOW BYPASS AND TRENCH DEWATERING. SEE SPECS FOR PERMIT REQUIREMENTS.
7. WORK WITHIN THE SCVWD RIGHT OF WAY SHALL ONLY TAKE PLACE BETWEEN APRIL 15 AND OCTOBER 15, UNLESS OTHERWISE SPECIFIED IN THE SPECIFICATIONS OR AS ORDERED BY THE ENGINEER. MIN 10 WORKING DAYS IN ADVANCE OF WORK IN THE SCVWD RIGHT OF WAY, THE CONTRACTOR SHALL NOTIFY THE CITY SO THAT THE CITY CAN INSTALL SIGNS INFORMING THE PUBLIC THAT THE CREEK TRAIL IS CLOSED DURING CONSTRUCTION.

PROFILE
1"=20' H 1"=4' V

RMC Water & Environment

REGISTERED PROFESSIONAL ENGINEER TAMMY A. QUALLS No. 70885 Exp. 06-30-11 CIVIL STATE OF CALIFORNIA

30 0 10 20 40 60 80 100
GRAPHIC SCALE - USE WHEN PLAN IS REDUCED

As-Bid Drawing

PROJECT No. CE 07-08-11			
ACCOUNT No. 594-4443-8030-1909			
DATE	No.	REVISION	BY

CITY OF SANTA CLARA
ENGINEERING DEPARTMENT

WALSH AVENUE SANITARY SEWER AND RECYCLED WATER IMPROVEMENTS

PLAN AND PROFILE
STA 81+75 TO STA 76+25

APPROVED BY			
TITLE			
DATE			
	INITIAL	DATE	CSC TRACING No. 11, 657-D
DESIGNED BY	EE	06/10	
DRAWN BY	SJ	06/10	SHEET: PP-7
CHECKED BY	DB	06/10	
AS BUILT BY			13 OF 75

FILENAME: 0149-003-PP-1 6-03-10 04:26pm sjung || XREFS: X-Santa Clara-TBLK | X-Santa Clara Walsh - prelim topo 040708 | X-Santa Clara Walsh - topo east Walsh to DLC 040808 | X-Santa Clara Walsh - aerial topo full alignment plus pwr plant comstock 041008 | X-Parcels | pl_sewer | X-Santa Clara Walsh-SC

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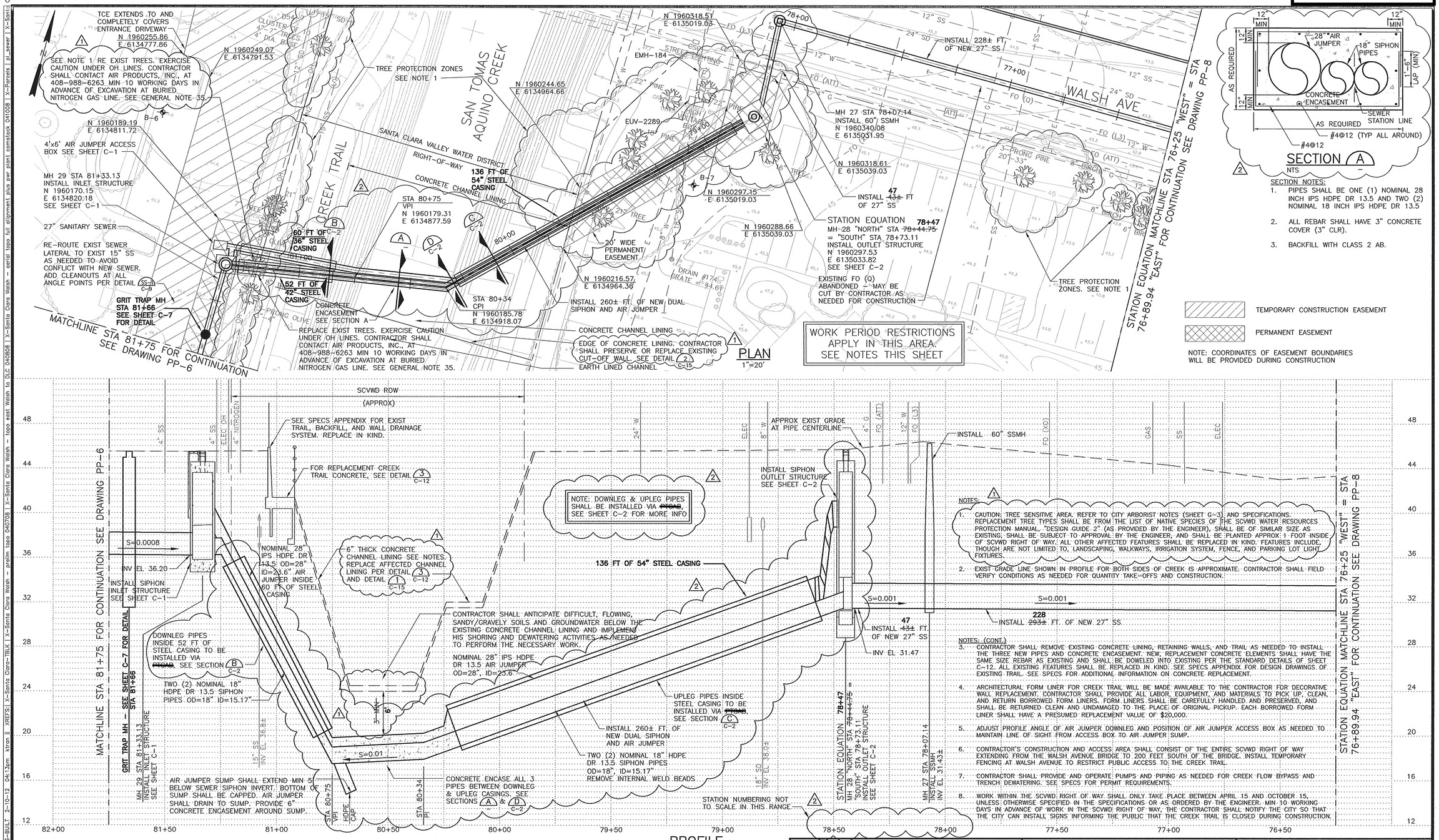
Record Drawing



NOTES:

1. CAUTION: TREE SENSITIVE AREA. REFER TO CITY ARBORIST NOTES (SHEET G-3) AND SPECIFICATIONS. REPLACEMENT TREE TYPES SHALL BE FROM THE LIST OF NATIVE SPECIES OF THE SCVWD WATER RESOURCES PROTECTION MANUAL, "DESIGN GUIDE 2" (AS PROVIDED BY THE ENGINEER). SHALL BE OF SIMILAR SIZE AS EXISTING; SHALL BE SUBJECT TO APPROVAL BY THE ENGINEER; AND SHALL BE PLANTED APPROX. 1 FOOT INSIDE OF SCVWD RIGHT OF WAY. ALL OTHER AFFECTED FEATURES SHALL BE REPLACED IN KIND. FEATURES INCLUDE, THOUGH ARE NOT LIMITED TO, LANDSCAPING, WALKWAYS, IRRIGATION SYSTEM, FENCE, AND PARKING LOT LIGHT FIXTURES.
2. EXIST GRADE LINE SHOWN IN PROFILE FOR BOTH SIDES OF CREEK IS APPROXIMATE. CONTRACTOR SHALL FIELD VERIFY CONDITIONS AS NEEDED FOR QUANTITY TAKE-OFFS AND CONSTRUCTION.

NOTES: (CONT.)

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7. CONTRACTOR SHALL PROVIDE AND OPERATE PUMPS AND PIPING AS NEEDED FOR CREEK FLOW BYPASS AND TRENCH DEWATERING. SEE SPECS FOR PERMIT REQUIREMENTS.
8. WORK WITHIN THE SCVWD RIGHT OF WAY SHALL ONLY TAKE PLACE BETWEEN APRIL 15 AND OCTOBER 15, UNLESS OTHERWISE SPECIFIED IN THE SPECIFICATIONS OR AS ORDERED BY THE ENGINEER. MIN 10 WORKING DAYS IN ADVANCE OF WORK IN THE SCVWD RIGHT OF WAY, THE CONTRACTOR SHALL NOTIFY THE CITY SO THAT THE CITY CAN INSTALL SIGNS INFORMING THE PUBLIC THAT THE CREEK TRAIL IS CLOSED DURING CONSTRUCTION.

RMC Water & Environment

GRAPHIC SCALE - USE WHEN PLAN IS REDUCED (30 0 10 20 40 60 80 100)

Record Drawing

PROJECT No. CE 07-08-11			
ACCOUNT No. 594-4443-8030-1909			
DATE	No.	REVISION	BY
11-22-10	1	UPDATED FOR PERMIT COMPLIANCE	EE
04-11-11	2	NEW ~~PTCAB~~ TUNNEL CONFIGURATION	EE

CITY OF SANTA CLARA
ENGINEERING DEPARTMENT

WALSH AVENUE SANITARY SEWER AND RECYCLED WATER IMPROVEMENTS

PLAN AND PROFILE
STA 81+75 TO STA 76+25

APPROVED BY			
TITLE			
DATE			
	INITIAL	DATE	CSC TRACING No. 11, 657-D
DESIGNED BY	EE	06/10	
DRAWN BY	SJ	06/10	SHEET: PP-7
CHECKED BY	DB	06/10	
AS BUILT BY			13 OF 75

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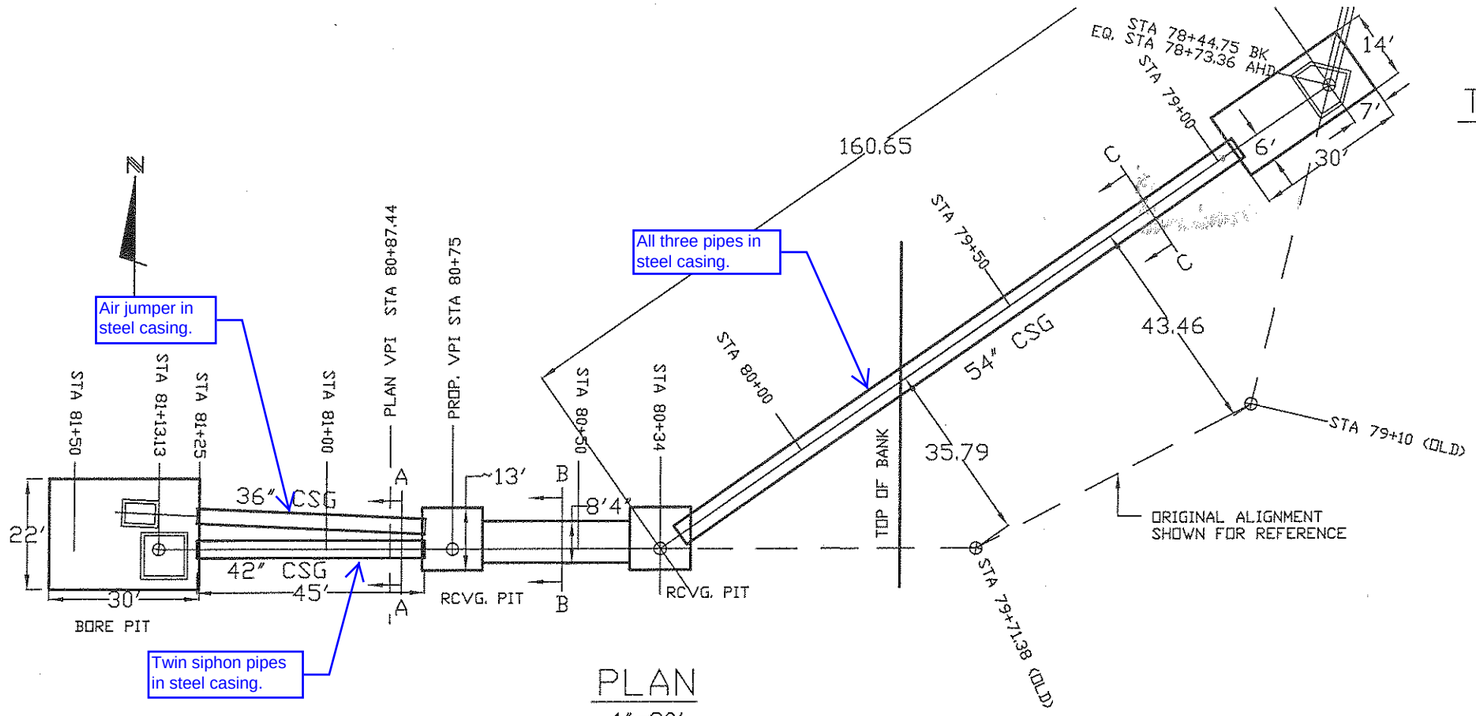
Last Saved By: ktran 2-10-12 04:12pm

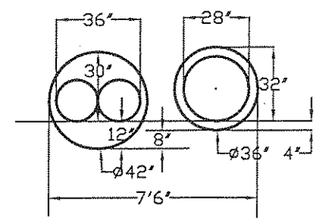
SAN TOMAS CREEK CROSSING PLAN
TEMPORARY FLOW DIVERSION & DEWATERING

SHEET 1 -GENERAL LAYOUT PLAN & PROFILE
SHEET 2 -PROPOSED GRADE VARIANCE, STA 80+75
SHEET 3 -TEMPORARY CREEK FLOW DIVERSION PLAN
SHEET 4 -DEWATERING PLAN
SHEET 5 -DEWATERING EQUIPMENT DATA

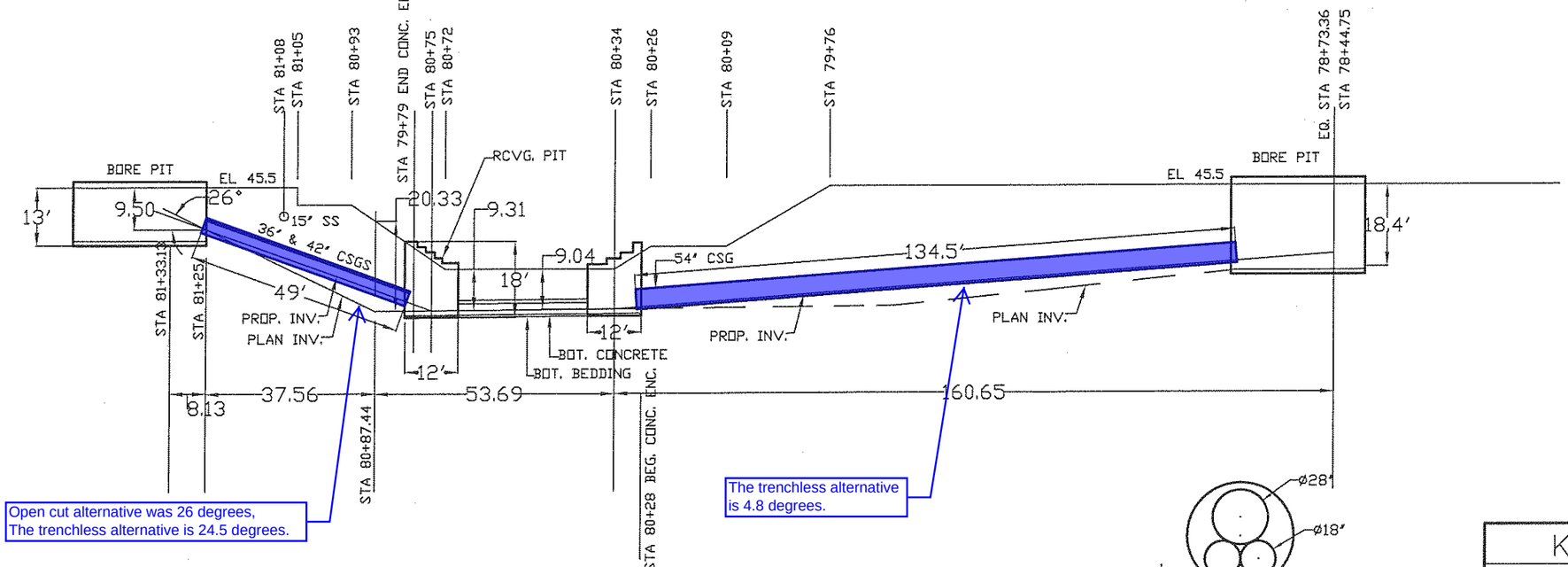
NOTES:
1. SHORING PLANS REFLECTING THESE PLANS WILL BE SUBMITTED UNDER SEPARATE COVER.
2. THESE PLANS ARE INTENDED TO SUPPLEMENT DESIGN DATA IN THE CONTRACT DOCUMENTS. IN CASE OF CONFLICT, DATA AND REQUIREMENTS SHOWN IN DWG PP-7 AND RELATED PLANS AND CONTRACT DOCUMENTS SHALL GOVERN.
3. SEE SHT. 2 FOR PROPOSED DESIGN VARIANCE BETWEEN STATION 80+75 AND 81+25.



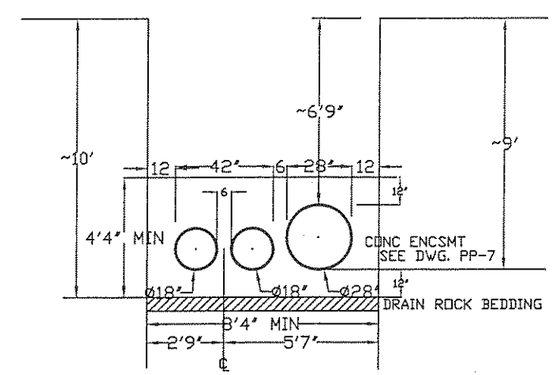
PLAN
1"=30'



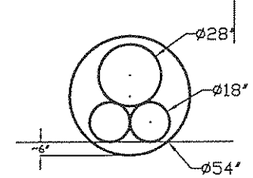
SECTION A-A
NTS



PROFILE ALONG SS ℄
H: 1"=30' V: 1"=30'



SECTION B-B
NTS



SECTION C-C
NTS

K. J. WOODS CONSTRUCTION, INC.		
SAN TOMAS CREEK CROSSING PLAN		
CITY OF SANTA CLARA		
WALSH AVE SS & RW PROJECT		
REV: 1	DATE: 4/6/11	SHT: 1 OF 5

LOG OF BORING B-6

LOCATION: 2400 Walsh Avenue parking lot, west of San Thomas Aquino Creek (see Plate I-2).

GROUND SURFACE: Approx. El. 44.5 ②

DEPTH feet	SAMPLE NO.	TYPE	PENETRATION RESISTANCE blows/ft.	GROUNDWATER	DESCRIPTION ①	MOISTURE %	DRY DENSITY lbs./ft.³	LIQUID LIMIT	PLASTICITY INDEX	GRAIN SIZE Gravel (>#4 sieve) %	GRAIN SIZE Sand (#4 to #200 sieve) %	GRAIN SIZE Fines (<#200 sieve) %	UNCONFINED COMPRESSIVE STRENGTH kips/ft.²	DIRECT SHEAR Cohesion p.s.f.	DIRECT SHEAR Internal Friction Angle
					PARKING LOT: 5 inches asphalt concrete over 5 inches aggregate base										
					FILL - SANDY LEAN CLAY (CL) - dark brown - fine sand - trace gravel and organics - medium plasticity - dry										
5	1		30		**LEAN CLAY (CL)** - very dark gray and gray mottled - trace sand - medium plasticity - very stiff - dry to moist ②③	25	98								
10	2		21		**LEAN CLAY (CL)** - light olive and olive brown mottled - trace gravel - locally contains few to some fine sand - medium plasticity - stiff - moist	22	105						3.74		
15	3		13		**LEAN CLAY (CL)** - dark gray and dark yellowish brown mottled - trace sand - medium plasticity - stiff - moist	26	99								
20	4		13		**LEAN CLAY WITH SAND (CL)** - dark gray and olive brown mottled - fine sand - little to some silt - medium plasticity - stiff - moist	24	101						1.83		
25	5 6		18 23		**LEAN CLAY WITH SAND (CL)** - dark gray and olive brown mottled - trace organics - trace coarse sand/fine gravel sized concretions - little to some silt - wet - stiff to very stiff ②④	24	102								

BORING CONTINUED AT 26.5 FEET ON SHEET 2 OF 2

REMARKS:
① Boring drilled on September 18, 2008. See Plate A-1 in Appendix A for definitions of terms.
② Ground surface and (projected) pipeline/casing elevation data from 95% project plans (RMC, 2008).
③ Gravity-fed sanitary sewer pipeline.
④ Siphon pipelines. Shown at creek undercrossing depth.

DCM | GEOENGINEERS

FILE NO. J-5079-1 | DECEMBER 2008

RMC WATER AND ENVIRONMENT
City of Santa Clara
Walsh Avenue Trunk Sewer Improvements Project
Santa Clara, California
LOG OF BORING B-6

PLATE NO.
B-6
(1 of 2)

LOG OF BORING B-6 (Continued)

LOCATION: 2400 Walsh Avenue parking lot, west of San Thomas Aquino Creek (see Plate I-2).

GROUND SURFACE: Approx. El. 44.5 ②

DEPTH feet	SAMPLE NO.	TYPE	PENETRATION RESISTANCE blows/ft.	GROUNDWATER	DESCRIPTION ①	MOISTURE %	DRY DENSITY lbs./ft.³	LIQUID LIMIT	PLASTICITY INDEX	GRAIN SIZE Gravel (> #4 sieve) %	GRAIN SIZE Sand (#4 to #200 sieve) %	GRAIN SIZE Fines (< #200 sieve) %	UNCONFINED COMPRESSIVE STRENGTH kips/ft.²	DIRECT SHEAR Cohesion p.s.f.	DIRECT SHEAR Internal Friction Angle
25				③	**BORING CONTINUED FROM 26.5 FEET ON SHEET 1 of 2** ② ④										
	7		14		**LEAN CLAY WITH SAND (CL)** - dark greenish gray - trace to few sand and gravel-sized concretions - sand content varies within unit - little to some silt - medium plasticity - stiff to very stiff - wet	24	103						2.51		
	8		15												
30															
	9		23		**LEAN CLAY (CL)** - dark greenish gray - trace fine gravel - few medium to coarse sand - medium plasticity - stiff to very stiff - wet	27	100			0	8	92			
	10		10												
35					**SANDY LEAN CLAY (CL) TO CLAYEY SAND (SC)** - dark greenish gray - fine to medium sand - unit gradually grades coarser with depth (transitions from CL to SC) - medium plasticity fines - very stiff (clay) - medium dense (sand) - wet	20	110								
	11		19												
	12		15							0	50	50			
40					**CLAYEY SAND (SC)** - dark greenish gray - may locally classify as a poorly graded sand (SP) - fine grained sand - medium dense to dense - wet										
	13		30			19				2	85	13			
45					**LEAN CLAY (CL)** - dark greenish gray - trace gray coarse sand sized concretions - medium plasticity - very stiff - wet										
	14		18			19									
50															
	15		15		- locally sandy sections in Sample 15	29									
					BOTTOM OF BORING AT 51.5 FEET										

CORROSION TEST
Sample B6-9
See Plate C-5

FINES
37% Silt
55% Clay

FINES
30% Silt
20% Clay

REMARKS:
① Boring drilled on September 18, 2008. See Plate A-1 in Appendix A for definitions of terms.
② Ground surface and (projected) pipeline/casing elevation data from 95% project plans (RMC, 2008).
③ See sheet 1 of 2 for groundwater notes.
④ Siphon Pipelines. Shown at creek undercrossing depth.

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RMC WATER AND ENVIRONMENT
City of Santa Clara
Walsh Avenue Trunk Sewer Improvements Project
Santa Clara, California
LOG OF BORING B-6

PLATE NO.
B-6
(2 of 2)

LOG OF BORING B-7

LOCATION: 2390 Walsh Avenue parking lot east of San Tomas Aquino Creek (see Plate I-2).

GROUND SURFACE: Approx. El. 45.5 ②

DEPTH feet	SAMPLE NO.	TYPE	PENETRATION RESISTANCE blows/ft.	GROUNDWATER	DESCRIPTION ①	MOISTURE %	DRY DENSITY lbs./ft.³	LIQUID LIMIT	PLASTICITY INDEX	GRAIN SIZE Gravel (> #4 sieve) %	GRAIN SIZE Sand (#4 to #200 sieve) %	GRAIN SIZE Fines (< #200 sieve) %	UNCONFINED COMPRESSIVE STRENGTH kips/ft.²	DIRECT SHEAR Cohesion p.s.f.	DIRECT SHEAR Internal Friction Angle
					PARKING LOT: 5 inches asphalt concrete over 4 inches aggregate base										
5	1		Drilled out to avoid utilities		**FILL - LEAN CLAY (CL)** - very dark grayish brown - locally intermixed with black and olive brown - trace sand and gravel - medium plasticity - dry to moist										
10	2		25		**LEAN CLAY WITH SAND (CL)** - olive brown mottled - fine grained sand - little to some silt - stiff - moist to wet	19	106								
15	3		13			26	98						1.92		
20	4		16		- becoming sandier (gradual transition to unit below)	21	109								
	5		22		**CLAYEY SAND (SC)** - olive brown and dark gray mottled - fine sand - medium plasticity fines - medium dense - wet	19	111								
25	6		17		**LEAN CLAY (CL)** - olive brown and dark gray mottled - trace sand - medium plasticity - very stiff - wet										

BORING CONTINUED AT 27 FEET ON SHEET 2 OF 2

REMARKS:
① Boring drilled on September 17, 2008. See Plate A-1 in Appendix A for definitions of terms.
② Ground surface and (projected) pipeline/casing elevation data from 95% project plans (RMC, 2008).
③ Gravity-fed sanitary sewer pipeline.
④ Siphon Pipelines. Shown at creek undercrossing depth.

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FILE NO. J-5079-1 | DECEMBER 2008

RMC WATER AND ENVIRONMENT
City of Santa Clara
Walsh Avenue Trunk Sewer Improvements Project
Santa Clara, California
LOG OF BORING B-7

PLATE NO.
B-7
(1 of 2)

LOG OF BORING B-7 (Continued)

LOCATION: 2390 Walsh Avenue parking lot east of San Tomas Aquino Creek (see Plate I-2).

GROUND SURFACE: Approx. El. 45.5 ②

DEPTH feet	SAMPLE NO.	TYPE	PENETRATION RESISTANCE blows/ft.	GROUNDWATER	DESCRIPTION ①	MOISTURE %	DRY DENSITY lbs./ft.³	LIQUID LIMIT	PLASTICITY INDEX	GRAIN SIZE Gravel (> #4 sieve) %	GRAIN SIZE Sand (#4 to #200 sieve) %	GRAIN SIZE Fines (< #200 sieve) %	UNCONFINED COMPRESSIVE STRENGTH kips/ft.²	DIRECT SHEAR Cohesion p.s.f.	DIRECT SHEAR Internal Friction Angle
25				③	**BORING CONTINUED FROM 27 FEET ON SHEET 1 OF 2** ② ④										
	7		17		**LEAN CLAY (CL)** - dark greenish gray and olive brown mottled - trace organics in Samples 9 and 10 - unit contains varying amounts of fine to medium sand (i.e., may locally classify as a lean clay with sand) - medium plasticity - stiff to very stiff - wet	22	107						④ 0.70		
	8		9												
30															
	9		25			22	106	35	17					370	27°
					- unit contains thin layers of clayey sand (SC) CLAYEY SAND (SC) - dark greenish gray - fine to medium sand - medium dense - wet					0	4	96	**FINES** 47% Silt 49% Clay		
	10		15												
35															
	11		25			22	105								
	12		15		- becoming coarser (gradual transition to unit below)										
40	13		10		**LEAN CLAY WITH SAND (CL)** - dark greenish gray and olive brown mottled - fine sand - little to some silt - stiff - wet	25									
45	14		11		**LEAN CLAY (CL)** - dark greenish gray - trace to few fine sand - stiff to very stiff - wet	20									
50	15		22			22									
					BOTTOM OF BORING AT 51.5 FEET										

REMARKS:
① Boring drilled on September 17, 2008. See Plate A-1 in Appendix A for definitions of terms.
② Ground surface and (projected) pipeline/casing elevation data from 95% project plans (RMC, 2008).
③ See sheet 1 of 2 for groundwater notes.
④ Unconfined compressive strength artificially low due to presence of a sand layer in the sample.
⑤ Siphon pipelines. Shown at creek undercrossing depth.

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FILE NO. J-5079-1 | DECEMBER 2008

RMC WATER AND ENVIRONMENT
City of Santa Clara
Walsh Avenue Trunk Sewer Improvements Project
Santa Clara, California
LOG OF BORING B-7

PLATE NO.
B-7
(2 of 2)