Draft

Alto Tunnel Scoping Study

Volume II – Engineering Summary and Proposed Supplemental Investigation

Prepared For:

Marin County Department of Public Works

Prepared By:

Jacobs Associates

August 31, 2001

JACOBS ASSOCIATES

Engineers/Consultants

500 Sansome Street San Francisco, CA 94111

(415) 434-1822

TABLE OF CONTENTS

1. INTRODUCTION

The goals of Volume II of this report are as follows:

- Present the findings of the June 5th inspection,
- Summarize the known information about the condition of the uninspected reaches of the tunnel.
- Propose additional investigation actions to further assess the condition of the tunnel.

2. SUMMARY OF TUNNEL CONDITIONS

Volume 1 of the Alto Tunnel Scoping Study contains a detailed history of the tunnel and summarizes all reference materials available at the date of this report. This section of the report summarizes each reach of tunnel as their conditions relate to the recommendations contained in this report. All references made are to documents contained in the Appendices of the Volume 1 report. Attached sketch SK-1 shows a profile of the Alto Tunnel which summarizes many of the conditions discussed in this report.

2.1. NORTH PORTAL INSPECTION

On June 5th, 2001, Marin Country Urban Search and Rescue (USAR) personnel opened the North Portal and an inspection was conducted by personnel from the County of Marin, Quincy Engineering, and Jacobs Associates. Rich Coffin, Mike McRae, and Victor Romero inspected the tunnel for Jacobs Associates

The visible cast-in-place portal structure was built in 1958 and appears to be in satisfactory condition with no visible signs of distress. The invert of the tunnel contained one to three feet of standing water completely covering the former track structure from side to side. This standing water is a result of tunnel inflows and inadequate drainage out of the north and south ends of the tunnel. The plugs and shallow longitudinal tunnel slope contribute to this condition.

The first 30.9 feet of the tunnel appears to be supported by cast-in-place concrete and is in good condition. The structure appears to match the work shown on drawings by Northwest Pacific Railroad (NWPRR) performed in 1958 (Ref. Plan No. 7). The next 139 feet of tunnel is shotcrete lined, which is a sprayed concrete mixture that adheres to underlying surfaces. Gunite is the brand name used for shotcrete contained in most of the reference drawings and reports by Southern Pacific Railroad (SPRR), NWPRR and Copple Foreaker Associates. Sprayed shotcrete can be unreinforced or reinforced as required for proper support loads. Based on visual observations, the shotcrete lining appears to be in good condition with evidence of underlying support at 4-feet on center. The 1981 report by Copple Foreaker (Ref. Rpt/Ltr No. 2) states that there is 139-feet of Gunite lining over 8-inch steel sets; however, no reference is given for this information.

A sample drilling through the shotcrete lining was preformed in 1972 by Kaiser Engineers (Ref. Rpt/Ltr No. 1) and showed a thickness of 6-12 inches with some wire mesh. It is not clear from the available reference documents whether the support showing is placed steel members or the existing timber supports, although there are later reports that the timber was removed. Based on the fact that the shotcrete surface is not tapered over the timber supports suggests that the shotcrete was sprayed directly over the timber supports. We suggest that a sample hole be cored through to the underlying support to confirm the material and check for possible voids behind the lining. Voids may be formed if the timber supports or wood lagging have decomposed behind the shotcrete lining. In addition, this1972 report states that 300-feet of the tunnel had been gunited, while the later references only show a 139-foot length (Plan Refs Nos. 5 and 7). It appears that the true extent of the shotcrete tunnel section cannot be absolutely confirmed until additional access is gained through the lean-mix plug.

It is also possible that the 139-foot shotcrete lined section was installed per standard NWP procedures as shown Plan Reference No. 4. This document shows typical sections and details for installation of a shotcrete lining over reinforcing steel sets. The standard configuration shown consists of removing the timber supports and replacing them with W8x31 steel beams. A minimum 4" thick layer of shotcrete is then applied over the steel beams and reinforced with wire mesh. Again, coring through the lining is the best way to verify the construction and condition of this reach of tunnel.

Approximately 170 feet from the face of the North Portal is the beginning of a concrete plug. According to NWP drawings (Plan Ref. No. 7), the plug is 124-feet long. The Northern end of the plug face is currently covered by a timber bulkhead that consists of horizontal planks (used as the form for the end of the plug) braced by a series of wooden kickers (utility pole size). The bulkhead appears to be intact and is shown below in Figure 2-1:

Figure 2-1. Timber Bulkhead at Face of Concrete Plug

The base of the bulkhead and kickers was not visible due to the standing water in the invert of the tunnel. There are a number of 3 to 6-inch diameter steel pipes visible in Figure 2-2 which protrude from the center-top of the bulkhead. These pipes were probably used to pump the closing portion of lean-mix concrete behind the bulkhead.

Figure 2-2: Top and Center of Timber Bulkhead

2.2. NON-INSPECTED TUNNEL REACHES

The balance of the tunnel was not inspected on June 5th, so the condition of these reaches can only be estimated from information gathered in the reference documents. These reaches and conditions are briefly summarized as follows:

2.2.1. Lean-Mix Concrete Plug (150 to 275 feet from North Portal)

The lean-mix concrete plug installed behind the timber bulkhead appears to be low-strength concrete with a compressive strength of approximately 500-900 psi (based on evidence that mix was "one-sack" from Ltr/Rpt. Ref. No. 5). This plug extends for 123 to 127 feet and may or may not be formed at the back side of the plug. This plug was placed in 1975.

2.2.2. Uncompacted Fill Plug (275 to 445 feet from North Portal)

There is evidence on one of the reference drawings by Copple Foreaker (Plan Ref. No. 5) that a portion of the tunnel behind the concrete plug was filled with uncompacted earthen material. However, there is a significant discrepancy in the documentation of the earth plug. The NWPRR profile drawing revised in February 1982 does not indicate any fill material behind the concrete plug. In addition, the Copple report does not mention any placement of fill materials; consequently, we believe that this fill was never placed. However, until a complete confirmation can be made on the existence of this fill, any work performed by a Contractor through the lean-mix plug should take the possibility of fill materials into consideration. Our cost estimate (Attachment A) includes an alternate total cost which includes this fill, in the unlikely event that there is confirmation that the fill was placed.

2.2.3. Central Tunnel (275 to 1,900 feet from North Portal)

The central reach of the tunnel is timber supported by 5-piece or 7-piece timber supports with lagging. A typical section of the 5-piece timber configuration is shown on Drawing SK-2. The historical spacing of the support is shown in the second profile on Drawing SK-1 and varies from 12 to 60-inches on-center. It is possible that portions of the primary reach of tunnel are now partially or completely filled with water since the installation of the plugs at both ends. It appears that some drainage piping may have been installed during the repairs at the South Portal in 1982 or previously when the tunnel was first abandoned in 1972.

Based on the last inspection reports in 1976 and 1981, there was already evidence of significant decay of the primary timbers and lagging support. The integrity of the timber supports since the complete closure of the south portal in 1982 depends on the atmospheric conditions in the enclosed tunnel reach. If the redwood timbers have been completely submerged, then decay may be occurring slower and much of the support could be in satisfactory condition for access. It is also very possible that the timbers have been partially submerged or exposed to a fluctuating and humid environment, which could be contributing to rapid decay.

2.2.4. South Portal (1,900 to 2,200 feet from North Portal)

The Southern portal area experienced a collapse in January 1982 which resulted in the backfill of over 300-feet of tunnel. Records indicate that 6-holes were drilled and filled with pea gravel with significant quantities of sand slurry placed in holes #2 and #3. As a result, there is no feasible access from the South side to investigate the balance of the tunnel's condition. There is also reported evidence that there was a significant collapse approximately 900-feet from the south portal prior to the 1982 collapse (Ref. Ltr/Rpt. No. 2). Other inspection reports from the 1970's indicated small collapses in the area near the South Portal, which culminated in the 1982 failure adjacent to Underhill Road.

Based on the shallow depth of cover and extent of backfill placed in the 1982 emergency fill operation, we estimate that nearly 400-feet of tunnel may have to be restored or re-mined. It is possible that much of the original tunnel support can be used and augmented with shotcrete; however, it is likely that the area in the vicinity of the 1982 collapse and filled portion South of Underhill Road will have to be rebuilt using surface excavation methods.

3. TUNNEL INVESTIGATION OPTIONS

Based on our observations and the background information collected to-date, it is recommended that the County retain a contractor to mine an exploratory tunnel access through the concrete plug. Other options considered but eliminated are described below:

One method of investigation considered would be to drill a small access hole (12 to 24 inches in diameter) from the surface into the tunnel. These holes could be used to lower small lights and video/camera equipment.

Another method of remote investigation would be to lower an exploratory vehicle from the surface into the tunnel. This would be accomplished by excavating a small shaft (approximately 8 feet in diameter) from the surface. This method would be expensive and might result in extremely limited data recovery, since it is possible that the tunnel could be impassible within just a few feet from the access shaft.

The biggest drawback to all remote investigation is the likelihood that there will be limited data recovery for the costs expended (i.e., poor cost/benefit ratio). Consequently, we do not recommend proceeding with any remote investigations from the surface into the tunnel at this time. It is possible that future geotechnical investigations may include the need for subsurface borings; however, the purpose of this work would be purely for engineering design and not for investigation of tunnel conditions.

3.1. RECOMMENDED ACTION

As discussed at our informal meeting after the inspection on June 5th, we believe the most efficient way to obtain additional information about the existing condition of additional reaches of the tunnel is to excavate through the backfill plug from the North end. The purpose of this work would be as follows:

- Determine the condition of the tunnel behind the plug, including the presence of water. This additional exploration could proceed as far as practical based on lining conditions and cost limitations.
- Confirm the extent of the lean-mix concrete plug, and determine if uncompacted fill was ever placed.
- Obtain information about the support configuration and thickness of the Gunite lining reach.

This approach would involve the following construction effort:

1. Mobilization and site preparation: Contractor (perhaps in conjunction with USAR crew) obtains access to site from Manzanita Road.
2. Dewatering: Most of North Portal steel "door" will be removed and water pumped out of tunnel invert to suitable location downstream.
3. Tunneling through the lean-mix plug: Partial or complete removal of the existing wood bulkhead. Excavation and support of approximately 150 linear feet of tunnel. See discussion below.
4. Ventilation: Contractor will have to provide suitable (active) ventilation during all work performed and in accordance with CalOSHA.
5. Demobilization and closure of tunnel: Tunnel should be closed for safety (replace existing door or provide new door). If excessive water or poor ground conditions are encountered behind the plug, then it may be necessary to abandon the tunnel and backfill the excavated plug with lean mix or cellular concrete.

The above work should be performed in the dry season to minimize the dewatering and site access constraints.

3.1.1. Anticipated Excavation Methods for Exploratory Tunnel

Excavation of an exploratory tunnel through the backfill plug at the north end of the Alto Tunnel would be most efficiently performed by roadheader equipment. Although excavation by drill-and-blast methods is technically feasible, the proximity of the tunnel to residential structures would probably preclude the use of explosives for environmental reasons. In addition, it is anticipated that excavation by a tunnel boring machine (TBM) would not be economically feasible for the lengths of excavation that would be involved.

Although roadheaders come in a variety of sizes and configurations, most roadheaders consist of a rotary cutterhead equipped with picks that are attached to a hydraulically operated boom, which in turn is mounted on a base frame, as shown in Figure 3-1. Handling of excavated materials (i.e., muck) is usually accomplished by an apron loader that transfers muck onto a short conveyor. The conveyor can dump into muck cars for transport out of the tunnel. The entire cutter, boom, frame, apron, and conveyor assemblies are usually mounted on either crawler tracks or rubber tires for propulsion.

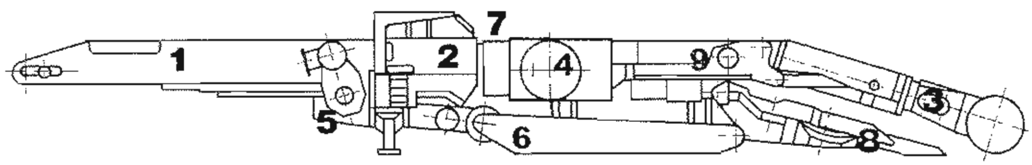


Figure 3-1. Roadheader Components (1-conveyor 2-operator's cab 3-cutterhead 4-electrical 5-base fame 6-crawler track 7-hydraulics 8-apron loader 9-turret)

Most roadheaders can excavate rock with an unconfined compressive strength of 10,000 to 15,000 psi. They are most efficient in rock with strength of less than 5,000 psi, but can cut rock from 22,000 to 30,000 psi for a limited duration, depending on the power of the roadheader. Based on a review of construction records, it is anticipated that the 124-foot long lean-mix concrete plug placed at the north end of the Alto Tunnel would exhibit strength of approximately 700 psi, and thus would be easily excavated by a roadheader. A photo of a roadheader excavating 3,000 psi rock in Napa County is shown in Figure 3-2.

Figure 3-2. Roadheader Excavation in 3,000 psi Rock in Napa County

As discussed above, it is possible (although unlikely) that a 170-foot long "fill" plug consisting of uncompacted earth material was placed beyond the 124 foot long concrete plug. If such a fill plug exists and has cohesion, a roadheader should have no difficulties in excavating this material. If fill plug material has no cohesion (i.e. sand), excavation by light earthmoving equipment (e.g., Bobcat excavator) may be necessary.

It is recommended that before each round of excavation, a 2-inch probe hole be systematically drilled ahead of the excavation to detect unstable conditions in the lean-mix plug or "fill" plug, and to detect water, since the tunnel downgrade from the end of the plug could be flooded with water.

3.1.2. Anticipated Exploratory Tunnel Support

As described elsewhere in this report, most of the Alto Tunnel is supported by timber sets blocked against exposed rock. Various historical documents for the Alto Tunnel also indicate that Gunite was used for supplemental tunnel support, primarily near the north portal. Gunite is an older term used in reference to dry-mix, fine aggregate concrete pneumatically projected onto a surface at high velocity. The more generic term, shotcrete, is commonly used today to refer to both wet-mix and dry-mix concrete with up to 3/8 inch aggregate that is pneumatically placed.

The exploratory tunnel can be excavated through the lean-mix concrete plug such that the crown and sidewalls of the exploratory tunnel consist of plug concrete that is at least 12 inches thick (see Figure 3-3). It is anticipated that the plug material will be self supporting and will only require supplemental support in localized zones where water or other weak materials have compromised the structural integrity of the lean-mix concrete. We recommend that the exploratory tunnel contractor be prepared to place shotcrete for support in these areas.

For possible excavation in the "fill" plug, supplemental shotcrete support should be anticipated in portions of the tunnel crown.

Due to access restrictions at the north portal, it is likely that dry-mix shotcrete would be used for support in the exploratory tunnel, as dry-mix concrete can be batched on site as needed. Wet-mix shotcrete would require a larger batch plant on site or could be delivered by ready-mix concrete trucks, however this would require foreknowledge of any supplemental support requirements, a condition that may not always be detected by probing ahead of the excavation.

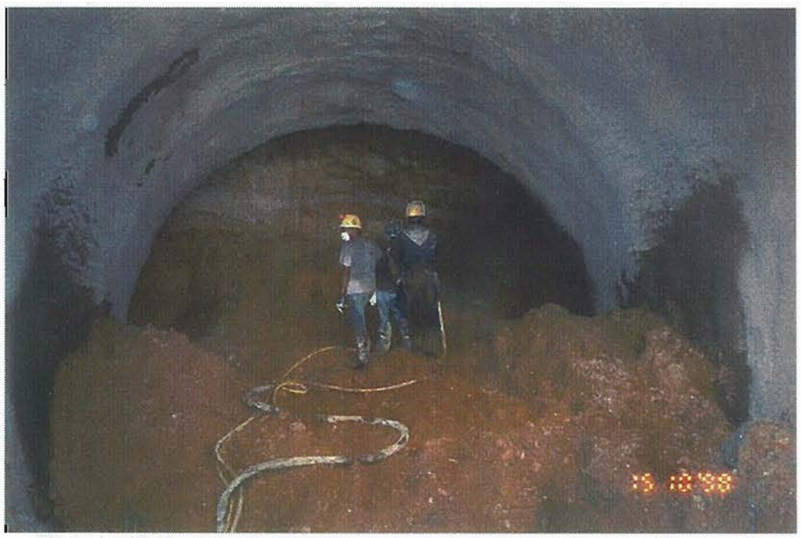


Figure 3-3. Typical Shotcrete Application in Tunnels

4. INSTRUMENTATION

Although careful excavation and timely installation of support in the exploratory tunnel is not anticipated to adversely impact structures above the tunnel, we recommend implementation of a geotechnical instrumentation and monitoring program to warn of any ground movements generated by the tunneling. This instrumentation should be installed before tunnel construction begins to establish a baseline measurement. Monitoring would then take place during and after tunnel construction. This instrumentation would be installed near the homes on Stetson Avenue to monitor the following:

- Surface settlement
- Subsurface ground movement
- Surface vibrations

Subsurface ground movements are most accurately and economically measured with Multiple Point Borehole Extensometers (MPBX). These devices are fixed borehole extensometers that measure the changing distance between an anchor point within a borehole and a reference point, usually the collar at the top of the borehole. The distance measured between the anchor point and the reference point is a relative distance, but absolute movements can be measured if the location of the extensometer reference point can be determined with respect to a fixed reference point. These types of extensometers are usually composed of steel or fiberglass rods that do not require movable probes for measurement of movements. Often several fixed borehole extensometers are installed in a single borehole at various depths, as shown on Drawing SK-4. These types of MPBX's can grouted into small bore holes drilled from the surface, and are easily read using a digital caliper, as shown in Figure 4-1.

The advantage of multi-point monitors is that they can detect movements closer to the crown of the excavation, often prior to any detection at the surface. If excessive movements were detected, then excavation could be halted and the situation evaluated. This would ensure that adjacent properties would not be subject to any significant ground movements.

Figure 4-1. Monitoring of MPBX Over a Tunnel

Surface settlements can be measured by traditional leveling methods using pre-set benchmarks. In addition, the top of the MPBX casings should be measured for settlement. Level accuracy should be within plus/minus 2 mm. Surface vibrations can be measured using a battery operated seismograph.

5. COST ESTIMATE

We recommend that the County pursue this exploratory contract on a unit price bid structure and allow a contingency for some additional work in conjunction with the Contract. This may include additional mining, exploration, or installation of support beyond the concrete plug. The conditions behind the plug can be evaluated after the completion of the mining and a determination made as to the practicality of additional investigations.

The details of the cost estimate for the exploratory tunnel are contained in the spreadsheet Attachment A. The total estimated cost for design, construction, geotechnical monitoring and construction management of the exploratory tunnel work is approximately $317,000. This final cost includes a construction contingency of 15% for the unknown conditions present in almost all tunneling. As mentioned in Section 2.2.2 of this report, an alternate cost estimate is provided for the unlikely determination that the uncompacted fill referenced on the Copple drawing was placed as shown.

The following assumptions regarding exploratory tunnel construction were used in the cost estimate:

1. Complete removal of steel bulkhead at the portal and replacement with an expanded steel bulkhead after tunnel construction. Complete removal of wood bulkhead and partial replacement after tunnel construction.
2. The exploratory tunnel will be excavated through 124 feet of lean-mix concrete backfill.
3. Approximately 20% of the tunnel through the lean-mix plug will require supplemental support in the form of 4-inches of unreinforced shotcrete placed above springline.
4. If the uncompacted backfill exists behind the lean-mix plug, then the exploratory tunnel would be extended and 100% of the tunnel through the uncompacted backfill will require support in the form of 6 inches of shotcrete around the entire tunnel periphery, reinforced with welded wire fabric.
5. Dewatering of portal site and exploratory tunnel both prior to and during construction.
6. Temporary ventilation for the duration of tunnel construction and inspection of the main tunnel.
7. Allowance for complete backfill of exploratory tunnel with lean-mix or cellular concrete at the conclusion of inspection of the main tunnel.
8. Geotechnical monitoring equipment and personnel will be required as detailed.
9. Engineering design and on-site construction management will be required.

6. CONCLUSIONS

Based on the information reviewed to-date and observations from the June 5^{th} inspection, we recommend that the most cost effective step to obtain additional information about the condition of the tunnel is to mine through the lean-mix plug as discussed above. Without additional information on the lining condition, it is impossible to develop a design that can be realistically estimated without a 50-100% contingency.

Although other exploratory methods may be equal or lower in cost, the work performed in conjunction with the exploratory tunnel is all work that would be required for final rehabilitation of the Alto Tunnel. As discussed in Section 3, other surface exploration methods may reveal very little information relative to the cost, while the exploratory tunnel method has the potential to reveal significant amounts of information about the condition of the northern and central portions of the tunnel.

It should be noted that there is the possibility that the condition of the existing lining behind the plug is quite poor and that the resulting access for inspection is not far beyond the excavated plug. In this case, further evaluation will have to be made as to the possible extent of the poor ground support and the practicality of doing further repairs to the lining to allow additional access and inspection.

As discussed in our June 5th meeting, the more tunnel reaches that are available for direct inspection, the greater the ability to accurately design and estimate feasible reopening solutions. We are hopeful that the information obtained from tunneling through the lean-mix plug and performing a direct inspection will be adequate to develop a feasibility study that is acceptable to meet the funding and political constraints of the project.

ATTACHMENT A

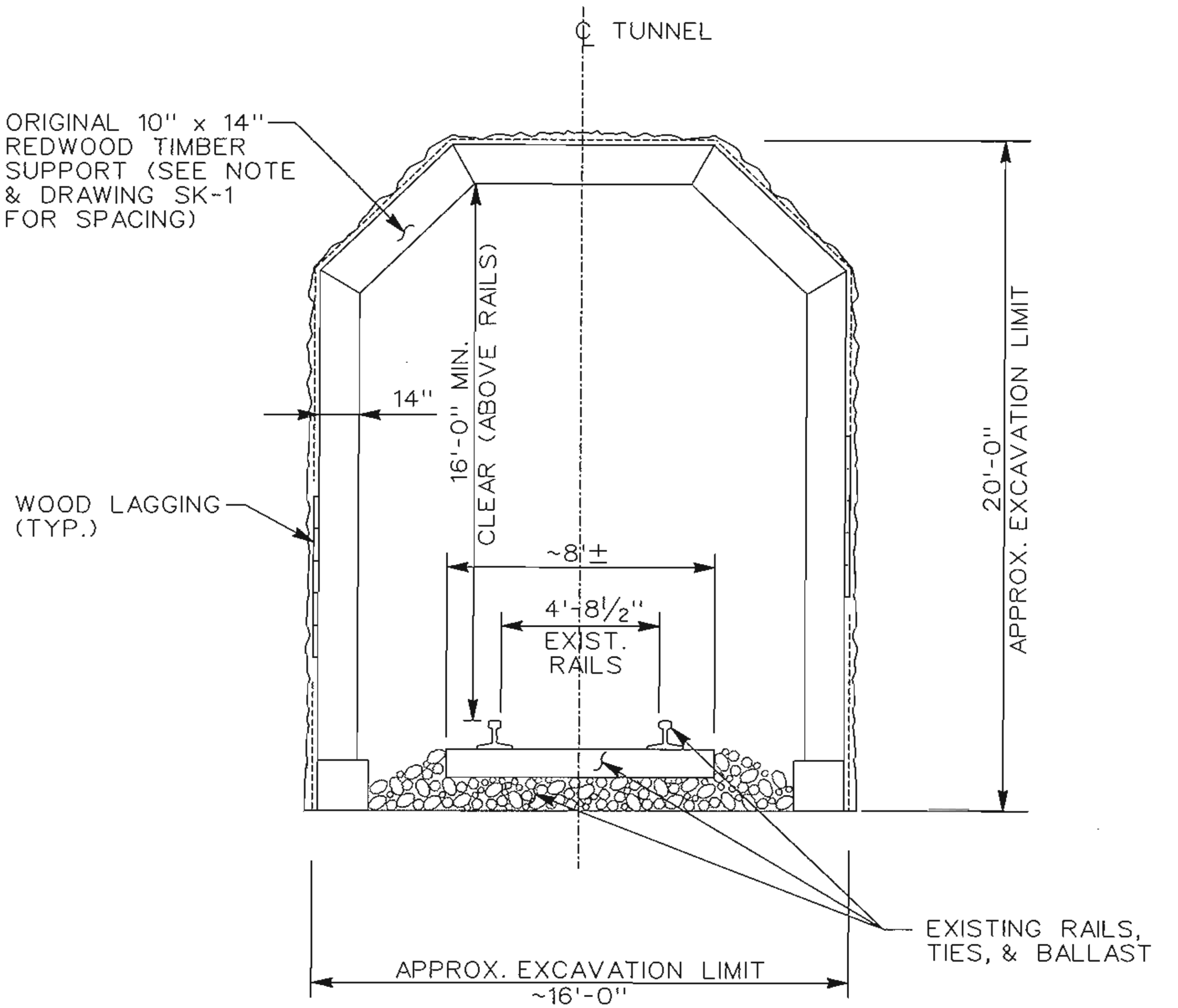
Activity	Note	Quantity	Unit Cost	Total Cost	Duration	
Mobilize		1 LS		$20,000	5 day	
Remove steel bulkhead at east portal		1 LS		$5,000	2 day	
Remove wood bulkhead at sta 217+67		1 LS		$5,000	2 day	
Pull and stockpile rail + ties		1 LS		$10,000	2 day	
Construct 15% ramp to expl. tunnel	1	100 CY	$50 /CY	$5,000	*2 day*	
Excavate tunnel thru Lean-mix plug	2	124 LF	$1,200 /LF	$149,000	10 day	
Excavate/stockpile uncompacted backfill	*3*	*1620 CY*	*$30 /CY*	*See Note 8*	10 day	*$49,000*
Haul 50% of uncompacted backfill to dump	*4*	*810 CY*	*$20 /CY*	*See Note 8*	incl.	*$16,000*
Fill lean-mix plug on completion	5	410 CY	$30 /CY	$14,000	5 day	
Repair/reinstall steel bulkhead at portal	6	1 LS		$8,000	3 day	
Drill 36" vent hole at sta 260+00 and plug	7	85 LF	$120 /LF	$10,000	3 day	
~~Temp. 2000 lf bagline and 40hp fan/genset~~	~~7~~	~~LS~~		~~$21,000~~	7 ~~day~~	
Subtotal				**$206,000**	**34 days**	*44 Days*
Contingency for Unknown Constrcution conditions		15% CONSTR.		$31,000		
Subtotal PROVIDE ACCESS TO TUNNEL				**$237,000**	**Say 2 months**	
Survey Support		1 MO	$12,000 /MO	$12,000		
Geotech Monitoring		1 MO	$7,000 /MO	$7,000		
Construction Management		2 MO	$20,000 /MO	$40,000		
Design Services		10% CONSTR.		$20,600		
Subtotal SERVICES DURING CONSTRUCTION				**$79,600**		
TOTAL				**$316,600**		
TOTAL (w/backfill removal contingency)				*$397,850*		

Notes/Estimate Assumptions

1 Import material. If uncompacted backfill not behind plug, can delete this work and drive tunnel at grade
2 Roadheader with nominal shotcrete support
3 170 ft reach. Use LHD to stockpile between station 217+67 and east portal.
Assume material is not self supporting-i.e., 16'w x 10'h but readily excavated.
Ramp down at 10%
4 Insufficient stockpile capacity in tunnel.
5 Build 2 bulkheads and construct 120ft plug with tunnel muck. Note-If there is no uncompacted backfill, will need to furnish/place concrete at a premium of $130/cy x 410 cy or $54,000 over what is shown
6 Refurbish and reuse existing bulkhead.
7 Assume natural ventilation will work, otherwise, have to string bagline and supply a fan/genset
8 This item is not required if 170 LF of Backfill is not present behind lean-mix plug. Add 5k for Ramp-down

NOTE:

5-PIECE TIMBER SECTION SHOWN PER PLAN REF No. 7. NWP TYPICAL AS-BUILT (PLAN REFERENCE No. 2) INDICATES 7-PIECE CONFIGURATION.



SECTION THRU ORIGINAL TUNNEL

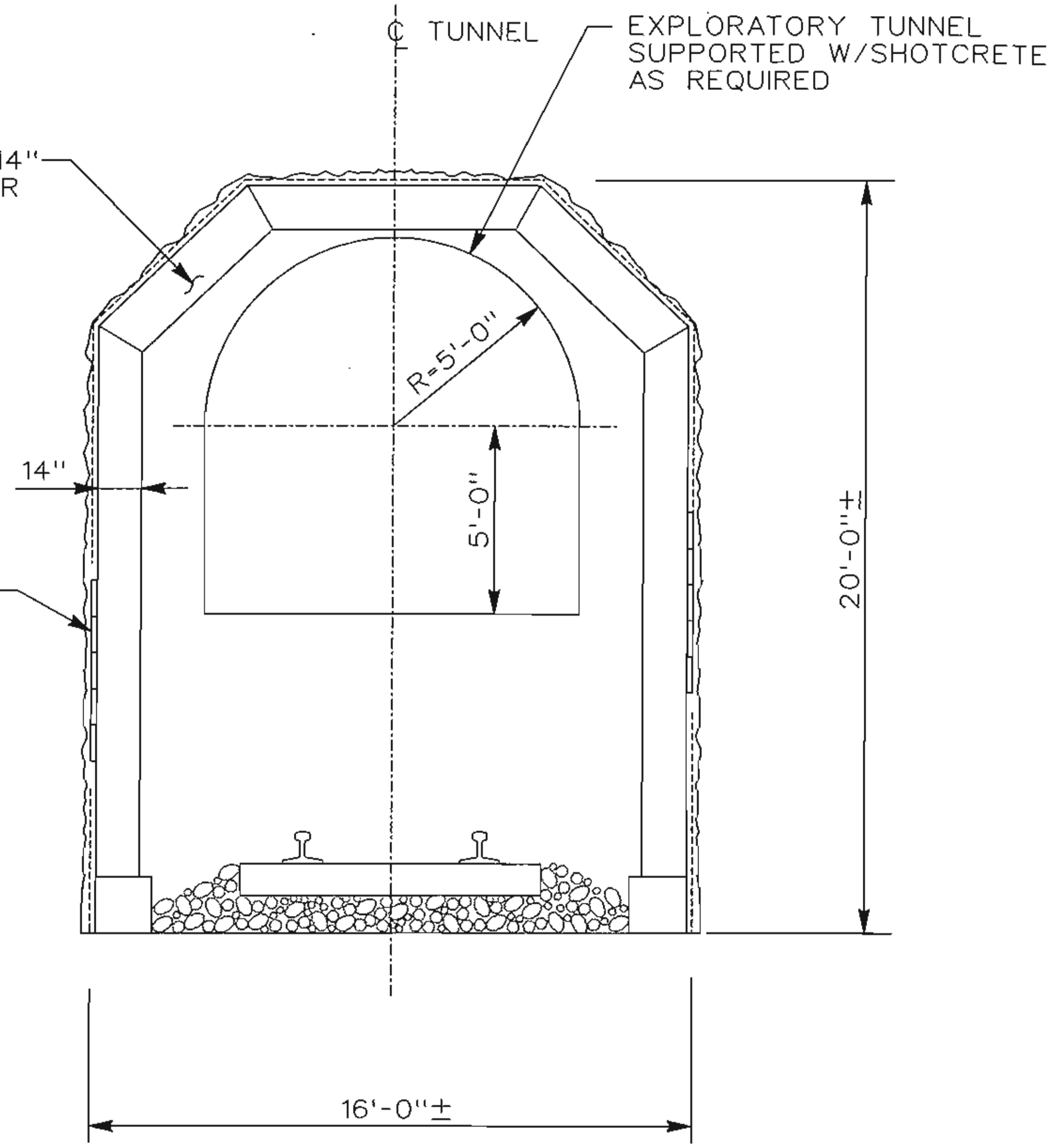
SCALE: 1"=5'-0"

SECTION A SK-1

SCALE: 1"=5'-0"

DRAFT

DRAWN BY D.H.	JACOBS ASSOCIATES	COUNTY OF MARIN ALTO TUNNEL - MILL VALLEY/ CORTE MADERA, CALIFORNIA	JOB NO. 3696
DATE 08/30/01	Engineers/Consultants 500 SANSOME STREET SAN FRANCISCO, CA 94111-3275	PRELIMINARY SCOPING STUDY EXISTING TIMBER LINING	DWG NO. SK-2

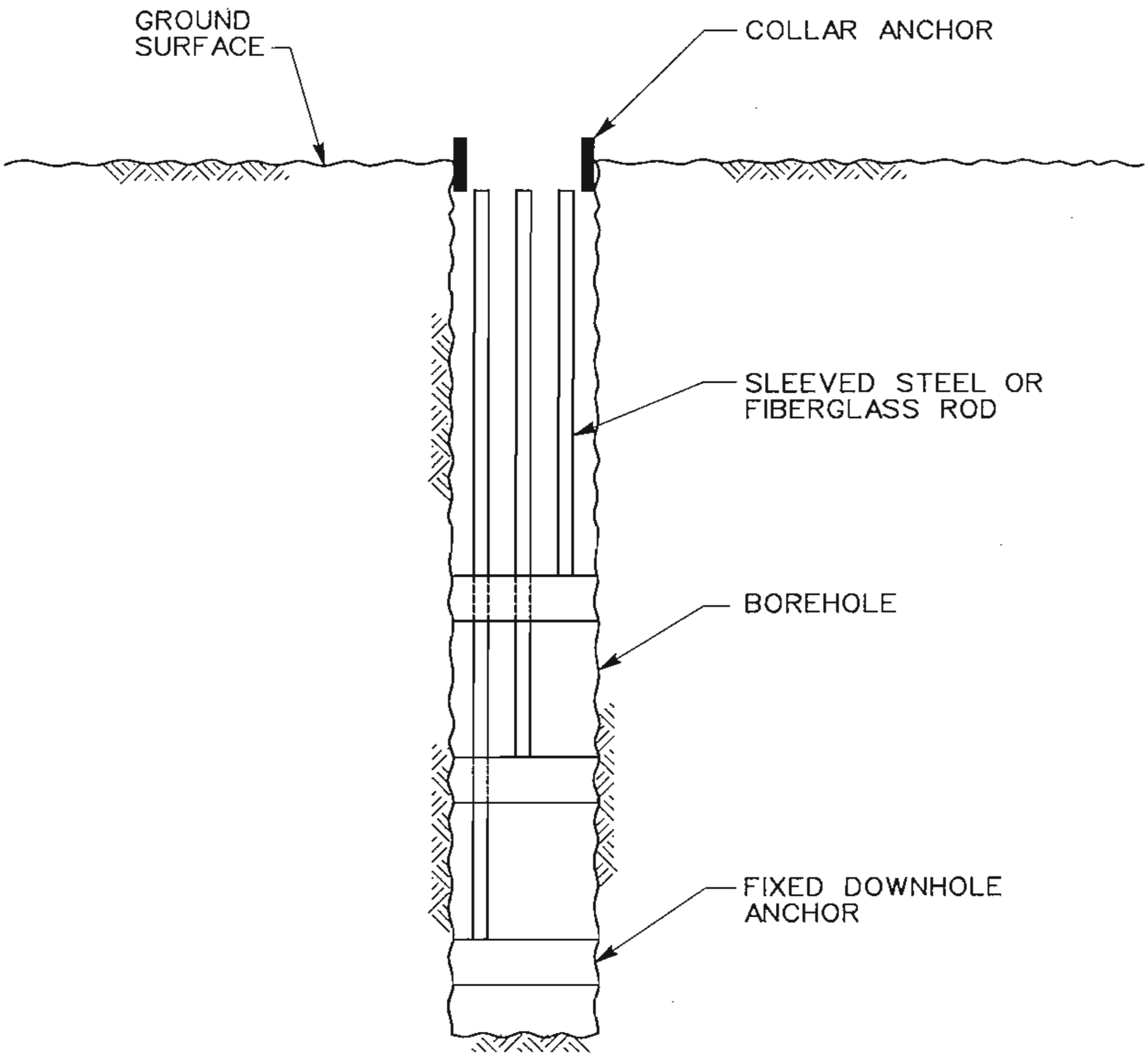


SECTION THRU ORIGINAL TUNNEL

SCALE: 1"=5'-0"

DRAFT

DRAWN BY D.H.	JACOBS ASSOCIATES	COUNTY OF MARIN ALTO TUNNEL - MILL VALLEY/ CORTE MADERA, CALIFORNIA	JOB NO. 3696
DATE 08/30/01	Engineers/Consultants 500 SANSOME STREET SAN FRANCISCO, CA 94111-3275	PRELIMINARY SCOPING STUDY PROPOSED EXPLORATORY TUNNEL	DWG NO. SK-3



MULTIPLE POINT BOREHOLE EXTENSOMETER (MPBX)

SCALE: NONE

DRAFT

DRAWN BY D.H.	JACOBS ASSOCIATES	COUNTY OF MARIN ALTO TUNNEL - MILL VALLEY/ CORTE MADERA, CALIFORNIA	JOB NO. 3696
DATE 08/30/01	Engineers/Consultants 500 SANSOME STREET SAN FRANCISCO, CA 94111-3275	PRELIMINARY SCOPING STUDY MULTIPLE POINT BOREHOLE EXTENSOMETER (MPBX)	DWG NO. SK-4