

**Barnard Impregilo SA Healy JV
Central Subway Project, C1252
Tunnel Contract
Fee Proposal for Alternative
Retrieval Shaft Location Design**

Rev 1 | March 1, 2013

This report takes into account the particular instructions and requirements of our client.

It is not intended for and should not be relied upon by any third party and no responsibility is undertaken to any third party.




Job number 219434

Arup North America Ltd
560 Mission Street
Suite 700
San Francisco 94105
United States of America
www.arup.com

ARUP

Document Verification

ARUP

Job title		Central Subway Project, C1252 Tunnel Contract		Job number		219434	
Document title		Fee Proposal for Alternative Retrieval Shaft Location Design		File reference			
Document ref							
Revision	Date	Filename	2013-03-01 PCC 1252-10 Alternate Shaft Site Proposal.docx				
Rev 1	Mar 1, 2013	Description	First draft				
			Prepared by	Checked by	Approved by		
		Name	Luis Piek	Jon Hurt	John Eddy		
		Signature					
		Filename					
		Description					
			Prepared by	Checked by	Approved by		
		Name					
		Signature					
		Filename					
		Description					
			Prepared by	Checked by	Approved by		
		Name					
		Signature					
		Filename					
		Description					
			Prepared by	Checked by	Approved by		
		Name					

		Signature			
--	--	-----------	--	--	--

Issue Document Verification with Document



1 Introduction

Barnard/Impregilo/Healy Joint Venture (BIHJV) is currently constructing the Central Subway Project C1252 Tunneling Contract in San Francisco, California for the City and County of San Francisco's (City) Municipal Transportation Agency (SFMTA). The SFMTA has issued a Proposed Contract Change (PCC) number 1252-10, Relocation of TBM Retrieval Shaft, dated January 9, 2013. BIHJV has asked Arup North America Ltd. (Arup) to provide scope, schedule and budget for providing engineering design services for the PCC 1252-10.

This proposal is based on the Conformed Contract Documents for the Third Street Rail Program Phase 2 – Central Subway Tunneling (Contract No. 1252) and the associated Contract Documents issued by the City and County of San Francisco Municipal Transportation Agency. The Contract Documents consist of the conformed drawings dated January 21, 2011, the Geotechnical Baseline Report Rev 0 dated February 21, 2011, and the Specifications dated February 2011. Use of the term "Contract Documents" in this proposal is a reference to those documents.

2 Project Understanding

The project involves the construction of approximately 1.7 miles of twin bore tunnels beginning under 4th Street at approximately Bryant Street and originally terminating at Columbus Street between Union Street and Filbert Street. The Contract scope of work also includes five cross passages along the alignment, a launch box, a retrieval shaft for the Tunnel Boring Machines (TBM), permanent portal structures and protective measures for Third Parties' assets.

The SFMTA has issued a proposed contract change (PCC) number 1252-10 entitled Relocation of TBM Retrieval Shaft, dated January 9, 2013. The purpose of this proposal was to initiate design activities, including the design criteria, schematic demolition plans for the Pagoda Theater, and to attend site visits and meetings as needed. Arup has prepared a lump sum bid price for professional design services for final design of the shaft relocation to be included in the bid submission by BIHJV to the SFMTA.

3 Proposed Scope of Work

BIHJV has requested the following Scope of Work, Budget and Schedule from Arup North America Limited.

3.1 Scope of Work and Deliverables

Based on PCC 1252-10 and our review, the scope of work envisioned for Arup as the designer for BIHJV will consist of the following items.

3.1.1 General Scope

Task 1: Final Design Criteria

The Preliminary Design Criteria for PCC 1252-10 prepared under a separate contract will be updated to form the Final Design Criteria following receipt and resolution of the SFMTA and BIHJV comments. The criteria includes design requirements for the retrieval shaft and the lining design of the additional length of tunnel, the design specifications for the retrieval shaft, shaft cover, temporary bulkhead, the required permanent reinforced concrete bulkhead of each tunnel on the Public Right of Way side of the Property Line, site restoration, and related works in accordance to the existing specifications for the C1252 Tunneling Contract where applicable.

3.1.2 Geotechnical and Tunneling Scope

Task 2: Geotechnical Desk Study

The proposed geotechnical desk study will consist of a review of existing information. This will include the documents for Contract 1252, existing information available for 1731-1741 Powell Street prepared by Treadwell and Rollo and dated December 1, 2008 and public documentation available from the City of San Francisco records department. Assistance by SFMTA in obtaining any available information, including all reports for the C1252 and C1300 contracts will be required to facilitate completion of this task. The deliverable will be a Geotechnical Desk Study Report.

Task 3: Geotechnical Investigation and Report

Arup will contract with a ground investigation company for two additional boreholes, one located in close proximity to the retrieval shaft, and another at the retrieval shaft location to verify the soil conditions and to determine the bedrock level. For timely receipt of subsurface information needed to undertake the design, the ground investigation must be carried out within two weeks of the Notice to Proceed. BIHJV will provide access to the site to meet this tight schedule. The first borehole will be performed in advance of the demolition works, while the second will be performed as soon as possible following building demolition.

The geotechnical investigation will characterize the soil and bedrock in the proposed retrieval shaft location. Boreholes will have to extend at least 15 feet below the toe of the shaft wall or 15 feet into bedrock, whichever is deeper. A depth of 100ft has been assumed. Standard penetration tests will be performed in soils. One borehole will include suspension logging and shear wave velocity testing. Soil and bedrock core samples will be retrieved for laboratory testing.

Risks of the presence of contaminated soils will be investigated through the State of California's database. Risk mitigation measures shall be developed in close collaboration with BIHJV, if required.

The obtained subsurface information will be presented in a Geotechnical Data Report for the retrieval shaft relocation and will also be utilized to verify the baseline conditions provided in the C1252 Geotechnical Baseline Report.

Task 4: Design of Temporary TBM Retrieval Shaft and Cover

The retrieval shaft will be re-located within the boundary of the 1731-1741 Powell Street property. The shaft layout shall be defined with the assistance of BIHJV to meet the project requirements and the construction constraints. In particular, the size of the shaft will be function of the horizontal alignment of the running tunnels and the spatial requirements advised by BIHJV to safely retrieve the two TBMs from the shaft.

The temporary retrieval shaft will be sized and designed in accordance to the contractor's preferred method of construction and in accordance with industry practice. It should be noted that while the shaft is defined as a temporary structure, some design load cases (e.g. seismic loading) will need to be checked in consideration of the expected design life of the shaft.

The shaft design shall also include provisions for breakout of the TBM tunnel into the shaft. The preliminary shaft design indicates a single row of Controlled Density Fill (CDF) Piles to be installed in front of the shaft wall where the TBMs will penetrate into the retrieval shaft. These CDF piles will be included at the request of the BIHJV as a means and methods for TBM entry and do not constitute a part of the Arup design. Therefore Arup takes no responsibility for the adequacy of these piles to allow safe entry of the TBMs, including the formation of a seal to prevent ground or groundwater inflows, or prevent ground loss and settlement.

At the direction of the SFMTA representative Ross Edwards on February 19, 2013 the shaft cover shall be designed for typical roof loading with no provision for traffic loading.

The deliverable will be a report and drawings for the shaft including the shaft walls, temporary and permanent bracing, invert slab, and the shaft cover.

Once the final design has been approved, Arup will review the shop drawings of the secant piles, temporary and permanent bracing arrangement, waterproofing, shaft cover, and temporary bulkhead for compliance with our design.

Task 5: Segmental Tunnel Lining Verification

The extension of the TBM tunnel section will require the verification of the segmental lining design over the length of the extended alignment. This scope of work will require the interpretation of the existing geotechnical information, state of stress analysis for the tunnels, and checking of the lining structural capacity. *It is assumed that the design for temporary and permanent loads for the original alignment will also be applicable to this section.*

The final horizontal and vertical alignment of the TBM tunnels will be developed and provided to BIHJV.

The deliverable will be revised alignment drawings, and adjusted segment design drawings, if required.

Task 6: Permanent and Temporary Concrete Bulkheads Design

The design of the concrete bulkheads shall be carried out to provide the required temporary protection to the running tunnels at completion of the C1252 Tunneling Contract. It is foreseen the bulkhead will be designed to carry full ground and water loads and the wall shall include waterproofing details to protect the running tunnels from any water infiltration.

A temporary bulkhead will need to be built within the first TBM tunnel to allow for flooding and backfill of the retrieval shaft a second time.

The deliverable will be drawings for the bulkheads.

Task 7: Site Visits to Existing Buildings for Construction Impact Report

Arup will perform site visits to the surrounding buildings to assess the general structural condition of the buildings and to confirm that the record drawings on file with the City of San Francisco generally reflect the construction of the buildings. The site visits will be performed once Arup has received all of the building information from the City. One visit to each building is planned, with a maximum of two visits to each building. No visits during construction are included in this scope.

Task 8: Settlement Analyses - Shaft Construction and TBM Arrival

The shaft location and size as well as the section of the running tunnels modified for the shaft re-location shall be evaluated for ground movement analysis. The purpose of this analysis is to calculate the effects of the shaft and TBM excavation on the existing buildings and utilities.

The deliverable will be a contour plan for the site based on an agreed volume loss provided to Arup by BIHJV.

Task 9: Construction Impact Assessment of Existing Buildings and Utilities

For all buildings and utilities the maximum settlement and induced distortion shall be determined and included in a report. The buildings and utilities in proximity of the newly proposed retrieval shaft will be analyzed for the combined effect of the shaft excavation and the TBM tunnel construction. It is assumed that BIHJV will provide the recommended performance parameters for the TBM in proximity of the retrieval shaft to complete this analysis.

If the induced movements exceed predicted displacements at a predetermined period during construction per the ground movement analysis and per the Contract Specification, a strategy to address the risk of excessive settlement will be developed with BIHJV. For the purposes of our scope and fee, it has been assumed that compensation grouting will be the preferred solution to control settlements.

The deliverable will be a Construction Impact Assessment Report for the site.

Task 10: Settlement Mitigation

Based on the resulting information from the Construction Impact Assessment Report as described previously, mitigation measures to limit or compensate for movement caused by shaft construction and/or passage of the TBMs will be developed and designed. While the extent of the potential for damage to the existing buildings is unknown at this time, this scope has been developed assuming that compensation grouting is BIHJV's preferred method of mitigating settlement.

The deliverable will be a Compensation Grouting Design for the site.

Task 11: Instrumentation and Monitoring Plan

The Instrumentation and Monitoring Plan shall first require BIHJV to establish baseline geospatial locations for adjacent buildings; improved surfaces such as roads, sidewalks, driveways; and utilities. Instrumentation to monitor the locations and conditions of these facilities will then be developed and may include, but not necessarily be limited to building settlement prisms, surface settlement points, utility monitoring points, inclinometers, and observation wells. The instrumentation shall be designed to detect movements associated with the demolition of the building, construction of the retrieval shaft and the additional tunneling. The data obtained from the instrumentation shall be managed in accordance to the Specifications for Contract 1252. The proposed instrumentation and monitoring shall be combined and managed by BIHJV's existing monitoring contractor, Wang Technologies.

Wang Technologies is responsible for all aspects of gaining access to and observations of facilities prior to and during the construction by BIHJV. Wang Technologies is also responsible for all permitting and permissions to enter property. Wang Technologies will install the instrumentation, collect the data on a real-time basis, and distribute the data immediately via internet portals that are readily accessible by Arup.

The Arup deliverable will be an Instrumentation and Monitoring Plan that includes the extended tunnel and facilities adjacent to the Pagoda Theater and surroundings as well as BIHJV's shaft excavation and TBM tunnel work and ground support work at the retrieval shaft. Adjustments to the specifications will be included, as required.

3.1.3 Structural Scope

Task 12: Demolition Support for 1731-1741 Powell Street

Under a separate agreement, Arup provided schematic demolition plans on February 6, 2013 suitable for starting but not completing the permitting process with the City. These schematic demolition plans reflect the particular instructions and requirements of BIHJV for demolition of the Pagoda Theater located at 1731-1741 Powell Street in San Francisco, CA in order to construct a retrieval shaft for the TBMs. The schematic demolition plans are intended only to start the permitting process and shall not be used for any other purpose. Further, these

drawings are not intended for, and shall not be relied on by, any third party and no responsibility is undertaken to any third party in relation to same. Arup shall interface with BIHJV's demolition sub-contractor once that sub-contractor has been selected.

3.1.4 Civil Scope

Task 13: Traffic Control Plans

Traffic Control Plans will be completed for three phases of work: Demolition, Construction, and TBM retrieval. All plans will be prepared at 1" = 20' scale. Information shall be limited to what is available from record drawings and as-builts and as provided to Arup by BIHJV. In order to meet schedule, this proposal assumes that the demolition and construction Traffic Control Plans will have an expedited review and acceptance process with the SFMTA of two weeks for both plan sets.

Task 14: Site Restoration

Site Restoration of 1731-1741 Powell Street will be included. This assumes the site is to be left empty with the shaft walls at or slightly above grade. A finish of 3" crushed gravel will serve as the final base with a catchment for stormwater that will drain into the existing City system. A sump in the shaft may be required. This sump will discharge into the City's stormwater system. Permanent power will be required for the sump. The design of the power supply is not within Arup's scope of work.

3.1.5 Clarifications and Exclusions

The following are not included in our scope of work:

- Any construction phase services.
- Any role for building monitoring or interpretation of data pertaining to building, utility, or ground movements.
- Any necessary permits to complete the work, including geotechnical borings.
- Roadway and intersection improvements and repairs within public right-of-way.
- Existing building, surface and utility improvements and repairs beyond the surface restoration of the Shaft Retrieval locations grading and drainage designs.
- Preparation of Temporary Erosion and Sedimentation Control (TESC) Plans
- Preparation of a Stormwater Pollution Prevention Plan (SWPPP) for Construction.

- Coordination with SFMTA for bus rerouting during closures of Powell Street.

The following are limitations on our Scope:

- A maximum of 20 meetings, not to exceed 2 hours each, with up to two Arup participants is included. Additional meetings and/or time at meetings will be charged at the fee schedule included in this proposal.
- Our design does not include the means and methods for BIHJV to complete the work. Means and methods remain the responsibility of BIHJV.

3.2 Deliverables

The design shall meet submittal requirements in Section 31 74 17 1.04 B 5 and 31 50 00 1.06 E 1 per Contract Specification of Tunneling Contract C1252.

Submittals will consist of the following packages:

- Final Design Criteria
- Geotechnical Investigation, including Desk Study and Borings
- Shaft Design, including Shaft Cover
- Segmental Tunnel Lining Design, including Bulkheads
- Instrumentation and Monitoring Plan including Settlement Analyses and Construction Impact Assessments
- Settlement Mitigation Plan
- Traffic Control Plans
- Site Restoration Plans

3.3 Information to be provided by Contractor

In order to proceed with the proposed design, the following information will be necessary prior to the start of the design:

- All relevant SFMTA contract drawings, including reference files shall be supplied by BIHJV to facilitate design. This shall include topographic information and utility files.
- Geospatial surveys in electronic format of the site, utilities and relevant adjacent properties.
- Condition information on the utilities and relevant adjacent properties that are to remain after completion of the construction.
- BIHJV and SFMTA shall facilitate in obtaining permission for geotechnical investigations as required.

Memorandum

ARUP

To	BIHJV	Date	January 15, 2013
Copies	Luis Piek, Jon Hurt, Ivan Hee	Reference number	219434-00.2
From	Michele Mangione	File reference	
Subject	Design Criteria - Central Subway Retrieval Shaft Relocation Works		

1 Scope of this Memorandum

This memorandum contains the Design Criteria and the specifications for the design of the scope of work that has been documented on PCC 1252-10.

The memorandum lists the design requirements for the tunnel lining and the retrieval shaft, including the design specifications for the retrieval shaft cover. The existing specifications for the C1252 Tunneling Contract will be used as a basis of design and modified to suit the works. Where the existing specifications are not suitable for the proposed scope of work, additional specifications will be assembled in general accordance with this document.

2 Geotechnical and Tunneling

2.1 Geotechnical desk study

The purpose of the geotechnical desk study will be to review the existing geotechnical information in order to assess whether the available data is sufficient to carry out the additional excavation and tunneling works.

This scope will be structured in the following actions:

1. The documents for Contract 1252 will be reviewed to ascertain ground properties and ground related risks such as risk of liquefaction, contamination, and adequacy of ground parameters.
2. Existing information available for 1731-1741 Powell Street prepared by Treadwell and Rollo and dated December 1, 2008 will be reviewed to gather more ground parameters and to define ground profile in close proximity of the retrieval shaft.
3. Further research will be carried out to locate any public documentation held by the City of San Francisco records department and any other available ground investigation reports for the area.

Memorandum

It is envisaged that the information above will not provide the required information to carry out the design to completion. It is therefore necessary that further geotechnical investigations defined and carried out prior to finalization of design. The description of the geotechnical investigation is included in the following section.

2.2 Geotechnical Investigations

It is recommended that an additional borehole, located in close proximity to the future shaft, is selected to verify the soil condition and to determine the bedrock level. It is recommended this investigation be carried out at the earliest opportunity (post-award). This borehole may be performed in advance of the demolition works.

The geotechnical investigation will characterize the soil and bedrock in the proposed retrieval shaft location. Boreholes will have to extend at least 10 feet below the toe of the shaft wall or 15 feet into bedrock, whichever is deeper. Standard penetration tests will be performed in soils. Soil and bedrock core samples will be retrieved for testing laboratory testing.

The geotechnical consultant shall ensure that the borehole is logged and descriptions and strata nomenclature are based on profiles and boring logs contained in the Geotechnical Baseline Report (GBR).

Risks of presence of contaminated soils will be investigated and the implementation of risk mitigation measures shall be recommended to BIHJV, if required.

The obtained information will also be utilized to verify the information provided on the C1252 Geotechnical Baseline Report.

Any ground investigation shall be performed in accordance with the requirements specified in Section 02 30 00 Subsurface Investigation.

2.3 Design of TBM Retrieval Shaft

The temporary retrieval shaft will be moved from its current location and be located within the boundary of 1731-1741 Powell Street property. The shaft layout and depth shall be defined with the assistance of BIHJV to meet the project requirements and the construction constraints.

The temporary retrieval shaft will be sized and designed in accordance to the contractor's preferred method of construction and in accordance with best industry practice. It is currently assumed that secant piles will be used to form a rectangular shaft. The shaft will have internal dimensions of approximately 45 ft long by 50 ft wide. A system of waling beams and struts will be used to support the secant piles walls during excavation and after TBM retrieval. The bottom of the shaft shall be at or above elevation 18 feet (CCSF Datum).

The design shall be prepared, sealed, and signed by a professional civil or structural engineer currently registered in the State of California.

The design of the Retrieval Shaft walls and support system shall be performed in accordance with the requirements specified in Section 31 50 00 Excavation Support and Protection.

Memorandum

The design criteria and the design loads shall be based on the Contract Drawings for the original Retrieval Shaft. It is foreseen that the provisions will be applicable; however a review of the ground parameters and associated loading diagrams will be carried out.

The reference drawings are listed below:

- C1252 – CL – 18134 – ES – 011 Excavation and Ground Support Shoring Design Criteria sh. 1 of 3
- C1252 – CL – 18135 – ES – 012 Excavation and Ground Support Shoring Design Criteria sh. 2 of 3
- C1252 – CL – 18136 – ES – 013 Excavation and Ground Support Shoring Design Criteria sh. 3 of 3

Further references for the design and the construction of the Retrieval Shaft, depending on the selected method of construction, will include:

- SECTION 01 57 23, ENVIRONMENTAL MANAGEMENT OF EXCAVATED MATERIAL
- SECTION 03 05 15, PORTLAND CEMENT CONCRETE
- SECTION 03 20 00, CONCRETE REINFORCING
- SECTION 03 25 13, GLASS-FIBER-REINFORCED POLYMER REINFORCING
- SECTION 03 30 00, CAST-IN-PLACE CONCRETE
- SECTION 05 12 00 STRUCTURAL STEEL FRAMING
- SECTION 31 23 19, DEWATERING
- SECTION 31 32 13.36, JET GROUTING
- SECTION 31 62 13.14, SECANT PILE DIAPHRAGM WALLS

The works shall include:

1. Design of shoring walls
2. Design of propping system, if required
3. Design of temporary cover
4. Design of support to temporary cover
5. Tunnel eye design for breakthrough of TBM
6. Permanent seal of wall following TBM breakthrough
7. Any ground treatment in proximity of the end wall to ease TBM breakthrough if required

The following loads will be considered in design with the load factors included in the Excavation and Ground Support Shoring Design Criteria drawings:

1. superimposed surface loading based on traffic and existing buildings;
2. load on the temporary cover;

Memorandum

3. ground and ground water loads;
4. seismic loading from ground and buildings;
5. prevention of floatation.

The top level of the strutting system shall be designed to support the temporary cover to the shaft. It is not expected the temporary cover will need to be designed for traffic load. Therefore the loads included in the Contract Documents will not be applicable for this shaft cover.

The maximum loads shall be agreed by the City and should be the same or higher than the expected construction load from BIHJV, if any load is envisaged. A provisional load of 500psf is recommended for the design.

The shaft design shall also include provisions for breakout of the TBM tunnel into the shaft. The preferred solution shall be selected with the assistance of BIHJV. The purpose of this design is to provide a localized strengthening of the soil and a water cut off to safely drive the machine into the shaft.

The shaft design will not include any consideration of future development of 1731-1741 Powell Street, or additional building loads from new construction on any adjacent properties.

2.4 Verification of the Precast Tunnel Lining

The extension of the TBM tunnel section will require the verification of the segmental lining design over the extended section of the alignment. The segmental lining design as previously approved for the 1252 Contract will be verified for adequacy along this extended section of the alignment.

The segmental lining shall be verified for temporary loads and permanent loads in accordance with Section 31 74 17 Precast Concrete Tunnel Lining and Section 31 71 19 Tunnel Excavation by Tunnel Boring Machine.

The design criteria and the design loads for the segmental lining shall be based on the Contract Drawings of Contract C1252. The reference drawing is:

- C1252 – CL – 18079 – ST – 001 Structural – General Notes

For surface loads, reference shall be made to the Excavation and Ground Support Shoring Design Criteria drawing series.

To verify the design, the most critical cross sections along the extended tunnel alignment will be selected to determine the state of stress within the segmental lining due to the permanent loads. Accidental loads will be calculated and included. Temporary loads will be verified in accordance to the procedure used for the original alignment.

The following loads will be considered in design with the load factors included in the Structural – General Notes drawing:

1. superimposed surface loading based on traffic loading, the loading due to existing buildings and the possibility of future developments. A minimum surcharge of 1000psf is recommended. The

Memorandum

SFMTA will advise if this minimum surcharge is appropriate, or if a higher surcharge for future development is required;

2. ground and ground water loads;
3. seismic loading;
4. railway loading;
5. annulus and subsequent back-grouting;
6. imposed distortion caused by lack of circularity;
7. poor segment ring build (including analysis of out of plane circumferential loading and bursting stresses due to axial loading caused by 'birds-mouthing' and stepping of segment joints);
8. prevention of floatation;
9. effects of first tunnel on the second tunnel.

2.4.1 Seismic Design of Precast Tunnel Lining

Underground tunnel structures undergo three primary modes of deformation during seismic shaking: ovaling/racking, axial, and curvature deformations. The ovaling/racking deformation is caused primarily by seismic waves propagating perpendicular to the tunnel longitudinal axis, causing deformations in the plane of the tunnel cross-section. Vertically propagating shear waves are generally considered the most critical type of waves for this mode of deformation. The axial and curvature deformations are induced by components of seismic waves that propagate along the longitudinal axis.

Seismic waves can occur in three forms, P-waves, S-waves and Rayleigh Waves. The compression-extension deformations due to the P-waves are not generally considered to control the design for circular tunnels. Generally, strains produced by Rayleigh waves would control only when the tunnel is shallow and a long distance from the earthquake epicenter. S-waves cause the largest strains and are generally the governing wave type to consider in design.

Using beam theory, total free-field axial strains are found by combining the longitudinal strains generated by axial and bending deformations (Hashash, et al., 2001). Values of Maximum Design Earthquake (MDE) and Operating Design Earthquake (ODE) will be obtained from Geotechnical Baseline Report Contract 1252 – Tunnels and Preliminary Engineering and Design - Task 1.06-00 Design Criteria – Structural, Revision 1b) (SFMTA, 2008b). Results from the report of shear strain from the free field one-dimensional site response analyses were also used to determine the seismic demand for segmental lining design.

2.5 Concrete Bulkhead Design

The proposed scope of work also includes a reinforced concrete bulkhead for each tunnel at the Property Line, Public ROW side.

The design of the concrete bulkheads shall be performed to provide the required temporary protection to the running tunnels upon completion of the C1252 Tunneling Contract.

Memorandum

It is currently foreseen that the concrete bulkhead will be designed for the full load that could be experienced by the wall at such depth. It is therefore assumed that full ground and water load will be applied to the wall and a full waterproofing system will be designed to protect the running tunnels.

The following specifications from Contract C1252 will be applicable to this design:

- SECTION 03 15 13, WATERSTOP
- SECTION 03 05 15, PORTLAND CEMENT CONCRETE
- SECTION 03 20 00, CONCRETE REINFORCING
- SECTION 03 30 00, CAST-IN-PLACE CONCRETE
- SECTION 31 50 00, EXCAVATION SUPPORT AND PROTECTION

2.6 Pre and post construction existing condition survey

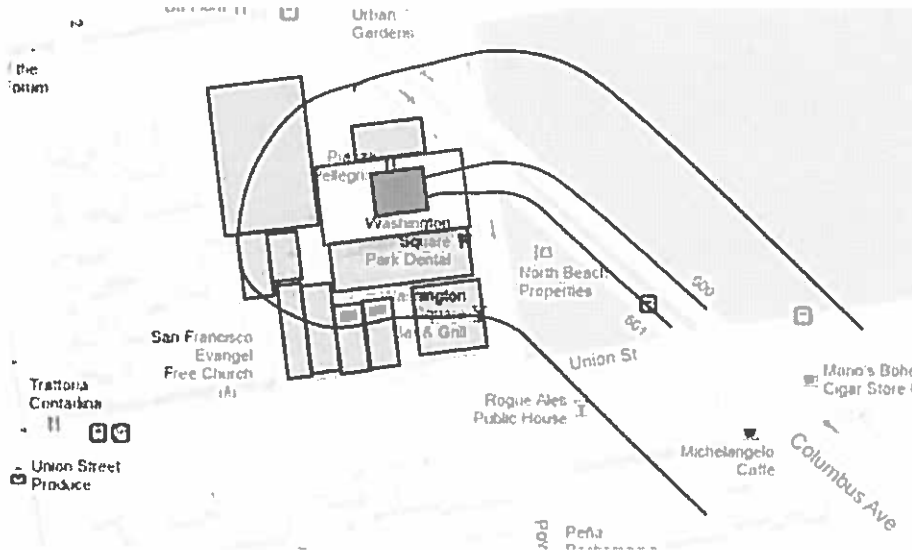
An indicative plan view showing the buildings and the potential influence zone of the tunnels is shown below. The highlighted buildings may be considered for pre-construction condition surveys. Tentatively, 10 buildings have been identified for condition surveys. This number shall be confirmed following the ground movement assessment and the final layout of the works.

Pre-construction condition surveys of the existing structures shall be performed in structures immediately adjacent to 1731-1741 Powell Street (marked in red) prior to commencement of demolition works. This is required in order to establish a baseline. Pre-construction surveys of the remaining buildings shall be performed prior to construction of the shaft works. Post-construction surveys will be performed at the conclusion of all subsurface works.

The pre-construction and the post-construction surveys shall be carried out in accordance with the following sections of the C1252 Specifications

- SECTION 01 76 29, PROTECTION OF EXISTING PROPERTY
- SECTION 01 32 33, PHOTOGRAPHIC DOCUMENTATION

Memorandum



Buildings in the influence zone of the Retrieval Shaft Works

2.7 Ground Movement and Damage Assessment of Existing Buildings and Utilities

The change in alignment of the running tunnels will require an assessment of the effects of the construction of the extended section to existing building and utilities.

The buildings and utilities in proximity of the newly proposed retrieval shaft will be analyzed for the combined effect of the shaft excavation and the TBM tunnel construction.

Ground movements due to the tunneling operation carried out with Earth Pressure Balanced Tunnel Boring Machines (EPB TBMs) in proximity of the affected buildings and utilities will be calculated using software which calculates the ground movements based on a 3D Gaussian settlement trough.

Ground movements due to the wall excavation for the retrieval shaft will be obtained by means of FE methods and superimposed to the tunneling ground movements.

Tunnels will be modeled as excavations of circular cross-sections in soil with the main parameters in the analyses being the volume loss (VL) and the shape of the trough (k). While the volume loss is dependent on the performance parameters used during the TBM operations, the shape of the trough is function of the ground type. A range of trough width parameters will be selected to ensure all effects are included. The volume loss will be selected in conjunction with the contractor. A value of 0.5% is considered appropriate in these ground conditions.

From this analysis the effects of the TBM excavation on the existing buildings and utilities (i.e. the maximum settlement and induced distortion) will be calculated. If the induced movements exceed the recommended limits for induced settlement per Specification Section 31 09 15, Structural Instrumentation and Monitoring, a strategy to address the risk of excessive settlement will be developed with BIHJV.

Memorandum

2.8 Instrumentation and Monitoring

An Instrumentation and Monitoring Plan shall be defined to monitor the effects of the retrieval shaft relocation works on the buildings and utilities. The proposed scheme shall be developed in accordance with the following sections of the C1252 Specifications:

- SECTION 31 09 13, GEOTECHNICAL INSTRUMENTATION AND MONITORING
- SECTION 31 09 15, STRUCTURAL INSTRUMENTATION AND MONITORING

The instrumentation shall be designed to detect movements associated with the demolition of the building, the construction of the retrieval shaft and the additional TBM tunneling and should be designed to work in conjunction with the existing instrumentation designed for Contract 1252.

Selection of trigger levels and actions and their implementation shall be developed in accordance to the specifications.

2.9 Mitigation Measures

Mitigation measures will be developed if the calculated ground movements are above the limits defined in Section 31 09 15, Structural Instrumentation and Monitoring. In particular, these limits are:

1. expected movements of the buildings higher than 1.0 inches and the distortion is higher than 1/400;
2. expected movements of the utilities higher 0.75 inches.

Potential mitigation measures will be developed with BIHJV and may include, but not be limited to, compensation grouting, compaction grouting, realignment of the TBM drives, imposition of tighter limits on volume loss along particular sections of the alignment, or underpinning of existing buildings.

3 Structural Scope

3.1 Demolition design and plans of 1731-1741 Powell Street

This demolition plan will form the basis of the scope of work for a demolition specialist sub-contractor. The design criteria for this scope of work are included in a separate document. The demolition plan shall be developed in accordance with Section 02 41 00 Demolition. Finalized demolition plan drawings will be provided once the SFMTA notice to proceed for the works described in PCC-10 is given to BIHJV.

4 Civil Scope

4.1 Final design of horizontal and vertical alignment

The tunnel alignment shall be defined to ensure that:

Memorandum

1. The alignment is compatible with the shaft location at the center of the property boundaries of 1731-1741 Powell Street as determined with the input of BIHJV taking into account construction risks and constraints;
2. The minimum radius of curvature of the tunnel segment is 450ft in accordance with the lowest radius of curvature of the alignment of the C1252 Tunneling Contract.
3. The new alignment ties to the current alignment at STA. 84+88.85 at elevation 18.36 ft as shown in PCC 1252-10 documents. The new tunnels shall be located under public right of way and into 1731-1741 Powell Street only.

4.2 Traffic Control Plan

A traffic control plan shall be developed with the assistance of BIHJV for the following three phases of work:

1. Demolition of 1731-1741 Powell Street.
2. Excavation and off haul of soil material and construction of TBM Retrieval Shaft.
3. Removal of TBM off site.

The plan shall be developed in accordance with Section 01 55 26 Traffic Control of the project specifications and the following constraints listed in the RFP:

1. No street closures are allowed on either Columbus or Filbert Streets.
2. Street closures will be allowed on Powell between Columbus and Union Streets.
3. Access through surface parking lot adjacent to the Project site will be limited to TBM removal operations only.

4.3 Existing Utilities Assessment Study

A desk study will be carried out in two phases to determine the location, size, and type of utilities that cross or parallel the proposed tunnel alignment between the current retrieval location on Columbus Street and the proposed location at 1731-1741 Powell Street and that may be affected by tunneling operations. The study's initial phase consists of reviewing as-built drawings, survey data, and existing utility information provided by BIHJV. The second phase involves obtaining additional as-built information from utility providers as needed. The information generated from this study will be used to develop the Instrumentation and Monitoring Plan.

4.4 Site restoration

Site restoration criteria after completion of TBMs removal shall be provided by the SFMTA and shall be incorporated as a change order item.