The RTM-handling system is likely to consist of continuous conveyor belts and a screw auger to transport the RTM to the ground surface. The RTM handling then consists of stockpiling RTM at the ground surface, with dewatering or drying of the RTM, and subsequent transfer of the solids to disposal areas. Transfer to disposal areas might be handled by conveyor, wheeled haul equipment, barges, or a combination of these methods.

11.2.6 Tunnel Support

Based on early project research and planning, a single-pass tunnel liner system is chosen to balance water conveyance requirements, project schedule, and construction cost. Coupled with modern TBM technologies in the anticipated ground conditions, the tunnel liner system will consist of precast concrete segmental liner with bolted-gasketed joints. The segmental liner will be designed to support external earth pressures; groundwater pressures; internal operating pressures; seismic loads; and construction loads due to handling, erection, and thrusting of the TBM. The segments are bolted together at the circumferential and longitudinal joints. The finished ring formed by the segments is smaller than the excavated tunnel cylinder, so the annular space between the segmental ring and the ground will be backfill-grouted to provide full contact for support. The backfill grout is typically injected through the tail shield of the TBM, which provides full circumferential liner support to ensure successful performance of the tunnel system. This lining system also minimizes impact to groundwater during construction and operation, as all concrete joints are sealed using high performance gaskets.

To minimize ground effects of one tunnel on an adjacent tunnel during parallel tunnels construction, the clear distance between adjacent tunnel bores is assumed to be two tunnel diameters (or 150 feet tunnel center to center). This is a conservative assumption because of insufficient geotechnical data to justify a closer spacing at the current study phase. For the 40-foot ID tunnels, it is anticipated that a 9-piece ring configuration would be used, with segment thickness of 20 inches minimum. The segments (7,000 psi minimum compressive strength) will be cast and steam-cured in concrete segment plants under strict quality control measures and delivered to the tunneling sites. Reinforcement will consist of both high strength steel reinforcement (up to 80,000 psi) and steel fiber for permanent ground loads and construction handling loads. Steel reinforcement will increase segment strength and durability and provide crack control.

Under the single-pass liner design, a typical joint between segments will be composed of gasket material to seal against water seepage and alignment bolts for tunnels subject to compression load only. Given the hydraulic grade line and ground cover of the tunnels, net tension where the internal pressure exceeds the external pressure (soil and water) is expected. If the segment ring is subjected to internal tension, special positive connections across the joint and tension reinforcement are necessary to transfer the tensile force throughout the segments. In general, however, a bolted-gasketed tunnel liner system is designed for compressive ring forces and is seldom subject to net tension. It is important that testing and analysis are conducted during preliminary and final design phases to optimize the tunnel liner system to resist the tension force.

In addition to strength requirements, leakage control through the liner is essential to ensure liner performance. Excessive leakage through the liner could lead to potential soil erosion, hydraulic fracturing and loss of liner support. Water leakage from the tunnel to the surrounding area also translates to economic loss. The leakage can be mitigated by a properly selected high performance gasket, concrete mix design of long-term durability, supplemental concrete admixtures to increase water tightness, and uniformly-distributed reinforcement and steel fibers for crack control. It is not anticipated that a PVC T-lock liner is required, and the PVC liner could complicate the tunnel construction and long-term operation. Once detailed geotechnical data is available during preliminary design, the segment liner will be designed to limit water leakage by considering surrounding ground-liner interaction and ground permeability.

For the net internal pressure design of the liner during conceptual phase, the external ground water pressure is assumed to be at elevation 0.0 (MSL) along the majority of the alignment. Occasionally, lower ground water elevation may occur due to local conditions. The exact ground water elevations will be determined along the alignment during preliminary design following geotechnical exploration.

The combined pumping plant is located at CCF, with control gates at each river intake. Using results from a preliminary hydraulics study that considers both steady state and surge conditions (see Appendix D), the maximum HGL elevations are summarized below. System hydraulics will be further refined and analyzed during preliminary and final design, and the tunnel liner will be designed for all applicable load cases based on results of accepted hydraulics and geotechnical criteria.

- Static shut-in condition (for all tunnels): HGL = 15 feet of net internal pressure
- Surge condition (North Tunnels @ +0.5 feet): HGL = 15 + 0.5 = 15.5 feet of net internal pressure
- Surge condition (Main Tunnels @ +5 feet): HGL = 15 + 5.0 = 20.0 feet of net internal pressure

Given the net internal pressures, several studies (Jacobs Associates, 2012; CH2M Hill 2014) were conducted to provide alternative tension-resisting elements in the tunnel liner. Such alternatives include effective ground overburden, high strength bolts, shear dowels, post-tensioning system, ferrous push-fit connectors, and proprietary joint connectors. A more detailed evaluation regarding the alternative join anchorage system is included in Appendix I and J.

The preliminary joint design utilizes a high strength bolt connection system as shown in the Concept Drawings (Volume 2), based on past performance in tunneling projects such as the San Diego Bay Outfall Tunnels. Once detailed geotechnical data is available, the following alternatives will be considered (separately or in combination) in the preliminary and final design phases:

- Effective ground overburden to resist internal pressure.
- High strength tension bolting for high tension load case.
- Shear dowels for light to moderate tension load cases.
- Other mechanical lock-fit connections (if applicable).

The tunnel liner system will be designed for all the following load cases to ensure reliable performance during the minimum 100-year design life of the system:

- Full external ground load and external ground water pressure.
- Net internal pressure (difference between internal hydraulic pressure and external ground water pressure). Ground overburden to counteract the internal pressure is ignored at this conceptual phase but will be considered during preliminary and final design once detailed geotechnical data is available.
- Earthquake design – Finite element model on ground-tunnel interaction based on Maximum Considered Earthquake (MCE) events.
- Segment handling loads such as lifting, hosting, TBM pushing.
- Leakage control based on acceptable performance criteria.

11.2.7 Precast Segment Plant and Yard

Multiple precast segment plants will be required to produce tunnel segments for this program. The size of each plant is dependent on the total number of segments required and the schedule for production, but it is likely that plants will require approximately 10 acres for offices, materials storage, concrete batch plant, and casting facilities. Additional segment storage space needs to be added to the plant space requirements and could be several times the space required for the plant. The segments can be transported by barge, rail, or truck where these modes of transport are available.

The current assumption for the segment casting facility is that it will not be located at the tunnel construction site and that tunnel segments will be delivered from off-site facilities. It is also assumed that only limited storage of segments is onsite to reduce the size of the working site required.

11.2.8 Logistics

The TBM consists of a front shield section plus additional trailing gantries carrying support equipment. Although the shield is transported in pieces, the size and weight of the pieces are substantial. It is currently expected that the TBMs complete the final stage of their delivery to the site by road.