Subject:	**Preliminary Precast Yard Study (Final Draft)**
Project feature:	Site Development / Logistics
Prepared for:	California Department of Water Resources (DWR) / Delta Conveyance Office (DCO)
Prepared by:	Delta Conveyance Design and Construction Authority (DCA)
Copies to:	File
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1. Purpose

At this time, the DCA recommends, for purposes of DWR development of the Delta Conveyance Project (Project) draft Environmental Impact Report (EIR), that tunnel segments would be obtained from an offsite commercial precast plant that had been permitted for many types of projects. However, DCA considered the types of facilities that would be required if use of those commercial industries were not available. This technical memorandum (TM) describes various potential locations, sizes, and improvements for sites used to fabricate precast tunnel segments, an integral part of the final conveyance tunnel. The purpose of this TM is to:

- Estimate potential locations of precast tunnel segment construction facilities
- Determine the approximate area needed for each potential facility

2. Geometric Properties of Tunnel Segments

This TM was developed based on assumed tunnel alignments extending between 38 and 45.5 miles from the intakes on the Sacramento River near Hood, California to a new pumping plant near the existing Clifton Court Forebay (Figure 1). These assumed tunnel alignments are based upon the Central and Eastern corridors identified by DWR in the Delta Conveyance Project Notice of Preparation (DWR, 2020).

This TM assumed the following geometric properties for the tunnels between the intakes and the pumping plant, as shown on Figure 1:

- Internal diameter (ID): 36 feet
- Segment thickness: 18 inches
- Segment width: 6 feet
- Number of segments in each ring: 7 segments plus 1 key segment

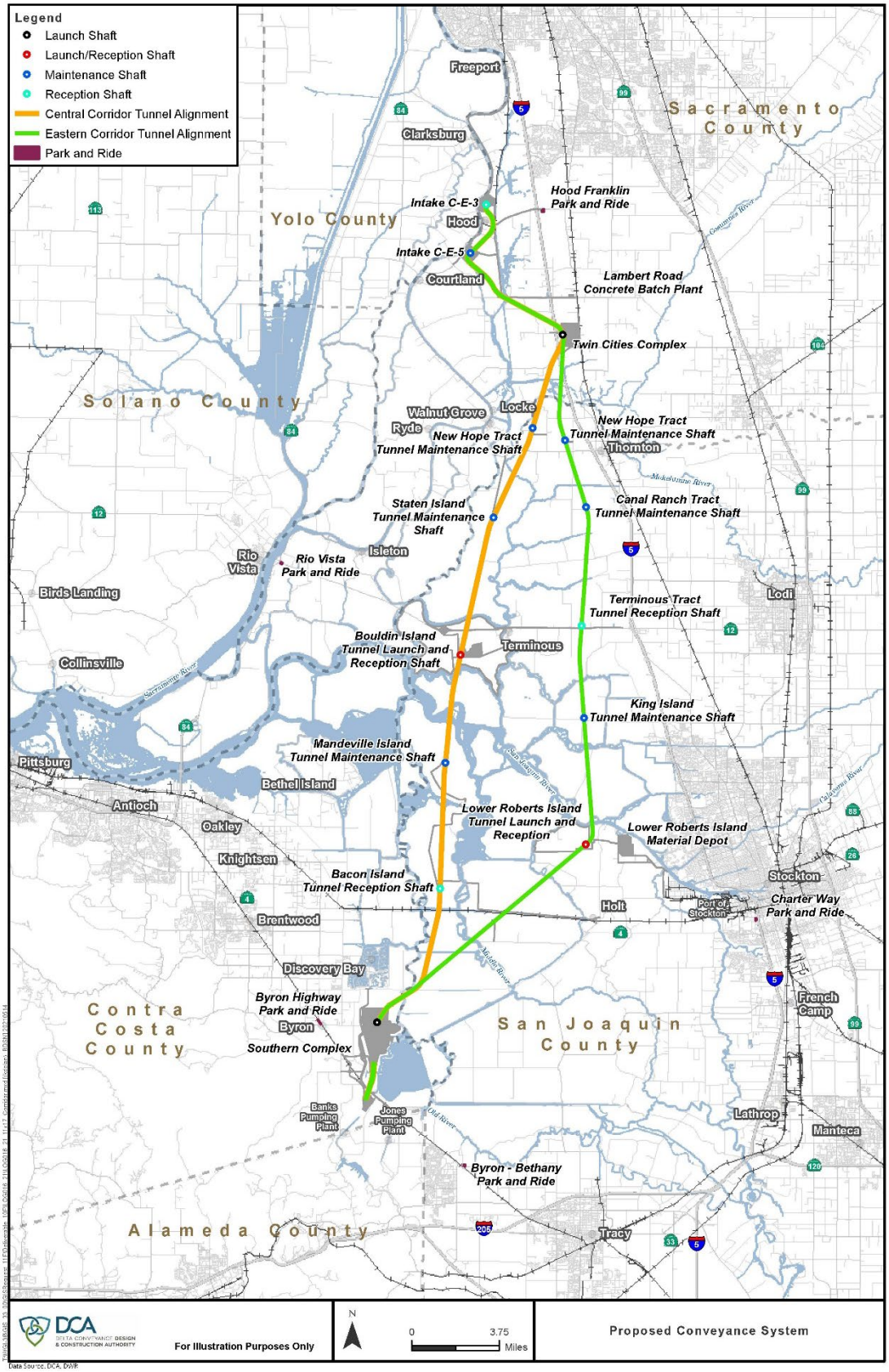


Figure 1. Preliminary Tunnel Alignments

This TM also addresses the South Delta Connection Facilities tunnels from the new Southern Forebay to the existing State Water Project Harvey O. Banks Pumping Plant (Banks) intake canal. The South Delta Conveyance Facilities tunnels would be twin tunnels approximately 2 miles in length. The tunnel lining used for these tunnels assumed the following geometric assumptions:

- ID: 40 feet
- Segment thickness: 24 inches
- Segment width: 6 feet
- Number of segments per ring: 8 segments plus 1 key segment

The exact tunnel diameters and liner geometry are critical in planning for the precast facility to determine the number of different size segments that need to be produced. Each additional size would require different molds, and possibly separate casting beds.

3. Precast Tunnel Segment Construction Facility

The precast tunnel segment construction facility (PTSCF) footprint requirements vary, depending on an analysis of precast tunnel segment casting rate verses the tunnel driving rate, which would determine the amount of segment storage and plant area needed at the production site. Discussions with DCA team members with experience in tunneling projects indicated that approximately 30 acres is typically needed for this type of facility. The land needs to be generally flat with an all-weather surface. The facility needs to have all-weather access to the transportation network to import and export raw materials and completed works, as well as transport personnel.

The PTSCF utility requirements are water, power, and fuel supply and storage. High-speed internet and telephone services are also required for the most efficient operation. The facility requires the following areas and components:

- A concrete batch plant
- Associated aggregate storage
- Quality control (QC) and quality assurance (QA), and management buildings
- A curing facility
- A system of molds for fabrication
- Overhead cranes
- A large, level storage area
- Storm water detention basins
- Office space
- Craft parking and facilities

Also required is construction equipment to feed the batch plant, move mixed concrete, consolidate mixed concrete in the molds, and move other materials (for example, reinforcing, molds) and completed segments. The PTSCF facilities are generally considered to be temporary, fully removed at the end of the project, and the land remediated and restored to original condition.

For this TM, it is assumed that a separate PTSCF would be commissioned for each tunnel diameter and drive by each individual contractor. Another option would be to construct one to three facilities in the project vicinity to supply all tunnel drives. A combination of these approaches also could be considered. Given the length of the tunnels, the duration of the program, and the logistical challenges of producing segments at potential launch shaft locations, additional study would be needed once a contracting

strategy becomes more formalized during subsequent design development following environmental approval.

4. Precast Tunnel Segment Construction Facility Logistics

PTSCF logistics include considerations for the following:

- Raw materials
- Haul and access routes
- Precast tunnel segment production
- Operations

4.1 Raw Materials

To produce a minimum of 7 rings per day for a 36-foot ID tunnel, a ready-mix concrete batch plant would need to produce approximately 300 cubic yards (cy) of concrete per day. Ready-mix concrete consists of cement, coarse aggregate, fine aggregate, water, and potential admixtures. Given the relatively small volumes of cement and aggregates, delivery of materials to the batch plant is expected to be by truck for the Project. Reinforcing steel, reinforcing fibers, or both would be needed for the precast tunnel segments. Delivery of these materials is expected to be by truck for the Project. Certain inserts would be required for the ultimate interconnection of the segments into rings within the tunnel system. Delivery of these materials is expected to be by truck for the Project.

Sufficient electrical power would be needed to operate the precast facility. This could be provided by the existing electrical grid, new power sources, or temporary onsite generation. Sufficient water would be needed for producing ready-mix concrete, curing, cleaning the molds, and other site activities. Water supply is expected to be available through municipal sources at the potential facilities.

4.2 Haul and Access Routes

Each PTSCF would need efficient and reliable transportation routes for delivering raw materials to the PTSCF and delivering completed segments from each PTSCF to the launch shafts. Potential material haul modes could consist of any combination of rail, barge, and truck. Consideration should be given to locating each PTSCF where more than one transportation option exists or could be reasonably constructed.

Access for crews that operate the plant would also be a critical factor and would be carefully considered in conjunction with the existing road network if constructed in the Delta or immediate vicinity, as mass transit by rail or ferry is not readily available in these areas. Haul and access routes are addressed in the *Logistics Strategy TM* (DCA, 2021).

4.3 Precast Tunnel Segment Production

The length of each tunnel drive controls the total number of precast segments to be produced. The rate of tunnel boring machine (TBM) advance controls the rate of production of precast segments. The PTSCF would be expected to be constructed approximately 6 months prior to commencement of TBM operations for any tunnel reach with segments for approximately 680 rings. A ring is defined as all segments and the key segment necessary to complete the tunnel lining ring.

Following manufacturing of the initial segments, the segments would continue to be manufactured at a rate at least equal to the expected TBM advance rate. For an average TBM advance rate of 40 linear feet

in a single working day, 7 rings would be required for each day. The rings stored onsite would operate as a contingency for days that exceed the average advance rate to provide approximately 97 production days (5 months). The storage of the additional segments at the launch shaft would reduce future risks if there were issues at the PTSCF or the transportation system. Table 1 summarizes the estimated number of rings (groups of segments completing a ring) based on the assumptions listed.

Table 1. Estimated Number of Tunnel Rings and Assumptions

Reach	Tunnel ID (feet)	Width of Ring	Ring Composition (segments + key)
Main Tunnel	36	5 feet 10.5 inches	7 + 1
South Delta Conveyance Tunnel	40	5 feet 10.5 inches	8 + 1

For the purpose of this TM, approximate tunnel lengths were assumed, as listed in Table 2.

Table 2. Approximate Tunnel Lengths

Reach	Length (miles)	~No. of Rings	~No. of Segments and Keys
Main Tunnel Eastern Corridor	40.29 to 45.29	35,455 to 39,855	283,640 to 318,840
Main Tunnel Central Corridor	37.35 to 39.62	32,868 to 35,637	262,944 to 278,928
South Delta Conveyance (twin tunnels for both Eastern and Central corridors)	2.02	3,556	32,004

Notes:

~ = approximate

No. = number

4.4 Operations

As precast technology has become increasingly sophisticated, techniques for constructing segments have evolved in terms of speed of construction and curing so that segments are ready for incorporation into the work more quickly. Methods vary by facility and generally include high early strength concrete, external vibration, and steam curing. Precast technologies include plants with one of two approaches:

- Assembly line facilities, where the molds travel to the work crews (carousel)
- Crews work at fixed locations (fixed mold or stationary molds), where the segments are constructed using stationary molds, and the crews move to each mold location

The parameters used to determine the best facility type are not addressed in this TM.

5. Precast Tunnel Segment Construction Facility Characteristics

5.1 Precast Tunnel Segment Construction Facility Locations

Given the Eastern and Central corridor tunnel alignment options, and specifically the launch shaft locations, the PTSCF options must be evaluated for a variety of characteristics related to logistics, including:

- Available space
- Zoning
- Utilities
- Options for efficient transportation of raw and finished materials
- Equipment and workers
- Cost and schedule considerations

The two options considered for PTSCF, included on-site at launch shafts and off-site within and outside the study area

5.2 Onsite –PTSCFs at Launch Shaft Sites

Locating the PTSCF at the launch shaft sites would ideally result in the most efficient solution for manufacturing and transportation of tunnel segments for the contractor. The space needed would be dependent on the contractor's means and methods which could result in smaller plant and storage areas and more efficient operations. There are also several disadvantages associated with having PTSCF located at the shaft sites as described below:

- Accommodating a PTSCF would increase the overall area of the launch shaft sites by approximately 30 acres.
- Additional agricultural land would be temporarily lost to accommodate the extra land needed for the PTSCF.
- The PTSCF would create additional environmental impacts in already sensitive area.
- The PTSCF would require substantial amounts of water to manufacturer tunnel liner segments.

Due to the limitations at the tunnel launch shaft sites at Twin Cities Complex, Bouldin Island, Lower Roberts Island, and Southern Complex, placement of the onsite PTSCF would not be included in the project.

5.3 Offsite –PTSCFs

To determine whether there were potential concrete batch plant locations near the Project tunnel launch shaft sites, properties with appropriate sizes and in areas with zoning that could include a concrete batch plant were identified. Attachment 1 includes a list of properties that are appropriately sized, located within areas zoned for a potential PTSCF, and close to various transportation options to convey the tunnel segments to the tunnel launch shaft sites. No analyses were conducted on these specific properties, adjacent land uses, or other potential constraints associated with city or county general plans and other land use limitations. Use of these or similar properties would require extensive analyses and coordination with property owners and regulatory agencies.

Alternatively, owner-controlled PTSCF would allow the owner to contract separately with suppliers to produce tunnel segments for the Project. This greater control would include inclusion of specific PTSCF facilities in the Project environmental documents and permit applications and reduce the need for supplemental analyses. The cost of manufacturing the tunnel segments could potentially be reduced through economies of scale and by using only a minimum number of facilities to produce all the segments. However, the disadvantages with this approach would be that the owner would assume the risk of delaying the construction schedule and for quality performance. By concentrating the manufacturing of the precast segments to a minimum number of facilities, more storage areas at both the PTSCF and the launch shafts would be required to support uninterrupted tunnel construction along multiple drives.

The precast facilities would be housed in either new or existing buildings. The interior space would need to be sufficiently sized for the operation of the plant, quality testing activities, and management activities. If these facilities would be located within the construction locations in the Delta, the facilities would be removed following construction. Examples of existing and previously used PTSCF are described in the following subsections.

5.3.1 Traylor Brothers Inc. Precast Facility - Littlerock, California

The Traylor Brothers Inc. (TBI) Precast Facility in Littlerock, California is located at 625 East Avenue Street, approximately 65 miles northeast of Los Angeles, and occupies 22 acres of leased property. The precast facility consists of two metal buildings, each approximately 20,000 square feet (ft^2) in area, a concrete batch plant, and 17 acres of storage area (TBI, pers. comm., 2020a).

As recorded on the TBI website, the plant has produced segments for the following projects (TBI, 2020b):

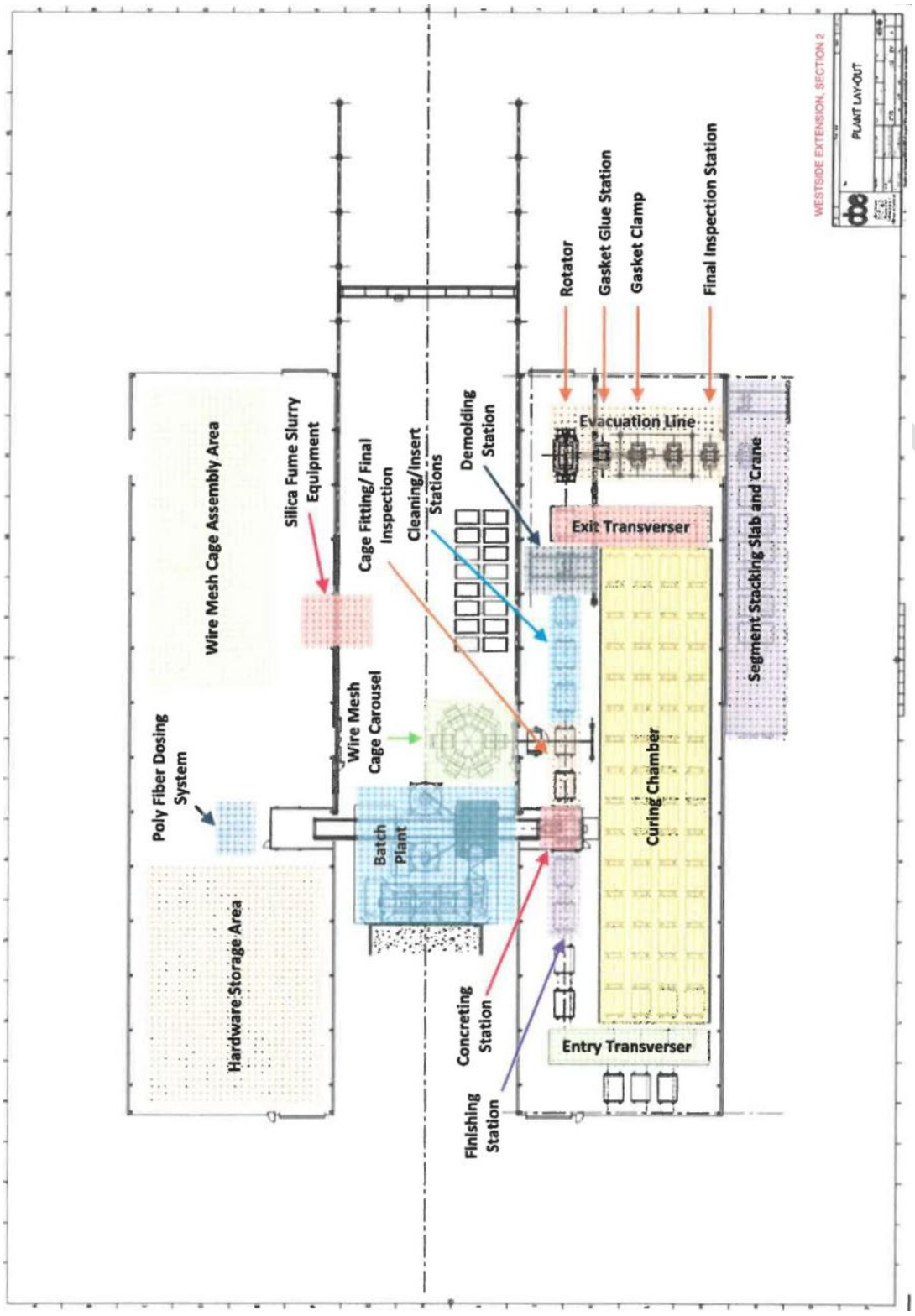
- City of Los Angeles North Outfall Sewer – East Central Interceptor Sewer and Northeast Interceptor Sewer tunnels in the Los Angeles, California area
- Metropolitan Water District Arrowhead tunnels in San Bernardino, California
- The Los Angeles County Metropolitan Transportation Authority (LA Metro) Red Line tunnel in Los Angeles, California
- San Diego County Water Authority San Vicente Pipeline tunnel in San Diego, California
- The City of Los Angeles Avenue 45 tunnels, LA Metro's Regional Connector

Currently, this plant is producing tunnel segments for LA Metro's Purple Line Segments 1 and 2 (LA Metro, 2017-2019).

The precast plant consists of Building 1, used for segment production; and Building 2, used for reinforcement cage production and material storage (Figure 2 shows the layout). Equipment descriptions and fabrication steps are as follows: (TBI, pers. comm., 2020a, 2020b):

1) Carousel equipped with eight rings of tunnel segment molds, and each ring consists of six segments.
2) Twelve molds on the fabrication line, 12 molds on curing line channel A, 12 molds on curing line channel B, and 12 molds on curing line channel C.
3) Overhead crane located between Buildings 1 and 2 is used to transport completed reinforcing cages.
4) Wire mesh cage carousel holds assembled reinforcing cages for distribution to the molds.
5) Concrete batch plant, with a 2.6-cy concrete mixer; concrete is delivered by flying bucket.

6) Before introducing water to the mixer, the moisture content of all dry materials (aggregate, cement, fly ash) is analyzed by microwave moisture sensors.
7) Water heater and chiller is used to maintain concrete temperature during cold and warm weather.
8) Poly fibers are added into the mixer with compressed air assistance.
9) Curing room maintains temperature up to 180 degrees Fahrenheit (°F) (170 feet long by 40 feet wide by 7 feet 6 inches high).
10) Steam generator produces steam to cure segments in not less than 5.5 hours; there are three zones (Z1 less than 120°F, Z2 is 110 to 140°F, and Z3 has no steam pipes and is subject to carry over steam and heat).
11) Demolding crane vacuum lift removes segment from the mold and places it on the segment rotator (segments can be demolded when strengths are greater than 2,000 pounds per square inch [psi], and verified by concrete cylinders that have been steam-cured).
12) Segment rotator rotates segment 180 degrees so that intrados faces up, and then the segment is lowered onto a transfer trolley.
13) Segment transfer trolley transfers the segments to the gasket glue station, gasket clamp station, final inspection station, and to the segment staking slab. Curing compound is applied.
14) Molds are cleaned so that the surface finish is free from irregularities, and form oil is applied; insert placement (dowels, grouting, and handling inserts) occurs prior to the cages being installed.
15) Segments are transported by forklift in stacks of three to the storage area and stored in stacks of six.
16) Once the segments achieve a strength of 6,500 psi, they are shipped to the site by flatbed 2 per truck load due to weight limitations.

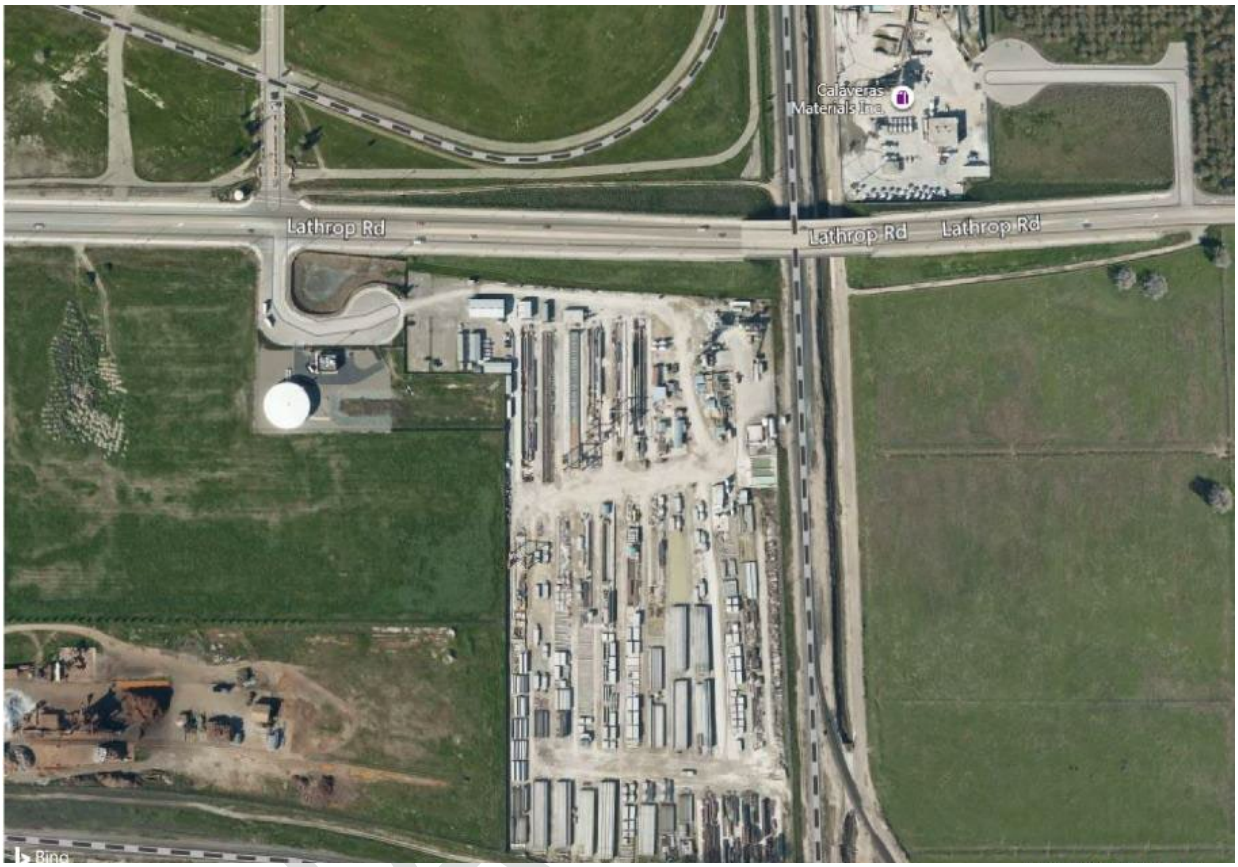


Source: Image supplied by TBI 2020

Figure 2. Traylor Brothers Precast Facility Plant Layout Littlerock, California.

5.3.2 Confab Lathrop Site

Name: Confab Lathrop Precast Facility (Figure 3)
Address: 1910 Lathrop Road, Lathrop, California 95330
Size: ±17 acres
Features: Onsite ready-mix plant, with rail and road access

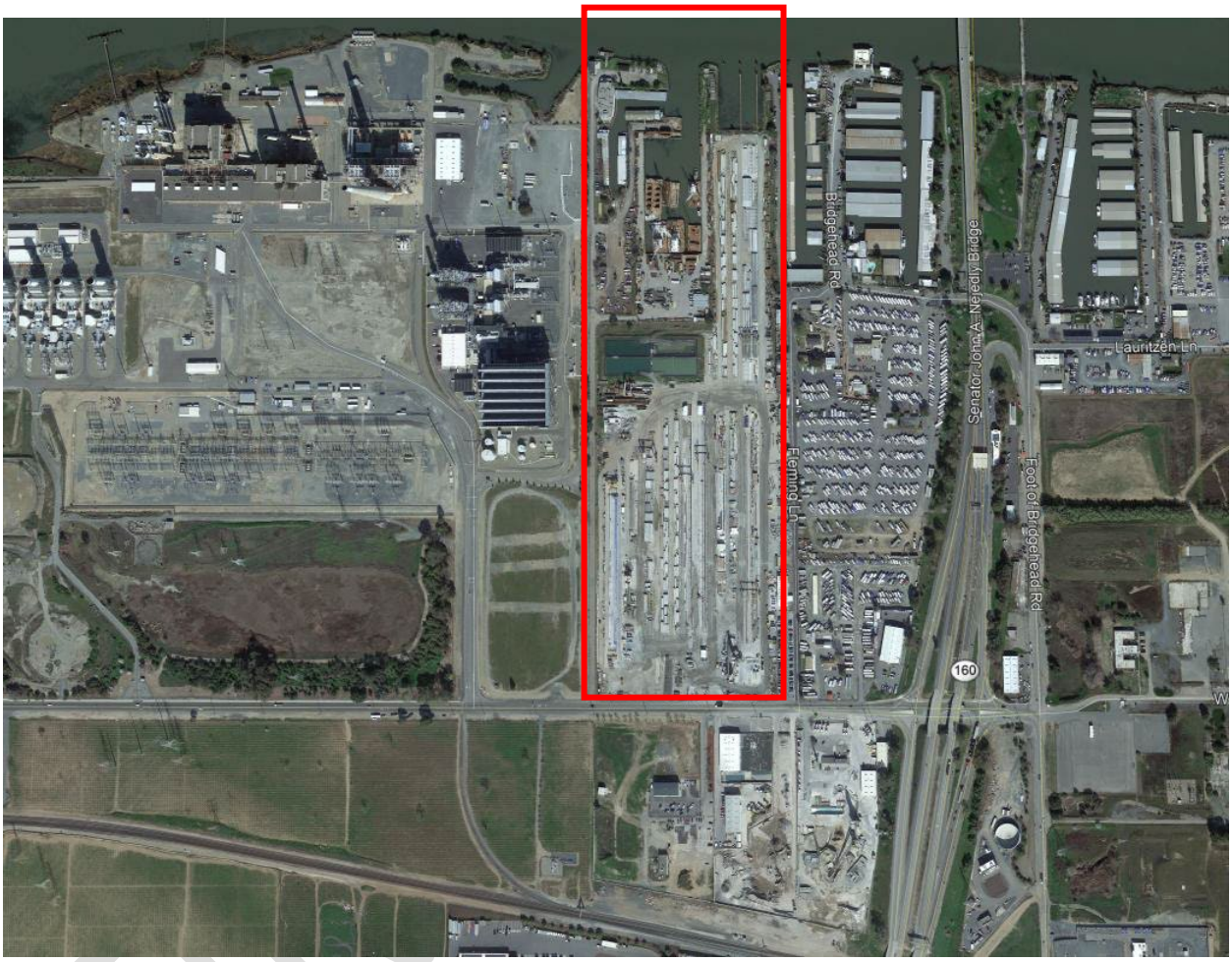


Source: Google Maps

Figure 3. Confab Lathrop Precast Facility

5.3.3 Kie-Con Site

Name: Kie-Con Precast Facility (Figure 4)
Address: 3551 Wilbur Avenue
Antioch, California 94509
Size: ±28 acres
Features: Onsite ready-mix plants (two each), with barge and road access



Source: Google Maps

Figure 4. Kie-Con Precast Facility

5.3.4 Port of Stockton Site

A 45-acre site off the western end of Fremont Street near the Port of Stockton was used as a precast yard for the recent California Department of Transportation (Caltrans) replacement project of the eastern span of the Bay Bridge. The site was demolished following construction (Caltrans, 2018).

6. Summary

Multiple precast segment plants would 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. Segment storage space is dependent on contractor means and methods which include tunneling schedule, on-site segment storage, segment production schedule, segment delivery schedule and transportation method (truck or rail) and segment fabrication facility storage space. The total acreage required could be several times the space required for the batch plant and casting facility. The current assumption for the segment casting facility is that it would not be located at the tunnel construction site and that tunnel segments would 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.

7. References

California Department of Transportation (Caltrans). 2018. *Bay Bridge Documents/Reports*. https://www.baybridgeinfo.org/bay-bridge-documentsreports.

California Department of Water Resources (DWR). 2020. Notice of Preparation of Environmental Impact Report for the Delta Conveyance Project. https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Delta-Conveyance/Delta_Conveyance_Project_NOP_20200115_508.pdf?la=en&hash=74B80DAAE5B9C4BC2EB0619B6A252011F72D1087.

Delta Conveyance Design and Construction Authority (DCA). 2021. Logistics Strategy Technical Memorandum. Final Draft.

Traylor Brothers Inc. (TBI). 2020a. Personal communication (telephone conversations) between Chris Hebert and Bryce Scofield, General Manager, TBI and Steve Dubnewych of DCA.

Traylor Brothers Inc. (TBI). 2020b. "Precast Facility, Littlerock, CA." *What We Do*. https://www.traylor.com/what-we-do/precast/precast-facility-littlerock-ca/

Los Angeles County Metropolitan Transportation Authority (LA Metro). 2017-2019. *Purple Line Extension*. https://www.metro.net/projects/westside/

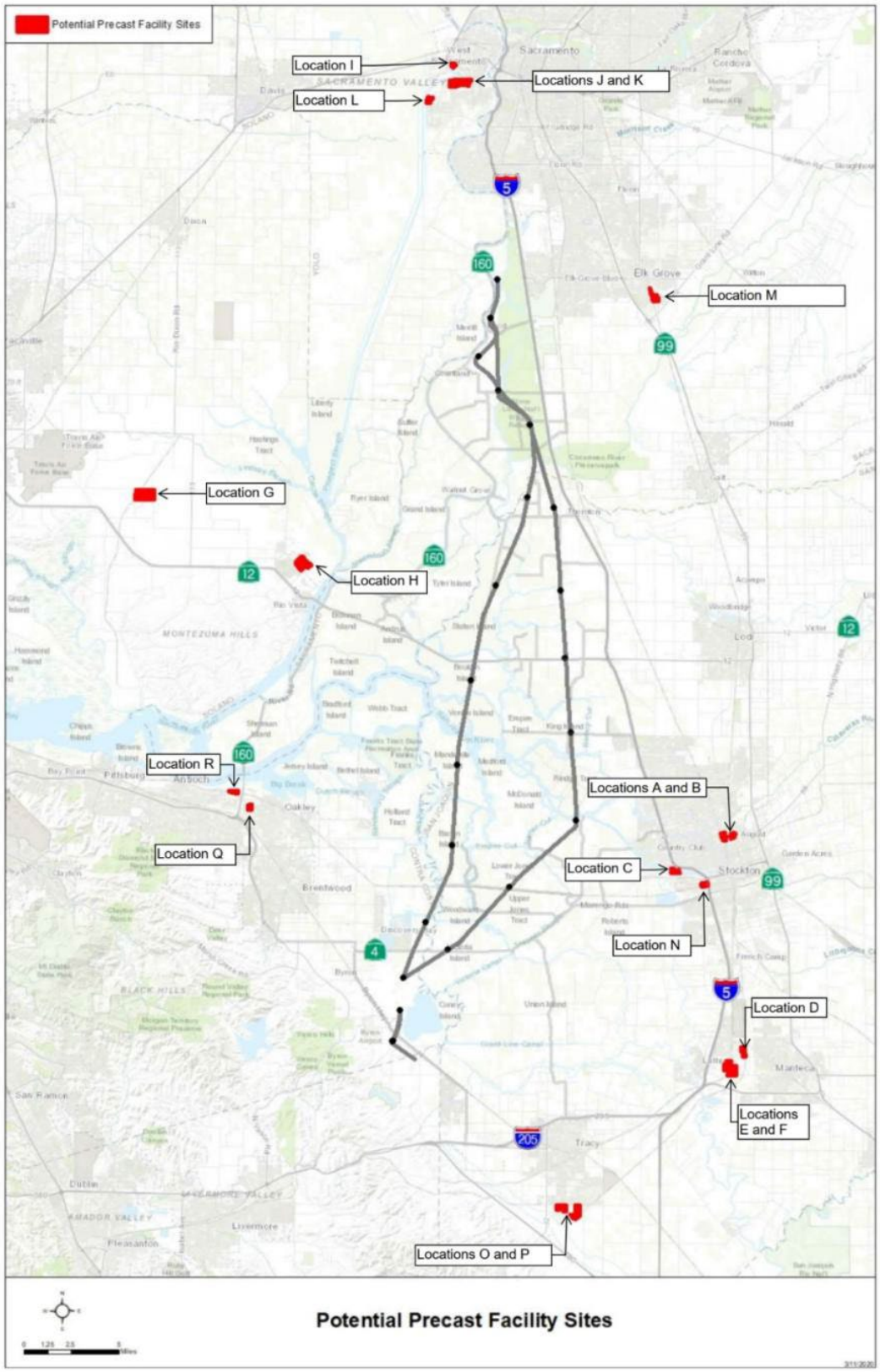
8. Document History and Quality Assurance

Reviewers listed have completed an internal quality review check and approval process for deliverable documents that is consistent with procedures and directives identified by the Engineering Design Manager (EDM) and the DCA.

Approval Names and Roles			
Prepared by	**Internal Quality Control review by**	**Consistency review by**	**Approved for submission by**
Steve Dubnewych / EDM Tunnel Lead	Bob Cermak/ EDM QC Reviewer	Gwen Buchholz / DCA Environmental Consultant	Terry Krause / EDM Project Manager

This interim document is considered preliminary and was prepared under the responsible charge of Steve Dubnewych, California Professional Engineering License C66922.

Attachment 1
Listing of Properties near Delta Conveyance Construction with Existing Zoning and Acreage that could Accommodate a Precast Plant



Source: Map prepared by DCA.

Location	APN	Intersection	County	City	Notes	Acres
A	117-090-010-000	E. Alpine Ave & West Lane	San Joaquin	Stockton	Zoned: General Industrial. Highway (CA 99) and rail access.	45.87
	117-360-070-000					5.06
	117-360-080-000					4.13
	117-360-090-000					4.17
	117-360-120-000					12.72
B	117-360-130-000	El Pinal Drive	San Joaquin	Stockton	Zoned: General Industrial. Highway (CA 99) and rail access.	9.1
	133-060-060-000					28.81
	133-060-090-000					36.82
	133-100-020-000					
C	133-100-030-000	W. Fremont St	San Joaquin	Port of Stockton	Zoned: Industrial. Highway (I-5) and rail access	12.67
	198-100-180-000				Zoned: General Industrial or Limited Industrial. One or combination. Highway (I-5, CA 120, CA 99) and rail access.	16.45
D	198-090-170-000	Park Street @ Louise Avenue	San Joaquin	Lathrop		29.84
	198-150-040-000					23.82
	198-150-080-000				Zoned: General Industrial or Limited Industrial. One or combination. Highway (I-5, CA 120, CA 99) and rail access.	32.79
E	198-150-010-000	McKinley Ave @ Vierra Road	San Joaquin	Lathrop		42.67
	198-150-006-000					6.57
	198-180-050-000				Zoned: General Industrial or Limited Industrial. One or combination. Highway (I-5, CA 120, CA 99) and rail access.	81.08
F	198-130-057-000	South Howland Rd	San Joaquin	Lathrop		4.88
	42-110-380	Creed Rd & Goose Haven Road				37.43
G	42-110-450		Solano Co	n/a	Zoned Industrial. Highway (CA 12) and rail access	266.93
H	177-100-120	Airport Rd	Solano Co	Rio Vista	Zoning: Industrial? Highway (12) and), Barge (Through Dutra).	191.84
I	67-980-004-000	Industrial Dr	Yolo	West Sacramento		19.7
J	45-030-044-000	Southport Pkwy	Yolo	West Sacramento	Zoned: Heavy Industrial/Water Related Industrial. Highway (US 50 / I-80), rail and barge access .	72.02
K	45-551-057-000	Southport Pkwy	Yolo	West Sacramento	Zoned: Heavy Industrial/Water Related Industrial. Highway (US 50 / I-80), rail and barge access .	105.35
	45-910-030-000					12.89
	45-910-031-000					23.08
L	45-551-068-000	Ramos Dr	Yolo	West Sacramento	Zoned: Heavy Industrial/Water Related Industrial. Highway (US 50 / I-80), rail and barge access .	22.62
	134-0100-060-0000					7.5
	134-0100-084-0000					9.68
	134-0100-085-0000					9.83
	134-0181-041-0000					10
M	134-0181-042-0000	10000 Waterman Rd, Elk Grove CA 95624-4010	Sacramento	Elk Grove	Zoned: HI - Heavy Industrial https://www.cityofwestsacramento.org/home/showdocument?id=4240	24.46
N	145-230-040-000	800 W. Church Street	San Joaquin	Port of Stockton	Zoned: Industrial. Highway (5) and rail access	38.41
O	253-110-090-000	10808 W. Linne Road	San Joaquin	Tracy	Zoned: Heavy Industrial. Highway access, possible rail access.	56.03
P	253-120-480-000	9500 W. Linne Road	San Joaquin	Tracy	Zoned : General Industrial. Highway access, possible rail access.	115.53
Q	37-080-005-4	50 Sandy Lane, Oakley, CA	Contra Costa	Oakley	Zoned: Light Industrial. Highway access, close to Barge Access.	26.49
R	51-032-008-8	Wilbur Ave	Contra Costa	Antioch	Zoned: Heavy Industrial. Highway access, Rail Access close to Barge Access.	29.77