Dynamic barrier used to solve a large construction dewatering problem

C.E. Holley¹, J.E. Ross², & B.M. Ghadiali³
¹Clayton Group Services, USA
²Moffatt & Nichol Engineers, USA
³DMJM-HARRIS, USA

Abstract

This paper outlines the description of a dynamic barrier installed between a railroad trench under construction and an existing toxic plume floating on the surface of ground water adjacent to an oil recycling facility. The Alameda Corridor Transportation Authority (ACTA), in April, 2002 completed construction of a 32km railroad transportation project which ranks as one of the largest freight transportation projects ever undertaken and one of national significance. The project includes 16km of surface tracks and a 16km below-surface Trench section along Alameda Street. The Trench portion will carry two railroad tracks beneath existing streets. During Trench construction, significant quantities of toxic waste were encountered in soil and groundwater from adjacent facilities. This paper describes one such encounter and the solution chosen to avoid costly construction delays while providing for environmental safeguards.

1 Project overview

Until now, the Alameda Street carried surface railroad tracks in addition to the high volume automobile, truck and pedestrian traffic. The tracks carried freight shipment to and from the Ports of Los Angeles and Long Beach to the transcontinental hub area in downtown Los Angeles. The entire alignment is divided into three sections, The north and south sections total 16km in length and the center section, the Mid-Corridor Trench, is 16 km in length, Figure 1.
To reduce traffic congestion, automobile and train emissions, and noise pollution, as well as to enhance both the auto and freight traffic, a deep trench was constructed, effectively eliminating all at grade crossings with vehicles and pedestrian traffic. The Trench, a three-sided concrete structure, will carry two tracks with a provision for a third track in the future, Figure 2.
The Mid-Corridor Trench portion is 16m in width and 10m in depth. A by-pass track for use during construction was built at street level adjacent to the Trench within railroad right of way. The existing ground water beneath the Trench alignment varies from 10m deep at the south end and over 70m in depth at the northern terminus. The alignment passes through seven municipal cities and through Los Angeles County, each with its own share of toxic releases from adjacent industrial facilities in close proximity to the Trench. Toxic materials released to soil and groundwater that impacted the Trench from these adjacent facilities include gasoline, diesel and naphtha, heavy metals including lead, arsenic, and chrome including hexavalent chrome and asbestos, Table 1.

Table 1. Toxic materials impacting the Alameda Corridor

<table>
<thead>
<tr>
<th>SOIL / GROUNDWATER</th>
<th>CONTAMINANT</th>
<th>QUANTITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil</td>
<td>Metals</td>
<td>222,000 metric tons</td>
</tr>
<tr>
<td>Soil</td>
<td>Fuel / Hydrocarbon</td>
<td>596,000 metric tons</td>
</tr>
<tr>
<td>Soil</td>
<td>Asbestos</td>
<td>28,000 metric tons</td>
</tr>
<tr>
<td>Groundwater</td>
<td>Hexavalent Chrome</td>
<td>25 million liters</td>
</tr>
<tr>
<td>Groundwater</td>
<td>Metal / Hydrocarbons</td>
<td>3.6 billion liters</td>
</tr>
</tbody>
</table>
2 Geologic setting

The Mid-Corridor project is within the Los Angeles Basin, a low coastal plain surrounded by Santa Monica Mountains on the north, San Joaquin Hills on the south, Santa Ana Mountains and Repetto and Puente Hills on the east and Pacific Ocean on the west. The basin is underlain by a thick sequence of sediments and sedimentary rocks, followed by igneous and metamorphic basement rocks. The coastal plain is also referred to as the Downey Plain. The surface materials at the site consist of Holocene-age alluvial sediments basically sands and gravels. These sediments are underlain by late Pleistocene-age Lakewood formation and early Pleistocene marine San Pedro formation. The project site slopes very gently to the south, with elevations ranging from 66m at the north to about 18m near the south end. The Basin sediments are interpreted as layers of granular aquifers separated by fine-grained aquicludes. The unconsolidated Quaternary sediments within the Basin include granular aquifer zones referred as Gaspur (recent and shallowest) followed by Exposition, Gage, Hollydale, Lynwood, Silverado and Sunnyside aquifers at the deeper end. The silt and clay zones which are extensive in the Basin, and separating the upper aquifers are referred to as Lakewood and Bellflower aquicludes. The aquifers and aquicludes are not always uniformly continuous in the Basin and vary greatly in thickness from a meter to as much as 60 meters. This may be due to slightly tilting of these layers near the margins of the basins due to synclinal structures. The tilting or the uplift may be due to subsurface faulting resulting in crustal warping throughout Quaternary times.

There are no subsurface geological faults crossing the Mid-Corridor alignment. However, the project site is located near and within the seismically active region of southern California. The nearest surficial fault is the Newport-Inglewood structural zone which crosses the alignment south of the Mid Corridor. It is strike-slip, about 8km southwest of the alignment. The Basin is also underlain by active subsurface faults. These subsurface faults comprise north-dipping thrust faults, approaching to within 3km of the surface, displacing rocks as young as Pliocene. The seismotectonic stress field in the Los Angeles region is one of north-northeasterly compression at the rate of about one-half to one centimeter per year.

The subsoils encountered under the Alameda Street along the 16km Mid Corridor Trench are Holocene-age alluvium. It contains sands, silty sand, sandy silt and gravels along with pockets of clayey silt and silty clay. Both the sand and gravels are fine to coarse in gradation. The soils are heterogeneous in nature. These are medium dense to dense in general, and become dense to very dense with increasing depths at around 10 meters below the ground surface.
3 Problem identification

At one location of the Trench construction, a significant release of liquid hydrocarbon was present on the surface of the shallow ground water and threatened to impact Trench excavation dewatering. The source of this release was a nearby former oil refinery currently operating as an oil storage and recycling facility. The liquid hydrocarbon, a light non-aqueous phase liquid (LANPL) was classified as an “off-specification petroleum distillate” with a flash point of 7 degrees centigrade. At 25 degrees centigrade, the LNAPL viscosity is 1.73 and the specific gravity is 0.18. It is comprised of BETX compound concentrations up to 41,000 µg/l, along with other volatile compounds at lesser concentrations. California environmental regulators had for the past several years been directing the facility in subsurface site investigation and remediation of these conditions. It was known that the LNAPL was floating on ground water beneath the facility and recovery was underway by pumping from one recovery well within the LNAPL plume. Additional subsurface investigation collected by ACTA just prior to Trench construction included new monitoring well data along with cone pentrometer testing and aquifer testing and showed the leading edge of the LNAPL plume to be within 6m of the edge of the Trench. The shape and size of the plume at the time of construction and its close proximity to the Trench are shown in Figure 3.

Figure 3: Toxic plume location
Since the radius of influence of the design-builder’s Trench dewatering system was known to be substantially greater than 6m, a method was needed to avoid any impact of the LNAPL and associated dissolved hydrocarbon on Trench construction dewatering. The challenge was to ensure sufficient depression of the groundwater gradient to allow the trench construction to proceed in the dry, and at the same time, control hydrocarbon plume migration, both horizontally and vertically. Compounding the challenge was the identification of two distinct water bearing zones each requiring dewatering and with substantially different physical characteristics. A shallow semi-perched water-bearing zone termed the “S1/S2” unit, was present along with a deeper ground water unit termed the “S3” aquifer unit. These units were approximately 10m and 19m in depth respectively, Figure 4.

4 Problem solution

To meet the challenge, the concept of a dynamic barrier [1] was proposed by the environmental firm representing the design-builder. Initially a system close to the Facility involving seven deep extraction wells screened in the “S3” unit and twenty shallow extraction wells screened in the “S1/S2” unit was proposed. This system was determined to be not only expensive but also, difficult to construct under heavy street traffic and with a significant number of existing underground utilities. Also, the fate of the LNAPL plume, cut off by the close dynamic barrier, could not be assured during construction dewatering. A modified form of this dynamic barrier, installed within the Trench as an added part of the Trench contractor’s normal proposed dewatering system, was then studied by the Facility’s environmental consultant and finally chosen as a preferred solution. It became the primary function of this barrier to compete with construction dewatering within the Trench, to contain and control LNAPL and dissolved hydrocarbon before impact on the Trench dewatering occurred. Numerous data showed that the shallow water-bearing zone “S1/S2” in the area of LNAPL contamination is comprised of two thin beds of fine sand and silty clay, which are interbeded with silt, sandy silt, clayey silt and clay. The two sand beds each range from one to two meters in thickness. LANPL and dissolved hydrocarbon contamination are more prevalent in this thinner, finer grained portion of the “S1/S2” unit. The aquifer tests that were conducted more accurately described how the contaminated “S1/S2” unit would likely respond to Trench dewatering. The testing indicated that the “S1/S2” aquifer had permeability ranges from 1m to 4m per day and transmissivity from 5 to 19 square meters per day with an average of 12 square meters per day. Storativity ranged from 0.0024 to 0.48 with an average of 0.022. It was concluded that an extraction rate of up to 40 liters per minute for the “S1/S2” unit in the LNAPL plume area would be likely. Aquifer tests [2] in the deeper S3 unit showed de-watering of much higher rates, more in the low to mid-hundreds of liters per minute. However, this unit contained only trace levels of dissolved contamination not likely to impact Trench dewatering. It was concluded that only the significantly contaminated
"S1/S2" unit could be problematic and this shallow unit was fine grained and thin and would yield only small volumes of water requiring special handling.

Figure 4: Well construction details

The design-builder's Trench dewatering plan specified dewatering of both the shallow and deeper units at the same time with single extraction wells screened
across the “S1/S2” and the “S3” units from 9 to 24 meters. In order to prevent LNAPL in the shallow “S1/S2” from impacting the “S3” unit during normal construction dewatering, it was decided to modify three Trench dewatering wells in the vicinity of the leading edge of the LNAPL plume area. This resulted in the “S1/S2” unit and the “S3” unit being dewatered through the separate screened intervals of the three nested wells as shown in Figure 4. The resulting extracted “S1/S2” ground water was plumbed in such a way as to become the responsibility of the Facility to handle and provide for proper disposal. The contractor continued, uninterrupted in handling and disposing of the extracted ground water from the “S3” screened portion of the three nested wells along with his normal Trench dewatering water. Also, a plan by the facility to install additional recovery wells inside the facility, to accelerate LNAPL removal by both hand bailing and pumping, was initiated.

This created essentially a reversal of the ground water gradient away from Trench and aided in the containment and control of LNAPL and dissolved contaminant migration. Groundwater modeling scenarios were also evaluated to show the potential fate and transport of the contaminated groundwater in the “S1/S2” unit. Taken together, all the facility recovery wells and the three modified Trench dewatering wells became a dynamic barrier that would function to contain and control plume migration and ensure high probability that LNAPL would not be drawn into any of the design-builder’s Trench dewatering wells. Also, it was planned that only non-significant quantities of dissolved contamination would be drawn into the three separately screened “S1/S2” portions of the three nested wells. Installation of the three nested wells was performed by the Facility’s environmental consultant at no inconvenience to the construction contractor.

During an approximately 90 day period, the nested “S1/S2” wells were activated first, followed by initiation of the lower “S3” wells, and finally the remaining design-builder’s Trench construction dewatering wells in the area were started. The Facility recovery wells had been in continuous operation prior to and during this period. Well yields results indicated that the “S1/S2” water level was drawn down below static water levels effectively dewatering the “S1/S2” unit and that LNAPL was not drawn into either the “S1/S2” portion of the nested wells, the “S3” portion, or any of the deeper Trench dewatering wells and that all other construction Trench dewatering system operated as planned. In the end, only the “S1/S2” nested wells yielded any volume of contaminated ground water in the discharge and ultimately the yield from these three wells was not measurable.

5 Conclusion

It became necessary to install a dynamic barrier to contain and control migration of a toxic material, migrating from a storage and disposal facility and threatening to impact a large dewatering system operating during the construction of a railroad trench. At the time of construction, the toxic plume, floating on ground
water, was within 6 meters of the face of the excavated Trench and within 1 to 2 meters of the Trench bottom. Pump tests, soil probes, observation wells, along with ground water modeling were employed to provide a solution. Ultimately a 100m long dynamic barrier was implemented. The barrier utilized many on-site Facility recovery wells and three specially constructed nested wells, which prevented any impact to a railroad trench dewatering system during construction. Between July and September of 2000, the barrier operated successfully and without delaying construction. The project opened to railroad traffic in April 2002 as planned, with no cost overruns and no contractor claims; a remarkable feat given the three-year time period allowed for the completion of this $2.3 billion dollar railroad corridor. Success of this project can be attributed to cooperative efforts between owner, design-builder, the Facility and their respective consultants and sub-contractors. All parties met often and shared data to ensure success and meet the challenge facing all concerned.

References
