Technical Memorandum

Northwest County Recycled Water Strategic Plan

Subject: **Task 6.3 – Using Groundwater from Temporary Dewatering Systems for Irrigation**

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Contents

1 Background

In the City of Palo Alto (City), dewatering is often required for construction of underground parking garages and for construction of residential basements. Dewatering occurs when a basement is constructed in an area of shallow groundwater, typically in locations closer to the San Francisco Bay (Bay). Dewatering extracts groundwater from just beneath the ground surface and discharges this groundwater to the City's storm drain system, which indirectly augments local stream flows and ultimately flows into the Bay. Construction dewatering is temporary and ceases after basement construction is completed. Community discussions during the recent drought expressed interest in understanding the potential to redirect water from basement construction dewatering for nonpotable reuse throughout the City. This study looks at the feasibility of using groundwater pumped from temporary dewatering activities for irrigation of City facilities, such as parks.

The City currently relies on potable water from the San Francisco Public Utilities Commission (SFPUC), which consists of about 85% Sierra Nevada snowmelt delivered through the Hetch Hetchy water distribution system. Groundwater from dewatering sites that is suitable for irrigation can be trucked to nearby City sites, such as parks and open spaces, and sprayed by the water truck onto areas that require irrigation. Using groundwater from dewatering for irrigation has the benefit of offsetting the City's demand of potable water supplied from Hetch Hetchy.

This study analyzes groundwater pumped from temporary dewatering activities at commercial and residential construction sites in the City, using data from July 2019 to August 2020 as an example of a typical year (permanent dewatering sites are addressed in a separate study). The quality of the groundwater is evaluated for suitability for irrigation and the groundwater quantity is compared to the demand needed for irrigation of City property. The cost to convey the water between the dewatering sites and irrigation sites is estimated by hauling using a 2,500-gallon tanker truck. Greenhouse gas emissions in the form of carbon dioxide (CO_2) are estimated based on trucking water from dewatering sites to irrigation sites in accordance with the City's dewatering regulations.

Note that connecting temporary dewatering sites to permanent irrigation facilities is not feasible given the temporary nature of these sites as well as the system controls and pressure requirements of permanent irrigation systems.

2 Regulations

Construction activities can directly affect the health of the surface waters and are regulated in several ways. All construction sites are required to implement stormwater Best Management Practices (BMPs) to prevent construction dirt, debris, and other pollutants from entering storm drains and creeks. Some construction sites may also be required to prepare a Stormwater Pollution and Prevention Plan (SWPPP). Further, some dewatering activities are regulated by both the City's dewatering regulations and the State and Regional Water Quality Control Boards.

2.1 State Water Resources Control Board General Permit Page

Stormwater discharges associated with construction and land disturbance activities greater than 1 acre are regulated by the General Permit 2009-0009-DWQ from the State Water Resources Control Board. Basement dewatering is typically below this threshold and is generally not subject to the General Permit.

2.2 San Francisco Bay General Order

Discharge from groundwater facilities to surface water from structural dewatering is regulated by the San Francisco Bay Regional Water Quality Control Board's General Order No. R2-2018-0026. The General Order permits structural dewatering discharges to surface waters of over 10,000 gallons per day (gpd) that do not require treatment for volatile organic compounds or fuels. The General Order does not cover temporary dewatering associated with construction dewatering activities and basement dewatering is generally not subject to the General Order.

2.3 City of Palo Alto Dewatering Regulations

In 2016 the City established requirements to standardize the pumping of groundwater from construction dewatering of below-ground structures to outline when and how long dewatering can occur during construction and what facilities need to be installed to minimize discharge to the City’s storm drain system. The dewatering season is April 1 through October 31 when there is typically available capacity in the City's storm drain system. Dewatering typically continues until enough of the building has been constructed to keep the basement in place. City regulations allow dewatering for 12 weeks, including a 2-week start-up period. The 2-week start-up period is intended to provide adequate time for the contractor to meet the City’s dewatering requirements, as well as for City staff to inspect and monitor the dewatering start-up operation.

Dewatering beyond 12 weeks is allowed only under special circumstances and if approved by the City Engineer. The City will consider allowing groundwater discharges to the storm drain system from November 1 to March 31 if the applicant can provide sufficient evidence that the receiving storm drain line and water body has sufficient capacity to accommodate a 10-year, 6-hour storm event in addition to the dewatering discharge (a pipe capacity calculation). Dewatering to the sanitary sewer system is allowed under special circumstances and a discharge permit must be obtained through Public Works Watershed Protection Group.

To minimize discharges to the storm drain system from construction dewatering, the applicant is asked to first use pumped groundwater on the construction site as needed and whenever possible. This includes controlled infiltration, irrigation of existing landscaping, dust suppression and other construction needs. At all times, the dewatering applicant is responsible for pumping groundwater into a settling tank where the solids separate to clarify the water. The volume of water pumped into the settling tank is measured by a flowmeter and recorded. Data recorded from the sites evaluated as an example in this study are presented in Section 4.1.

After the settling tank, the applicant is required to construct a fill station where a water truck can connect to and be filled. The applicant is responsible to contract with or otherwise provide water truck service, and the water truck operator/company is responsible to contact the City’s Urban Forestry staff to determine the location of sites to be irrigated. City dewatering requirements indicate that during the first 6 weeks of dewatering activities (not including the 2-week start-up period), water should be trucked one full day (8 hours) per week from the project site to irrigation sites. The frequency increases to 5 days per week for the remainder of the dewatering period.

3 Groundwater Supply

The City overlies a groundwater aquifer called the Santa Clara Subbasin (DWR Bulletin 118 Basin 2-009.02), which consists of a shallow “unconfined” aquifer and a deep “confined” aquifer. The shallow and deep aquifers are separated by extensive clay deposits that form a confining layer or “aquitard” which prevents groundwater from moving between the shallow and deep aquifers (Todd Groundwater, 2018). The confining clay layer that separates the shallow and deep groundwater aquifers is generally located east of State Route 82, as shown on Figure 1. Figure 1 also shows the elevation of the shallow groundwater table. The blue lines indicate that the overall direction of shallow groundwater flow is toward the Bay. Fall 2016 contour maps are based on water levels measured between October 1 and October 22, 2016 and represent groundwater elevations at the end of the multi-year drought.

The aquifer is recharged by rainfall at the “unconfined” or “recharge” areas near the foothills, generally west of State Route 82. In areas where the groundwater elevation is higher than the creek elevation, groundwater can flow from the shallow aquifer into the creeks. In areas where elevations in the creeks are higher than the elevation of the groundwater, the creek can recharge the aquifer. Creeks within the City include Adobe, Barron, Matadero and San Francisquito. Dewatering flows that are directed to the storm drain system end up in one of these creeks depending on the drainage area. Figure 3 shows the drainage areas for the City creeks.

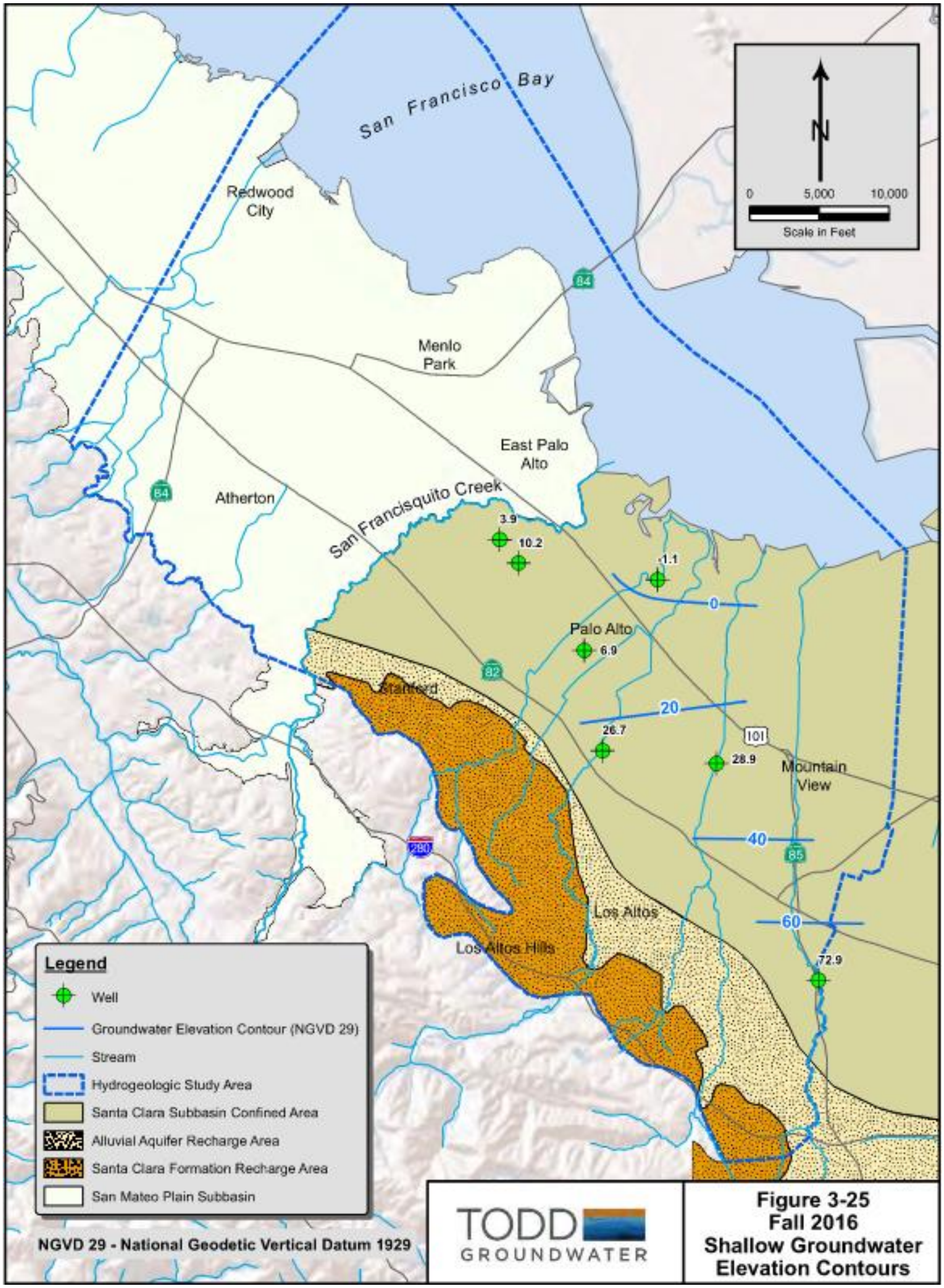
Located along the northern City boundary, San Francisquito Creek has the largest watershed (45 square miles) and is the only riparian, unchannelized urban creek on the south Peninsula. San Francisquito Creek is a documented source of recharge to the shallow and deep aquifers. Estimated recharge to groundwater from the creek totals about 950 acre-feet (AF) per year during an average year, with the greatest losses (recharge to groundwater) occurring between the San Mateo Drive bike path and Middlefield Road (Todd Groundwater, 2018). Flows in the unlined portion of San Francisquito Creek have the highest probability of recharging the groundwater basin.

All remaining City creeks, other than San Francisquito Creek, have substantial percentages of the channel converted to concrete-lined, engineered channels. The lining greatly restricts flow between these creeks and the groundwater system. In general, flows in Adobe, Barron, and Matadero Creeks will not recharge the groundwater table and will discharge to the Bay.

Groundwater contamination has been identified in Palo Alto based on reports of releases and site investigations required by State and Federal environmental policies and regulations, or during due diligence investigations for real estate property transactions. Many of these sites have been investigated through installation and sampling of monitoring wells, and some sites have been partially or completely remediated, while others remain contaminated. Investigation and remediation are typically conducted by the responsible party or property owner under the supervision of the regulating agency or agencies.

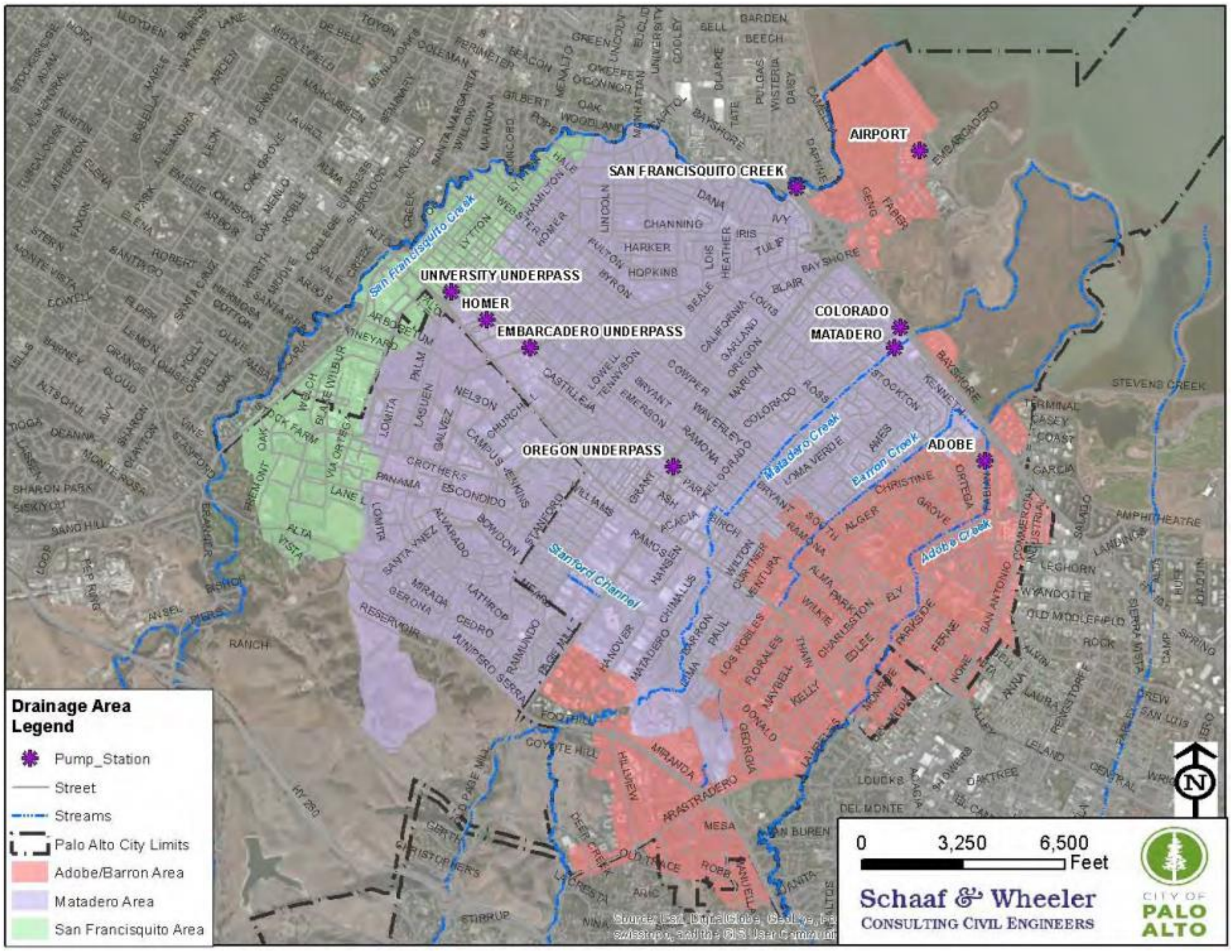
At sites with groundwater contamination, downward gravity-driven migration through the vadose (unsaturated) zone causes contaminants to enter the saturated groundwater zone, where they flow via advection in groundwater, spread laterally and vertically due to dispersion and molecular diffusion, and depending on chemical type, can adsorb onto the solid aquifer matrix and/or degrade into other compounds. The extents of chemical plumes in groundwater are controlled by chemical properties and site-specific hydrogeologic conditions (e.g., groundwater flow rates and directions, both laterally and vertically, and the presence of fine- and coarse-grained layers that could impede or allow migration), as well as the size, duration, and timing of the release.

When contamination is found or suspected at a construction site, it is the responsibility of the discharger to notify all appropriate local, State, and federal agencies, including the appropriate Regional Water Board. Discharge of water with known contaminants will typically require an individual discharge permit. Such discharges are not the subject of this study. Figure 3 maps locations of known contaminant sites within the City, including leaking underground storage tank (LUST) locations, which is provided for general information.



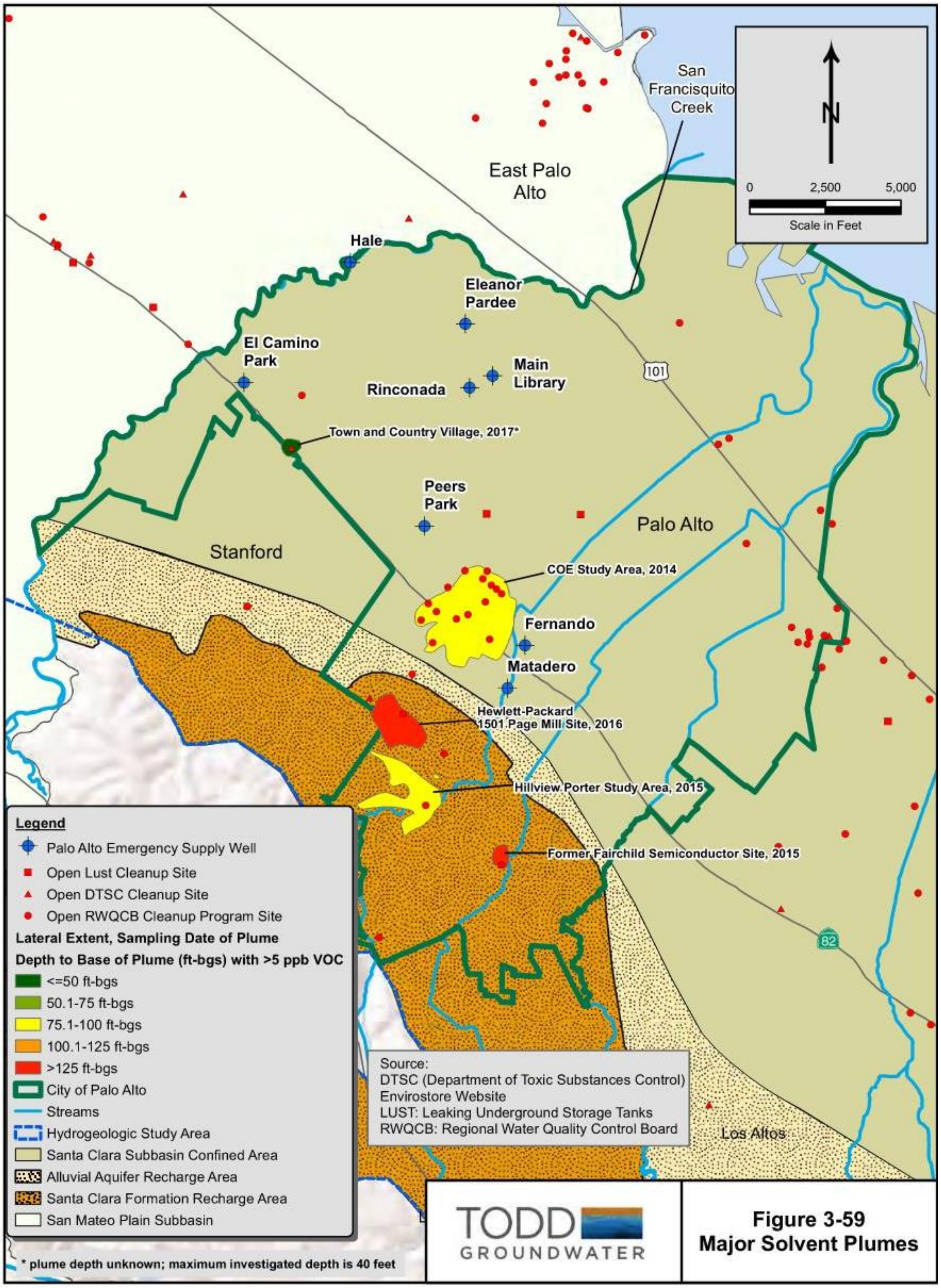
Source: Todd Groundwater, 2018

Figure 1: Shallow Groundwater Elevation Contours – Fall 2016



Source: Schaaf & Wheeler, 2015

Figure 2: Creek Drainage Areas



Source: Todd Groundwater, 2018

Figure 3: Groundwater Contaminant Plume Locations

4 Dewatering Groundwater from Temporary Construction Activities

During the period between July 2019 to August 2020, there were 15 temporary dewatering construction sites in the City. These 15 sites, presented in Figure 4, were located on or east of State Route 82 between San Francisquito Creek and Adobe Creek. These sites were over the confined portion of the Santa Clara aquifer, which means that groundwater pumped from these sites is from the shallow aquifer above the confining layer (as discussed in Section 3, the confining layer, or aquitard, restricts flow between the shallow and deep groundwater aquifers). Most of the sites were in the drainage area of Matadero Creek, which is a concrete-lined engineered channel and not a significant source of groundwater recharge. Of the 15 sites, four were commercial and 11 were residential. These sites represent a typical sample of dewatering sites and are used for analysis in this study.

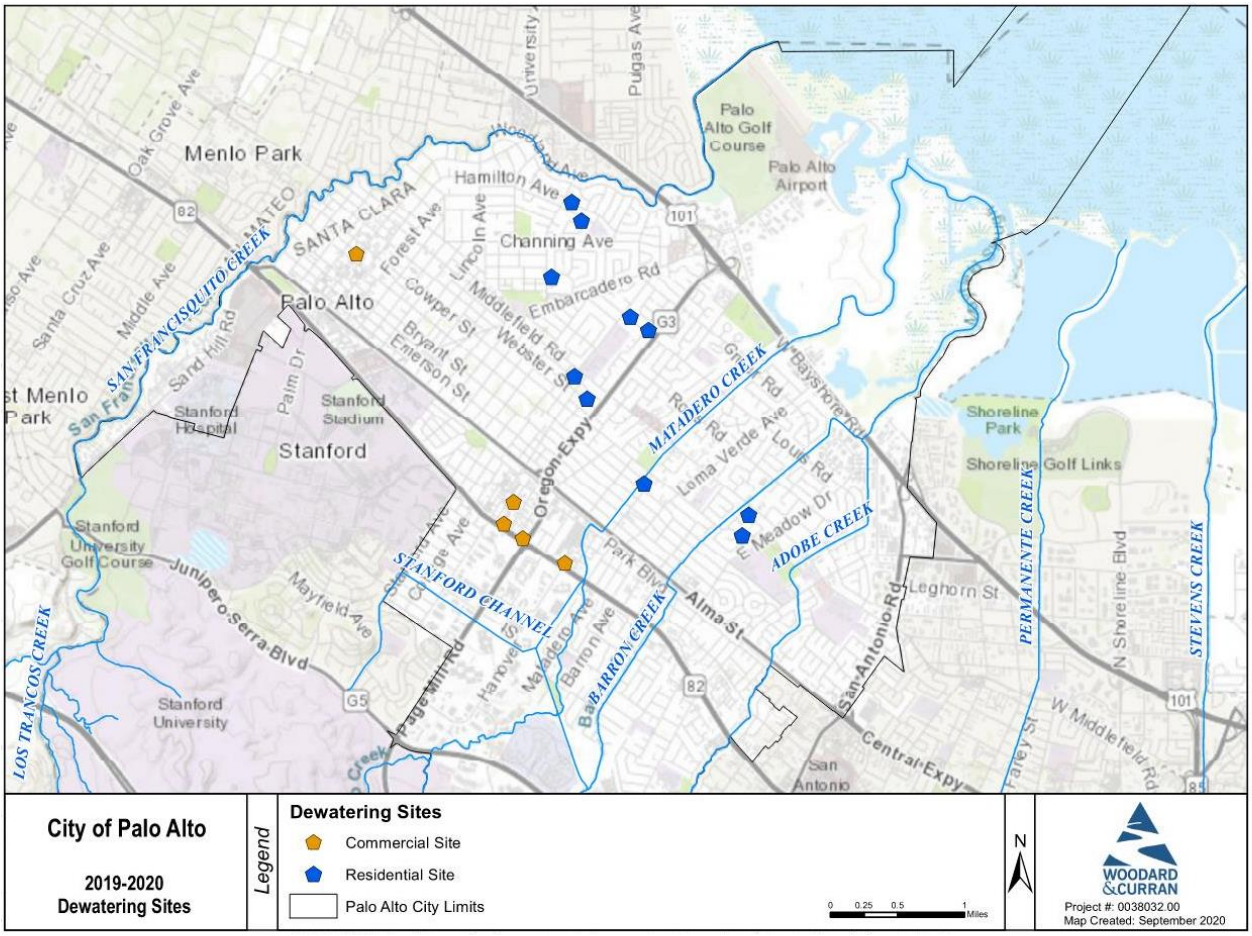


Figure 4: Dewatering Sites Evaluated

4.1 Dewatering Groundwater Quantity

The quantity of groundwater pumped and reused from each site was measured. Data from July 2019 through August 2020 are summarized in Table 1. Flowmeter data were unavailable for two of the 15 dewatering sites. For the year-long period, a total of 461 AF of water was pumped from the 13 metered sites. Of the 461 AF pumped, approximately 6 AF (about 1%) was reused at the construction sites (i.e. for irrigation, dust control, etc.).

Table 1: Quantity of Groundwater Pumped from Temporary Dewatering Sites

Dewatering Site	Site Type	Dewatering Period	Dewatering Duration (Days)	Quantity Dewatered (Gallons)	Quantity Reused (Gallons)
Sherman	Commercial	7/16/19-4/10/20	269	14,754,183	--
El Camino Real 3	Commercial	8/14/19-11/7/19	85	1,410,893	--
El Camino Real 2	Commercial	8/22/19-4/2/20	224	1,231,217	--
University	Commercial	12/19/19-2/5/20	48	6,331,880	--
El Camino Real 1	Commercial	4/24/20- 8/27/20	125	8,308,000	--
Louis Road 1	Residential	7/12/19-11/14/19	125	40,484,994	516,602
Cowper	Residential	7/23/19-11/1/19	101	10,115,851	195,801
Murdoch	Residential	8/13/19-11/8/19	87	12,363,280	387,763
Walnut	Residential	8/22/19-10/31/19	70	7,985,595	214,076
Byron Street	Residential	8/6/19-11/25/19	111	36,627,404	512,399
Waverly	Residential	9/3/19-10/14/19	41	5,494,625	55,940
Webster	Residential	7/28/20- 8/27/20	30	392,500	--
Louis Road 2	Residential	8/10/20- 8/28/20	18	4,636,857	84,846
			Total Dewatered (gallons)	**150,137,279**	**1,967,427**
			Total Dewatered (acre-feet)	**461**	**6**

4.2 Dewatering Groundwater Quality

Water quality data from samples of groundwater at each dewatering location were collected from 13 of the dewatering sites and included pH, turbidity, and conductivity; these data are summarized in Table 2.

Table 2: Groundwater Quality Summary

Dewatering Site	Sample Date	pH	Turbidity (NTU)	Conductivity (uS/cm)	Total Dissolved Solids (mg/L)
Louis Road 1	7/12/2019	8.27	2.9	864	432
Sherman	7/16/2019	7.52	8.4	1,261	630.5
Cowper	7/24/2019	7.36	1.2	1,201	600.5
Byron Street	7/25/2019	7	5.1	1,068	534
El Camino Real 3	7/31/2019	-	8	1,769	884.5
Murdoch	8/13/2019	7	18.5	1,197	598.5
Walnut	8/16/2019	-	8.7	1,090	545
Waverly	9/3/2019	-	2.3	1,390	695
University	11/12/2019	-	220	-	-
El Camino Real 1	4/16/2020	-	0.14	1,449	724.5
Louis Road 2	7/22/2020	7.2	1.2	1,144	572
	Average	**7**	**25**	**1,243**	**622**

A numerical measure of the acidity or alkalinity of a solution is measured on the pH scale from 0 to 14. Neutral solutions (such as pure water) have a pH of 7, acidic solutions have a pH lower than 7, and alkaline solutions have a pH higher than 7. The National Secondary Drinking Water regulations acceptable range for pH is 6.5 to 8.5. All groundwater samples fell in the acceptable range.

Turbidity is caused by suspended matter or impurities that caused cloudiness in the water. Clear water has lower turbidity values than cloudy water. Turbidity is measured in nephelometric turbidity units [NTU]. Turbidity values from the dewatered samples ranged between 1 and 220, with an average of 25 NTU. Water with high turbidity is not typically a concern for irrigation, but extremely high turbidities could result in sedimentation within the water trucks and should be avoided.

Conductivity is a measure of water's capability to pass electrical flow. These conductive ions come from dissolved salts and inorganic materials such as alkalis, chlorides, sulfides and carbonate compounds. Salinity is the total concentration of all dissolved salts in water. As such, salinity is a strong contributor to conductivity. Conductivity increases with increasing ion content, which means that in most cases, it gives a good approximation of the total dissolved solids (TDS) using the conversion factor of 1 ppm TDS = 2 uS/cm conductivity.

TDS concentrations above 500 mg/L may be linked to hardness, deposits, colored water, and staining. Concentrations below 500 mg/L are considered "good" from a plant tolerance perspective. TDS values for the dewatered samples ranged between 400 and 900, with an average of 622 mg/L. Overall, the TDS levels are not excessive for general irrigation (i.e. turfgrass) but water with TDS greater than 800 mg/L could be problematic for salt-sensitive plant species such as redwood trees if used for long durations. As a comparison, the City has adopted a goal for their recycled water program (also used for irrigation) of 600 mg/L TDS.

The City's potable supply from Hetch Hetchy has significantly lower average conductivity and TDS values of 50 uS/cm and 30 mg/L, respectively, than the shallow groundwater from dewatering supplies. Thus, groundwater from dewatering is lower quality than the Hetch Hetchy supply. Figure 5 maps the conductivity and turbidity values for each site.

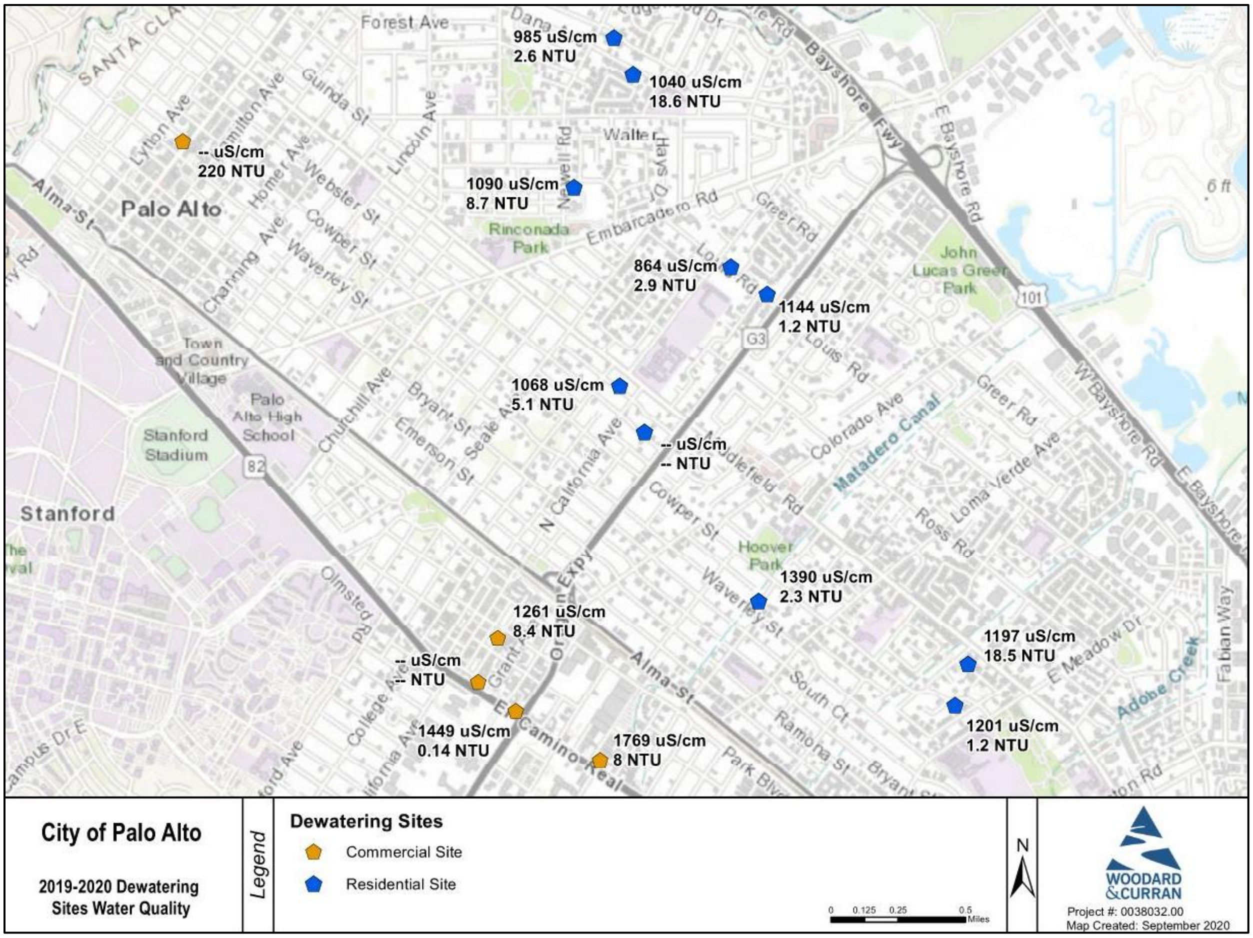


Figure 5: Dewatering Water Quality

5 City Irrigation Demand

The 2019 *Northwest County Recycled Water Strategic Plan* (Strategic Plan) was prepared by the City in collaboration with Valley Water to assess drought-proof recycled water expansion opportunities throughout the Palo Alto Regional Water Quality Control Plant service area. The Strategic Plan evaluated non-potable uses including landscape irrigation, dual plumbing, cooling towers, industrial process water, habitat enhancement, street cleaning, car washes, and demands for Boronda Lake at Foothill Park.

The potential annual average recycled water demand for all non-potable users in the Study Area was estimated to be 4,456 AF per year. Of these demands, over 3,900 AF per year of landscape irrigation demands were identified throughout the City (Woodard & Curran, 2019). Landscape irrigation sites identified for this study included parks, schools, commercial landscaping, multi-family residential landscaping, cemeteries, and golf courses.

Demand for irrigation within the City exceeds the volume produced from temporary dewatering activities by about 9 times; water estimated to be available for irrigation from temporary dewatering activities makes up only 10 percent of the total irrigation demand for City facilities.

6 Greenhouse Gas Emissions

Connecting temporary dewatering sites to permanent irrigation facilities is not feasible given the temporary nature of these sites as well as the system controls and pressure requirements of permanent irrigation systems. As these dewatering facilities are temporary, reuse of the groundwater is possible by hauling the water to other City irrigation sites. Potential greenhouse gas emissions from water hauling were estimated based on fuel efficiency (miles per gallon [mpg]) and a carbon dioxide (CO_2) emissions factor for diesel fuel.

Based on Oak Ridge National Laboratory's *Transportation Energy Data Book*, the average fuel economy of a loaded water truck was estimated at 6.1 mpg (Oak Ridge National Laboratory, 2020). The average diesel emission factor used was 22.51 pounds of CO_2 per gallon of diesel (EPA, 2014). This intensity factor does not account for other greenhouse gases, such as nitrous oxide (N_2O), that may be emitted from truck trips. Based on these figures, the average CO_2 emissions would be 3.7 pounds per mile traveled with a full water truck. For an empty water truck, it was estimated that fuel economy would improve by 2 mpg, for a fuel economy of 8.1 mpg. The average CO_2 emissions from an empty water truck would be approximately 2.8 pounds CO_2 per mile.

Groundwater from dewatering sites that is suitable for irrigation can be trucked to nearby City sites, such as parks and open spaces, and sprayed by the water truck onto areas that require irrigation. A typical water truck can deliver 2,500 gallons of water in a single trip. As an example, Table 3 summarizes the theoretical number of daily truck trips that would be required each day to fully utilize the flow each site produced daily.

Table 3: Theoretical Number of Water Trucking Trips

Dewatering Site	Site Type	Average Gallons/Day	Water Trucks/Day*
Sherman	Commercial	109,697	44
El Camino Real 3	Commercial	16,599	7
El Camino Real 2	Commercial	5,497	2
University	Commercial	131,914	53
El Camino Real 1	Commercial	66,464	27
Louis Road 1	Residential	328,013	131
Cowper	Residential	102,096	41
Murdoch	Residential	146,564	59
Walnut	Residential	117,138	47
Byron Street	Residential	334,593	134
Waverly	Residential	135,380	54
Webster	Residential	13,083	5
Louis Road 2	Residential	262,317	105
Total			**709**

**Assuming use of a 2,500-gallon water truck*

Depending on the amount of groundwater produced at each dewatering site, the truck trips required to transport water from each site ranges from 2 to 134 daily trips. To transport all the water from all dewatering sites would require 709 truck trips and would generate 2.3 tons of CO_2 emissions daily. For the sites that dewater large volumes of water, it would not be technically feasible to haul all the water produced due to the high number of truck trips required.

Per dewatering regulations, the City requires the dewatering applicant to deliver groundwater to nearby irrigation sites via a water truck 1 to 5 days per week. This study assumes that in a typical year, 15 dewatering sites will deliver 2 trucks of water per week to a City irrigation site located 1 mile away (each round trip consists of 1 mile with a full truck and 1 mile with an empty truck) over a 12-week dewatering period. Assuming 2 trips per week is a conservative approach based on the anticipated traffic concerns in residential areas where the construction sites are typically located.

These assumptions would result in 360 roundtrip truck trips to reuse 900,000 gallons of water for irrigation (2.8 acre-feet). Using the emissions factors described above, these activities would emit approximately 1.2 tons of CO_2 and would approximately cost $73,000 in water hauling.

Table 4: Hauling Cost and Greenhouse Gas Emissions Analysis

Number of temporary dewatering sites each year	15
Water truck volume	2,500 gallons
Dewatering period	12 weeks
Truck trip frequency	2 trips per week per site (360 trips per year)
Water truck cost (2,500-gallon)	$135 per hour
Estimated time per trip (includes filling and irrigation)	1.5 hours per trip
Approximate water hauling cost	$72,900 per year
Annual volume of water reused for irrigation	900,000 gallons (2.8 acre-feet)
Trip length	2 miles round trip (1 mile with full truck, 1 mile with empty truck)
CO_2 emissions per mile – Full truck	3.7 pounds CO_2 per mile
CO_2 emissions per mile – Empty truck	2.8 pounds CO_2 per mile
Annual CO_2 emissions	1.2 tons CO_2 per year

7 Summary

Groundwater from temporary construction dewatering in the City is pumped from a shallow unconfined aquifer that is not a source of potable water for the City. When discharged to the City's storm drain system, groundwater from dewatering activities enters one of four creeks that discharge to the Bay. Most dewatering sites discharge to creeks that have been channelized and offer negligible groundwater recharge opportunities. San Francisquito Creek is the only creek in the City with potential to recharge the shallow groundwater basin because it is not channelized within the City boundaries.

Groundwater pumped from basement dewatering is, in general, of suitable quality to be used for irrigation after treatment in a settling tank. Temporary groundwater dewatering from July 2019 to August 2020 produced over 461 AF, about 12% of the City's irrigation demand of over 3,900 AF per year. It is not feasible, however, to use all the groundwater for irrigation due to the high number of daily truck trips that would be required to haul it to irrigation sites.

If an average of 15 dewatering sites haul water to City irrigation sites twice per week over the 12-week dewatering period, approximately 900,000 gallons (2.8 AF) of groundwater could potentially be reused for irrigation each year, which is less than 1% of the groundwater produced by temporary dewatering. The 360 truck trips required to haul this amount of water would cost approximately $73,000 and would generate approximately 1.2 tons of CO_2 emissions. To put this amount of carbon in different terms, it would take about 18 tree seedlings grown for 10 years to sequester this amount of carbon (https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator).

This study was based on an assumed volume of water generated from dewatering in a typical year. The volume of water generated from dewatering will vary each year depending on the number of basement construction projects. The City therefore cannot depend on a fixed volume of water each year for irrigation from temporary dewatering.

8 References

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