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Santa Cruz Mid-County Groundwater Agency

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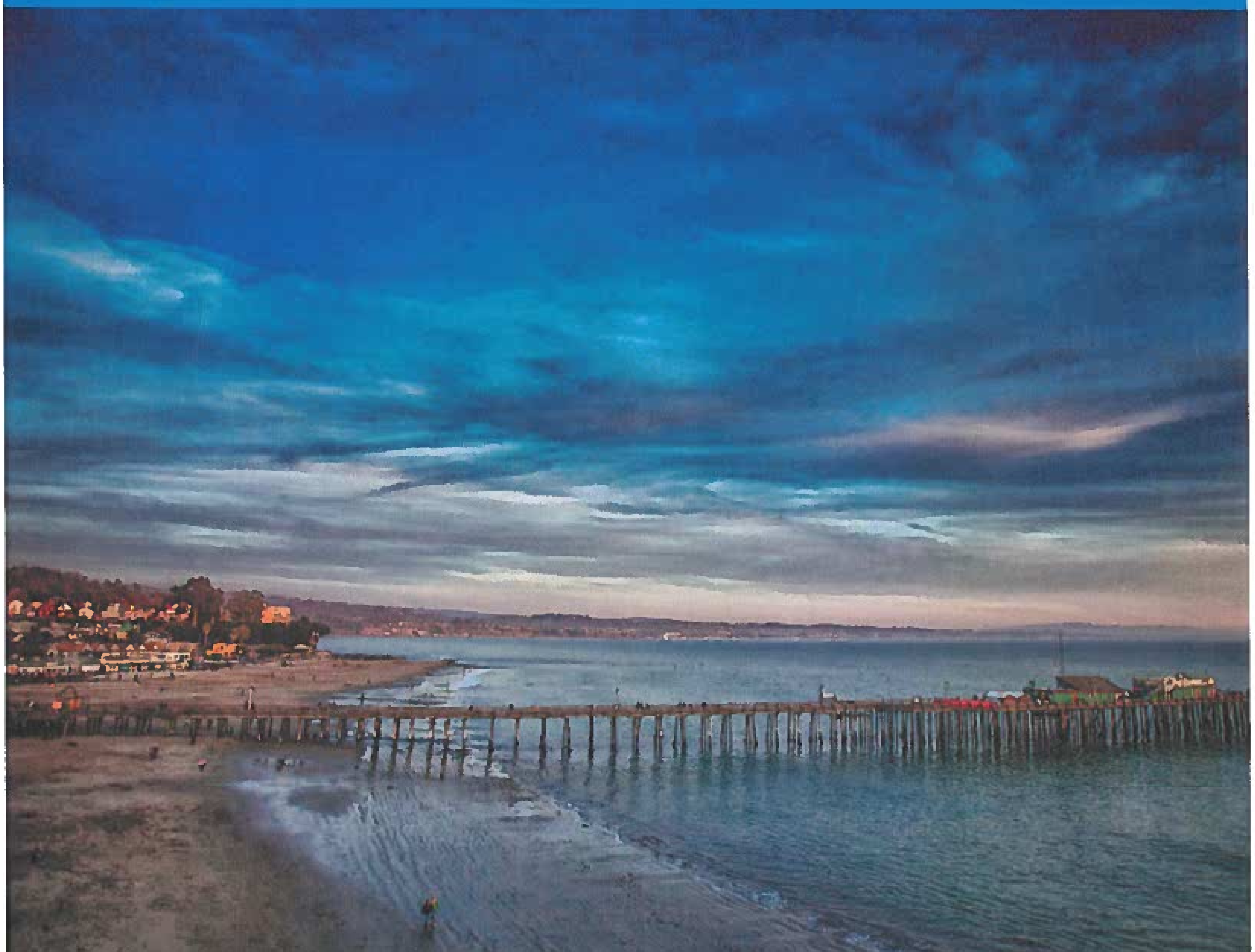
FINAL

PURE WATER SOQUEL ENGINEERING REPORT

PREPARED FOR

SOQUEL CREEK WATER DISTRICT

MARCH 2023



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11.1.4 Simulated Groundwater Flow for PWS Scenario

PWS simulated groundwater elevations in 2025 are significantly higher than the baseline scenario in both the Purisima BC and Purisima A units. In the Purisima BC unit, elevations are uniformly above sea level across the area of interest (**Figure 11-6**). While only 5 percent of recharge at the TLC well enters the Purisima BC unit, this recharge translates to an increase of 10-30 ft in elevations across the area of interest even with increased pumping at the Estates well from baseline as part of the pumping redistribution. In the Purisima BC unit, groundwater elevations are above MT at the SC-9C coastal monitoring well, and roughly 4 ft below MT at the SC-8B coastal monitoring well though the MT for SC-8B was established to protect production at the Aptos Creek well, which is no longer assumed. PWS benefits are similarly present in the Purisima A unit, raising groundwater elevations by around 15-45 ft in the area of interest even with increased pumping from baseline in the A unit as part of the pumping redistribution (**Figure 11-7**). Elevations are more than 10 ft and 20 ft above MT at the Purisima A unit coastal monitoring wells SC-3A and SC-5A, respectively. Elevations are about 2 ft above MT at the SC-1A coastal monitoring well in the Purisima A unit. Even with a small depression from pumping at Garnet, elevations are uniformly above sea level along the coast.

Between 2025 and 2047, recharge and pumping redistribution continue to raise simulated groundwater elevations in the Purisima A and Purisima BC units. In the Purisima BC unit, elevations are raised by roughly an additional 5 ft in the area between SC-8B and SC-5C, a product of recharge at TLC even with increases in pumping from baseline at the Estates well (**Figure 11-8**). Groundwater elevations are about 5 ft above MT at the SC-9C coastal monitoring well in the Purisima BC unit. Groundwater elevations do not rise high enough above MT at the SC-8B coastal monitoring well to counteract simulated sea level rise though the MT for SC-8B was established to protect production in the Purisima BC unit at the Aptos Creek well, which is no longer planned for pumping. In the Purisima A unit, elevations are similarly raised an additional 5-10 ft across much of the area of interest: specifically, near the TLC and Estates wells, in the eastern areas near SC-19, and near the Garnet well (**Figure 11-9**). Elevations near the Rosedale and Cunnison Lane wells are slightly lower than in 2025, a result of pumping at the Cunnison Lane well. Elevations are above MT by around 10-15 ft and 20-25 ft at the Purisima A unit coastal monitoring wells SC-3A and SC-5A, respectively, and roughly 6 ft above MT at the SC-1A coastal monitoring well in the Purisima A unit. By 2047, groundwater elevations are uniformly above sea level across the area of interest, including the depression at Garnet.

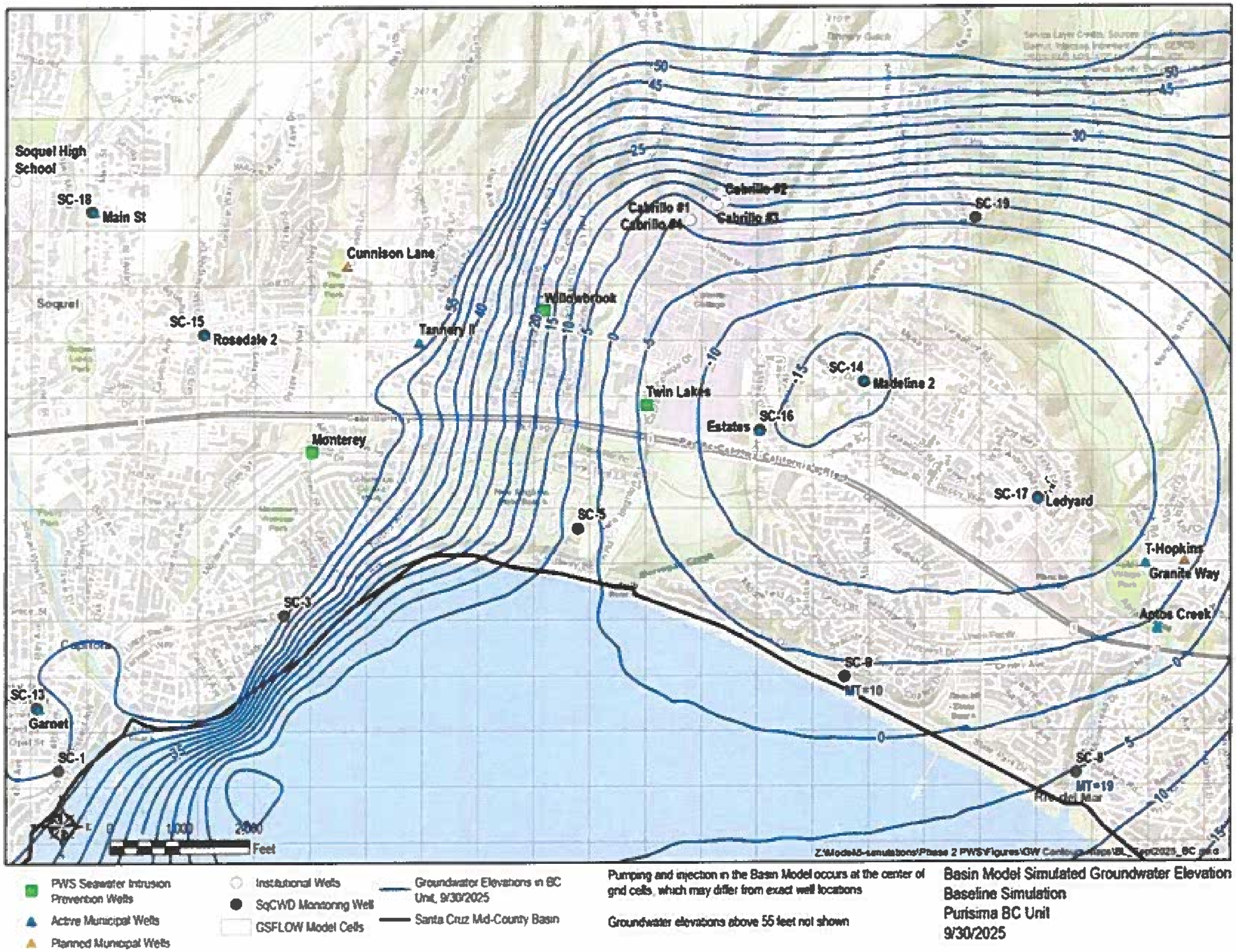

Figure 11-2. Simulated baseline (no recharge at SWIP Wells) groundwater elevations (ft msl) in Purisima BC unit, September 30, 2025

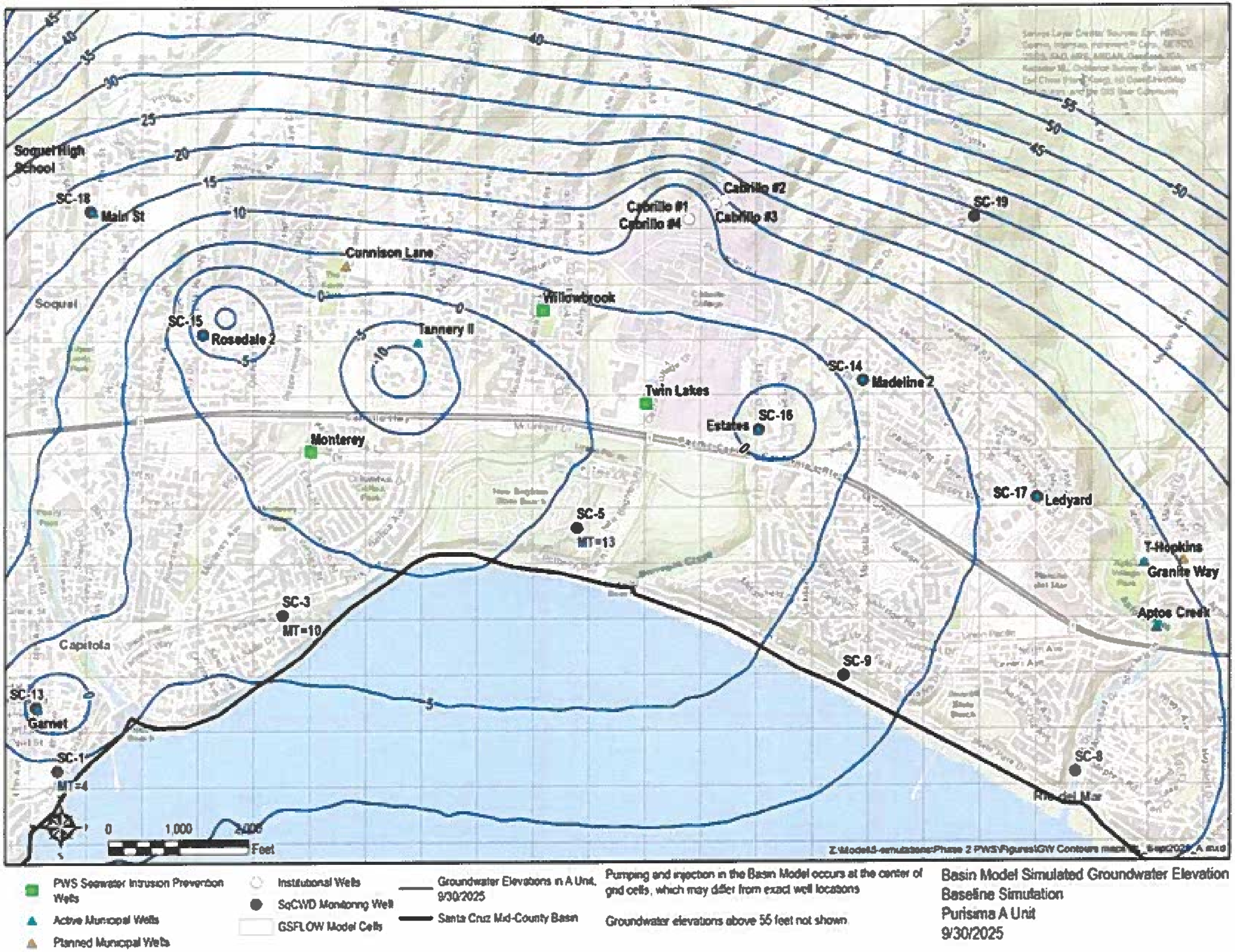

Figure 11-3. Simulated baseline (no recharge at SWIP wells) groundwater elevations (ft msl) in Purisima A unit, September 30, 2025

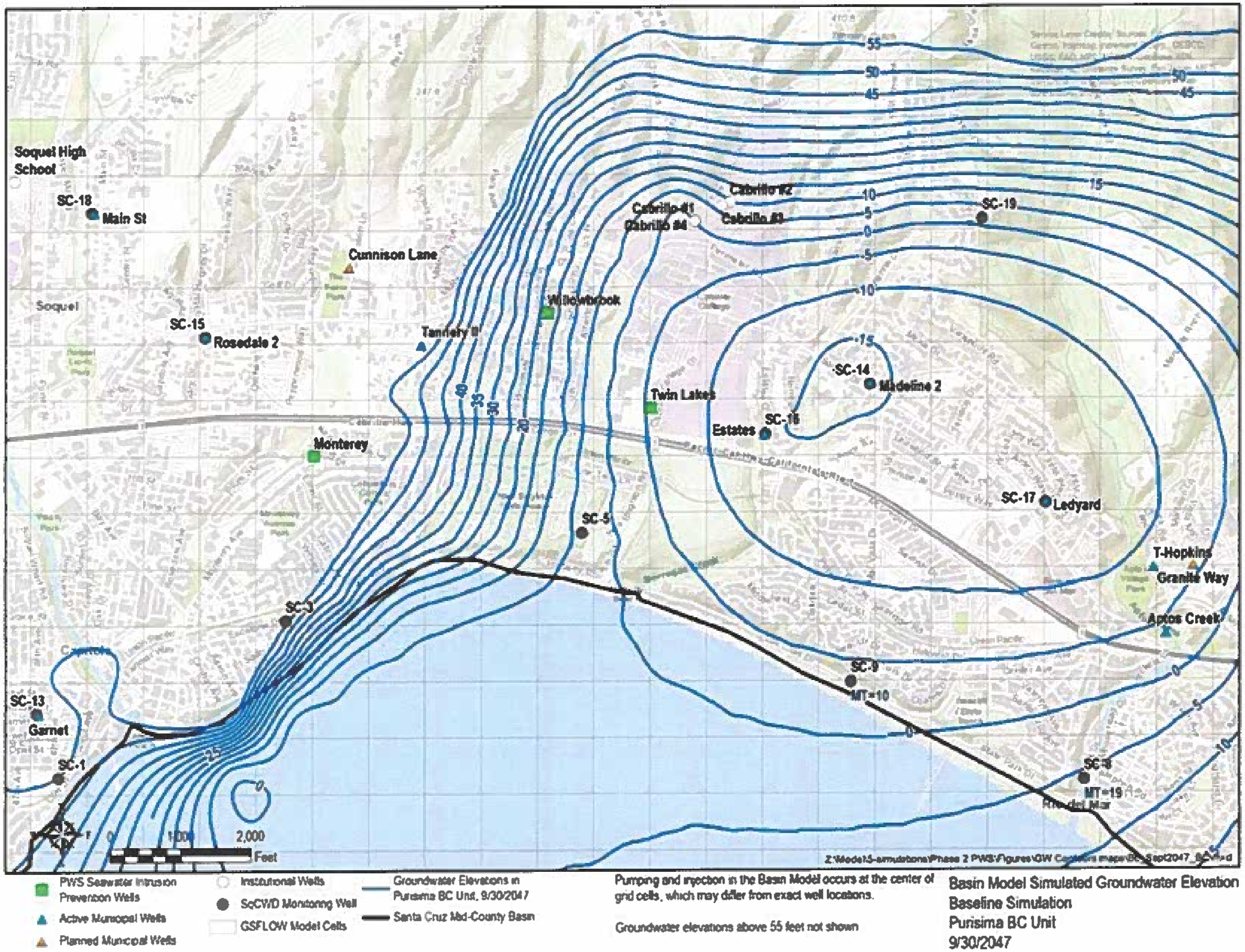

Figure 11-4. Simulated baseline (no recharge at SWIP wells) groundwater elevations (ft msl) in Purisima BC unit, September 30, 2047

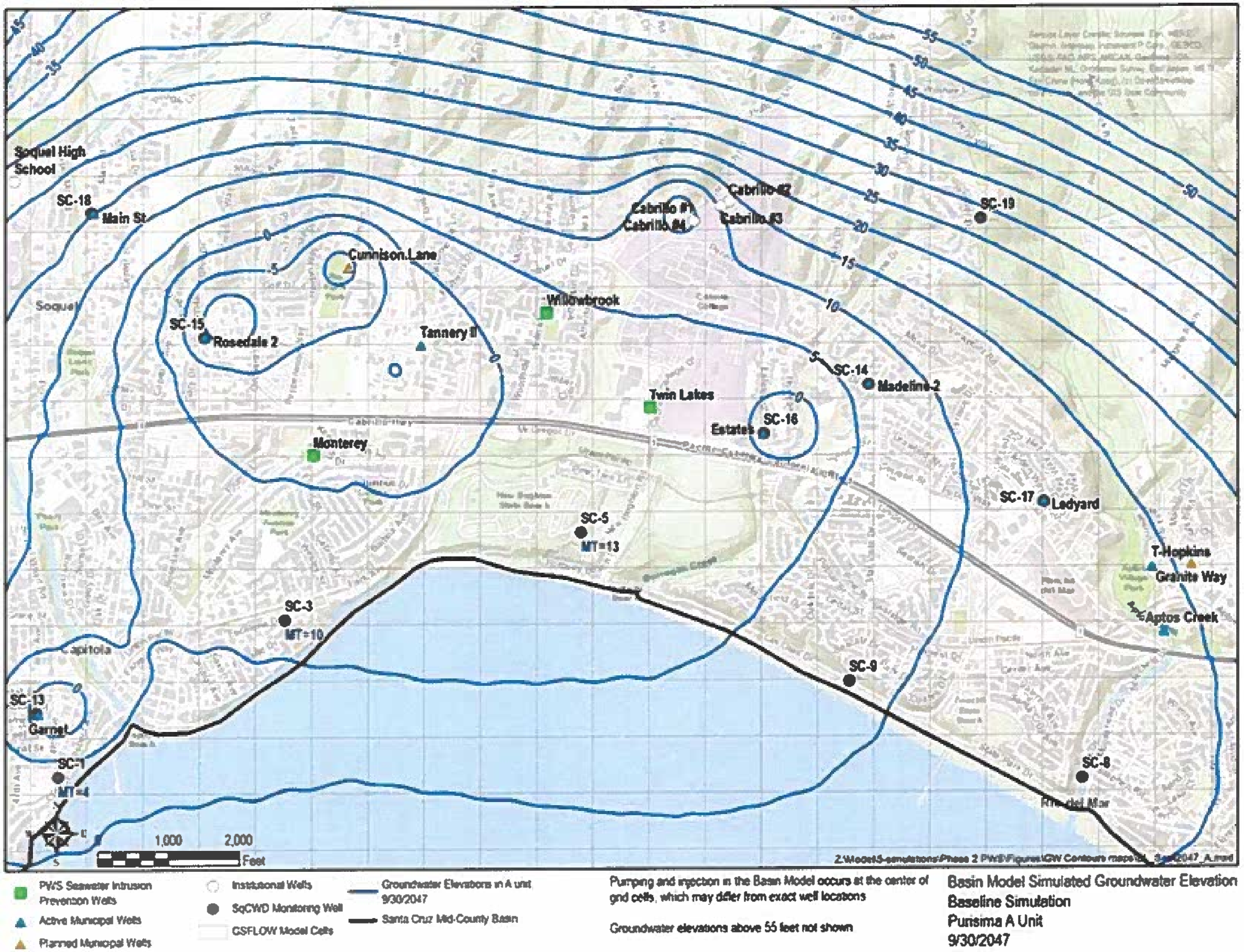

Figure 11-5. Simulated baseline (no recharge at SWIP wells) groundwater elevations (ft msl) in Purisima A unit, September 30, 2047

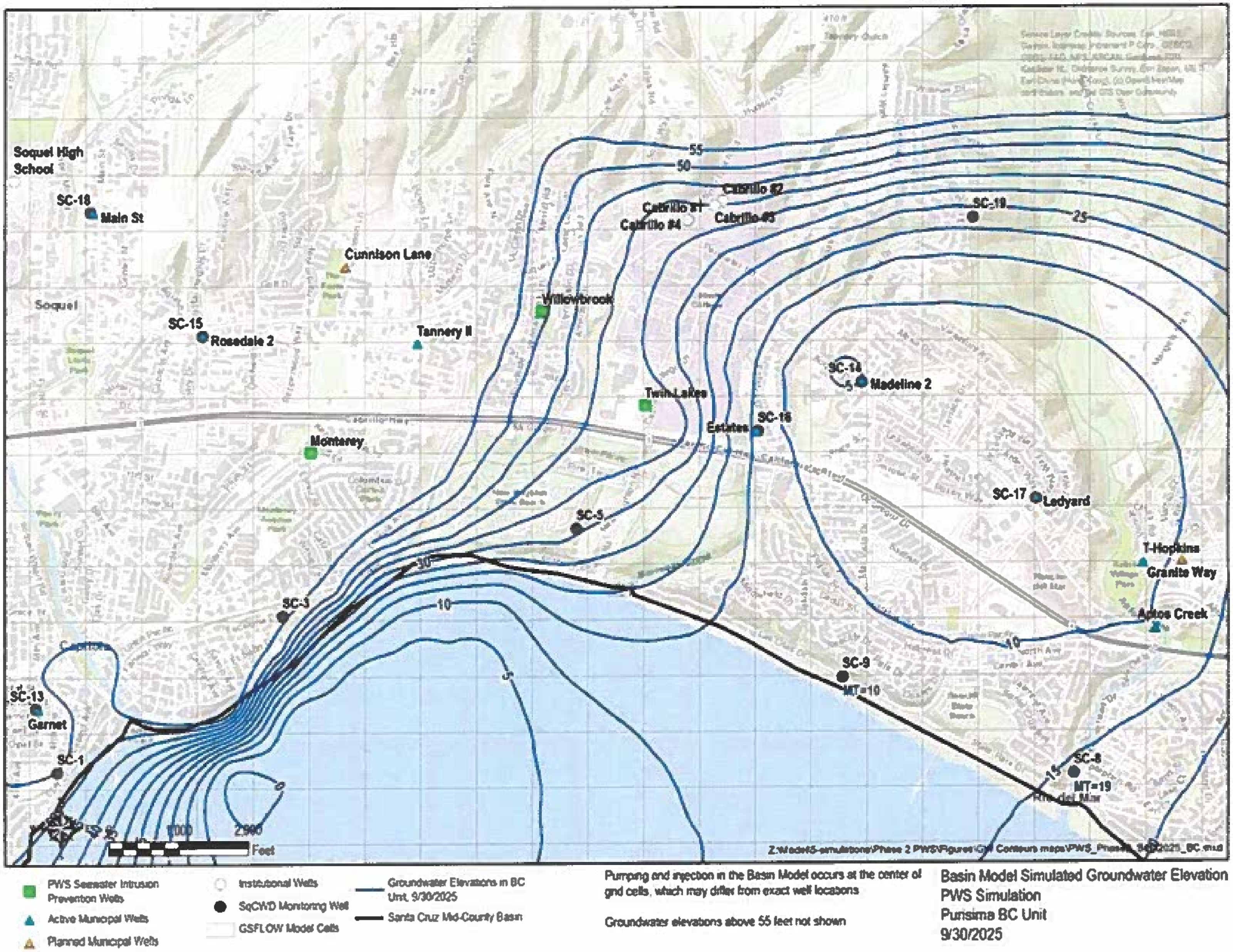

Figure 11-6. Simulated PWS groundwater elevations (ft msl) in Purisima BC unit, September 30, 2025

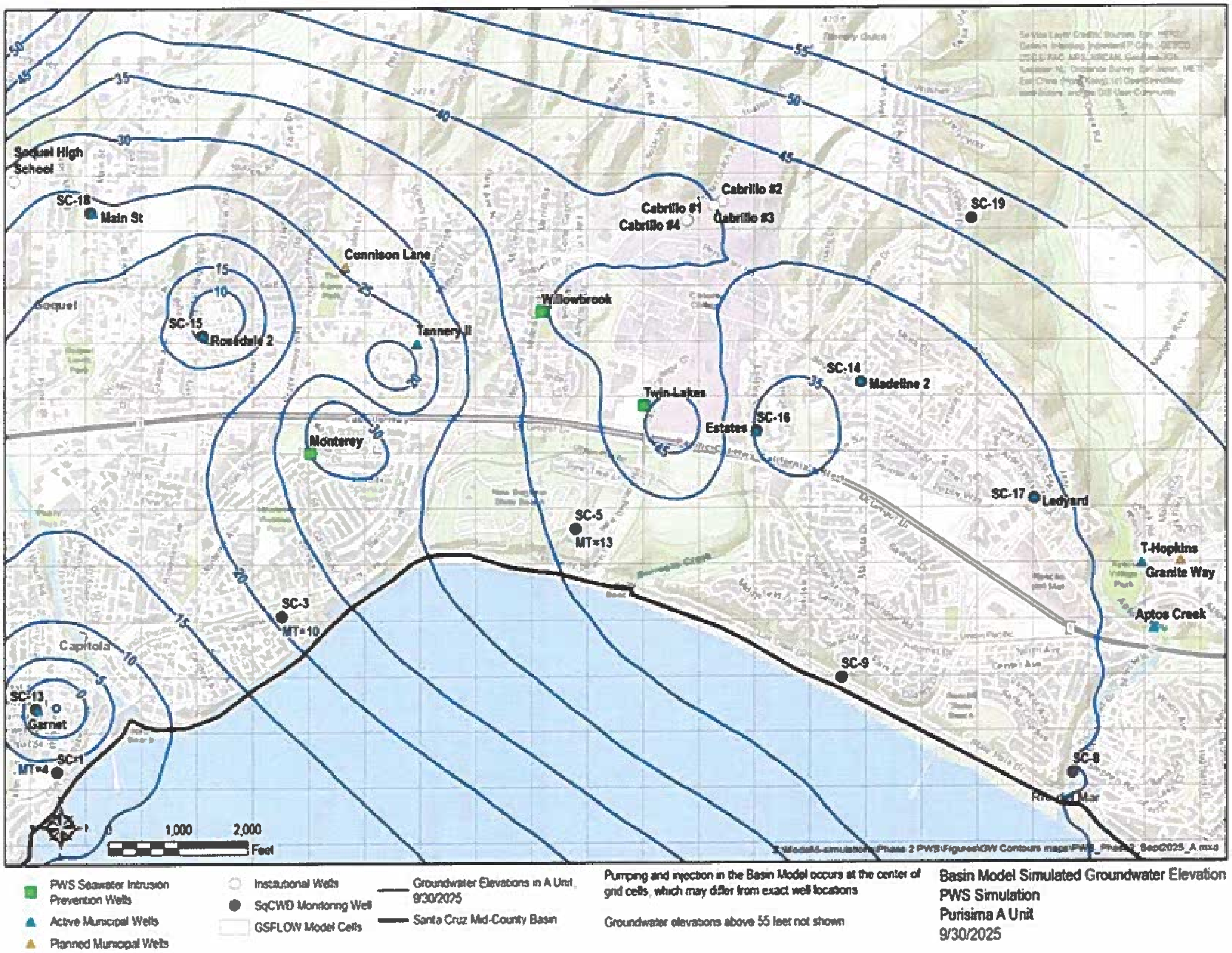

Figure 11-7. Simulated PWS groundwater elevations (ft msl) in Purisima A unit, September 30, 2025

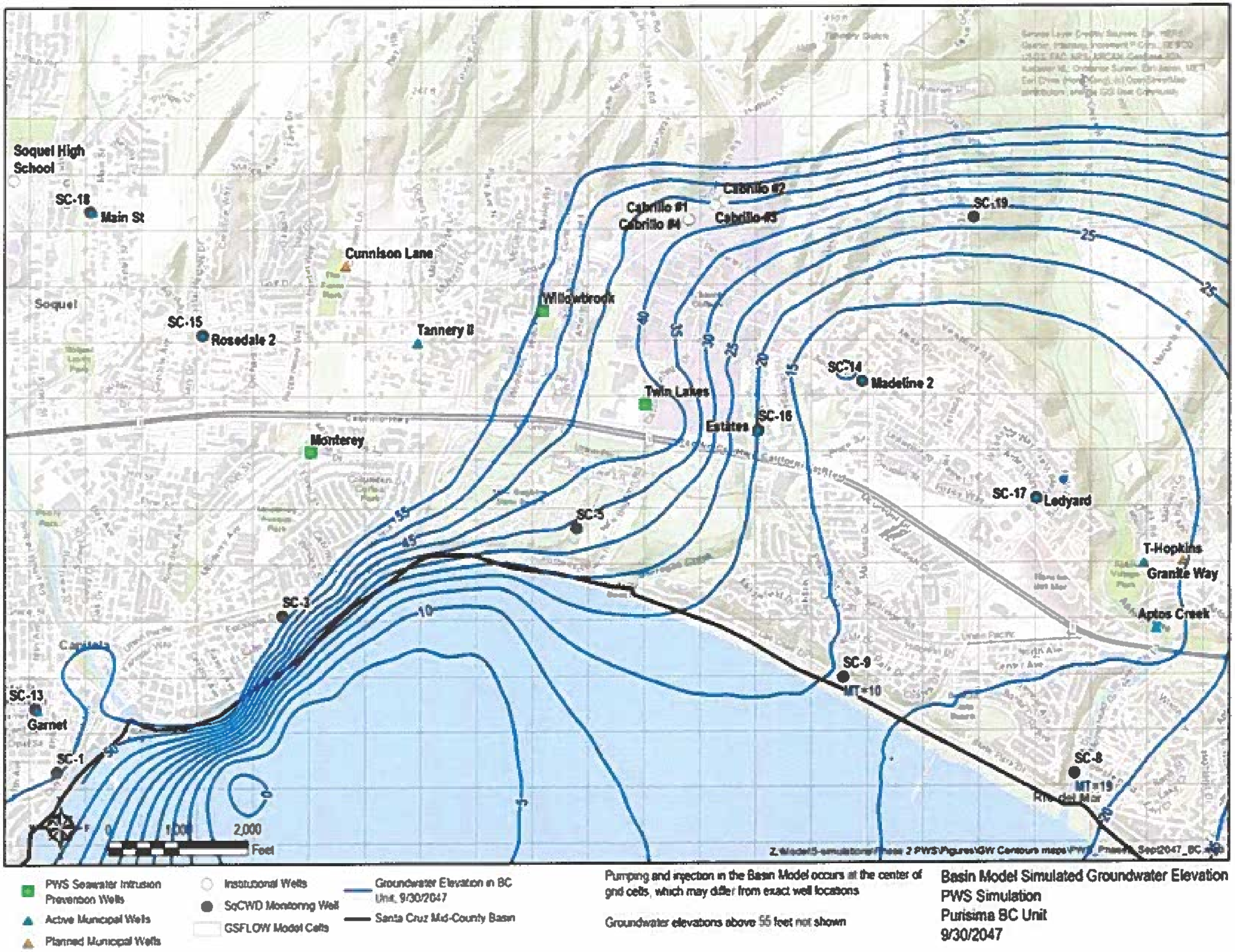

Figure 11-8. Simulated PWS groundwater elevations (ft msl) in Purisima BC unit, September 30, 2047

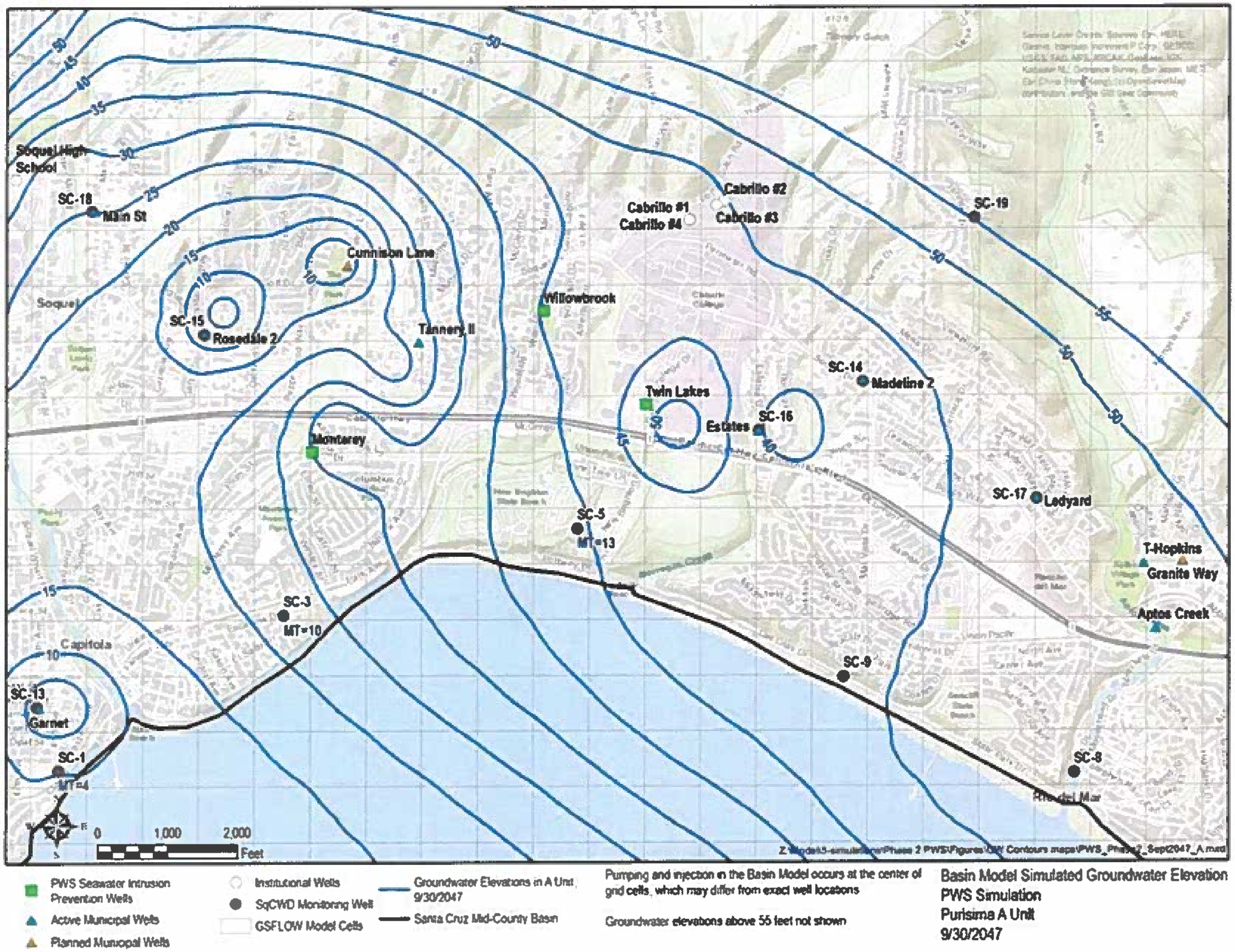

Figure 11-9. Simulated PWS groundwater elevations (ft msl) in Purisima A unit, September 30, 2047

The simulated potentiometric surfaces show the mounding that forms around the recharge wells, with flow directions being dominantly radially outward from the recharge wells within the first thousand ft or so around each recharge well before being drawn by the drawdown cones of closest large municipal production wells and also the regional flow gradients towards the coast.

11.2 Recycled Water Contribution to Aquifer Zones and Water Supply Wells

SqCWD is proposing to conservatively apply a 100 percent Recycled Water Contribution (RWC) for regulatory compliance in conformance with Title 22 Section 60320.216 with no diluent water required. The purified water to be used for recharge will receive FAT as described in **Section 5**. Any dilution in the subsurface due to groundwater underflow will not be counted.

This subsection describes the modeled long-term contribution of recharged purified water to the Basin aquifers and individual extraction wells. This long-term spatial extent of recharged purified water is evaluated using United States Geological States (USGS) MODPATH particle tracking based on results of the Basin Model simulation of the PWS scenario described in **Section 11.1.1.** The evaluation of the long-term fate of recharged purified water includes modeled results for where the purified water travels in the Basin, which wells eventually extract purified water, and estimates of the percentage of purified water in extracted water. These results are also incorporated into an anti-degradation analysis (BC, 2020c).

As described in **Section 11.3**, MODPATH results are not used to estimate underground retention time to meet Title 22 requirements for response retention times and virus log reduction credits.

11.2.1 MODPATH Setup for Particle Tracking based on Basin Model

MODPATH is set up so that particles are released from the Basin Model cells that contain simulated TLC, Willowbrook, and Monterey SWIP recharge wells monthly during the time period that the SWIP wells are in operation under the PWS scenario. The number of particles released from each SWIP well is proportional to the recharge flow rate at each well, so that the number of particles approximately equates to the amount of recharged water mass. For example, doubling the flow rate at a constant concentration effectively doubles the amount of mass being recharged to the aquifers, therefore twice the number of particles is released if the flow rate is doubled.

The starting points for the particles are evenly distributed in both the horizontal and vertical directions along the sides of each of the 800x800 ft Basin Model cells containing the three SWIP wells. It is not possible in MODPATH to start particles in the cell interior, such as at actual well locations. The amount of flow and corresponding number of particles released by each well is summarized in **Table 11-3** below.

Table 11-3. Volumes of Purified Water Recharged and Particle Distribution Used in MODPATH

SWIP Well Screening	Recharged Volume (afy)	Number of Particles Released Monthly
Willowbrook (A)	233	164
TLC (A)	690	484
TLC (BC)	52	37
Monterey (A)	500	350
Total	1,475	1,035

Effective porosities used for the MODPATH particle tracking are 9 percent for the Purisima BC unit and 13 percent for the Purisima A unit based on adding an estimated specific retention of 5 percent to specific yield values in the Basin Model (M&A, 2019a). Porosities exceed specific yield by specific retention (Robson, 1993) and a relatively low specific retention was used for the semi-consolidated Purisima Formation. The effective porosities used are also in the range of porosities presented for the Purisima Formation (8 to 15 percent) in the primary basis for the hydrogeological conceptual model for the GSP (Johnson et al., 2004).

11.2.2 MODPATH Results for Spatial Extent of Recharged Purified Water

Long-term spatial extent of recharged water in Purisima A and BC units are based on particle locations at the end of Water Year 2047. **Figure 11-10** and **Figure 11-11** show the spatial extent of 25 years of recharged purified water based on MODPATH particle locations at the end of Water Year 2047 for the Purisima BC and A units, respectively. The 25-year time span encompasses the long-term pumping distributions assumed for the PWS scenario that includes Cunnison well pumping coming online in Water Year 2026 (**Table 11-2**).

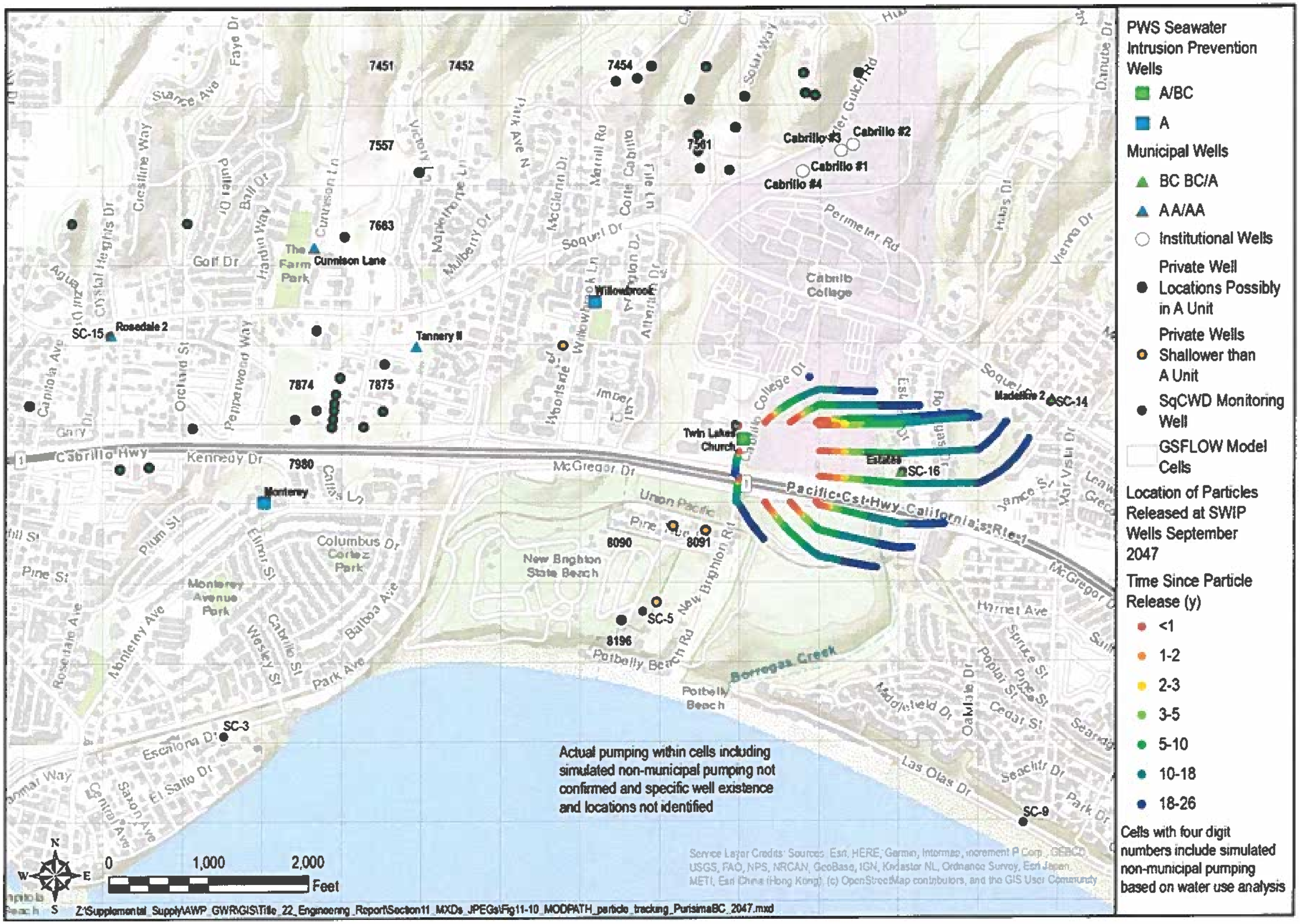

Figure 11-10. MODPATH particle tracking in Purisima BC unit, end of water year 2047

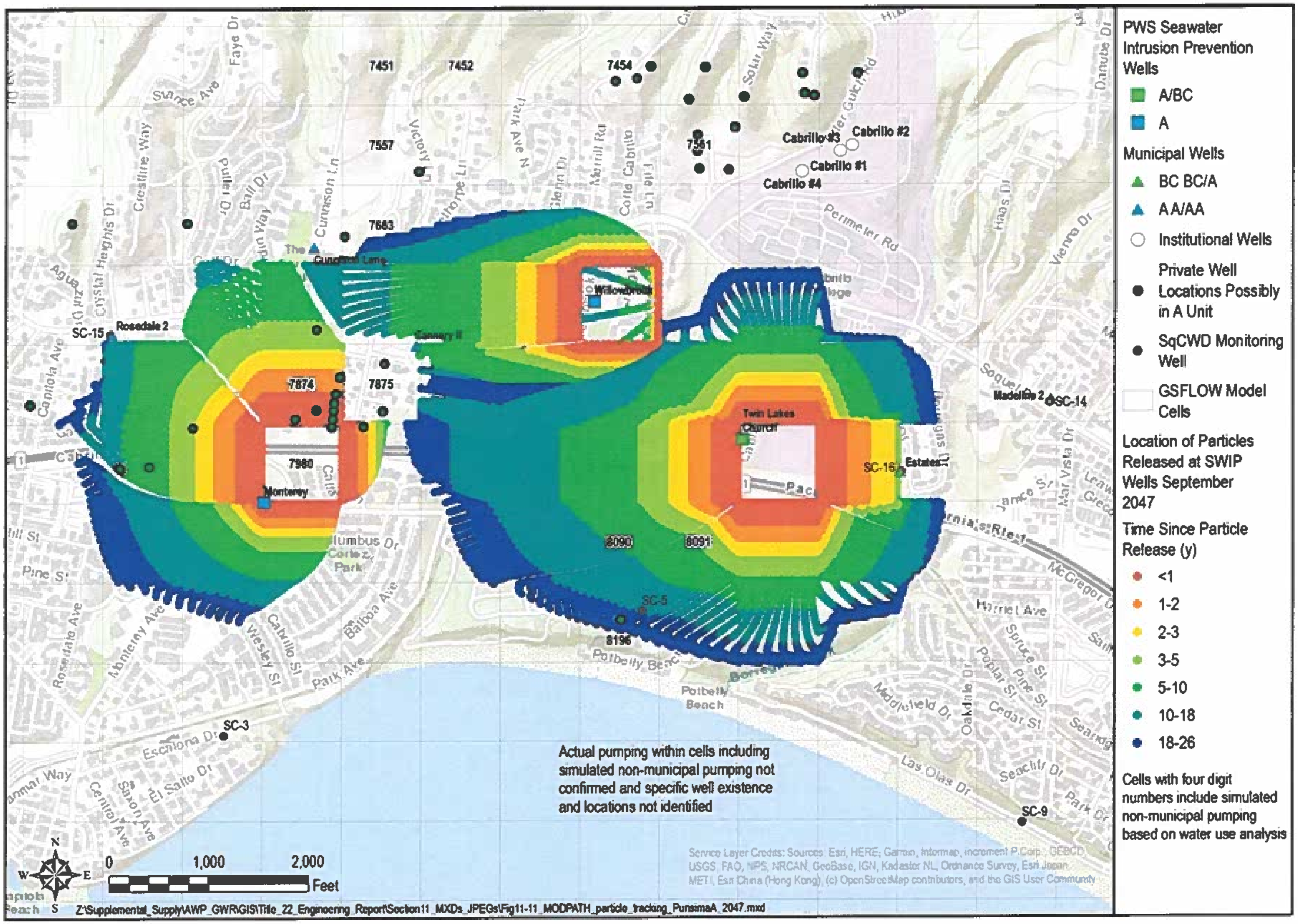

Figure 11-11. MODPATH particle tracking in Purisima A unit, end of water year 2047

The spatial extent of recharged purified water even over this long period is much smaller than the area where recharge by PWS increases groundwater elevations as shown when comparing **Figure 11-6** through **Figure 11-9** for the PWS simulation to **Figure 11-2** through **Figure 11-5** for the baseline simulation. For example, recharge at the SWIP wells increases groundwater levels at SC-3A in the Purisima A unit (**Figure 11-9**) and SC-9C in the Purisima BC unit (**Figure 11-8**) very soon after recharge commences in simulated Water Year 2023, but recharged purified water does not reach these locations within 25 years.

Figure 11-10 shows that recharged purified water from the Monterey and Willowbrook SWIP wells screened only in the A unit are not simulated to travel to the shallower BC unit. Therefore, purified water is not expected to travel to the irrigation well at 6120 Abbey Road just southwest of the Willowbrook well because its depth of 130 ft measured by SqCWD in March 2020 is to the top of the BC unit. The lack of connection between this irrigation well and the Willowbrook SWIP well is reinforced by monitoring of the irrigation well during pump tests at the SWIP well in December 2020. Groundwater levels at the irrigation well showed no response to a 10 hour step test with pumping rates ranging from 491-1,509 gpm and a 24 hour constant rate test with a pumping rate of 1,012 gpm (M&A, 2021). This lack of hydraulic connection indicates that purified water will not travel from the Willowbrook SWIP well to the irrigation well at 6120 Abbey Road.

MODPATH assumes that once a particle reaches a model cell simulating a well with high enough extraction to create a "strong sink", the particle is removed from the system by the well. Extraction flow rate for a strong sink is high relative to total flow through the aquifer at that cell. Municipal wells in the Purisima A unit are simulated as strong sinks. Therefore, the particles are removed at the cell boundary at municipal wells, and **Figure 11-11** shows no particles within the cells where particles are removed in the A unit.

There are a couple of model cells where wells add water to aquifer units, but at rates low enough that particles can pass through the model cells. This occurs at the Estates well in the BC unit where higher recharge in the A unit at TLC SWIP well results in flow from the A unit to the BC unit at the Estates well. This flow does not change the overall west to east gradient simulated by the Basin model (**Figure 11-8**) and particles pass through this model cell in the BC unit (**Figure 11-10**). The particles passing through the Willowbrook model cell in the A unit (**Figure 11-11**) indicate that particles released on the eastern edge of the cell move to the west due to the overall east to west gradient simulated at the 800x800 grid resolution (**Figure 11-9**).

As shown on **Figure 11-11**, some particles pass through cells where private wells are located because the wells are considered "weak sinks" by MODPATH. Extraction flow rate for a weak sink is low relative to total flow through the aquifer at that cell so weak sink pumping is not strong enough to capture particles in MODPATH. As MODPATH does not show capture of particles at these wells, MODPATH does not reflect the reality that the wells will intercept purified water as it travels to the well. **Figure 11-11** does show particles traveling to private well locations so those wells are expected to extract purified water. Therefore, the amount of purified water captured by private wells are estimated outside of MODPATH as described below. Private wells shown in **Figure 11-11** are assumed to provide potable domestic supply (BC, 2019a) although this has not been confirmed at all mapped wells.

11.2.3 Estimates of Purified Water Contribution to Wells and Aquifer

Estimates of the amount of recharged purified water extracted from wells versus remaining in Basin aquifers are primarily based on the number of particles simulated by MODPATH as extracted at municipal wells and remaining in the model over the 25-year period. As described in the previous section, treatment of private wells as "weak sinks" requires estimating the amount of purified water extracted by the private wells separately from MODPATH.

The estimate of the amount of purified water captured by private wells is based on the assumption that once purified water reaches the private well, all water extracted from the well is purified water. This first requires assessing which private wells are expected to extract purified water at all. **Figure 11-10** shows private well locations known to be screened in the Purisima BC unit and shows no purified water travelling to these locations in the BC unit. **Figure 11-11** shows private well locations assumed to be screened in Purisima A unit. The only non-municipal well locations where purified water travels are the locations near the Monterey SWIP well. As will be later described in **Section 11.3.2**, estimated retention time of purified water between Monterey SWIP well and the nearest private well is approximately 33-39 months for the range of recharge rates evaluated. Assuming that all of private extraction near the Monterey SWIP well after 33 months is purified water, up to 89 percent of the non-municipal extraction over the 25-year period is purified water. The estimated total non-municipal extraction simulated by the Basin Model near the Monterey SWIP well over the 25-year period is approximately 125 acre-ft (AF). Therefore, the amount of purified water estimated to be extracted by non-municipal wells near the Monterey SWIP well and overall is up to approximately 110 AF or 0.3 percent of the total amount of purified water recharge. This extraction of purified water by private wells would reduce extraction of purified water by municipal production wells Tannery II, Rosedale, and Cunnison slightly from estimates based on particle capture in MODPATH.

Based on the MODPATH results and the above estimate for private wells near the Monterey SWIP well, approximately 37 percent of recharged purified water is captured by SqCWD production wells and up to 0.3 percent of recharged purified water is captured by private wells. The remaining approximately 63 percent remains in the aquifer system after 25 years of simulated recharge operations.

Table 11-4 shows the estimated total amount of recharged purified water from the PWS Project extracted by each well and the fraction of the total water pumped by each well consisting of recharged water captured by SqCWD production wells and non-municipal wells simulated in the Basin Model through the end of Water Year 2047. Note that the percentages of pumped purified water in the middle column are shown as a fraction of total pumping at each individual well, rather than as total pumped purified water across all wells, and so do not add up 100 percent along all rows. The last column totals up to the 37 percent of all recharged water that is captured at the wells.

Table 11-4. Estimated Total Amount of Purified Water Captured at Wells through end of Water Year 2047

Supply Well	Total Pumped at Well through end of WY 2047 (AF)	Percent Purified Water of Total Water Pumped at Well	Percent of All Recharged Purified Water Captured at Well
Tannery	14,700	41%	16%
Estates	10,300	40%	11%
Rosedale	13,600	19%	7%
Cunnison Lane	9,600	10%	3%
Madeline	3,000	1%	0.1%
Private Wells around Monterey SWIP Well (APN 3719112)	125	<=89%	<=0.3%

Table 11-5 shows the fate of recharged purified water by aquifer unit. For water recharged into the Purisima A unit, 44.7 percent of the recharged water is captured by wells after 25 years of recharge. Almost none of the smaller amount of water recharged into the Purisima BC unit is captured by wells during the same period. Recharged water remains in the same aquifer unit that they are recharged indicating flow is two-dimensional for the spatial extent of the recharged purified water simulation. This is consistent with the calibrated three-dimensional Basin Model flow output showing that 99.9 percent of total particle velocity throughout the area of influence of the project is parallel to the modeled aquifer layering and that flow gradients orthogonal to the layering are negligible. This also means that no supply well is simulated to extract purified water recharged in a different unit than where the supply well is screened.

Table 11-5. Fate of Purified Water through End of Water Year 2047 by Aquifer Unit

Aquifer where Particles Released	Percent Purified Water Recharged into Each Unit	Percent Purified Water Remaining in A Unit	Percent Purified Water Remaining in BC Unit	Percent Purified Water Captured by Wells
A	~96%	59%	0%	37%
BC	4.1%	0%	4%	0.1%

11.3 Underground Retention Time

Modeled retention time estimates are necessary for the purpose of siting SWIP and monitoring wells during project planning to meet California regulations for Groundwater Replenishment with Recycled Water. The regulations provide different levels of virus log reduction and response time credit per month of modeled retention time depending on the method used for estimating the retention times. A virus log reduction and response time credit of 0.50 per month is assigned for retention times estimated using numerical modeling consisting of calibrated finite element or finite difference models using validated and verified computer codes used for simulating groundwater flow. A virus log reduction and response time credit of 0.25 per month is assigned for analytical calculations using existing academically accepted equations such as Darcy's Law to estimate groundwater flow conditions based on simplifying aquifer assumptions. Retention time estimates are presented in the following subsections using two methodologies: (1) refined particle tracking based on the numerical Basin Model and (2) analytical equations. Retention time estimates will be updated based on the tracer study to be started within the first 3 months of purified water recharge at the SWIP wells (see **Section 14.7**).

11.3.1 Retention Time Estimates Using Refined Particle Tracking

Retention times based on calibrated numerical modeling results are expected to be more accurate than analytical calculations. However, the grid cell size of the calibrated Basin Model is not fine enough to accurately represent short term travel times between recharge and extraction wells because: (1) simulated wells are represented as 800 ft by 800 ft grid cells rather than their actual positions, and (2) water levels are averaged over each grid cell and do not accurately capture the steeper hydraulic gradients closest to the wells. In addition, the Basin Model using GSFLOW requires setup of the integrated PRMS watershed component model on the same grid and resolution as used for the MODFLOW groundwater model, so grid refinement of the full Basin Model itself is not a simple or straightforward process. Therefore, a refined numerical model for the local subarea of the Basin Model was developed, which combines the regional hydraulic heads and aquifer parameters from the calibrated Basin Model with simulated SWIP recharge wells and municipal extraction wells placed at their actual locations. This refined local numerical model can more accurately represent the steeper near-well hydraulic gradients at a finer scale, using the Analytic

Element Method (AEM) numerical modeling approach (Strack & Haitjema, 1981a; 1981b; Haitjema, 1995; and Bakker & Strack, 2003).

The results of this local model were used as the basis for a refined particle tracking analysis to evaluate the retention times over the first three years (36 months) of purified water recharge under the PWS Scenario (**Table 11-2**). The details of the refined modeling approach are described fully in the PWS Phase 2 Modeling report (M&A, 2020), included in **Appendix E**. The PWS Phase 2 Modeling report also describes justification for applying a 0.50 per month credit to retention times estimated by the refined particle tracking, but retention time estimates meet Project requirements even with a 0.25 per month credit.

Figure 11-12 shows refined particle tracking results for recharge from the TLC SWIP well into the Purisima BC unit. **Figure 11-13** shows refined particle tracking results for recharge from the three SWIP wells into the Purisima A unit. The refined particle tracking analysis indicates that no particles released at any of the SWIP wells in either the Purisima A or BC units reach any municipal pumping wells within 3 years as modeled. In the Purisima A unit, particles released from the Monterey SWIP well reach the horizontal locations of two of the private wells identified in the Monitoring Network Analysis shown on **Figure 11-12** and **Figure 11-13** and assumed to provide domestic supply (BC, 2019) approximately 33 months into the three-year refined particle tracking period of the model. 33 months is the best estimate of shortest underground retention time to a drinking water well because the PWS scenario assumes 500 afy recharge at the Monterey SWIP well, which is the maximum rate at the well. The private domestic well with the shortest retention time from the Monterey SWIP well is at 2603 Monterey Avenue (APN 37-191-12). This well is screened to a depth of 360 ft and therefore extracts water from the Purisima A unit that the Monterey SWIP well would recharge. Applying a 0.25 credit, this would provide an 8.25-month credited retention time to provide planned log virus reduction credit of 6 months as described in **Section 9**.

Figure 11-13 shows a private well shallower than A unit overlying the three-year refined particle tracking period simulated for the A unit by the model around the Willowbrook SWIP well. This is the irrigation well near 6120 Abbey Road discussed in **Section 11.2.2**. As discussed, this well has a depth just to the top of the BC unit and monitoring of the well during pump testing of the Willowbrook SWIP well indicates a lack of hydraulic connection between the irrigation well and the Willowbrook SWIP well. **Section 11.2.3** also explains that the calibrated Basin Model does not simulate purified water being transported to aquifers other than the recharged aquifer. Purified water is unlikely to be observed at this irrigation well.

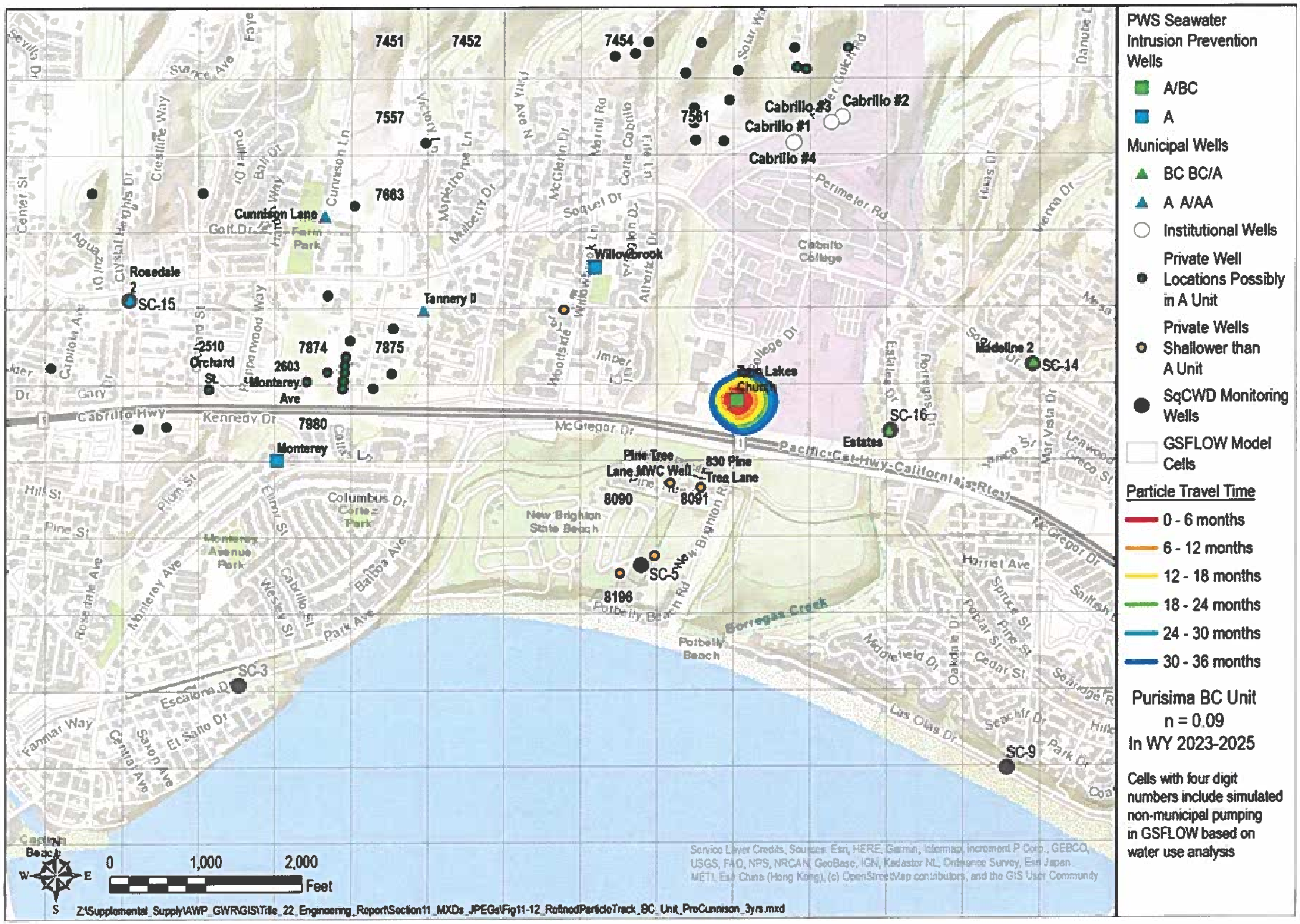

Figure 11-12. Refined particle tracking results in Purisima BC unit (Layer 5)

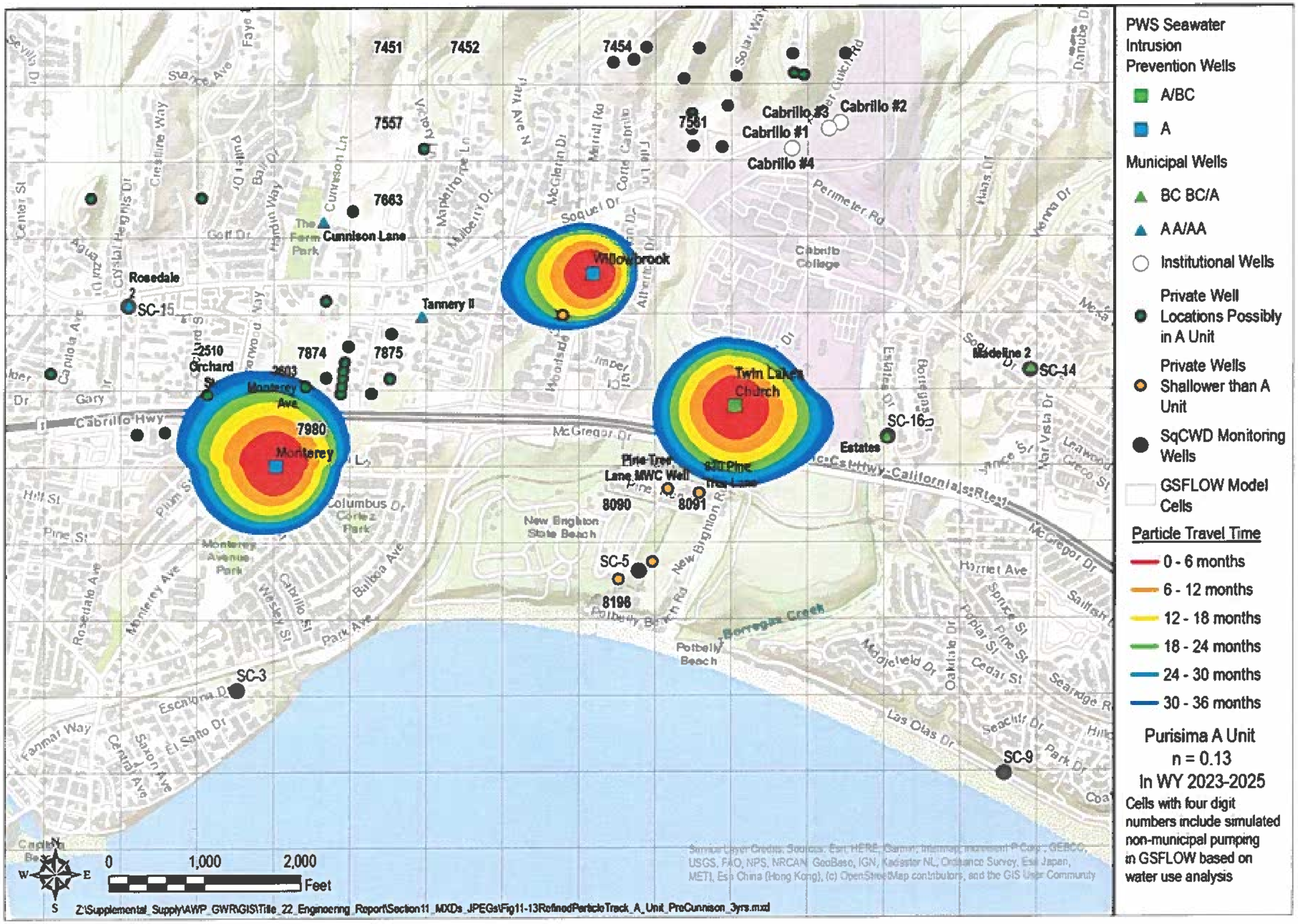

Figure 11-13. Refined particle tracking results in Purisima A unit (Layer 7)

11.3.2 Retention Time Estimates Using Analytical Equations

Analytical equations are used to estimate retention times not estimated by the refined particle tracking. These include:

- Retention times between SWIP wells and drinking water wells beyond the three years simulated by the refined particle tracking are calculated using analytical equations with results presented below.
- Retention times between the SWIP wells and proposed monitoring well locations beyond 3 years as discussed in **Section 14.5.2**.
- Retention times between proposed monitoring well locations and drinking water wells as discussed in **Section 14.5.2**.
- Retention times between wells to evaluate the range of recharge rates at the SWIP wells not simulated with refined particle tracking. The resulting estimates for ranges of retention times between SWIP wells and drinking water wells are presented below. Ranges of retention times to and from monitoring wells are presented in **Section 14.5.2.**

The analytical equations that can be used to estimate retention times between pumping and recharge wells are solutions of Darcy's law for simplified conditions. One such analytical solution is described by Luo & Kitanidis (2004) for the shortest travel time between a single recharge and extraction well pair operating in a uniform regional gradient. This analytical solution relies on a number of simplifying assumptions, including a homogenous aquifer of uniform conductivity and thickness between the two wells, and that both wells are pumping at equal and opposite pumping rates. The solution assumes that only those two wells are pumping and does not account for effects of additional pumping or recharge wells operating simultaneously that the MODPATH and refined particle tracking approaches do.

To estimate retention times in a direction with no extraction by a SqCWD production well or a location where extraction is much lower, an analytical equation (USEPA, 1987) is used that assumes only recharge at the SWIP well drives the gradient. This means that retention times are calculated to some wells even though recharge and pumping induced gradients may result in purified water never reaching those wells. Examples of these wells are the Pine Tree Lane wells southwest of the TLC SWIP well (in cell 8091) as shown in **Figure 11-10** of the MODPATH results from the Basin Model. Although not definitive based on retention times up to 36 months, refined particle tracking shown in **Figure 11-12** also indicate that purified water may not reach the Pine Tree Lane wells that extract from the BC unit.

Table 11-6 shows the estimated retention times using the analytical equations for retention times to drinking water wells beyond the 36 months estimated by refined particle tracking assuming recharge rates at the SWIP wells assumed for the Basin Model as shown in **Table 11-2** and **Table 11-3**. The estimated retention times using analytical equations to these wells are all over 36 months.

Table 11-6. Estimates of Retention Times Based on Analytical Equations for Retention Times Beyond 36 Months

SWIP Well	Purisima Aquifer Unit(s)	Closest Municipal Well in Direction of Flow	Approx. Distance of Municipal Well from SWIP Well (ft)	Drinking Water Well	Approximate Distance from SWIP Well (ft)	Estimated Retention Time from SWIP Well (months)
Monterey	A	Tannery II	2200	Tannery II	2200	80[a]
Willowbrook	A	Tannery II	1770	Tannery II	1770	72
TLC	A	Estates	1630	Estates	1630	52
TLC	BC	Estates	1630	Estates	1630	456
TLC	BC	None	N/A	Pine Tree Lane Wells	1,000	280[b]

a. Corrected from ***Appendix E.***

b. Based on equation 4 (USEPA, 1987) for travel time from a single well using SWIP recharge rate only, which results in shorter retention time than equation 3 (Luo & Kitandis, 2004) for an injection-extraction well pair using average of recharge and municipal pumping rates.

As discussed in **Section 11.1.1**, the SWIP well recharge rates simulated as the PWS Scenario with the Basin Model and used for refined particle tracking estimates of underground retention time represent endpoints of potential ranges of recharge rates at the SWIP wells. Due to uncertainty of recharge rates that can be achieved at the SWIP wells during long-term operation, PWS may operate at lower recharge rates than the 500 afy at the Monterey SWIP well used for refined particle tracking and higher recharge rates than the 233 afy and 742 afy at the Willowbrook SWIP well and TLC SWIP well, respectively. In order to provide operational flexibility over the potential range of recharge rates, analytical equations are used to evaluate underground retention time associated with a minimum recharge rate at the Monterey SWIP well and the maximum recharge rates at the Willowbrook SWIP well and TLC SWIP well. **Table 11-7** shows the estimated retention times for these recharge rates using analytical equations to evaluate the range of potential recharge rates at the SWIP wells to allow for flexibility in operation of PWS. The minimum recharge rate results in the maximum estimated retention time and vice-versa. **Table 11-8** summarizes the range of potential retention times based on the range of potential recharge rates evaluated, combining results from refined particle tracking (**Section 11.3.1**) and analytical equations (**Table 11-6** and **Table 11-7**). Even compared to estimated retention times for maximum recharge rates at Willowbrook and TLC SWIP well, 33 months based on the maximum recharge rate at Monterey SWIP well is the shortest underground retention time to a drinking water well.

Table 11-7. Estimates of Retention Times Based on Analytical Equations to Evaluate Range of Recharge Rates at SWIP Wells

SWIP Well	Purisima Aquifer Unit(s)	Recharge Rate Evaluated with Analytical Equation (afy)	Minimum or Maximum Rate at SWIP Well	Drinking Water Well	Approximate Distance from SWIP Well (ft)	Estimated Retention Time from SWIP Well at Evaluated Rate (months)
Monterey	A	200	Minimum	2603 Monterey Ave.	900	39
Monterey	A	200	Minimum	Tannery II	2200	107
Willowbrook	A	500	Maximum	Tannery II	1770	56
TLC	A	1000	Maximum	Estates	1630	43
TLC	BC	1000	Maximum	Estates	1630	352
TLC	BC	1000	Maximum	Pine Tree Lane Wells	1,000	211[a]

a. Based on equation 4 (USEPA, 1987) for travel time from a single well using SWIP recharge rate only, which results in shorter retention time than equation 3 (Luo & Kitandis, 2004) for an injection-extraction well pair using average of recharge and municipal pumping rates.

Table 11-8. Estimates of Retention Times for Range of Recharge Rates at SWIP Wells

SWIP Well	Purisima Aquifer Unit(s)	Range of Recharge Rates Evaluated (afy)	Drinking Water Well	Approximate Distance from SWIP Well (ft)	Range of Estimated Retention Time from SWIP Well (months)
Monterey	A	200-500	2603 Monterey Avenue	900	33-39
Monterey	A	200-500	Tannery II	2200	80-107
Willowbrook	A	233-500	Tannery II	1770	56-72
TLC	A	742-1000	Estates	1630	43-52
TLC	BC	742-1000	Estates	1630	352-456
TLC	BC	742-1000	Pine Tree Lane Wells	1,000	211-280

Estimates using the analytical equations also demonstrate the robustness of proposed log reduction virus credits even when using a 0.25 credit, as discussed in **Appendix E**. Results using simplified analytical equation approaches, derived from Darcy's Law and based on simplifying aquifer assumptions, show credited retention time exceeding log reduction virus credits of six months across the range of recharge rates from all three SWIP wells with a 0.25 credit applied. The minimum retention time estimated with analytical equations is 29 months between Monterey SWIP well and the private well at 2603 Monterey Ave., which is equivalent to 7.2 months applying the 0.25 credit. As refined particle tracking incorporates Basin specific information from the Basin model and a more plausible representation of recharge and pumping distribution, the 33 months estimated by refined particle tracking between the Monterey SWIP well and the private well at 2603 Monterey Ave is considered the best estimate of the shortest potential underground retention time.

11.4 Drinking Water Well Control Zones

Title 22 Section 60320.200(e)(2) requires defining a three-dimensional zone called the primary control zone in which drinking water well construction around each SWIP recharge is restricted. This primary control zone is defined by the extent of the greatest horizontal and vertical distance travelled reflective of either the underground retention time needed for pathogenic microorganism control, or the RRT, whichever is greatest. As described in earlier sections, the pathogenic microorganism control retention time for the Project is 6 months. As calculated in **Section 12** using estimates of underground travel time to the nearest monitoring well (MM-1) to a SWIP well, the RRT is 7.5 months based on maximum recharge rate of 500 afy at the Monterey SWIP well and 9.2 months based on the minimum recharge rate of 200 afy at the Monterey SWIP well. Thus, the primary control zone is evaluated based on underground retention times of 7.5-9.2 months estimated for the range of recharge rates used for RRT.

The regulations also require a secondary boundary (secondary control zone) representing an extended zone of potential controlled drinking water well construction requiring further study and potential mitigating activities prior to drinking water well construction. It is proposed that this secondary control zone be defined based on retention times of 8.5-10.2 months estimated for the range of recharge rates used for RRT.

As described in **Section 11.3.2**, the range of SWIP well recharge rates are evaluated to provide operational flexibility given the uncertainty of the long-term operational recharge rates at the SWIP wells. As indicated by the range of estimates for underground retention times on **Table 11-8,** the range of recharge rates results also results in different control zones. Control zones around the Monterey SWIP well for minimum recharge rate of 200 afy use RRT of 9.2 months based on 200 afy while the control zones around the well for maximum recharge rate of 500 afy use RRT of 7.5 months based on 500 afy. However, because total recharge is planned to be approximately 1,500 afy, control zones around the Willowbrook and Twin Lakes Church SWIP wells for their minimum recharge rates use RRT of 7.5 months based on the maximum rate at the Monterey SWIP well, 500 afy. Conversely, control zones around the Willowbrook and Twin Lakes Church SWIP wells for their maximum recharge rates use RRT of 9.2 months based on the minimum rate at the Monterey SWIP well, 200 afy.

The extent of the zones will be conservatively based on applying a 0.25 credit to estimated underground retention times over the range of recharge rates evaluated for the SWIP wells. For primary and secondary control zones of 7.5-8.5 months based on maximum recharge rate at Monterey SWIP well, underground retention times are estimated based on refined particle tracking of the PWS scenario simulated with the Basin Model described in **Section 11.1.1** with maximum recharge of 500 afy at Monterey SWIP well and minimum recharge rates of 233 afy and 742 afy at the Willowbrook SWIP well and TLC SWIP well, respectively. Applying the 0.25 credit, control zones of 7.5-8.5 months are based on refined particle tracking estimates of underground retention times of 30-34 months.

If recharge at Monterey SWIP well is at its minimum rate of 200 afy resulting in control zones of 9.2-10.2 months, recharge at the Willowbrook SWIP well and TLC SWIP well will be higher than what was simulated with the PWS scenario simulated with the Basin Model. Therefore, the control zones of 9.2-10.2 months are estimated based on analytical equations of the minimum recharge rate at the Monterey SWIP well and the maximum recharge rates of 500 afy and 1,000 afy at the Willowbrook and TLC SWIP well, respectively. This results in circular control zones with radii based on the retention time calculated between the SWIP well and the nearest municipal production well. Applying the 0.25 credit, control zones of 9.2-10.2 months are based on the analytical equation estimates of underground retention times of 36.8-40.8 months.

The sets of proposed primary and secondary control zones for each SWIP well in the Purisima BC and Purisima A units are shown on **Figure 11-14** through **Figure 11-17**. The vertical extents of the control zones are defined by the aquifer units recharged by each SWIP well as the calibrated Basin Model indicates minimal vertical flow between aquifer units. In other words, **Figure 11-14** shows the extent of the control zones for the TLC SWIP well in the BC unit only. **Figure 11-15** through **Figure 11-17** shows the extent of control zones for the three SWIP wells in the A unit only.

No drinking water wells are presently located within the proposed primary control zones for the aquifer units recharged by the SWIP wells. At the TLC SWIP well that recharges both the Purisima A and BC units, no drinking water wells are located in the primary or secondary control zones. **Figure 11-15** shows that the Pine Tree Lane wells overlie the primary control zone for the A unit based on maximum recharge at the TLC SWIP well. These drinking water wells are not in the control zones as they are understood to be screened shallower than the A unit as shown on **Figure 11-18**. In addition to the calibrated model indicating lack of vertical flow between aquifer units, there are no known vertical conduits between the TLC SWIP well and the Pine Tree Lane wells that could transport water from the A unit to the Pine Tree Lane wells. SqCWD will seek access to sample the Pine Tree Lane wells as part of the tracer study to evaluate whether the three-dimensional control zones should include these wells.

No drinking water wells are located in the primary or secondary control zones of the Willowbrook SWIP well that will recharge the Purisima A unit. The irrigation well at 6120 Abbey Road overlies the primary control zone for the Willowbrook SWIP well, but is not screened in the same aquifer unit as the control zones of the Willowbrook SWIP well that are located only in the A unit. As described in **Section 11.2.2**, this irrigation well is completed to a depth that is near the top of the Purisima BC unit (**Figure 11-19**) and did not show water level response to pumping at the Willowbrook SWIP well. The Willowbrook SWIP well will recharge purified water in the Purisima A unit. As described in **Section 11.2.2**, purified water recharged from the Willowbrook SWIP well is not simulated to travel through the overlying B aquitard unit into the BC unit. There are no known vertical conduits between the TLC SWIP well and the Pine Tree Lane wells that could transport water from the A unit to the Abbey Road well. SqCWD will seek access to sample the Abbey Road well as part of the tracer study to evaluate whether the three-dimensional control zones should include this well.

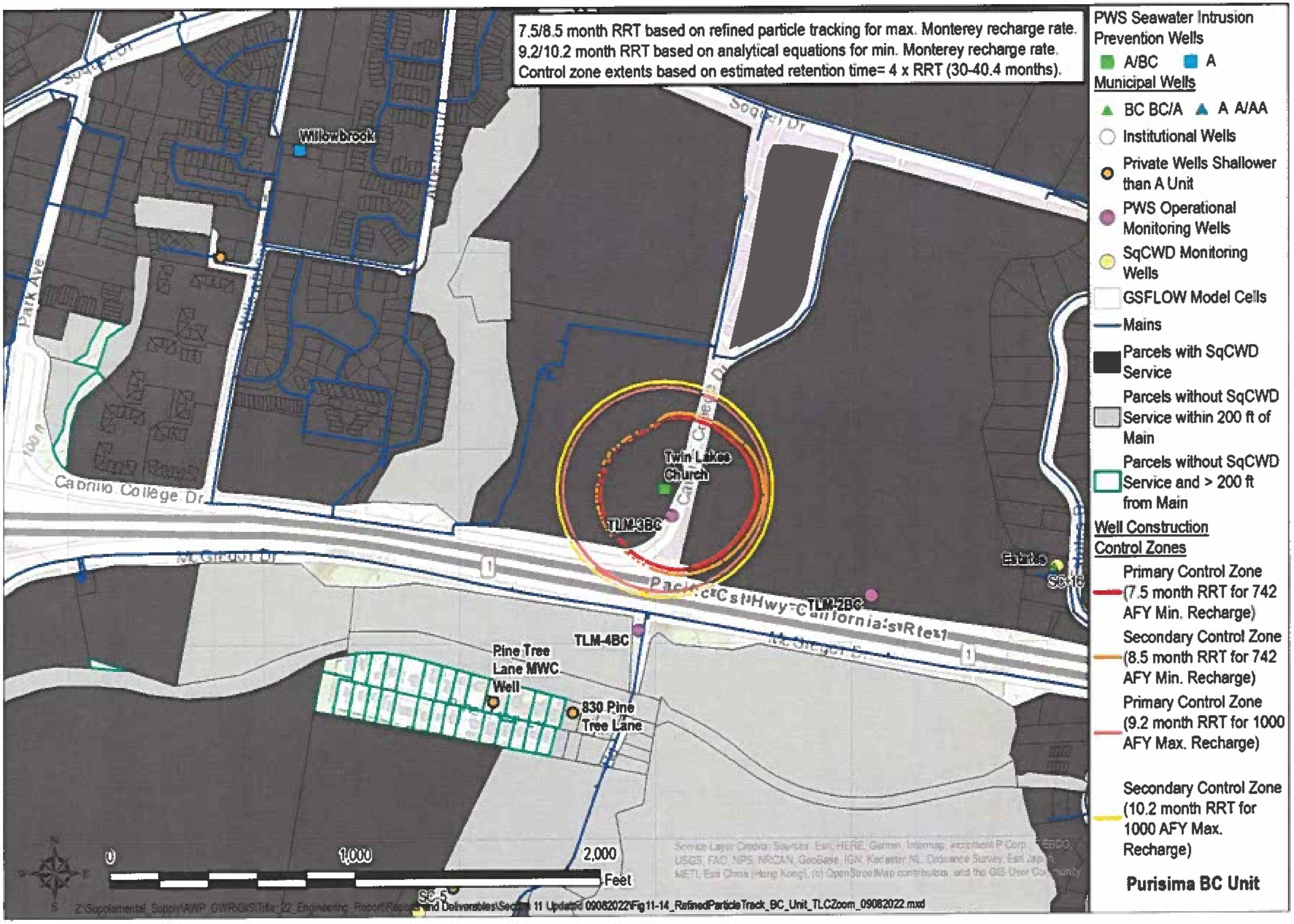

Figure 11-14. Primary and secondary well construction control zones for TLC SWIP well in Purisima BC unit

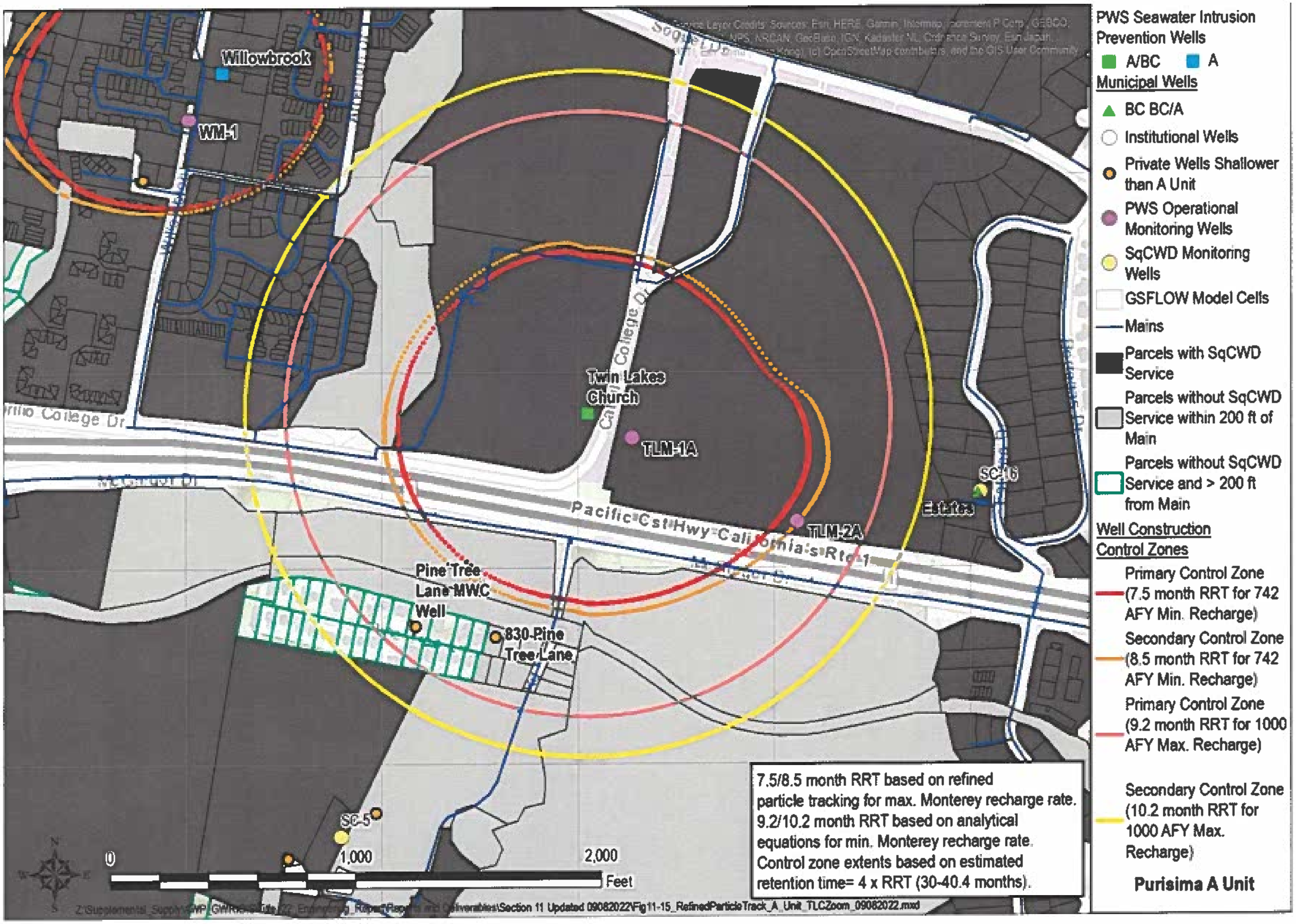

Figure 11-15. Primary and secondary well construction control zones for TLC SWIP well in Purisima A unit

Figure 11-16. Primary and secondary well construction control zones for Willowbrook SWIP well in Purisima A unit

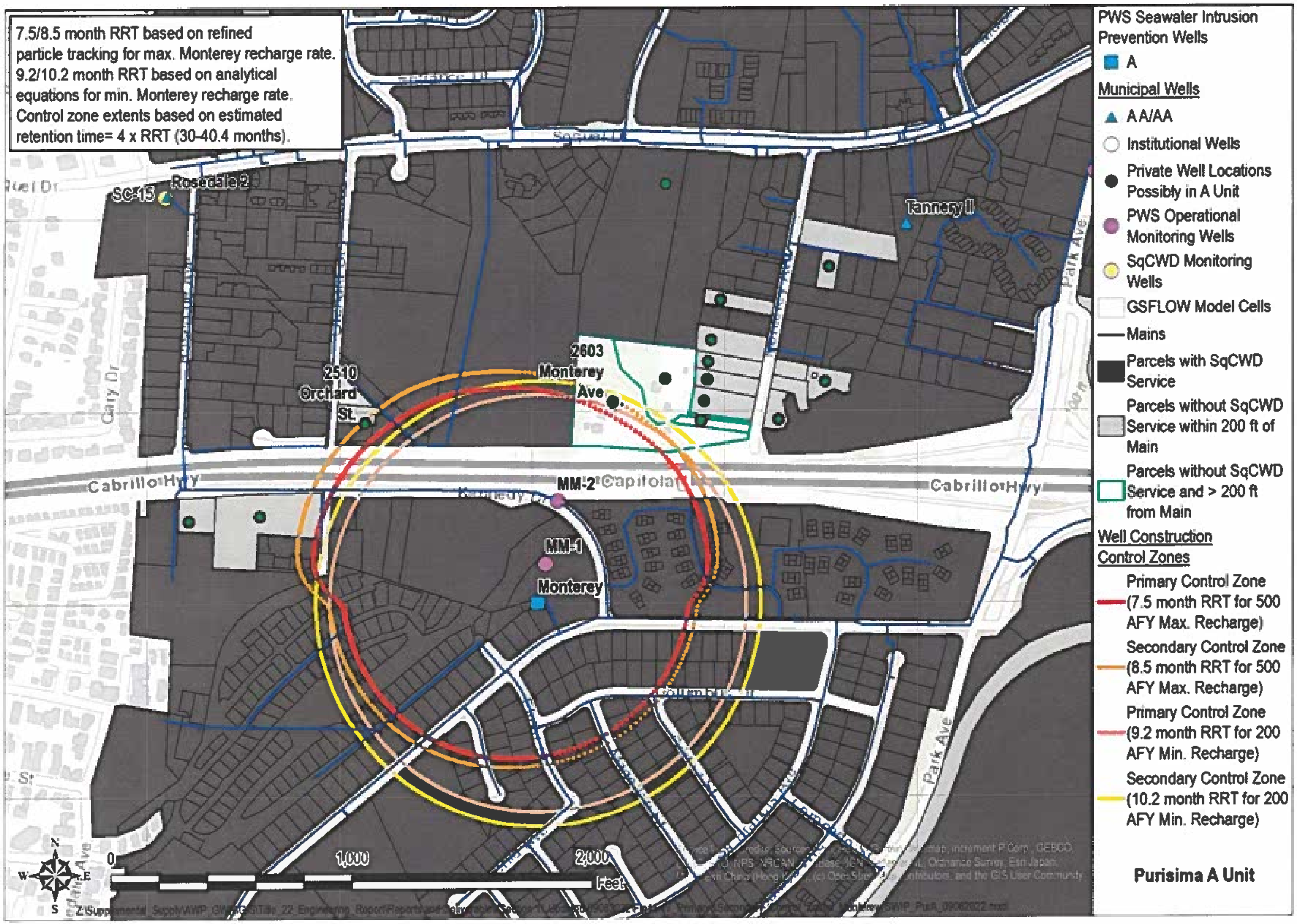

Figure 11-17. Primary and secondary well construction control zones for Monterey SWIP well in Purisima A unit

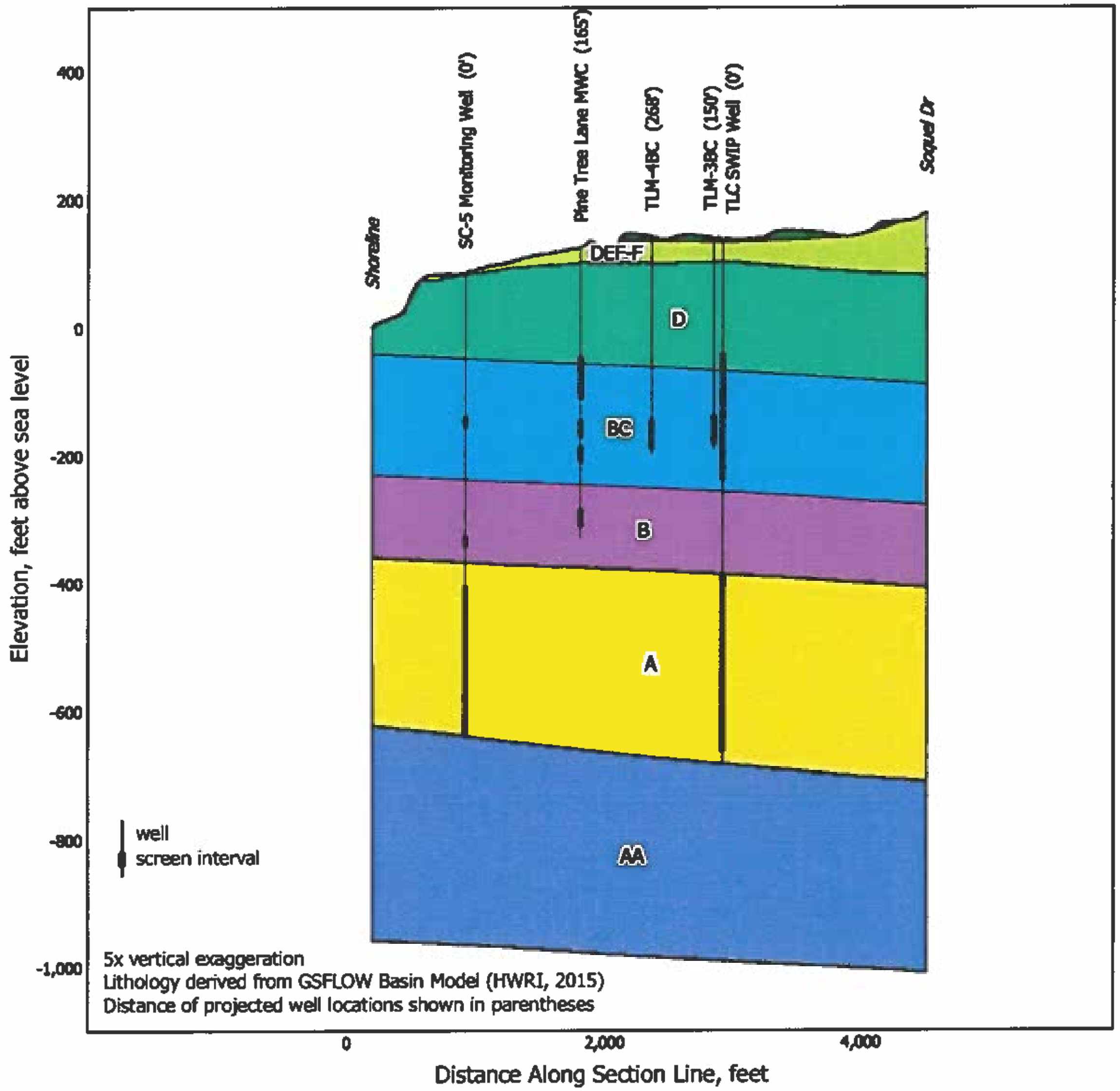

Figure 11-18. Hydrogeologic Cross-section for TLC SWIP Well and Pine Tree Lane MWC Well

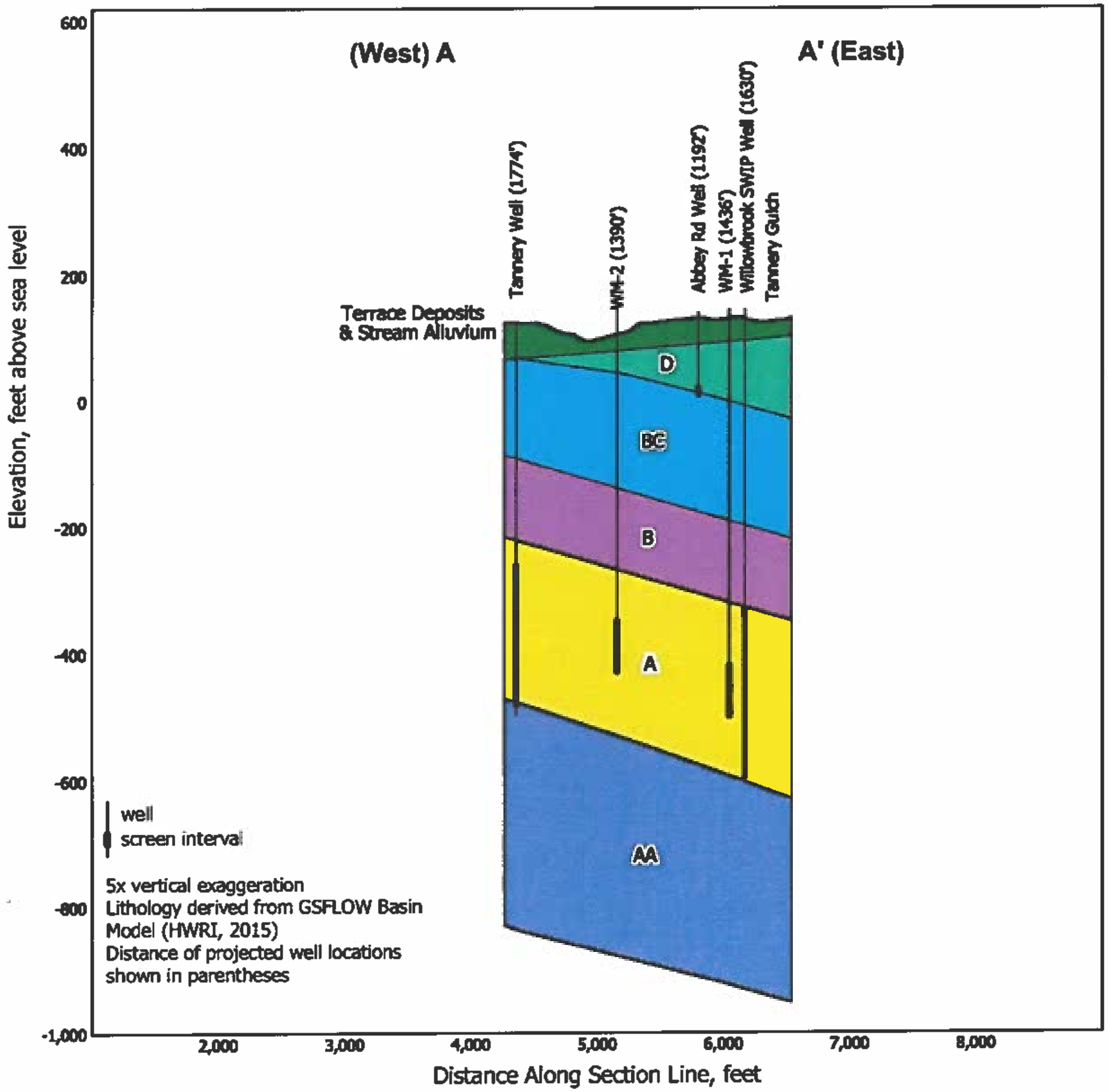

Figure 11-19. Hydrogeologic Cross-section for Willowbrook SWIP Well and Abbey Rd. Well

The drinking water well at 2603 Monterey Avenue (APN 37-191-12) is in the secondary control zone for the Monterey SWIP well in the Purisima A unit. The drinking water well at 2510 Orchard Street (APN 37-171-09) is in the secondary control zone for the Monterey SWIP well in the Purisima A unit based on the maximum recharge at the Monterey SWIP well. The analytical equations do not account for extraction rates at private domestic wells. However, extraction rates at the private domestic wells are assumed to be low; modeling for the GSP assumed 0.23 acre-feet per residence per year (HydroMetrics WRI, 2017a). These low extraction rates at the private domestic wells in the secondary control zone have minimal effects on the overall flow gradients that develop between the project recharge wells and SqCWD's large capacity production wells. SqCWD will seek access to sample these private wells as part of the tracer study to evaluate whether the three-dimensional control zones should include these wells. The proposed control zone extents have been developed in regard to the construction of new private domestic wells screened in the same aquifer unit as the control zone's SWIP well. Like the two existing wells in the secondary control zone for the Monterey SWIP well, new private wells would have low extraction rates relative to large municipal water supply wells, and which would not be expected to change the overall flow gradients. If new high capacity municipal production wells, or changes to municipal production well pumping rates, are planned in the future, these changes would impact large scale flow gradients and inter-well travel times, and this analysis would need to be updated and revised.

The County of Santa Cruz, which is the local well permitting agency, prohibits new drinking water well construction for parcels within 200 feet of a SqCWD water distribution main and within the SqCWD service area of the Basin. In August 2022, SqCWD submitted an update of its service area boundary to only include areas served by SqCWD in response to a request from the Monterey office of DDW. **Figure 11-17** show that most parcels overlying primary and secondary control zones are subject to the County's prohibition. The prohibition includes all parcels overlying the primary and secondary control zones for the BC unit **Figure 11-14**.

SqCWD has been in communication with the County of Santa Cruz and will continue to work with the County staff to enforce the requirements that no drinking water wells be constructed in the control zones for PWS Project to be in compliance with CA Title 22 Section 60320.200(e). County staff plans to develop an update to its well ordinance with the goal of Board of Supervisors adoption by the end of 2023. County staff plans to propose that the update include compliance with state requirements for restrictions on new and replacement drinking water well construction in control zones for Project and Management Actions in adopted GSPs. This would apply to control zones for PWS as a project in the adopted GSP for the Basin. Additionally, SqCWD will adopt a resolution supporting the County's proposed actions for construction of new drinking water wells to comply with these state regulations.

Until the County adopts a new well ordinance, SqCWD and County will use available legal means to restrict or discourage well construction in the control zones. The County currently sends permit applications for wells in SqCWD's jurisidiction to SqCWD for review. SqCWD will object to any permit application for new wells in the current control zones and work with the County and applicant to postpone submittal of applications for well construction until after the control zones are updated based on the tracer study. In addition, in compliance with the Governor's Executive Order N-7-22 for the current drought emergency, the County is not allowed to approve a permit or a non-deminimus (>2 AFY) non-public[4] well in the Basin unless it receives written verification from the MGA that the well is not inconsistent with the GSP. As PWS is a project in the GSP for achieving sustainability, well construction in the control zones would be inconsistent with the GSP.

[4] Public water systems are exempt from this executive order, but it appears that State small water systems are not exempt. As the public water system for the area, SqCWD will not construct drinking water wells in the control zones.

The primary and secondary control zones will be re-assessed based on the tracer study to begin within the first three months of the onset of purified water recharge at the SWIP wells (see **Section 14.7**). In addition, any needed revision to control zones for operational changes including recharge and municipal pumping rates would be based on analytical equations and/or modeling calibrated to tracer study results.

11.5 Anti-Degradation Assessment

One of the requirements for a recycled water project is that it must be compatible with SWRCB Resolution 68-16 (Antidegradation Policy) and the Recycled Water Policy (SWRCB, 2018). Under the new version of the Recycled Water Policy (SWRCB, 2018), a groundwater recharge project where no SNMP is in development defaults to a project-specific antidegradation analysis study instead of being able to use basin-wide assimilative capacity.

A Final-Draft version of an Antidegradation Evaluation was prepared in late 2018. Due to ongoing changes in recycled water policy and further interpretation while the Antidegradation Evaluation drafts were in development, completion was postponed until the monitoring program details required for this Title 22 Engineering Report for the Project became available. Groundwater Monitoring Plan details are provided in **Section 14**. The full Final Antidegradation Evaluation Report is being provided separately, with only summary results and discussion provided in this report.

The Basin Plan applies antidegradation policy as follows:

"Wherever the existing quality of water is better than the quality of water established herein as objectives, such existing quality shall be maintained unless otherwise provided by the provisions of the State Water Resources Control Board Resolution No. 68-16, "Statement of Policy with Respect to Maintaining High Quality of Waters in California," including any revisions thereto" (Chapter 3, Section II.A)."

The main focus of the antidegradation analysis was on TDS, chloride and nitrate. Boron and sodium are also minerals of concern for agricultural beneficial uses. Other minerals that can sometimes be susceptible to mobilization were also evaluated.

Groundwater quality objectives were taken from the Basin Plan for municipal, industrial, and agricultural beneficial uses. The municipal and industrial water quality objectives were the Title 22 primary and sMCLs. An agricultural boron water quality objective of 0.75 mg/L was applied based on the Basin Plan language and RWQCB staff guidance. An agricultural fluoride water quality objective of 1.0 mg/L was also applied. All other agricultural water quality objectives are higher than drinking water MCLs.

The antidegradation evaluation was performed on the combined AA, A, and BC aquifer unit volumes within the Basin boundary. Phase 2 project modeling (M&A, 2020a) was performed after aquifer and hydraulic testing data had been obtained from the TLC Pilot well. As described earlier in this Section, the model simulated recommended recharge and pumping conditions for recharge starting in year 2023 and extending to 2069 for the assumed model hydrology.

11.5.1 Assimilative Capacities

The antidegradation evaluation involved both an assimilative capacity evaluation and a direct comparison of Project impacts with the oldest readily available groundwater quality data since 1968. Concentrations of most constituents have trended flat to slightly upward since the oldest post-1968 available data.

The advantage of an assimilative capacity evaluation is that the results will be compatible with any future SNMP related efforts in the Basin. If applying maximum benefit factors, a comparison with Basin Plan water quality is also necessary under Antidegradation Policy to show that a project "will not unreasonably affect present and anticipated beneficial use of such water and will not result in water quality less than that prescribed in the policies."

The Recycled Water Policy states that available assimilative capacity for a constituent shall be calculated by comparing the mineral water quality objective with the average concentration of the basin/sub-basin, either over the most recent five years of data available or using a data set approved by the RWQCB. The minimum time frame for evaluating the impacts of the project must be at least ten years.

Water quality objectives, recent average water quality results, and historical water quality are provided in **Table 11-9**.

Table 11-9. Relevant Groundwater Quality Objectives and Existing and Historical Concentrations

Constituent	Water Quality Objective (mg/L)	Type	Existing Background[a] (mg/L)	Historical[b] (mg/L)	Trend (mg/L per year)[c]
Chloride	250/500[d]	Secondary	41.2	55.9	-0.146
Nitrate (as N)	10	Primary	0.06	0.25	-0.005
TDS	500/1000	Secondary	436	513	1.15
Arsenic	0.010	Primary	0.0006	ND	NS
Boron	0.75	Basin Plan/Ag	-	0.22	0.007
Cadmium	0.005	Primary	-	ND	ND
Chromium	0.050	Primary	-	ND	ND
Fluoride	1.0	Basin Plan/Ag	-	0.34	0.0017
Hexavalent Chromium[e]	0.010	Primary (suspended)	ND	0.0016	ns
Iron	0.3	Secondary	0.2-0.758	0.3	0.023
Manganese	0.050	Secondary	0.096-0.277	0.14	0.005
Nickel	0.1	Primary	-	ND	NS
Sodium	NA	NA	-	63.7	0.083
Sulfate	250/500	Secondary	-	87.3	0.39

a. Mostly 2016 values for AA, A, BC subunits including monitoring wells and City of Santa Cruz Beltz wells.
b. Earliest multi-year data since 1968 for SqCWD Estates, Monterey, Rosedale 2, Tannery, and Tannery II wells.
c. Trends are calculated as later period averages minus early concentrations divided by the number of years. Trends were calculated using available data. Recent concentrations for existing background were not always available, especially for wells that have been replaced.
d. Where applicable for secondary objectives, values shown are recommended/upper limits
e. The hexavalent chromium limit was judicially suspended and is under review for modification and reissuance.
NA=not applicable
ND= non detect
NS= insufficient samples

The anticipated water quality of the purified water used for recharge was provided in **Section 8**. Except for nitrate-N, the concentrations of constituents of concern are all projected to be lower than the historical water quality values shown in **Table 11-9**. This indicates that state antidegradation policy is satisfied on a straight mixing basis without considering geochemistry effects (discussed later).

Two guidelines included in **Table 3-1** in the Basin Plan refer to permeability risks associated with agricultural irrigation use of water having a high SAR and low EC. The projected SAR for the stabilized purified water is 0.5, which is far below where research shows significant permeability effects, even with water low in EC.

Using the values for existing background groundwater quality and the water quality objectives for the main salt and nutrient constituents (TDS, chloride, and nitrate) as listed in **Table 11-10**, assimilative capacities were calculated. These assimilative capacities are shown in **Table 11-11**.

Table 11-10. Salt and Nutrient Mass Totals and Assimilative Capacities

Subunit	Volume (af)	TDS		Cl		NO_3-N	
		mg/L	tons	mg/L	tons	mg/L	tons
AA	239,000	377.0	122,000	33.3	10,800	0.06	18.0
A	593,000	471.0	380,000	46.0	37,100	0.06	45.8
BC	57,000	381.0	30,000	33.0	2,600	0.05	3.9
Totals or Weighted Avg.	889,000	440.0	532,000	41.7	50,500	0.06	67.7
Objectives	889,000	500	604,000	250	302,000	10	12,100
Assimilative Capacities (rounded)		60.0	72,000	210	251,500	9.9	12,030
10% of Assimilative Capacities		6.0	7,200	21.0	25,200	1.0	1,200

Table 11-11. Assimilative Capacity Usage Projection (2023-32)

Constituent	Recharge Water (mg/L)	Difference from Background (mg/L)	Assimilative Capacity		
			Usage (tons)	Usage (mg/L)	% of Total
Chloride	10.1	-31.6	-634	-0.5	-0.25%
Nitrate (as N)	1.7	1.6	32	0.03	0.27%
TDS	101	-339	-6,790	-5.7	-9.44%

Relevant water quality objectives were shown in Table 11-7.
Assimilative capacity usage projections are based on the mass balance values on drawing 000-G-7003 (Appendix C)

The usage of assimilative capacity was calculated for the first 10 years of groundwater recharge by the project. These results are shown in **Table 11-11**. Because the purified water is very low in mineral content, the assimilative capacity usages for TDS and chloride are actually negative.

The concentrations for the PWS Project scenario in **Table 11-12** below provide an estimate of average concentrations in water recovered from the nearby SqCWD wells after the injectate reaches those wells, assuming chloride and TDS are conservative in the aquifer zones. Based on the information presented previously in **Table 11-11**, average nitrate-N concentrations in the managed aquifer volume are not expected to be affected by an appreciable amount relative to the water quality objective. Actual constituent concentrations will be affected by dispersion, mixing, and geochemical reactions.

Table 11-12. Estimated Effects on Production Well Salinity After Beginning of Capture

Well	Production (AF)	Recharge Water			Chloride		TDS	
		Captured (% of total particles released)	Captured (AF)	Captured (% of production)	Current (mg/L)	Project (mg/L)	Current (mg/L)	Project (mg/L)
Estates	10,277	11.4	4,155	40	49	30	472	318
Tannery II	14,710	16.1	5,966	41	61	38	561	371
Rosedale	13,635	7.1	2,626	19	44	36	496	418
Cunnison	9,580	2.5	917	10	53	48	529	487

Note:
Well production based on 2028 - 2047 projections for pumping
Assumes approximately 5 years until beginning of capture for Tannery II and Estate wells
Assumes approximately 15 years until beginning of capture for Rosedale and Cunnison wells
Assumes 37,000 AF total injected through 2047

11.5.2 Geochemistry Effects

Aquifer soil samples were collected during drilling of the TLC Pilot Well for a Phase II Geochemical Characterization evaluation (BC, 2020b), which is provided in **Appendix F**. The objective of the Phase II geochemical characterization program was to collect samples from the pilot borehole for geochemical laboratory analyses, evaluate the geochemical conditions present in the aquifer units of the injection well, identify the constituents which could become mobilized during the injection process, and evaluate if the chemistry of the treated water could be adjusted to minimize or mitigate constituent mobilization.

An overview of the analytical methods, the aquifer subunits analyzed, and additional notes on the methodology are summarized in **Table 11-13**.

Table 11-13. Phase II Geochemical Characterization Laboratory Analysis

Analysis	Target Subunits	Number of Composite Samples	Investigation	Methodology Details
Soil Leaching				
Modified SPLP (4:1 solution:solids ratio) (USEPA, 1994)	Purisima D, BC, B, A, AA	5	Phase I and Phase II	De-ionized and 3 stabilized pure water aliquots from existing treatment plants
Modified MWMP (1:1 ratio, 4 cycles) (ASTM, 2013)	Purisima BC, A	2	Phase II	One stabilized pure water type, week-long submersion, repeated 4 times
HA-HCL extraction (Tessier et al. 1979)	Purisima BC, D, B, A, AA	5	Phase II	Metals only
Mineralogical Characterization				
Whole-rock chemistry	Purisima D, BC, B, A, AA	5	Phase II	Major, minor and trace elements
XRD	Purisima D, BC, B, A, AA	5	Phase I and Phase II	Major and trace mineral phases

ASTM = American Society of Testing Materials; HA-HCl = hydroxylamine-hydrochloride; MWMP = Meteoric Water Mobility Procedure.

Using the results of the testing, the constituents of interest were classified according to presence and potential mobility as shown in **Figure 11-20**.

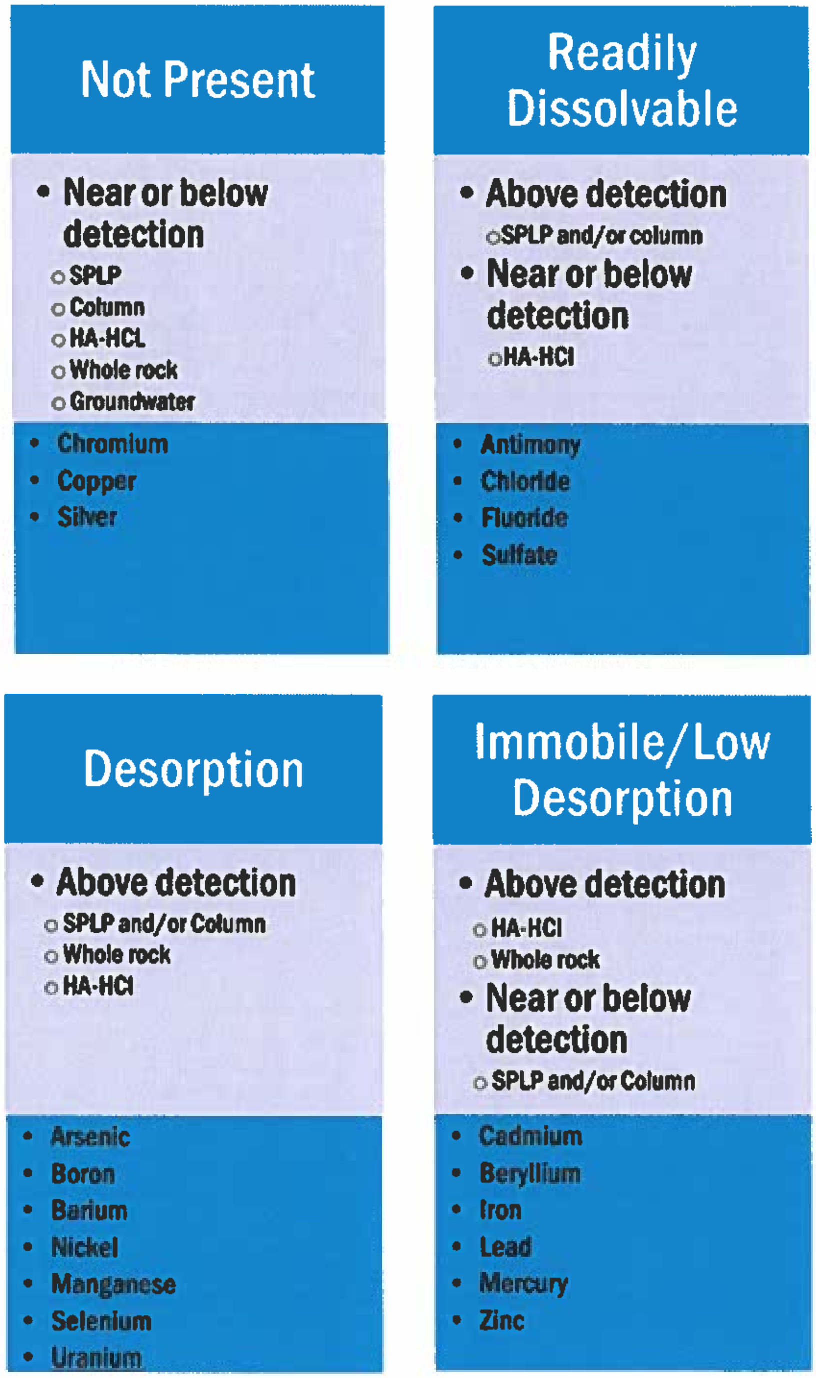

Figure 11-20. Classification of constituents and potential mobility

Interpretations of the potential water quality effects based on results of the TLC SWIP Pilot Project, the geochemistry testing, and the supporting information are listed below:

- Several regulated constituents are likely not present in the TLC SWIP Pilot well samples and will potentially not be of concern for the project:
  - Chromium, copper and silver were near or below the analytical detection limit for all laboratory geochemical analyses and zone groundwater quality analyses.
- Metals can be desorbed from clay or iron and/or manganese oxide minerals in the samples:
  - Concentrations of arsenic, barium, nickel, strontium, and uranium were detected in the aggressive HA-HCl soil leaching test and the modified SPLP and column tests.
- All three purified waters used for testing mobilized some metals and other constituents, although to a lesser degree than would cause MCL exceedances:
  - The tested advanced purified waters mobilized some arsenic from the Purisima A and BC units, although concentrations were below the MCL for the SPLP test and for successive rinses in the MWMP tests.
- Most constituent concentrations tended to decrease over the short-term, as multiple pore volumes of purified water were allowed to react the target units:
  - Arsenic, barium, calcium, magnesium, potassium, sodium, strontium, and uranium showed decreasing trends for one or both of the Purisima A and BC units evaluated in the modified column tests.
  - Decreasing trends were likely the desorption of constituents from clay and oxide minerals and the dissolution of dissolvable mineral phases.
- Multiple rinses altered the equilibrium of the system:
  - Increasing fluoride and decreasing calcium concentrations could have indicated the dissolution of fluorite with multiple rinses.
  - Increasing extracted solution pH values could have indicated the removal of iron oxide mineral phases with multiple rinses, although iron concentrations remained well below the MCL.

Results from subsequent geochemical modeling analysis provided some support to the observations from the Geochemical Characterization analysis which indicated potential reactions such as constituents mobilizing through desorption and the dissolution of mineral phases could occur during the interactions of the purified water with the Purisima units. The geochemical modeling also indicated that stabilizing the purified water could mitigate the release of some metals (arsenic and antimony).

A Phase III Geochemical Characterization study (BC, 2022), provided in Appendix G, was also recently completed using similar methods as the Phase II study on samples from the entire Purisima A unit of the Willowbrook SWIP and from high conductivity zones of the Willowbrook and TLC SWIP wells. Samples of purified water from additional treatment plants were also tested. Trends were generally similar to the Phase II study results, although peak concentrations of constituents of interest were generally lower in the Phase III study.

Overall, the geochemistry results indicated that with proper post-treatment stabilization of the purified recharge water, the geochemistry effects are most likely to be temporary and not cause exceedances of water quality objectives. The geochemistry results are also likely to be conservative results in that samples from the entire depth range of the respective subunits were used in the Phase II tests, whereas most recharge water will travel in the coarser, higher permeability portions of the subunits that are less likely to be reactive as shown in the Phase III tests. Some discrepancies between results for different test methodologies for fluoride and boron highlight the need for some initial extra scrutiny of those constituents as part of the groundwater monitoring program.