Valley Water

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Groundwater Response to Tides, Seawater Intrusion, and Sea-Level Rise in Santa Clara County, California

SANTA CLARA VALLEY WATER DISTRICT

Groundwater Response to Tides, Seawater Intrusion, and Sea-Level Rise in Santa Clara County, California

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Cover Photo: Valley Water staff, Victoria Garcia, sampling seawater intrusion monitoring wells (06S02W05F001/F002/F003) near Mayfield Slough and Don Edwards San Francisco Bay National Wildlife Refuge. Photo credit: Jason Gurdak (Valley Water), taken August 13, 2024.

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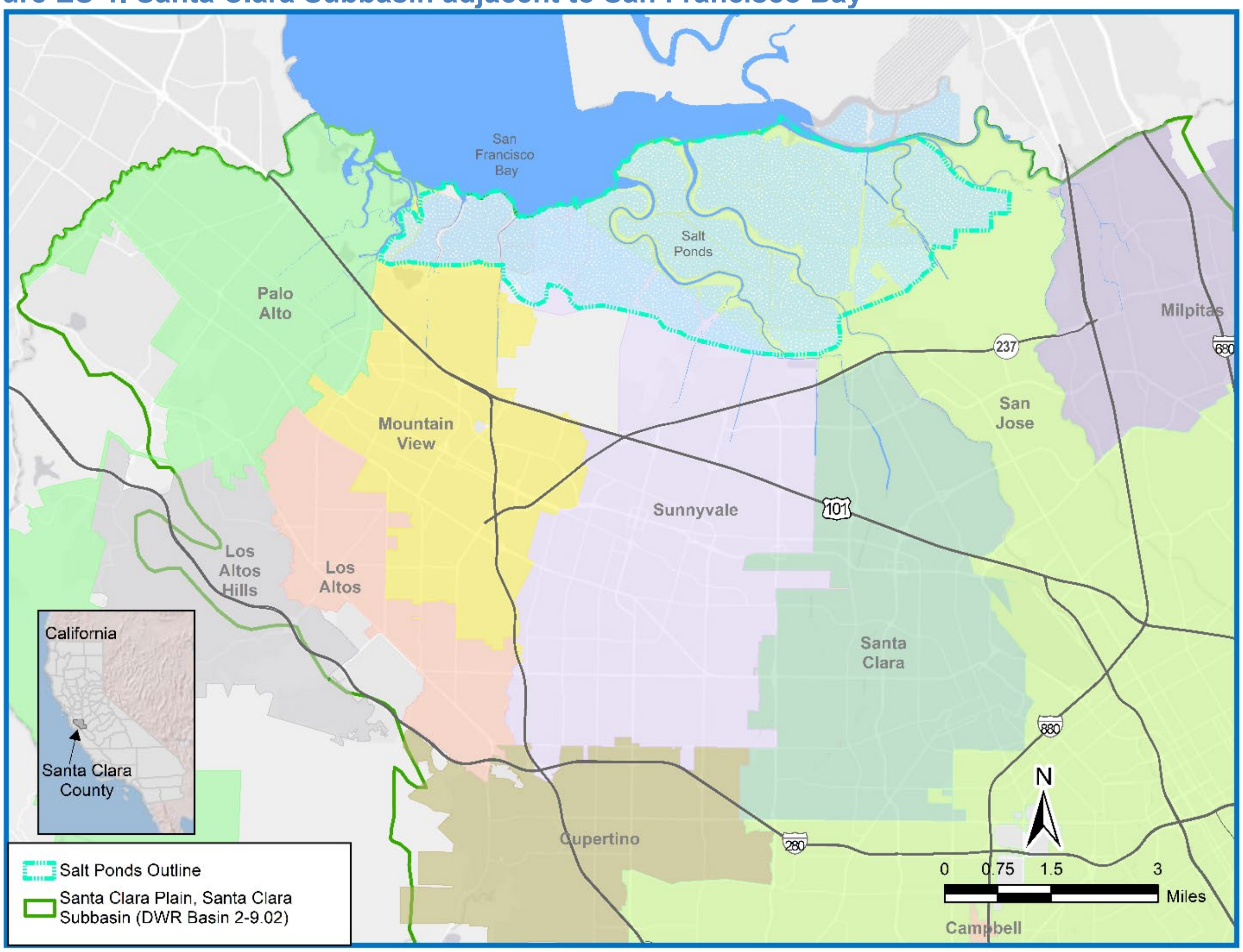
EXECUTIVE SUMMARY

The Santa Clara Valley Water District (Valley Water) has the responsibility and authority to manage groundwater in the Santa Clara and Llagas subbasins[1] in Santa Clara County, California under the Santa Clara Valley Water District Act (District Act) and as a Groundwater Sustainability Agency (GSA) under California's Sustainable Groundwater Management Act (SGMA). Valley Water has many programs and projects[2] to sustainably manage groundwater. This report describes Valley Water's study of groundwater in the Santa Clara Subbasin adjacent to the San Francisco Bay (Bay) (Figure ES-1), including the impacts of tides, seawater intrusion, and sea-level rise on groundwater rise and emergence at land surface. This northern part of the Santa Clara Subbasin is home to several cities and the heart of Silicon Valley.

Figure ES-1. Santa Clara Subbasin adjacent to San Francisco Bay



Introduction

Historic groundwater overdraft and associated permanent land subsidence, beginning in the early 1900s and ending in the early 1970s, caused seawater intrusion in the shallow aquifer of the Santa Clara Subbasin. Seawater intrusion (also called saltwater intrusion) refers to the temporary or permanent flux

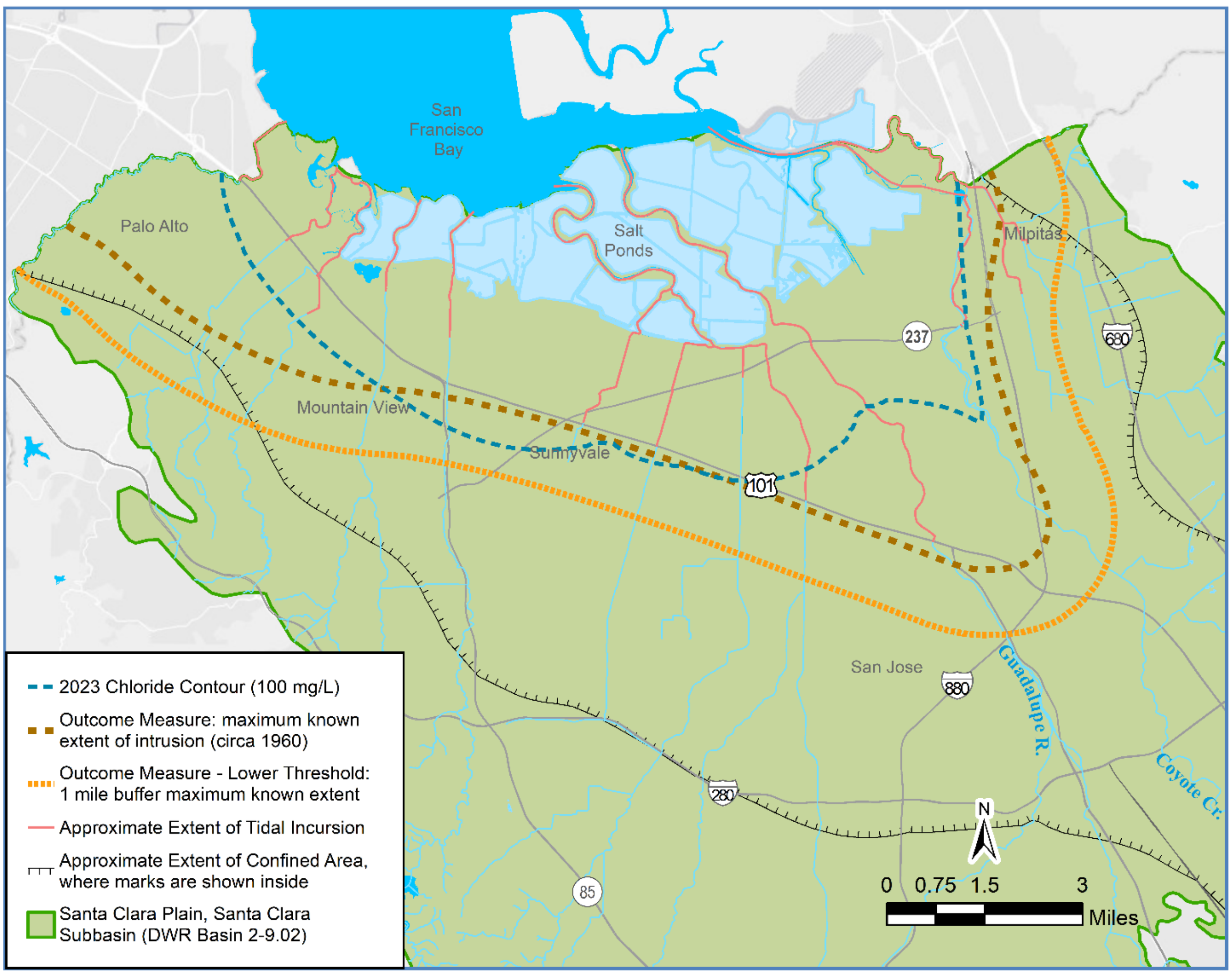
[1] California Department of Water Resources (DWR) Basins 2-9.02 and 3-3.01, respectively.

[2] Valley Water's groundwater management activities are described in the 2021 Groundwater Management Plan (GWMP). In 2024 DWR approved this plan as Valley Water's first required periodic evaluation of an approved Alternative to a Groundwater Sustainability Plan for continued SGMA compliance.

of seawater into coastal freshwater aquifers. Seawater intrusion is a groundwater management concern because it can degrade groundwater quality and lead to undesirable conditions that may include limiting groundwater availability as a water supply for municipal, industrial, agriculture, and domestic uses, or degrading groundwater dependent ecosystems or infrastructure. Reclaiming freshwater aquifers after seawater intrusion is often costly and slow, and in many cases, may be practically infeasible. Valley Water's sustainable groundwater management focuses on preventing and mitigating undesirable results including resumed chronic overdraft, subsidence, and seawater intrusion.

Climate change-driven sea-level rise is likely to affect groundwater conditions in the shallow aquifers of the Santa Clara Subbasin, which has implications for groundwater management, including the seawater intrusion outcome measure under SGMA. Valley Water developed various outcome measures related to groundwater supply, quality, and subsidence as quantifiable goals to track performance in managing groundwater. The seawater intrusion outcome measure focuses on the shallow aquifer of the Santa Clara Subbasin near the Bay. The outcome measure and outcome measure–lower threshold (Figure ES-2) are functionally equivalent to the measurable objective and minimum threshold, respectively, under SGMA[3]. In delineating the seawater intrusion outcome measure, Valley Water conservatively uses the 100 milligram per liter (mg/L) chloride isocontour as an early indicator of impairment.

Figure ES-2. Seawater intrusion outcome measure and lower threshold



[3] SGMA requires quantitative metrics to reflect desired groundwater conditions (measurable objective or functional equivalent) and conditions that may cause undesirable results (minimum threshold or functional equivalent).

Groundwater Response to Tides, Seawater Intrusion, and Sea-Level Rise

There has been a recent increase in scientific publications and related coverage in news outlets about groundwater rise and emergence in response to sea-level rise, particularly focused on Bay Area counties. As demonstrated by this report and the referenced studies, the impacts of sea-level rise on groundwater are actively being acknowledged, evaluated, and addressed. The number of scientific and engineering studies, planning and management actions, and related policies and regulations addressing groundwater-related impacts on the built environment and natural systems is likely to continue growing as sea-level rise intersects with low-lying coastal regions. These regions are home to large populations and dense development in the Bay Area and other coastal regions of California, U.S., and the globe.

Objectives

This report describes aquifer and groundwater conditions in the Santa Clara Subbasin near the Bay, including the impacts of tides, seawater intrusion, and sea-level rise on groundwater. Existing and future highest groundwater conditions in the shallow aquifer are evaluated. Maps are presented that show projected groundwater rise (also called groundwater shoaling) and emergence at land surface due to climate change-induced sea-level rise. A goal of this report is to provide both a non-technical overview for the public and policymakers, as well as relevant technical details for practitioners in groundwater science, engineering, and management. Additionally, this report includes major advances in the hydrogeologic conceptual model of the Santa Clara Subbasin shallow aquifer system near the Bay.

Findings

Findings from the study are largely based on Valley Water's extensive stream gaging and groundwater monitoring networks. These include a seawater intrusion groundwater monitoring network near the Bay designed to identify tidal influences on groundwater and provide an early warning of seawater intrusion and groundwater rise and emergence. Valley Water has been monitoring groundwater quality and seawater intrusion in the shallow aquifer for many decades. Due to Valley Water's comprehensive groundwater management programs and investments, the area of shallow groundwater affected by seawater intrusion has decreased considerably since its peak in the 1960s. Importantly from a water supply perspective, there is little evidence of seawater intrusion in supply wells screened in the deeper, principal aquifer, which serves as the primary groundwater supply in the Santa Clara Subbasin.

The most significant findings from this study are as follows. Many of these findings have important implications for forecasting groundwater response, including groundwater rise and emergence to future changes in sea level, tides, and precipitation patterns from climate change, as well as salt pond restoration or other shoreline projects.

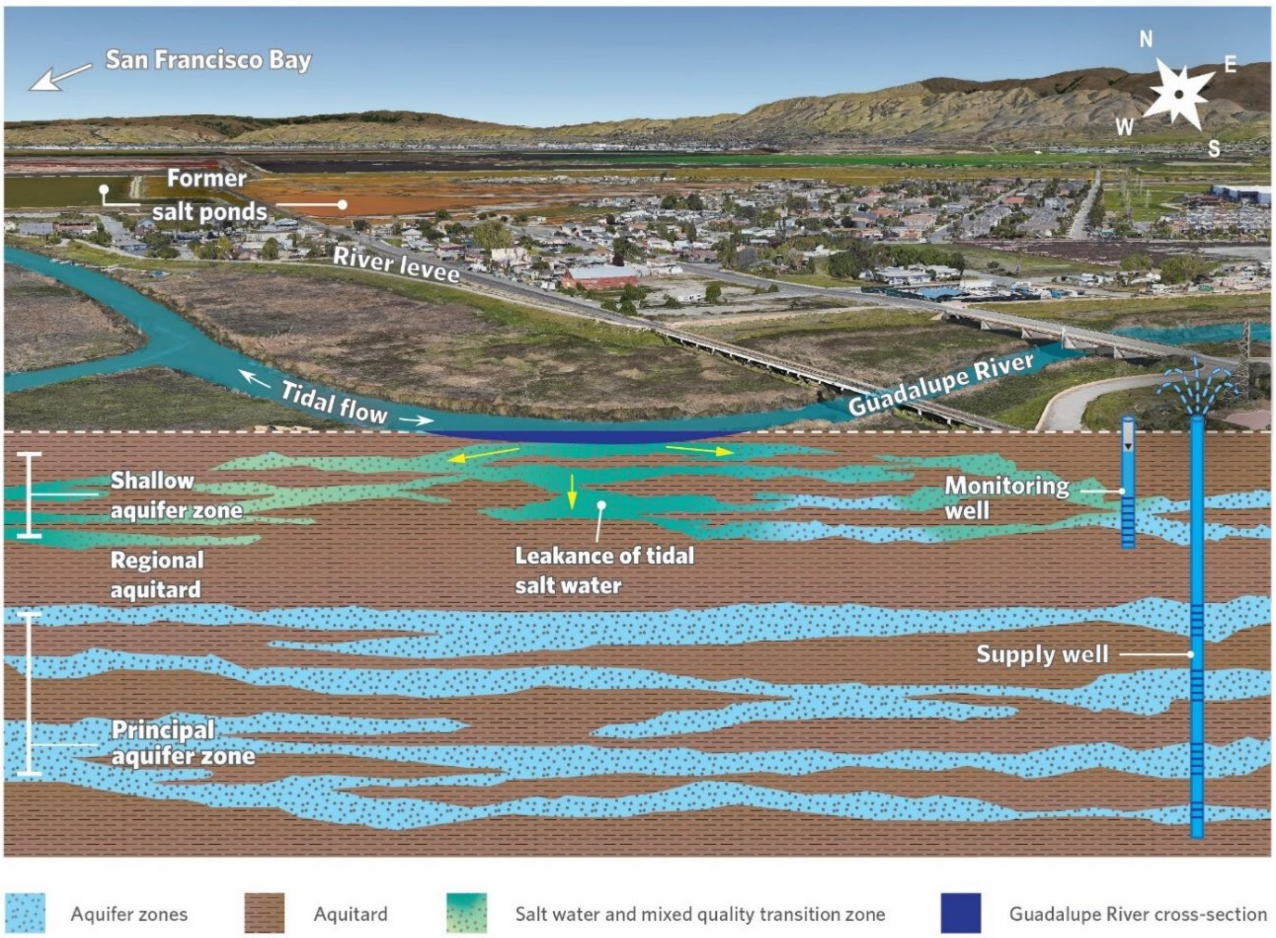
1. **Near the South Bay, aquifers are generally not connected to the Bay.**

The south Bay is shallow, with an average depth of less than 10 feet. Local data confirm that aquifer units near the Bay are relatively thin and typically separated from the Bay and streams by relatively thick clay layers. Estimated hydraulic conductivity values of the clay and Bay mud are three to four orders of magnitude smaller than the aquifer sediments, further indicating that the flow of fresh groundwater and Bay water is likely restricted by the clay layers and Bay mud. See Chapters 2 and 3 for details.

2. **Saltwater leakance from tidal streams dominates seawater intrusion in shallow aquifers.**

Several mechanisms contribute to seawater intrusion in the shallow aquifer. However, the leakance of saltwater and brackish water beneath tidal streams (Figure ES-3) is likely the most influential mechanism affecting the spatial extent and inland migration of seawater. The stream reaches with the greatest tidal influence are within the approximate extent of tidal incursion[4] and closest to the Bay. These reaches extend considerable distances inland, generally aligning with the extent of the seawater intrusion outcome measure (Figure ES-2). Given the shallow south Bay and typical separation from shallow aquifers, the “classic” seawater intrusion mechanism plays a relatively minor role in the extent of seawater intrusion. Similarly, classic seawater intrusion will likely have a limited role in contributing to groundwater rise and emergence in the Santa Clara Subbasin due to sea level rise. See Chapters 2 and 3 for details.

Figure ES-3. Conceptual diagram of seawater intrusion in the Santa Clara Subbasin by saltwater leakance beneath tidal streams.



3. **Construction activities may affect localized seawater intrusion in shallow groundwater.**

While saltwater leakance beneath tidal streams is likely the most influential mechanism, construction activities that pierce the protective Bay mud and clay layers may contribute to localized seawater intrusion in the shallow aquifer. For example, data from one monitoring well indicates that nearby Highway 237 bridge piles and piers may have created preferential pathways for brackish water from the tidally influenced Guadalupe River to reach depths more than 70 feet below ground surface in the shallow aquifer. This highlights the importance of appropriate environmental planning and regulations for the construction of bridges or other infrastructure with subsurface features that pierce the protective clay layers in tidally influenced areas near the Bay. Although Valley Water does not have authority over such

[4] The extent of tidal incursion is the inland limit of the effects of average high tides on tributary stream flows and water surface elevations and thus represents the transition zone between tidal (saltwater) and fluvial (freshwater river) processes and conditions.

infrastructure, the managed aquifer recharge program is operated to create upward hydraulic gradients in the deeper, principal aquifer to help prevent the downward migration of saltwater and contaminants into the principal aquifer used for water supply. See Chapter 4 and Appendix D for details.

4. **Future changes to tidal dynamics will likely affect shallow groundwater.**

All seawater intrusion monitoring wells have statistically significant tidal variance in groundwater levels, while only about half have significant tidal variance in groundwater conductivity[5]. Given the similar tidal pattern in stream stage and groundwater levels, any future changes to stream stage tidal dynamics, whether from climate change, other human activities, or shoreline projects, are likely to alter groundwater level dynamics. The lack of consistent tidal variance in groundwater quality (conductivity) suggests the actual leakance of seawater beneath streams and the flow of seawater in the shallow aquifer is not widespread. Instead, tidally driven pressure waves are propagating through stream stage causing consistent tidal response in groundwater levels. See Chapter 3 and Appendix A for details.

5. **Shallow groundwater responds to pressure changes from rainfall, king tides, and streams.**

Groundwater level responses to some of the highest high tides of 2023 and 2024, including king tide events on January 11 and February 9, 2024, provide important insights into the shallow groundwater system and how groundwater may respond to future sea-level rise. Groundwater level variability in the shallow aquifer tends to closely match the tidal pattern, although with a highly dampened amplitude. However, the largest groundwater level variability during the king tides was a response to large rainfall immediately preceding the king tide. This immediate rise in groundwater levels from wells screened in a confined aquifer is likely a pressure response to the increase in rainfall and soil moisture, rather than actual infiltration and recharge from the rainfall. This highlights the complexity of groundwater level responses near the Bay, which are influenced by factors including pressure changes from tides, stream stage, and rainfall- and soil moisture-loading. See Chapter 4 and Appendix D for details.

6. **Localized groundwater emergence occurs but is not a widespread concern.**

The shallow aquifer system is extremely complex, and the highest groundwater conditions are influenced by various factors such as localized clay layers, proximity to tidal streams, seasonal and annual rainfall variability, tidal patterns, and sea-level rise. These factors can contribute to groundwater rise and, in turn, groundwater emergence above land surface, leading to temporary or permanent flooding in localized areas.

Groundwater rise and emergence above land surface is more likely in areas closer to the Bay and in low-lying elevations or surface depressions, particularly those where the land surface is below sea level. Groundwater rise in the shallow aquifer typically follows seasonal and annual patterns in rainfall and tides. Under current conditions, groundwater emergence is not a widespread concern, as it has only been observed in localized areas near the Bay, typically in undeveloped lands, wildlife preserves, and parks.

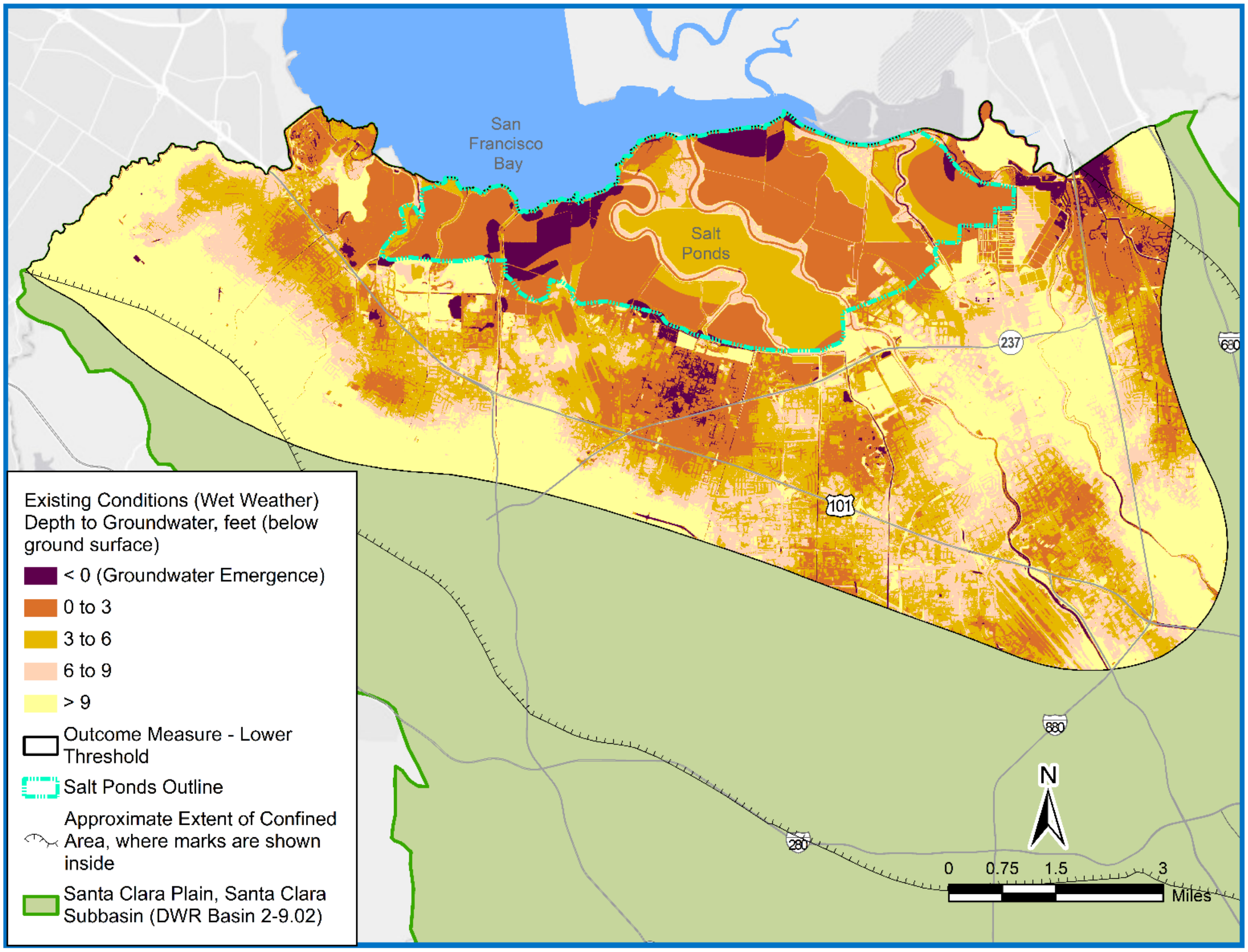
For consistency with previously published groundwater rise and emergence maps from around the Bay, this report presents existing highest groundwater condition maps created using similar methods. Groundwater elevations are presented relative to mean sea level and as depth to water relative to ground surface (Figure ES-4). See Chapter 4 and Appendix B for details.

Much of the seawater intrusion outcome measure–lower threshold area (81 square miles)[6] has

[5] Conductivity (also called electrical conductivity) is a water quality property that is directly proportional to the concentration of dissolved ions (salts) in the water.
[6] The outcome measure–lower threshold designates conditions that relate to undesirable results under Valley Water's SGMA plan.

groundwater elevations greater than 9 feet above mean sea level (Figure ES-4). These areas are unlikely to be affected by seawater intrusion or sea-level rise because the groundwater elevations are much higher than current or future sea level and tides. However, existing highest groundwater elevations are below mean sea level across nearly 4 square miles inland of the salt ponds, which is equivalent to about 5% of the outcome measure–lower threshold area. These areas are more likely to be affected by seawater intrusion and sea-level rise because the groundwater elevations are lower relative to current mean sea level.

Figure ES-4. Existing highest groundwater conditions from 2000 to 2020



Note: This map is a temporal composite of the highest recorded groundwater levels at individual wells between 2000 and 2020 and thus is a theoretical highest case scenario for shallow groundwater conditions. Under real-world conditions, it is unlikely that all wells would simultaneously have the highest recorded water levels. This map tends to overestimate the presence of shallow and emergent groundwater.

The co-location of areas with groundwater elevations below sea level and tidally influenced creeks further indicate that seawater leakance beneath tidal streams is likely a dominant mechanism affecting seawater intrusion. Additionally, many salt ponds likely have shallow (0 to 3 feet below ground surface) or emergent groundwater due to their proximity to the Bay and land elevations at or below sea level (Figure ES-4). See Chapter 4 for details.

7. **Measured data confirm theoretical maps tend to overestimate shallow and emergent groundwater.**

Groundwater level data from the exceptionally wet winter of 2022 to 2023 was used to help validate the map of existing highest groundwater conditions (Figure ES-4). This map tends to overestimate locations of shallow and emergent groundwater, with observed depth to water generally being greater (deeper) than estimated on the interpolated, theoretical highest case map. Additionally, many of the wells used to create the map are likely screened in confined or semiconfined aquifer zones. Wells in these zones have limited direct contact and flow with Bay water, and thus have little response to tides, rainfall, or sea-level rise that could otherwise lead to rapidly rising groundwater levels or emergence at land surface in an unconfined aquifer. A pressure-driven water level rise in a monitoring well screened in a confined or semiconfined aquifer does not necessarily indicate that groundwater will also rise and emerge from these aquifers because the thick clay layers restrict the upward flow of groundwater. For these reasons, maps of existing highest groundwater conditions may also overestimate shallow and emergent groundwater in some areas. See Chapter 4 and Appendix C for details.

8. **Future sea-level rise may cause expansion of current emergent groundwater areas.**

Under future sea-level rise scenarios, groundwater rise and emergence could become more widespread and/or permanent in some areas. To illustrate potential groundwater rise and emergence response to climate change, this study presents maps using sea-level rise scenarios of 0.5, 1.0, 3.0, 5.0, and 6.5 feet, assuming a linear (1:1) response between sea-level and groundwater rise, consistent with previous Bay Area studies[7]. These sea-level rise scenarios correspond to the California Ocean Protection Council 2024 recommended Intermediate, Intermediate-High, and High scenarios in San Francisco Bay.

Under the 3.0 feet sea-level rise scenario, 23 square miles outside the salt pond area are estimated to have shallow groundwater (0 to 3 feet below ground surface) and 7 square miles to have emergent groundwater (Figure ES-5). This corresponds to 28% and 8.6%, respectively, of the saltwater intrusion outcome measure–lower threshold area[8]. Generally, the projected maps of future groundwater emergence indicate expansion of the estimated existing areas. However, these future projections likely overestimate shallow and emergent groundwater because they are based on existing highest conditions (Figure ES-4) that have been shown to overestimate actual conditions in recent, exceptionally wet years. Additionally, other factors that will affect future groundwater conditions, such as changes in rainfall patterns, are not considered in these maps. See Chapter 4 and Appendix D for details.

9. **Field observations confirm limited groundwater emergence and are important to characterize uncertainty and variability.**

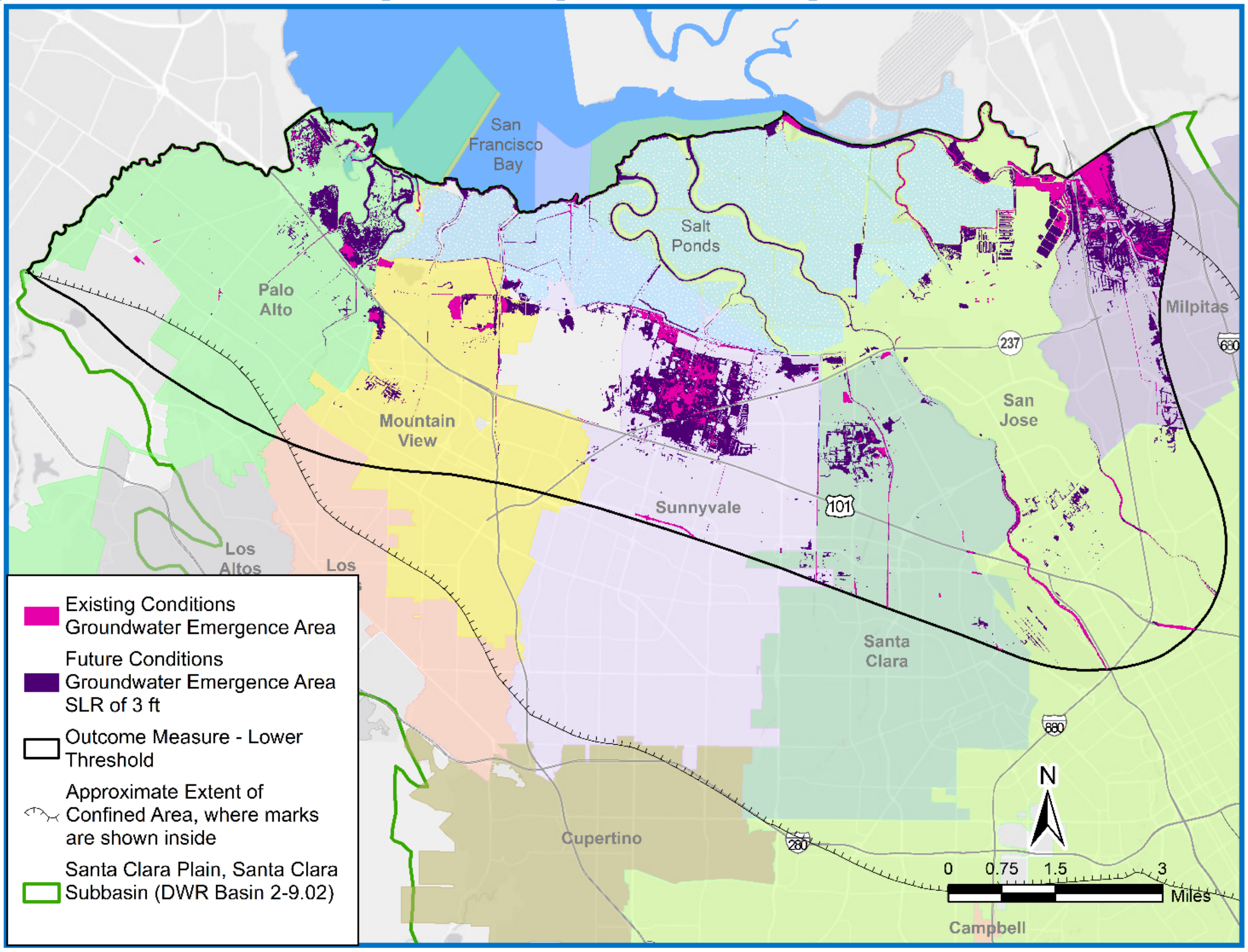
To characterize the uncertainty and likely overestimation of future groundwater conditions in response to sea-level rise, a field study was conducted during the January and February 2024 king tides to help validate the maps of future groundwater rise and emergence. King tides in the Bay are typically one to two feet higher than the average high tide and therefore approximate projected future sea-level rise of one to two feet. Additionally, these two king tides occurred during one of the wettest winters in recent record, when many groundwater elevations were at their highest in decades.

[7] The shallow aquifer of the Santa Clara Subbasin is not an unconfined aquifer that is in direct hydraulic connection with the Bay. Therefore, assuming a linear response between sea-level rise and groundwater rise is conservative and may overestimate groundwater rise response to sea-level rise.

[8] Comparison is made to the seawater intrusion outcome measure–lower threshold for context purposes only. The outcome measure and lower threshold are quantifiable goals under SGMA to track sustainable groundwater management performance related to seawater intrusion and were not established to track groundwater rise and emergence.

During these king tides, Valley Water staff observed groundwater emergence in some very localized areas. However, most areas mapped as having existing groundwater emergence (Figure ES-5) either had a direct connection to tidally influenced surface water or showed no evidence of groundwater emergence during the king tides. Of 42 specific areas mapped as having groundwater emergence, only 3 (7%) had confirmed groundwater emergence based on field observations, 11 (26%) had suspected groundwater emergence, 19 (45%) had a direct connection to surface water or the Bay but with unknown groundwater emergence, and 9 (22%) had no groundwater emergence. Valley Water staff observed suspected groundwater emergence in two areas that were not mapped as groundwater emergent.

Figure ES-5. Estimated existing and future groundwater emergence with 3.0 feet of sea-level rise



Note: This map conservatively assumes a linear (1:1) response between sea-level and groundwater level rise. Because the map of existing highest groundwater condition tends to overestimate shallow and emergent groundwater, this map may also overestimate future shallow and emergent groundwater. Existing conditions groundwater emergence area is from Figure ES-4.

In all cases of field-based confirmed or suspected groundwater emergence, the areas were in undeveloped locations near the Bay, such as open spaces, wildlife preserves, or parks and included long-term, natural features like ephemeral ponds, wetlands, and surface depressions. The confirmed and suspected groundwater emergence areas covered about 0.007 and 0.176 square miles, respectively, for a total of about 0.183 square miles[9]. Nearly all areas of confirmed groundwater emergence had land surface elevations below sea level, indicating that is an important predictor of groundwater emergence in the Santa Clara Subbasin.

[9] These three values are respectively equivalent to 4.48 acres, 113 acres, and 117 acres.

Because only 33% of observed areas mapped as having groundwater emergence had confirmed or suspected groundwater emergence during the early 2024 king tides, the field observations support the finding that existing highest groundwater condition maps overestimate actual conditions. Conversely, 67% of areas mapped as having groundwater emergence either had a direct connection to tidally influenced surface water or showed no observed groundwater emergence during the king tides. Since king tides approximate one to two feet of future sea-level rise and the field observations were during one of the wettest years on record, the general lack of observed groundwater emergence supports the conclusion that maps of existing and future groundwater rise and emergence may tend to overestimate conditions (Figure ES-5). The nearly complete lack of observed groundwater emergence in these areas (only 1 of 42) during the November 2024 king tide further supports this finding. See Chapter 4 and Appendix D for details.

Based on field observations during the king tides, groundwater quality results, and geologic evidence, the groundwater emergence phenomenon is not likely a new process caused solely by present-day tides or climate change induced sea-level rise. Instead, this phenomenon is likely a geologically persistent and endemic process of the south Bay shoreline and associated shallow groundwater system. Localized groundwater emergence has likely occurred throughout the geologic past and will likely continue in the future. See Chapter 4 and Appendix D for details.

The field observations during the January, February, and November 2024 king tides represent a snapshot in time and a baseline for existing conditions and confirm that land surface elevation is an important predictive factor of groundwater emergence. Repeated field observations at groundwater emergent areas, particularly in areas below sea level, will help track how conditions change with rising sea levels. Valley Water plans to regularly evaluate the tidally driven groundwater emergent areas to track if these conditions become more permanent or expand.

10. **It is important to identify uncertainties and appropriate uses of groundwater rise and emergence maps.**

Because communities are beginning to use groundwater rise and emergence maps for planning and policy decisions, it is important to identify and discuss the inherent uncertainties, limitations, and appropriate use of these maps (Figures ES-4 to ES-5) to help communities make best-informed decisions. Most recent studies about groundwater rise and emergence assume an unconfined aquifer in direct hydraulic connection with the ocean or Bay and a linear (1:1) response between sea-level rise and groundwater rise and emergence. However, this study shows that most of the shallow aquifer of the Santa Clara Subbasin is not in direct hydraulic connection with the Bay. Therefore, assuming a linear response between sea-level rise and groundwater rise may be misleading. To address this common assumption, this study improved the understanding of the physical hydrogeologic system and local-scale controls, thereby highlighting the uncertainties of modeling and mapping of sea-level rise-driven groundwater rise and emergence in the Santa Clara Subbasin shallow aquifer.

The existing highest groundwater conditions map (Figure ES-4) was created using the spline interpolation method, which produces representative groundwater elevation contour maps and groundwater surfaces. To illustrate the inherent uncertainty introduced by interpolation, this study compared spline to three other commonly used methods. Each interpolation method results in substantially different locations and areas of shallow and emergent groundwater. The spline method produced the smallest areas of shallow and emergent groundwater, while the other three methods resulted in 2.5 to 3 times greater areas, often incorrectly identifying large areas that do not have emergent groundwater based on historical or current observations. These findings support the best-use practice of using the spline interpolation method to create maps of existing highest groundwater conditions.

This report describes other uncertainties and limitations of the groundwater rise and emergence maps and offers some potential implications regarding appropriate uses and interpretations. Users of these maps may have different goals or needs and should carefully evaluate the appropriate uses and make their own interpretations.

Conclusions

Under current conditions, seawater intrusion and groundwater rise and emergence are not substantial or widespread concerns for much of Santa Clara County. Shallow groundwater is a naturally occurring feature of the Santa Clara Subbasin and presents challenges for the urban built environment. Shallow groundwater can seep into basements or intersect other below-grade infrastructure in some parts of Santa Clara County, particularly during wet winters, such as the historic winters of 2022-2023 and 2023-2024. Shallow groundwater seepage into basements typically decreases during the dry summer and fall months and does not usually occur during average rainfall and drought years. Under current conditions, groundwater rise in the shallow aquifer typically follows seasonal and annual patterns in rainfall and tides. Additionally, groundwater emergence is not a widespread concern, as it has been observed only in localized areas near the Bay, typically in undeveloped lands, open spaces, wildlife preserves, and parks, almost exclusively where the land surface elevation is below mean sea level.

Climate change and sea-level rise are expected to impact future groundwater conditions in some areas of the Santa Clara Subbasin near the Bay. Monitoring and understanding current groundwater responses to present-day variability in tides, including king tides, rainfall, and seawater intrusion can help inform how and where groundwater may respond to future sea-level rise. For example, some localized areas currently have groundwater emergence, which may continue and potentially expand as a response to future sea-level rise. However, not all areas of the northern Santa Clara Subbasin are likely to be impacted by future groundwater rise and emergence.

These areas of present-day and tidally driven groundwater emergence provide an important window into forecasting future groundwater conditions. As sea-level rise continues in the Bay, the areas of present-day tidally driven groundwater emergence are likely to have more persistent periods of emergence and expand over time. The increasing persistence and expansion of individual tidally driven groundwater emergent areas may occur before other areas with higher land surface elevations begin to experience noticeable groundwater rise and emergence. Therefore, present-day tidally driven groundwater emergent areas provide an opportunity for monitoring and forecasting how groundwater rise and emergence may expand or increase in other areas as sea-level rise continues in the 21st century.

Previous studies have warned that groundwater emergence due to sea-level rise may occur in some areas potentially years to decades before marine inundation and shoreline overtopping. Field observations and findings from this study support some aspects of that warning. While the Bay mud and clay layers generally provide protection from seawater intrusion in the shallow aquifer, some localized areas have tidally driven groundwater emergence with likely subsurface connections to the Bay. Dewatering of shallow groundwater in these areas as a potential approach to mitigate the risk of groundwater emergence could exacerbate seawater intrusion into the shallow aquifer. Careful site-specific investigations are needed before Santa Clara County communities use dewatering as a mitigation measure against sea-level driven groundwater rise and emergence because of the potential for other undesirable outcomes.

Valley Water will remain engaged with local communities and other agencies in Santa Clara County as they consider groundwater rise and emergence for land-use planning, policy, and regulatory decisions under future climate change and sea-level rise. Whether using groundwater rise and emergence maps, or other types of models, it is important to understand the inherent uncertainties, limitations, and appropriate use of such tools to support best-informed decisions about future sea-level rise. Valley Water will continue to provide local groundwater management expertise to support these important efforts.

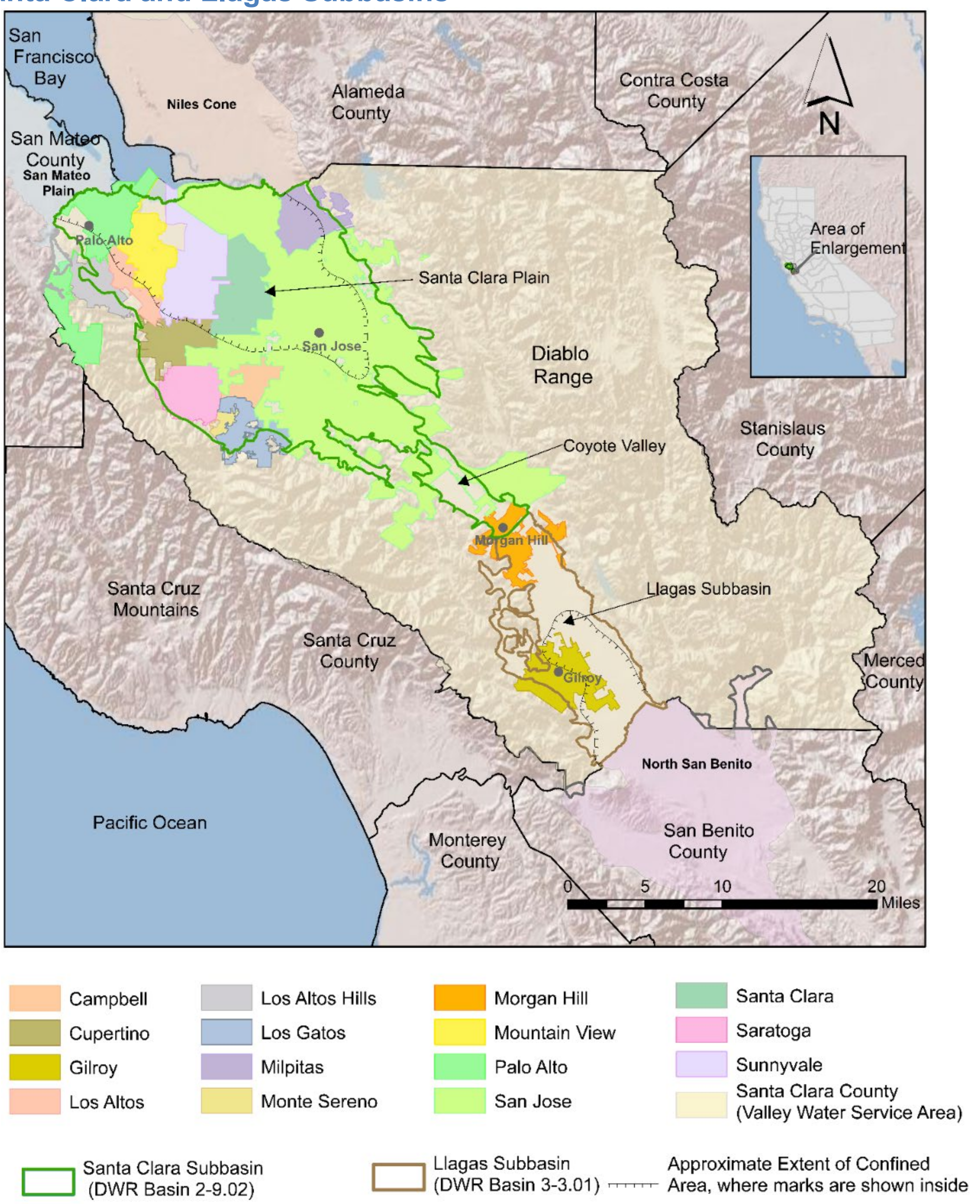
CHAPTER 1

Aerial view of the salt ponds, looking south across the Santa Clara Subbasin. Photo credit: Michael MacWilliams (Anchor QEA), taken April 9, 2017. Used with permission.

CHAPTER 1 – INTRODUCTION

The Santa Clara Valley Water District (Valley Water) has the responsibility and authority to manage the Santa Clara and Llagas groundwater subbasins (Figure 1-1) in Santa Clara County per the California legislature.[10] As part of compliance with California's Sustainable Groundwater Management Act (SMGA), Valley Water formally became the Groundwater Sustainability Agency (GSA) for these subbasins in 2016. Valley Water's comprehensive groundwater management activities and investments, described in the 2021 Groundwater Management Plan (GWMP)[11], have resulted in sustainable groundwater conditions for many decades.

Figure 1-1. Santa Clara and Llagas Subbasins



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[10] Santa Clara Valley Water District Act, Water Code Appendix, Chapter 60.

[11] Santa Clara Valley Water District, 2021 Groundwater Management Plan for the Santa Clara and Llagas Subbasins. In 2024, the California Department of Water Resources (DWR) approved this plan as the first required periodic evaluation of Valley Water's approved Alternative to a Groundwater Sustainability Plan.

Groundwater Response to Tides, Seawater Intrusion, and Sea-Level Rise

Valley Water's groundwater management objectives and authority under the Santa Clara Valley Water District Act (District Act) are to recharge groundwater basins, conserve, manage and store water for beneficial and useful purposes, increase water supply, protect surface water and groundwater from contamination, prevent waste or diminution of the water supply, and do any and every lawful act necessary to ensure sufficient water is available for present and future beneficial uses.

Valley Water Board of Directors (Board) Water Supply Objectives 2.2.1 and 2.2.2 reflect the mission to protect groundwater resources: *"Manage groundwater to ensure sustainable supplies and avoid land subsidence" and "Aggressively protect groundwater from the threat of contamination."* Pursuant to the District Act and Board policy, the 2021 GWMP identifies the following groundwater sustainability goals:

- Groundwater supplies are managed to optimize water supply reliability and minimize land subsidence.
- Groundwater is protected from contamination, including saltwater intrusion.

1.1 Purpose

The purpose of this study is to evaluate the aquifers and groundwater conditions in the Santa Clara Subbasin near the San Francisco Bay (Bay), with a particular focus on shallow groundwater response to current tides and seawater intrusion and future sea-level rise. This report also provides maps of projected groundwater rise (also called groundwater shoaling) and emergence at land surface from climate change induced sea-level rise. The overall report goal is to present both a non-technical description of the current understanding of these issues for the public and policymakers and to present relevant technical details for practitioners in groundwater science, engineering, and management.

1.2 Study Area

This study focuses on the Santa Clara Plain groundwater management area of the Santa Clara Subbasin, which is identified by the California Department of Water Resources (DWR) as Basin 2-9.02 (Figure 1-1). Valley Water divides the Santa Clara Subbasin into two groundwater management areas, the Santa Clara Plain and the Coyote Valley, due to different land use and management characteristics. Groundwater in the Santa Clara Subbasin generally flows toward Bay. The study area is the northern part of Santa Clara Plain, adjacent to the South Bay and generally within the confined area of the aquifer.

The Santa Clara Plain has two distinct hydrogeologic areas, the recharge (unconfined) and confined areas (Figure 1-1). Located adjacent to the Bay, the confined area has a laterally extensive aquitard (low permeability clay and silt) that separates the shallow and principal aquifers, with the latter generally defined as greater than 150 feet below ground surface. The confined area boundary is approximate and is a simplification of natural conditions, based on the extent of artesian wells. The recharge area is generally unconfined with no laterally extensive aquitards and occurs along the margins and southern portion of the Santa Clara Plain.

1.3 Outcome Measure for Seawater Intrusion

To help meet the previously described groundwater sustainability goals, Valley Water has developed and implemented quantifiable goals (outcome measures) to track the performance of sustainable management practices. Outcome measures are functionally equivalent to measurable objectives under SGMA. Outcome measure–lower thresholds are used to define undesirable results and are functionally equivalent to minimum thresholds under SGMA. The outcome measure–lower thresholds account for a reasonable margin of operational flexibility below the outcome measures that accommodates drought, climate change, conjunctive water management, and other groundwater management activities.

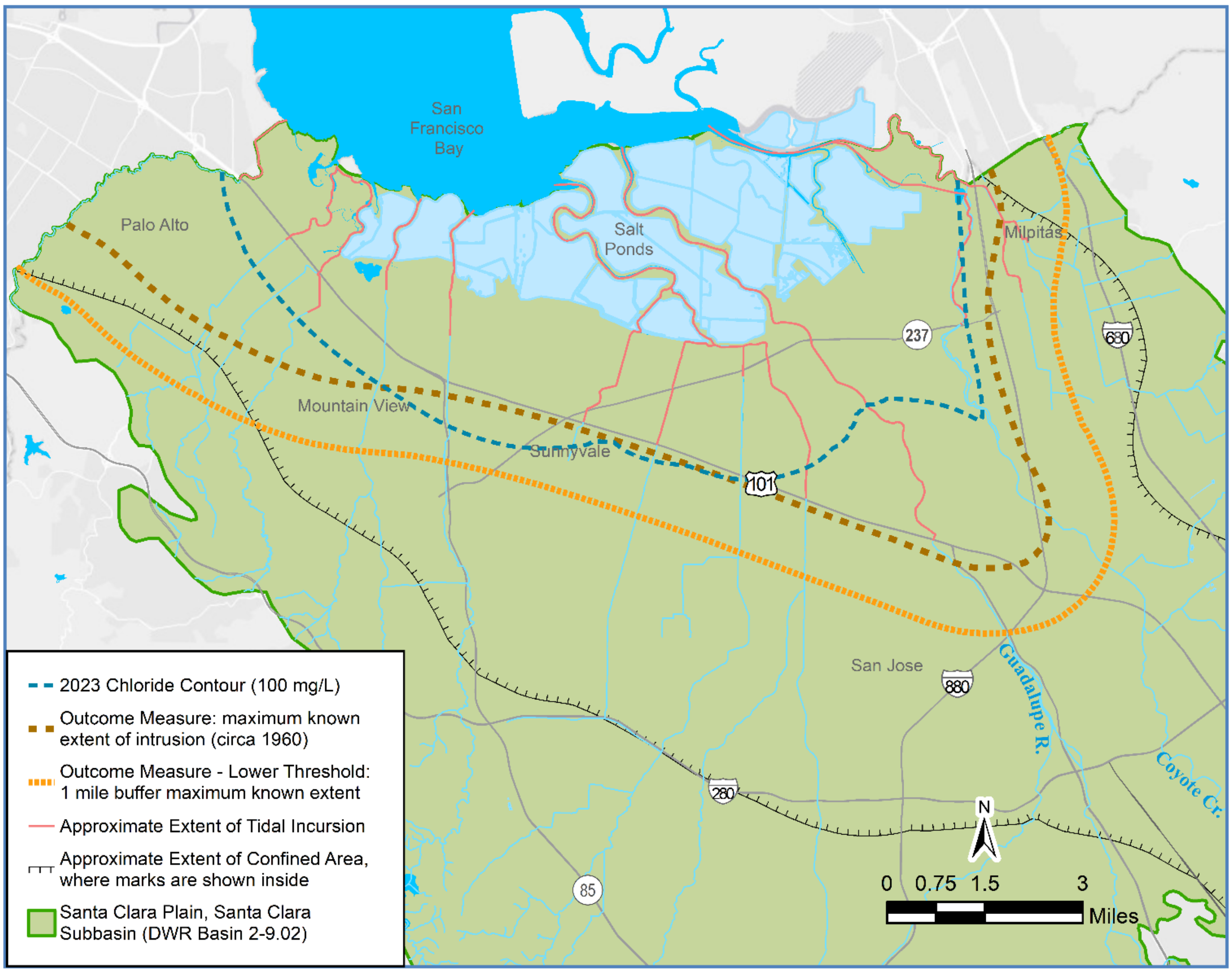
Groundwater Response to Tides, Seawater Intrusion, and Sea-Level Rise

Valley Water has a long history of sustainable groundwater management and will continue to proactively manage groundwater to minimize the risk of undesirable results. Outcome measures related to groundwater supply, land subsidence, and groundwater quality are detailed in Valley Water's 2021 Groundwater Management Plan.

Most relevant to this study are Valley Water's seawater intrusion outcome measure and outcome measure–lower threshold (Figure 1-2):

> **Outcome Measure:** In the Santa Clara Subbasin shallow aquifer, the 100 milligram per liter (mg/L) chloride isocontour area is less than the historical maximum extent area (57 square miles).
>
> **Outcome Measure–Lower Threshold:** In the Santa Clara Subbasin shallow aquifer, the 100 mg/L chloride isocontour area is less than 81 square miles, which represents a one-mile radial buffer of the historical maximum extent area.

Figure 1-2. Seawater Intrusion Outcome Measure and Outcome Measure–Lower Threshold



Valley Water has been monitoring and evaluating groundwater quality in the Santa Clara Subbasin for decades, with regular testing since the mid-1980s. Most supply wells are screened in the deeper, principal aquifer zone, where no widespread seawater intrusion has been observed. The 100 mg/L chloride isocontours are based on monitoring wells screened in the shallow aquifer zone and thus represent potential vulnerability of contamination of the deeper, principal aquifer, by way of improperly constructed or destroyed wells that may serve as vertical conduits for poorer quality water from the shallow zone.

The seawater intrusion outcome measure compares the area within the recent 100 mg/L chloride isocontour to historical maximum extent of seawater intrusion in the 1960s (Figure 1-2). This historical period coincided with chronic groundwater overdraft conditions and historic low groundwater levels in much of the Santa Clara Subbasin. Using the 100 mg/L chloride concentration provides early warning of potential seawater intrusion because the U.S. Environmental Protection Agency (EPA) Secondary Maximum Concentration Level for chloride in drinking water is 250 mg/L. Moreover, no widespread impacts to water supply wells in the principal aquifer were associated with the historical maximum extent of seawater intrusion. While many other studies similarly use 100 mg/L chloride to identify the seawater intrusion front, some have used concentrations from 200 to 500 mg/L (Jiao and Post, 2019).

To account for reasonable operational flexibility, the outcome measure–lower threshold is based on a one-mile radial buffer of the historical maximum extent of seawater intrusion (Figure 1-2). Within this expanded area, there are 49 active wells that pump about 1,600 acre-feet per year (AFY). This is equivalent to about 2% of the total groundwater pumping in the Santa Clara Plain (75,500 AFY from 2010 to 2019) (Valley Water, 2021). Using a one-mile radial buffer as a lower threshold to the outcome measure helps minimize the risk of seawater intrusion for supply wells because most of the pumping (98%) is outside the 81 square miles encompassed by the outcome measure–lower threshold (Figure 1-2).

Sustainable groundwater management helped reduce the extent of seawater intrusion from 57 square miles in the 1960s to 40 square miles by 2019 (Figure 1-2). Importantly, from a water supply perspective, there is little evidence of seawater intrusion in supply wells screened in the deeper, principal aquifer (Valley Water, 2021). The low permeability clay and silt that separate the shallow and principal aquifers help prevent seawater intrusion in the shallow aquifer from negatively impacting the supply wells in the deeper, principal aquifer. Additional details are presented in Chapter 2, including more recent estimates of seawater intrusion based on the chloride contour in the shallow aquifer.

1.4 Chapter and Appendix Overview

The following is an overview of Chapters 2 to 5 and Appendices A to D.

Chapter 2

Chapter 2 presents Valley Water's current understanding of seawater intrusion and the effects of sea-level rise on groundwater in the Santa Clara Subbasin within the framework of a hydrogeologic conceptual model. The conceptual model is based on Valley Water's decades of monitoring and data collection, computer modeling, and groundwater management activities. It also integrates relevant research and monitoring studies from other organizations. This conceptual model includes the hydrogeologic setting and shallow groundwater near the Bay, dominant mechanisms and processes that cause seawater intrusion in the Santa Clara Subbasin, and the potential impact of future sea-level rise on groundwater conditions. This hydrogeologic conceptual model is further refined based on findings presented in Chapter 3 about tidally influenced shallow groundwater and in Chapter 4 about groundwater rise and emergence in response to king tides. Finally, Chapter 2 provides a brief overview of several regional-scale projects that are likely to create substantial changes to the Bay shoreline, which may, in turn, have implications for sea-level rise, seawater intrusion, and groundwater rise and emergence in the Santa Clara Subbasin.

Chapter 3

Chapter 3 describes the tidal dynamics of the Bay and evaluates tidal influence on streams and shallow groundwater of the Santa Clara Subbasin. This analysis is based on Valley Water's groundwater monitoring network near the Bay that is designed to identify tidal influence on groundwater and provide an early warning of seawater intrusion and groundwater rise and emergence. Groundwater level response to other factors, such as rainfall and king tides is discussed. Finally, groundwater quality data from the seawater intrusion network are summarized here to support the tidal analysis and identify areas of seawater intrusion in the shallow aquifer.

Chapter 4

Chapter 4 evaluates groundwater rise and emergence above land surface, which is more likely in areas closer to the Bay and in low-lying elevations or surface depressions, particularly those with land surface elevations below sea level. This chapter provides an overview of recent studies and current understanding of groundwater rise and emergence in response to sea-level rise, with a focus on aquifers adjacent to the Bay. New maps are presented that estimate areas near the Bay in Santa Clara County that may experience groundwater rise and emergence under existing conditions and future climate change scenarios. This chapter also describes field observations made by Valley Water staff, which help validate the accuracy of the groundwater rise and emergence maps. Finally, the inherent uncertainties, limitations, and appropriate use of these maps are discussed. Users of these maps may have different goals or needs and should carefully evaluate the appropriate uses and make their own interpretations.

Chapter 5

Chapter 5 provides a comprehensive summary and conclusion of the major findings of this report, organized by current and future groundwater conditions. The chapter also offers recommendations and outlines next steps, with a specific focus on groundwater management activities and monitoring programs within Valley Water's scope and authority as a GSA under SGMA and the District Act to ensure a safe and reliable groundwater supply to Santa Clara County.

Appendix A

Appendix A details methods and results summarized in Chapter 3 that were used to evaluate tidally influenced stream stage and shallow groundwater levels and conductivity near the Bay. Additionally, groundwater quality data from the seawater intrusion monitoring network are compiled and analyzed here to support the tidal analysis and identify areas of seawater intrusion in the shallow aquifer.

Appendix B

Appendix B describes the methods used to evaluate and map estimated areas in the shallow aquifer system near the Bay in Santa Clara County that may experience groundwater rise and emergence under existing conditions. This appendix also summarizes the minimum depth to water measurements and control points used to create the existing highest groundwater conditions map.

Appendix C

Appendix C compares the existing highest groundwater condition map created using four different interpolation methods: spline, kriging, inverse distance weighting (IDW), and multi-quadratic radial basis (MQRB). Interpolation inherently introduces uncertainty into maps, such as those of existing highest groundwater conditions (Chapter 4) and future groundwater conditions assuming sea-level rise (Appendix D). Appendix C also presents a validation of the spline-based map of existing highest groundwater conditions using an independent data set of groundwater levels from the historically wet winter of 2022-2023.

Appendix D

Appendix D describes the methods used to evaluate and map estimated groundwater rise and emergence in response to future sea-level rise, based on OPC (2024) recommended sea-level rise projections in the Bay. The appendix also presents a validation of the future groundwater condition maps using an independent data set of field observations during the January 11 and February 9, 2024, king tides.

Field observations conducted at Baylands Park groundwater emergence area A (additional details in Appendix D). Photo credit: Jason Gurdak, Valley Water, taken on January 11, 2024 during the king tide.

CHAPTER 2

San Francisco Bay, Hooks Island, and a tide marker, near the Palo Alto Flood Basin Tide Gate Structure. Photo credit: Scott Elkins (Valley Water), taken October 12, 2023.

CHAPTER 2 – CURRENT UNDERSTANDING OF SEAWATER INTRUSION AND SEA-LEVEL RISE

This chapter describes the current understanding of seawater intrusion and sea-level rise in the Santa Clara Plain groundwater management area within the Santa Clara Subbasin. Seawater intrusion and sea-level rise are not relevant for the inland Coyote Valley groundwater management area of the Santa Clara Subbasin or the Llagas Subbasin in southern Santa Clara County.

Seawater intrusion has been observed in shallow aquifers of the Santa Clara Plain near the San Francisco Bay (Bay), primarily due to the leakance of saltwater and brackish water beneath tidal creeks, such as the Guadalupe River and Coyote Creek. This was exacerbated by historical subsidence that allowed tidal streamflow further inland, as discussed below. Classic seawater intrusion, where seawater and aquifer are in direct hydraulic connection, has had very limited impact on the Santa Clara Plain shallow aquifers because of the local geologic setting, including thick deposits of Bay mud (Figure 2-1) and other clay layers.

Figure 2-1. Bay mud exposed during low tide

Note: Bay mud during low tide at Sunnyvale East Channel, south of salt pond A4 (photo by Jason Gurdak, Valley Water, taken on January 12, 2024).

Bay mud deposits are soft, water-saturated estuarine clays and silts less than 10,000 years old underlying the southern part of the San Francisco Bay and the salt ponds and former marshlands bordering the Bay. These low-permeable sediments underlie the Bay and help separate Bay water from the underlying shallow aquifers. Bay mud has very low hydraulic conductivity[12], ranging from 1.7 x 10^{-4} feet/day to

[12] The ability of geologic media in aquifers to transmit groundwater. Groundwater flows easier in geologic media, such as gravel or sand, with relatively higher hydraulic conductivity. Conversely, geologic media with relatively low hydraulic conductivity, such as clay, restricts groundwater flow.

1.13×10^{-3} feet/day (U.S. Army Corps of Engineers, 1999; Burns and McDonnell Waste Consultants, 1996) and an average vertical hydraulic conductivity of 4.75×10^{-4} feet/day (Nguyen, 2007). The hydraulic conductivity of Bay mud is at least three to four orders of magnitude less than sand and gravel aquifer sediments near the Bay, as explained in Chapter 3. The Bay mud thickness in Santa Clara County is typically 0 to 20 feet but extends to greater depths in other areas around the Bay. Below the Bay mud, other marine and non-marine clay and silt layers are more compacted and have a higher density.

Climate change-driven sea-level rise will likely affect shallow aquifers of the Santa Clara Plain, which has implications for monitoring and managing groundwater and the seawater intrusion outcome measure (Chapter 1). Sea-level rise may increase seawater intrusion relatively short distances inland from the Bay. The Bay mud and other clay layers are likely to mitigate some effects of groundwater rise and emergence at land surface in some areas. Previously published studies that assume unconfined aquifer conditions and direct connectivity between the Bay and adjacent aquifers neglect the very low hydraulic conductivity of the Bay mud and clay layers. This likely overestimates the magnitude and extent of sea-level rise-driven groundwater emergence within the Santa Clara Plain, as further discussed in Chapter 4.

The subsequent sections of this chapter outline Valley Water's conceptual model of the aquifer systems near the Bay, including the hydrogeologic setting, dominant sea-water intrusion mechanisms that affect shallow groundwater, and potential impacts of sea-level rise on shallow groundwater in the Santa Clara Subbasin. Additional details are in Valley Water's 2021 Groundwater Management Plan[13].

2.1 Conceptual Model

A conceptual model reflects the current understanding and simplified view of a complex system, making complicated concepts easier to understand and communicate. Conceptual models are frequently used in science and engineering disciplines to help with analysis, visualization, communication, and decision-making. In hydrogeology[14], these models often describe complex systems, including groundwater flow systems and geochemical interactions. These simplified frameworks are important tools for improving understanding and supporting decision-making in groundwater resource management.

Seawater intrusion, sea-level rise, and associated groundwater rise and emergence at land surface are complex processes that can vary considerably over space and time, particularly in the complex hydrogeologic setting of the Santa Clara Plain shallow aquifers near the Bay. In this chapter, the conceptual model simplifies these complexities based on Valley Water's long-term monitoring and science-based groundwater management and integrates relevant research and monitoring studies from other organizations. The subsequent sections in Chapter 2 describe the various elements of this conceptual model, including the hydrogeologic setting and shallow groundwater near the Bay, the dominant mechanisms and processes that cause seawater intrusion, and how future sea-level rise may affect groundwater of the Santa Clara Subbasin. As needed, Valley Water refines the conceptual model over time with new data and findings, such as those presented in Chapters 3 and 4. In turn, Valley Water uses this refined conceptual model to adapt monitoring, modeling, and other groundwater management activities.

2.2 Hydrogeologic Setting

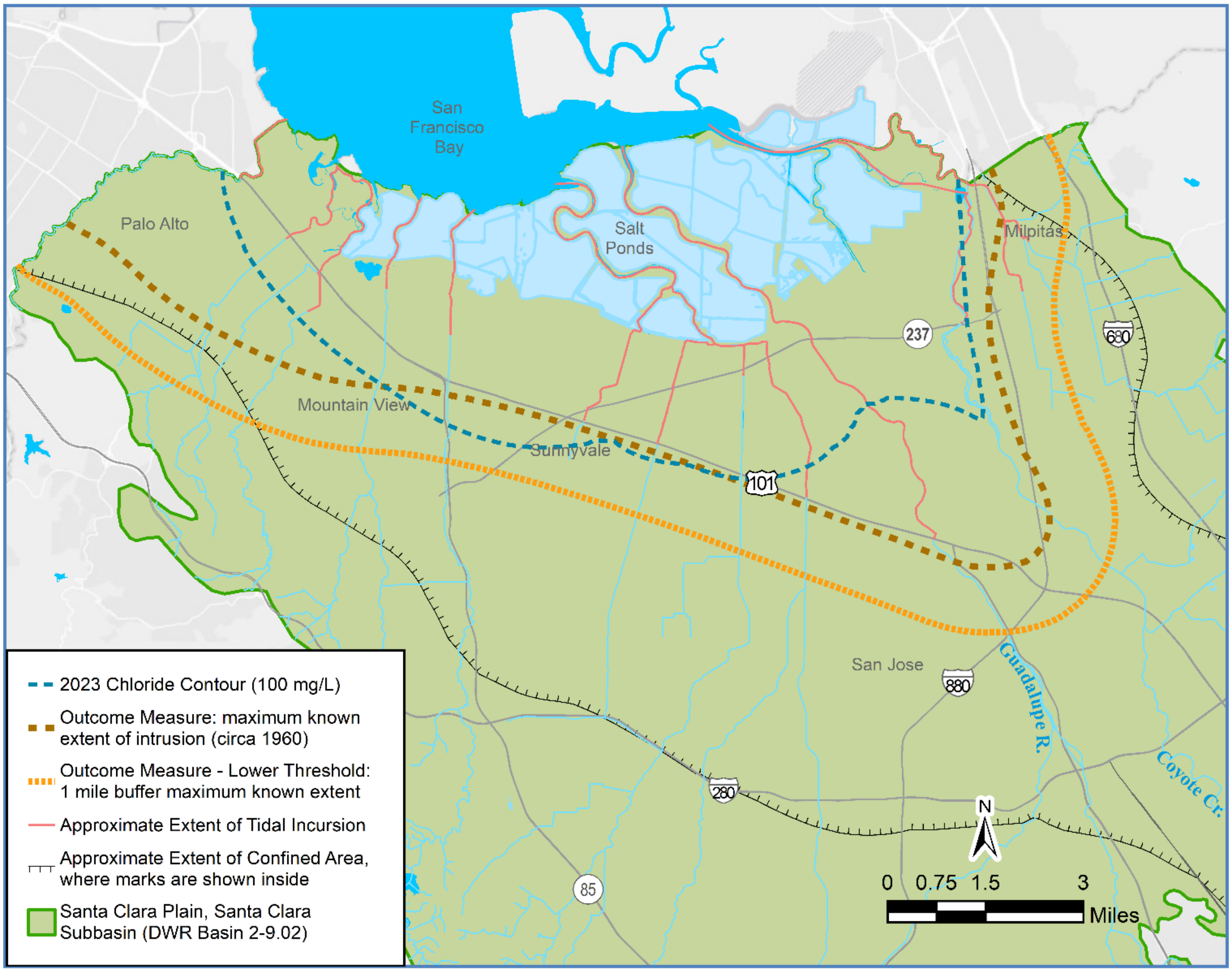
The hydrogeologic setting includes the broad alluvial plain surrounding the southern extent of the Bay shoreline, contained within Santa Clara County from Palo Alto in the west to Milpitas in the east, extending

[13] For additional details, see Appendix H: Seawater Intrusion Outcome Measure and Conceptual Model of Sea Level Rise Impacts on Groundwater for the 2021 Groundwater Management Plan, available here: https://s3.us-west-1.amazonaws.com/valleywater.org.us-west-1/s3fs-public/2021_GWMP.pdf

[14] Hydrogeology refers to a sub-discipline of geology that deals with the distribution and movement of groundwater in subsurface soil and rock, called aquifers.

south-southeast into Sunnyvale, Santa Clara, and San Jose (Figure 2-2). Salt evaporation ponds (Figure 2-2) are located adjacent to the Bay and are separated from the Bay and adjacent inland areas by systems of berms and levees. The planned restoration projects for these salt evaporation ponds are briefly described in subsequent sections of this chapter. The northernmost extent of the Santa Clara Plain, including the salt ponds, levees, and tidally influenced inland areas is called the Santa Clara County Baylands (Baylands), which is generally located within the outcome measure–lower threshold (Figure 2-2). Figure 2-2 shows the most recent (2023) chloride isocontour (100 mg/L) in comparison to the seawater intrusion outcome measure and outcome measure–lower threshold. The 2023 chloride isocontour covered an area of 44 square miles, less than the outcome measure (57 square miles).

Figure 2-2. Santa Clara Plain adjacent to San Francisco Bay



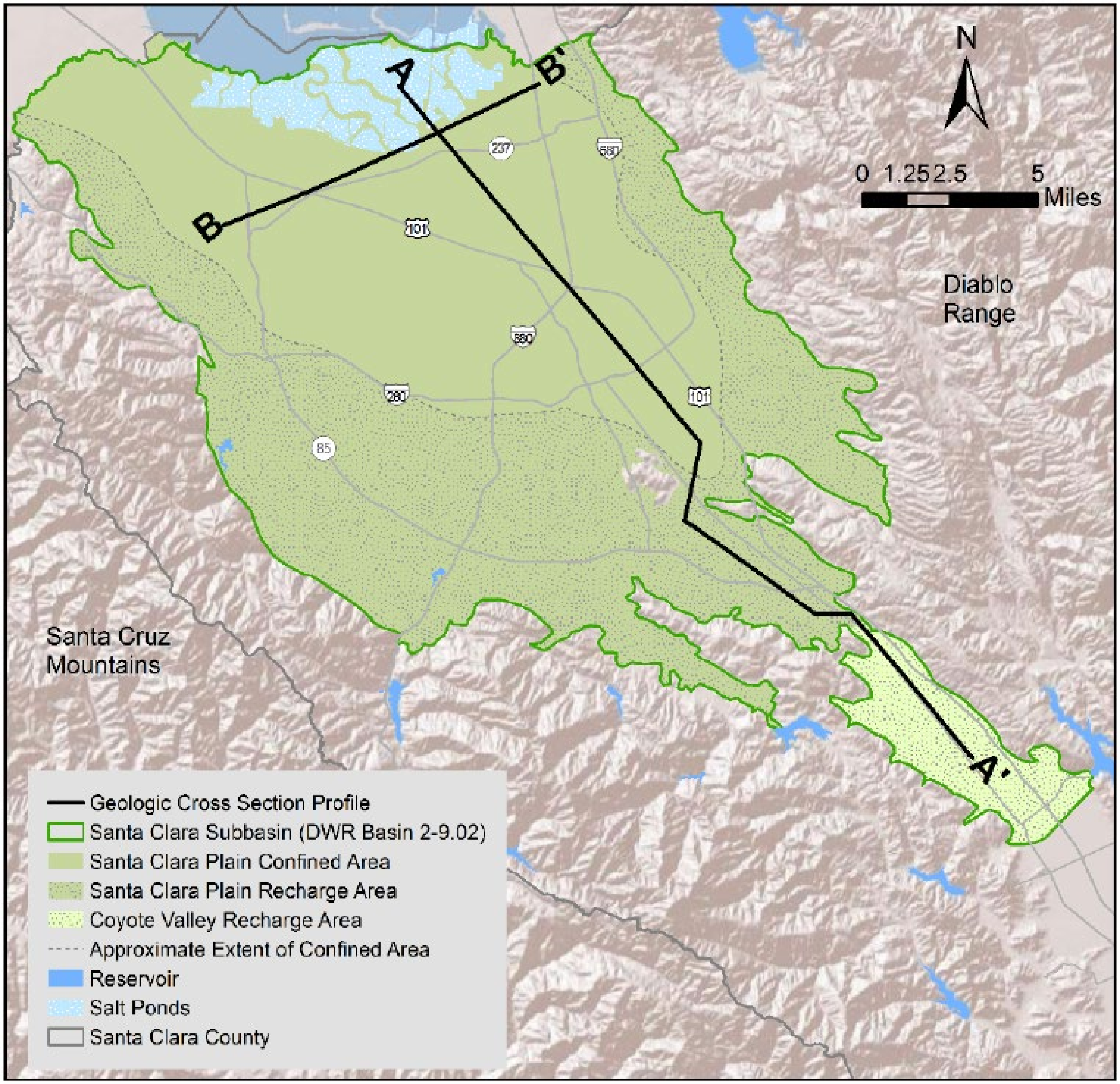
Several rivers and small streams flow through the Santa Clara Plain and Baylands and drain directly into the Bay (Figure 2-2). The most prominent of these are Coyote Creek and the Guadalupe River. The hydrogeologic setting consists of geologically young, unconsolidated material that forms the very low relief terrain of the Santa Clara Plain (Iwamura, 1980). Geologic units in the Baylands study area consist of Bay mud, alluvial fan, channel, flood basin, and levee deposits. The low-permeability Bay mud underlies the relatively shallow south Bay (average depth of 12 to 15 feet) and parts of the Baylands, and represents the upper-most aquitard, that along with other, deeper clay layers help to isolate Bay water from the underlying aquifers (Iwamura, 1980).

The stream-deposited alluvial sediments tend to be coarser and more permeable along the elevated edges of the Santa Clara Plain (near the foothills), while finer and less permeable alluvial deposits tend to be found in the basin interior along the valley floor (Iwamura, 1980). The coarser materials (sand and gravel) make up the aquifers and the finer-grained, nearly impermeable materials (silt and clay) make up the aquitards. Figure 2-3 shows sand, gravel, and clay collected during recent (2023) installation of a monitoring well near the Bay. The basin interior tends to have greater stratification (layering) of aquifer and aquitards, while the upper elevated edges of the basin have less stratification of aquitard materials (Figures 2-4 to 2-6). These upper elevated edges of the basin are recharge areas where groundwater occurs in one unconfined aquifer (Iwamura, 1980). Valley Water's managed recharge program in the Santa Clara Plain overlies the unconfined (or recharge) area.

Figure 2-3. Photos of sand, sand and gravel, and clay from the shallow aquifer zone

Note: Sediments from the shallow aquifer zone collected during drilling of a new monitoring well in Milpitas near the San Francisco Bay (photos by Scott Elkins, Valley Water, taken on April 17, 2024). The sand and gravel are wet from groundwater flow and storage while the clay is largely impermeable and restricts groundwater flow and storage.

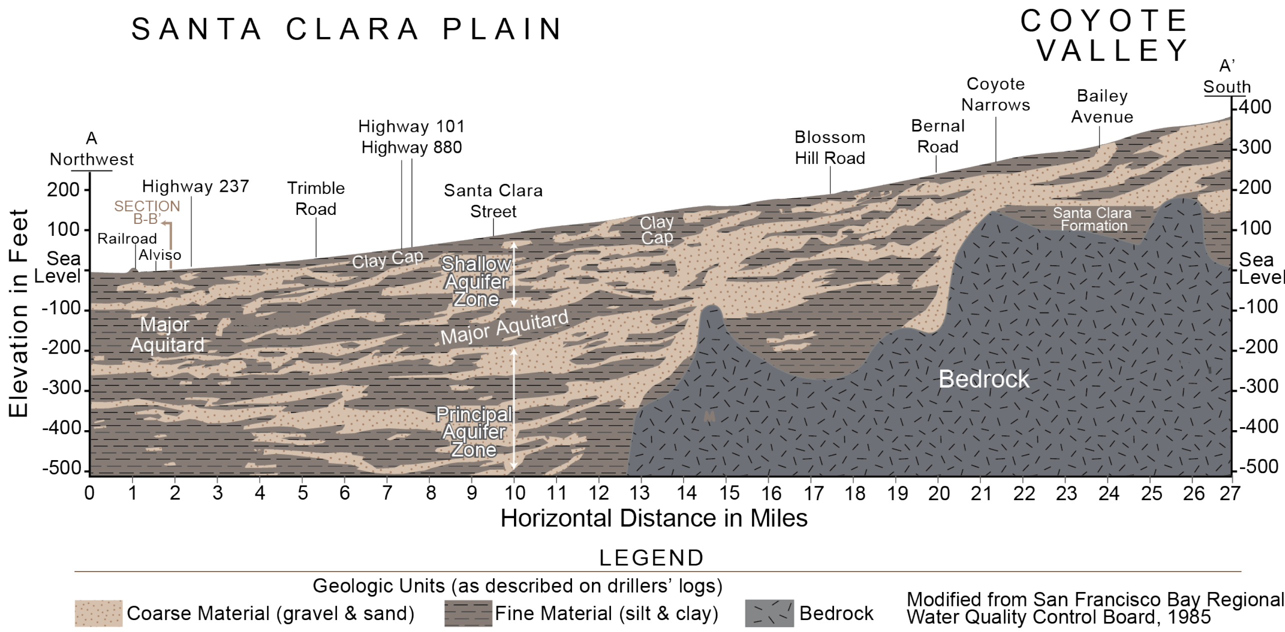
Figure 2-4. Santa Clara Subbasin recharge and confined areas, including the cross-sections A – A' and B – B'



Note: Figure taken from the 2021 Groundwater Management Plan.

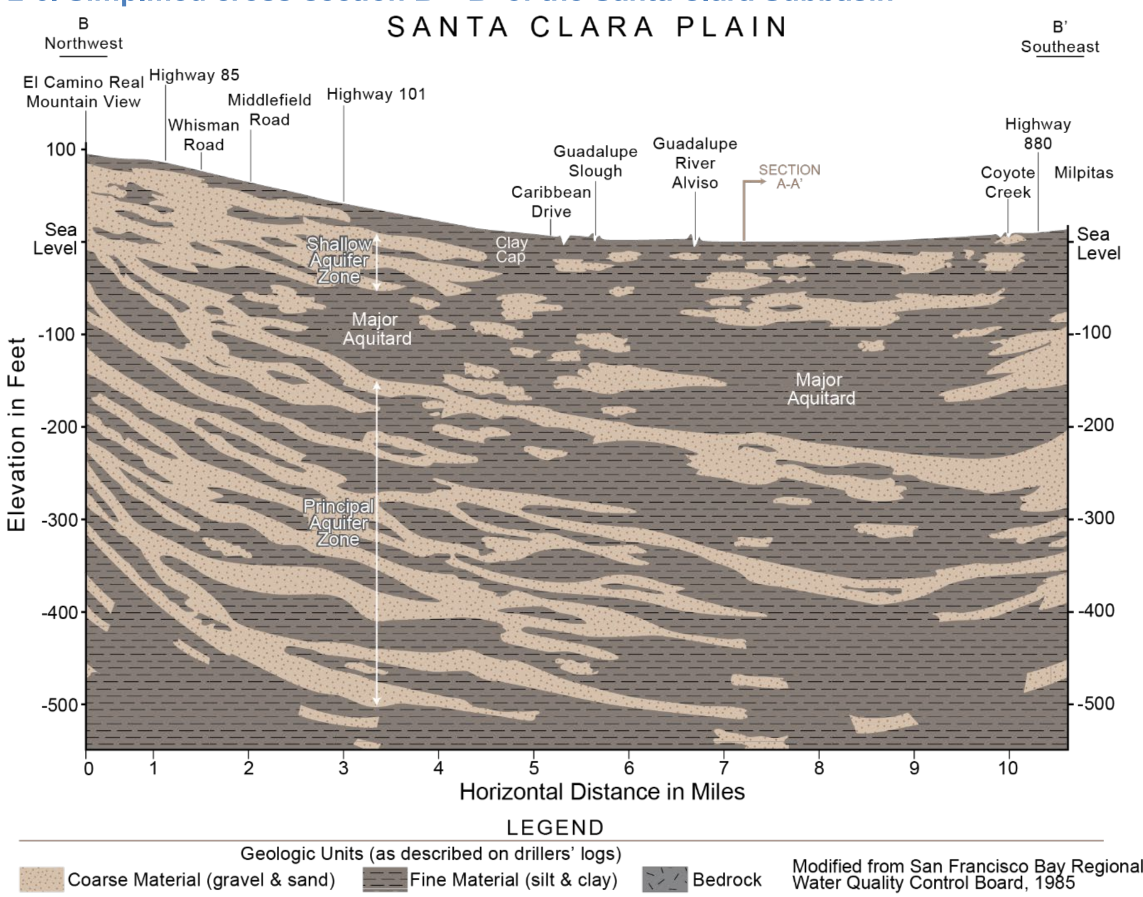
Toward the center of the basin and in the Baylands, stratification of aquifer and aquitard material increases, and the alluvial sediment is separated into an upper, shallow aquifer zone and a deeper, principal aquifer zone by a regionally extensive aquitard (Figures 2-5 and 2-6). The aquitard is thicker in the basin interior near the Baylands and pinches out (non-existent) in the elevated recharge area (Figures 2-5 and 2-6). The regional aquitard occurs at depths of about 100 to 150 feet below ground surface (bgs) in the Baylands (Figures 2-5 and 2-6) (Iwamura, 1980). The strong artesian conditions of wells screened in the principal aquifer indicate both a strong upward groundwater flow gradient from the principal aquifer toward land surface. Artesian conditions also indicate a highly impervious regional aquitard that restricts inter-aquifer flow, including both upward flow from the principal aquifer to the shallow aquifer zone and downward flow from the shallow aquifer to principal aquifer zone (Valley Water, 2021).

Figure 2-5. Simplified cross-section A – A' of the Santa Clara Subbasin



Note: Figure modified from the 2021 Groundwater Management Plan.

Figure 2-6. Simplified cross-section B – B' of the Santa Clara Subbasin



Note: Figure modified from the 2021 Groundwater Management Plan.

Due to the increased stratification of finer deposits near the Bay and basin center, these areas have numerous aquifers in the shallow aquifer zone, including beneath Guadalupe River and Coyote Creek. Conversely, there is less stratification and relatively fewer aquifers in the shallow aquifer zone farther from the basin center (Iwamura, 1980). The Baylands has groundwater in this shallow stratified aquifer zone, which is about 100 feet in thickness and is underlain by the regional aquitard and principal aquifer zone (Iwamura, 1980) (Figures 2-5 and 2-6). Drilling logs of the shallow system near the Bay indicate numerous and somewhat thin, laterally discontinuous layered aquifer units consisting of sand and gravel deposits separated by layers of silt and clay at most sites. These aquifer units were likely deposited by stream channels, which explains their lateral limited extent.

In the Baylands, the uppermost layer of the shallow aquifer zone is almost exclusively composed of Bay mud. Within this uppermost layer, Iwamura (1980) describes a semiperched, unconfined water table that is perched on clay layers or lenses within the predominantly clay (Bay mud) section but with no unsaturated zone beneath the perched groundwater and the main groundwater below it. Iwamura (1980) notes that the semiperched groundwater is in somewhat random locations but found across a large area of the Baylands and often within 10 to 20 feet bgs. Recharge to the semiperched groundwater is likely from surface sources that include rainfall, streamflow (both from the watershed and tides), and periodic flooding of streams (Iwamura, 1980). Recharge to the semiperched groundwater may also occur from upward flow through leaky confining (aquitard) units in the shallow aquifer zone (Iwamura, 1980). The semiperched groundwater has relatively small seasonal fluctuations in water levels because this zone is not pumped for water supply. However, temporary and permanent dewatering activities throughout the Santa Clara Plain likely pump groundwater from the semiperched groundwater and deeper parts of the shallow aquifer zone. Prior to groundwater pumping and other development in the Baylands, semiperched groundwater naturally discharged and flowed back to the Bay. Today, the berm and levee systems along the bayfront restrict natural discharge and surface drainage from the Baylands to the Bay. Consequently, drainage ditches have been constructed in the Baylands to help drain the semiperched groundwater and surface water toward the Bay.

Deeper in the shallow aquifer zone, the aquifer units often behave like confined aquifers because they are overlain by Bay mud and other clay layers (Figures 2-5 and 2-6). Iwamura (1980) described this shallow aquifer zone as ranging from perfectly confined to leaky (semi-) confined. This greater degree of confinement in the deeper parts of the shallow aquifer zone is caused by the increasing thickness of impermeable clay aquitards and Bay mud (Iwamura, 1980). The lateral continuity of individual aquifer layers in the shallow aquifer zone and the degree of interconnection between those sand and gravel aquifer layers are largely unknown because of a lack of spatially continuous driller's geologic logs (Iwamura, 1980). However, based on the relatively thin aquifers in the multi-layered shallow aquifer zone and the vertical and lateral predominance of clay and silt layers, the lateral continuity is likely substantially less than the shallow aquifers located farther from the Bay. Due to these complexities, many different groundwater levels have been recorded in wells screened in the shallow aquifer, indicating relative differences in aquifer confinement and restrictions in the hydraulic continuity between sand and gravel layers (Iwamura, 1980). As presented in Chapter 3, the hydrogeologic data from Valley Water's seawater intrusion monitoring well network confirm the complex aspects of the shallow, multi-layered aquifer zone conceptual model.

In general, the shallow aquifer zone is currently not used as a public water supply. Located below the regional aquitard is the principal aquifer that is used for public, industrial, and other water supply. The confined aquifers in the principal aquifer zone (deeper than 150 feet bgs) receive recharge from natural sources like rainfall and other water sources, as well as from Valley Water's managed recharge. These sources of recharge to the principal aquifer zone occur along the edge of the Santa Clara Plain in the recharge area of the unconfined aquifer. Currently, the shallow aquifer zone overlying the regional aquitard has limited groundwater pumping and thus relatively small seasonal fluctuations in water levels, and vertical recharge is attenuated by fine-grained deposits. However, the principal aquifer zone has substantial groundwater pumping that contributes to relatively larger seasonal fluctuations in water levels in some areas. Additionally, groundwater levels fluctuate in the shallow and principal aquifer zone due to barometric pressure variations, which is a function of the relative degree of aquifer confinement. In addition to barometric pressure, Chapter 3 discusses other types of pressure changes that influence groundwater levels in wells screened in the shallow aquifer zone.

This hydrogeologic framework of the shallow and principal aquifer zones reflects the complex geologic and hydrogeologic conditions of the Baylands. Due to the disconnected nature of the aquifer layers, each individual aquifer can have different groundwater levels (Iwamura, 1980). This variation is primarily due to the restricted hydraulic connectivity between the aquifers, caused by the Bay mud, interbedded aquitards, and regional aquitard. This conceptual model is supported by data presented in Chapter 3.

The groundwater conditions north of the Baylands and beneath the southern portion of the Bay are not well understood because of the complexity of the hydrogeologic setting and lack of geologic logs. Previous studies have identified a shallow aquifer zone, called the Newark aquifer, at depths from 60 to 140 feet below the Bay and a deeper aquifer, called the Centerville aquifer or 180-foot aquifer, at depths from 180 to 200 feet below the Bay. The shallower Newark aquifer has elevated chloride concentrations from seawater intrusion, while wells drilled in the Centerville aquifer have tapped freshwater (Iwamura, 1980). The Centerville aquifer is located beneath the Newark aquifer, is as extensive as the Newark aquifer, and is separated from it by a significant aquitard zone (Iwamura, 1980). The degree of hydraulic connection between the shallow and principal aquifer zones of the Baylands and the aquifers beneath the Bay and the Niles Cone area (Newark and Centerville aquifers) is not well understood. It is suspected that these aquifer systems are not directly connected (Iwamura, 1980) given the thick and relatively impermeable deposits of Bay mud that likely limit direct hydraulic connection. The lack of hydraulic connection between the two aquifer systems beneath the Bay and the Baylands shallow and principal aquifer zones is relevant for Valley Water’s conceptual model of seawater intrusion and sea-level rise, as described below.

2.3 Shallow Groundwater

The hydrogeologic setting of the northern Santa Clara Subbasin, including the abundance of clay and silt has resulted in many areas of naturally occurring shallow groundwater[15]. Figure 2-7 is a generalized depth to first groundwater map based primarily on shallow groundwater data from various sources, including contaminant release sites. The data was compiled from the State Water Resources Control Board GeoTracker database[16] and Valley Water’s monitoring programs. This interpolated map reflects the shallowest groundwater encountered at a given location between 1978 and 2019, rather than a specific and consistent point in time.

Areas of the northern Santa Clara Subbasin with the greatest abundance of clay and silt and shallow groundwater are primarily adjacent to the Bay and in the central part of the Santa Clara Plain (Figure 2-7), including areas within the cities of Palo Alto, Mountain View, Sunnyvale, Santa Clara, San Jose, and Milpitas. Naturally occurring shallow groundwater levels tend to be relatively lower during drought years, such as the 2012 to 2016 and 2020 to 2022 droughts, and relatively higher following wet winters, such as the record-setting winter of 2022/2023 and subsequent 2023/2024 winter that had many atmospheric rivers and well-above-average rainfall in Santa Clara County. In addition to annual and multi-year patterns, shallow groundwater follows general seasonal patterns, with seasonal lows during the fall

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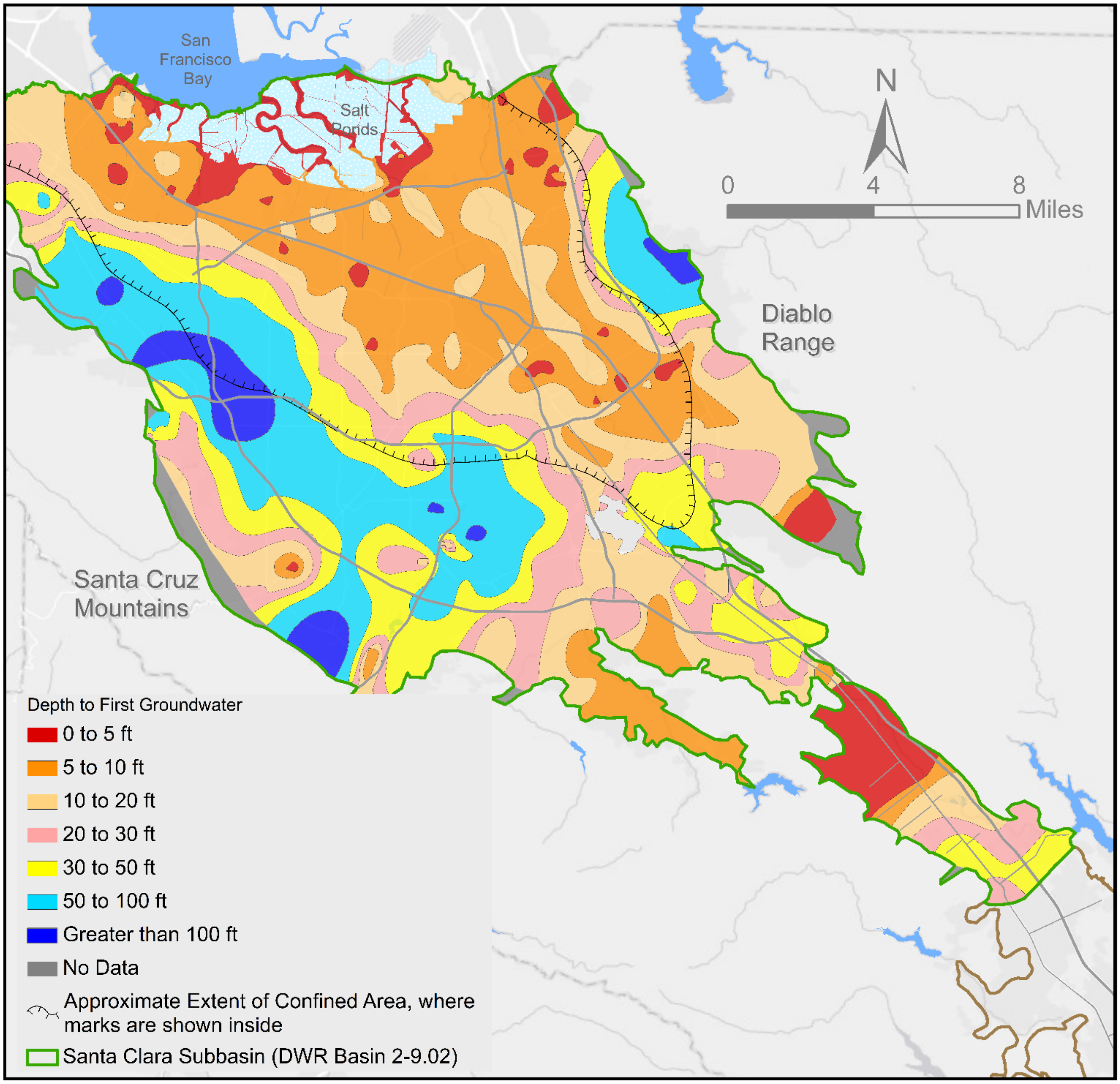
[15] The shallow groundwater system is separated from the underlying principal aquifer by a regionally extensive aquitard. Valley Water’s managed recharge operations targets the principal aquifer of the Santa Clara Plain, which supports nearly all groundwater pumping for water supply.
[16] GeoTracker is a data management system for groundwater sites with impacted groundwater quality, including site requiring cleanup, and is available here: https://geotracker.waterboards.ca.gov/

months (September and October) and seasonal highs during the spring months (April and May).

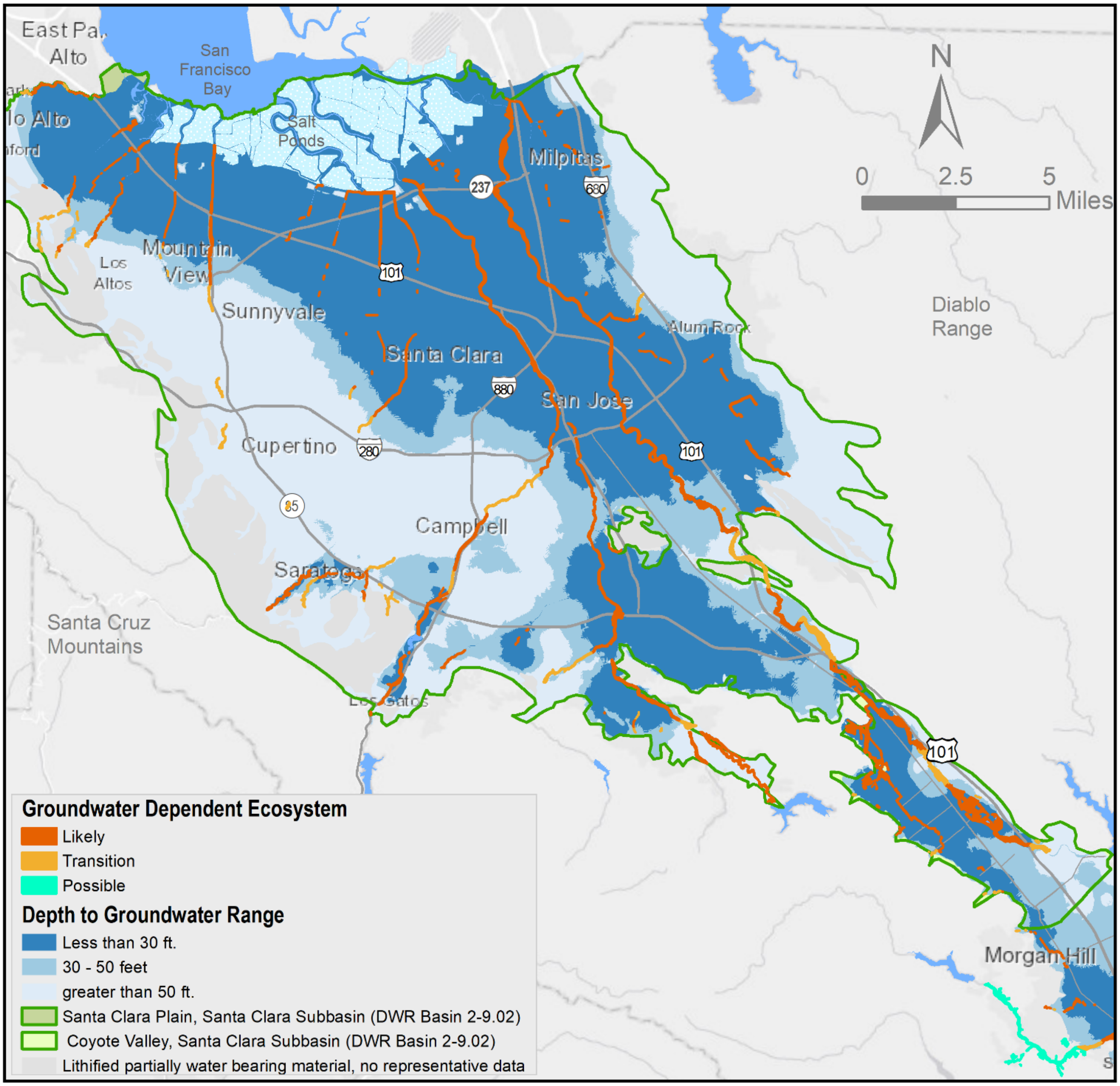
Figure 2-7. Depth to first groundwater in the Santa Clara Subbasin



Note: Figure taken from the 2021 Groundwater Management Plan.

Shallow groundwater in the Santa Clara Subbasin benefits ecosystems. Groundwater dependent ecosystems (GDEs) are present in various locations within the Santa Clara Subbasin (Figure 2-8) and are supported by shallow groundwater. Under SGMA, GDEs are “ecological communities of species that depend on groundwater emerging from aquifers or on groundwater occurring near the ground surface” (23 CCR § 351(m)). GDEs in Santa Clara County can include wetlands, rivers, streams, and estuaries, seeps and springs, and terrestrial vegetation. In the Baylands, the GDEs in streams (Figure 2-8) likely indicate gaining stream reaches where the shallow groundwater flow gradient is toward the stream. GDEs also include deep-rooted plants or plant communities that obtain water from the water table (called phreatophytes). A detailed technical study on the current understanding, approach, and methods used to identify and map GDEs is included in Appendix G of the 2021 Groundwater Management Plan.

Figure 2-8. Groundwater dependent ecosystems in the Santa Clara Subbasin



Note: Figure taken from the 2021 Groundwater Management Plan.

The naturally occurring shallow groundwater in the Santa Clara Subbasin also presents challenges for the urban and built environment. One of the most recognizable challenges relates to subsurface infrastructure, such as basements or underground parking structures for residential houses or commercial buildings. Construction companies often employ temporary dewatering of shallow groundwater during sub-grade construction in these areas. This temporary dewatering typically lasts for several months to a year or more, depending on various factors, including the time required to construct the structure (which is a function of the structure's depth and size) and the depth of the shallow groundwater. These sub-grade structures are often designed with waterproofing materials that eliminate the need for long-term dewatering after the construction has ended.

Permanent dewatering of shallow groundwater is often necessary for other facilities and transportation infrastructure, such as roads and airports. For example, the California Department of Transportation employs permanent dewatering of shallow groundwater at some highways and intersections in the Santa Clara Subbasin, particularly those constructed below grade in areas of shallow groundwater. Similarly, dewatering of shallow groundwater occurs at San Jose Mineta International Airport.

As discussed further in Chapter 4, the naturally occurring shallow groundwater in the Santa Clara Subbasin also has implications for sea-level rise driven groundwater rise and emergence. The following sections describe the current conceptual model of sea-water intrusion into the Santa Clara Subbasin.

2.4 Sea-Water Intrusion Mechanisms

Seawater intrusion (also called saltwater intrusion) is the temporary or permanent flux of saltwater or brackish water into coastal freshwater aquifers, which can be a groundwater management concern because it can degrade groundwater quality. If severe enough, seawater intrusion may result undesirable conditions that include limiting groundwater as a water supply for municipal and industrial uses, agriculture, and domestic uses, or negatively impacting groundwater dependent ecosystems (GDEs) and infrastructure. Reclaiming freshwater aquifers after seawater intrusion is very costly and time consuming, if not practically infeasible in many cases. Therefore, sustainable groundwater management actions and policy choices that prevent or mitigate seawater intrusion are preferred to costly seawater-intrusion remediation.

Seawater intrusion can occur to varying degrees in either unconfined or confined aquifers and can result from anthropogenic (human) or natural processes. A common human cause of seawater intrusion is groundwater overdraft and lowering of groundwater levels in coastal aquifers (Figure 2-9). This “classic” case of seawater intrusion can occur when the groundwater pumping lowers the water table, creating a hydraulic gradient and density driven flow of seawater inland (often called the saltwater wedge) that displaces fresh groundwater (Figure 2-9). Additionally, climate change from human activities is likely to result in sea-level rise driven seawater intrusion into coastal aquifers.

Another potential human cause of seawater intrusion is the disturbance or bypassing of natural geologic barriers that formerly prevented the migration of seawater. This could result from removing or boring through low-permeability geologic materials during construction activities of buildings or bridges, or from improperly constructed or destroyed wells acting as vertical conduits.

Climate change not associated with human activities also caused seawater intrusion in the geologic past. However, this type of natural seawater intrusion is not currently relevant for sustainable groundwater management of coastal aquifers.

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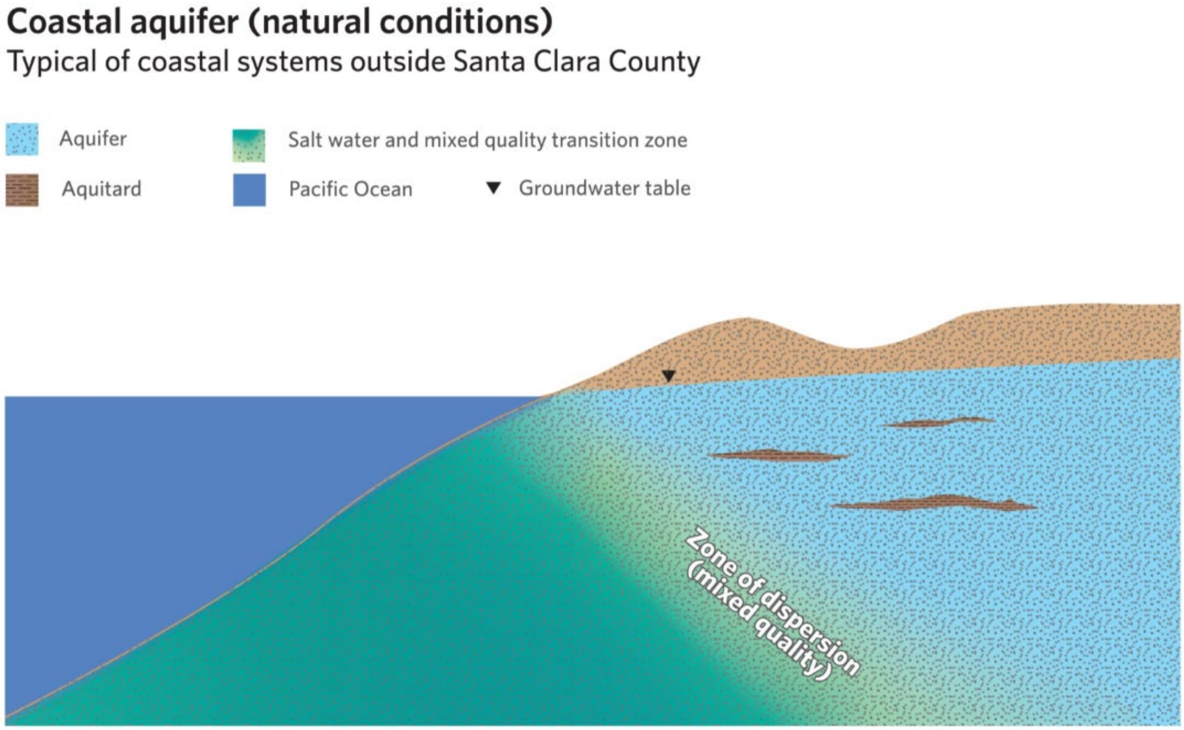
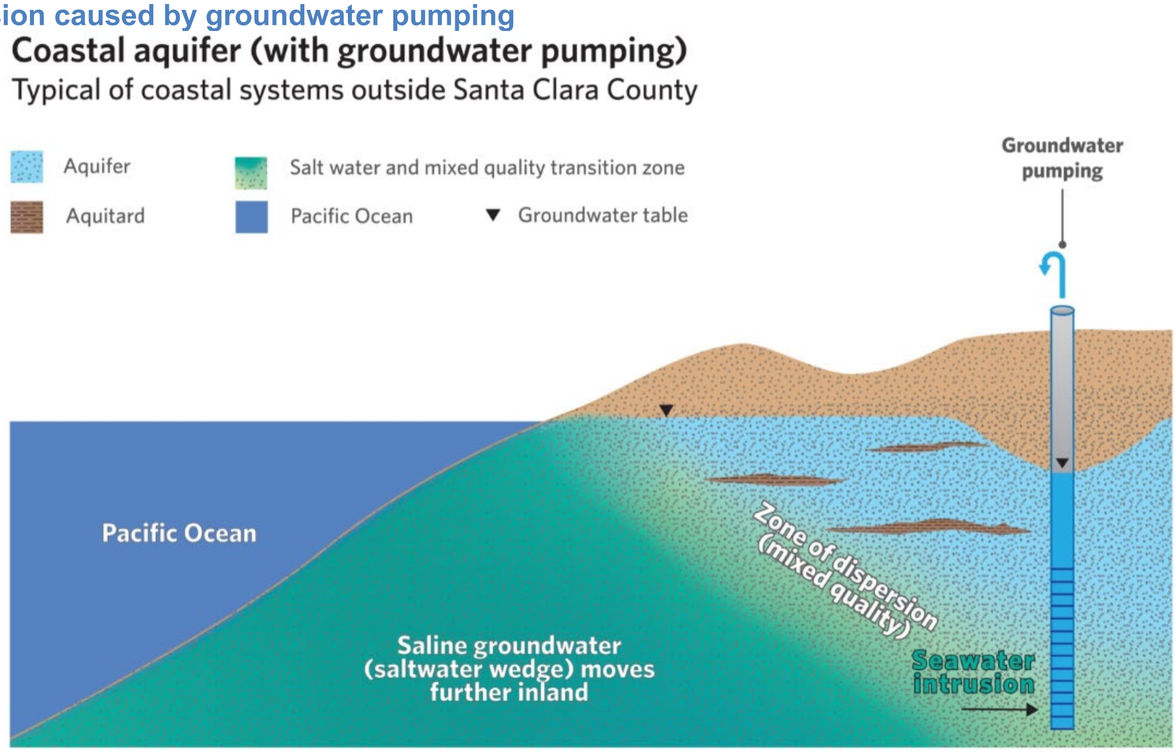
Figure 2-9A. Typical unconfined coastal aquifer outside Santa Clara County under natural conditions



Note: Figure taken from the 2021 Groundwater Management Plan.

Figure 2-9B. Typical unconfined coastal aquifer outside Santa Clara County with seawater intrusion caused by groundwater pumping



Note: Figure taken from the 2021 Groundwater Management Plan.

Groundwater Response to Tides, Seawater Intrusion, and Sea-Level Rise

The historical cause of seawater intrusion in the shallow aquifer of the Santa Clara Subbasin was high groundwater pumping and resulting land subsidence, particularly in the years following World War II (Valley Water, 2021). However, the problem of seawater intrusion from groundwater pumping dates to at least the 1920s where wells in Palo Alto near the Bay had elevated chloride indicative of seawater intrusion (Tolman and Poland, 1940). Additionally, seawater intrusion in the shallow aquifer is attributed to the tidal incursion of Bay water within the tidal reaches of creeks and rivers, which subsequently transported to shallow groundwater through lateral and vertical percolation, improperly abandoned wells, cathodic protection wells, and other vertical conduits (Valley Water, 2021). This mechanism was exacerbated by land subsidence, which caused tidal incursion to extend farther inland due to permanent changes in the land surface along stream channels. Historically, seawater intrusion affected only a small portion of the principal aquifer zone, and chloride concentrations have remained relatively low. Although inter-aquifer transfer from the shallow to principal aquifer zones through improperly sealed or destroyed wells is a potential mechanism for seawater intrusion in the principal aquifer (Valley Water, 2021), it has never been observed or quantified.

Under present conditions in the Baylands and Santa Clara Plain shallow aquifer zone, at least four mechanisms contribute in varying degrees to seawater intrusion and affect the overall extent of the 100 mg/L chloride isocontour. These mechanisms include “classic” seawater intrusion, leakance of saltwater beneath tidal stream flow, bypass flow from the shallow to principal aquifer zone, and entrapped connate water (Valley Water, 2021). These mechanisms, along with the groundwater system(s) most at risk, are summarized below:

> **“Classic” seawater intrusion**: This mechanism likely has a relatively minor role in the overall spatial extent of the 100 mg/L chloride isocontour across the Santa Clara Subbasin. This mechanism is largely limited and constrained by the hydrogeologic setting, which includes thick deposits of Bay mud and other clay layers that have very low hydraulic conductivity and create confined, semiconfined, perched, and semiperched groundwater conditions. The upper shallow aquifer zone is the part of the system with the greatest relative risk from this seawater intrusion mechanism.
>
> **Leakance of saltwater beneath tidal stream flow**: This mechanism likely has a relatively major role in the overall spatial extent and inland migration of the 100 mg/L chloride isocontour across the Santa Clara Subbasin. The leakance of saltwater and brackish water is relatively localized to areas near tidal rivers and creeks but can potentially migrate laterally in the shallow aquifer system. The shallow aquifer zone, especially inland near the Guadalupe River and Coyote Creek, is the part of the system that is most at risk from this seawater intrusion mechanism.
>
> **By-pass flow down improperly constructed or destroyed wells**: This mechanism likely has a relatively minor and localized role in the overall spatial extent of the 100 mg/L chloride isocontour across the Santa Clara Subbasin. However, if this mechanism occurs, it presents the greatest risk to groundwater quality in the principal aquifer zone because seawater or other contaminants in groundwater of the shallow aquifer zone could flow downward to the principal aquifer.
>
> **Entrapped connate water**: This mechanism likely has a relatively minor role in the overall spatial extent of the 100 mg/L chloride isocontour across the Santa Clara Subbasin. This mechanism has a localized influence on groundwater quality in the shallow and principal aquifer zones near the bayfront in Palo Alto (Iwamura, 1980).

The following sections describe these four mechanisms in more detail and their relative contribution to the spatial extent of seawater intrusion in the shallow aquifer zone.

"Classic" Seawater Intrusion

The Baylands hydrogeologic setting (Figures 2-5 and 2-6) does not readily support the "classic" case of seawater intrusion. The thin, sinuous, and laterally discontinuous aquifer layers in the Baylands are both blanketed by Bay mud and interbedded by relatively impermeable clay aquitards. These aquifers behave much differently to groundwater pumping and tidal hydrodynamics than unconfined coastal aquifers with laterally extensive aquifer sediments in direct hydraulic connection to the ocean, as illustrated in Figure 2-9. The conceptual model that the predominant seawater intrusion process of the Baylands is likely not the "classic" case of seawater intrusion is supported by the following discussion of groundwater quality in the Baylands.

The classic case of seawater intrusion has likely occurred only a short distance inland from the bayfront, estuaries, or salt evaporation ponds (Iwamura, 1980). This area is characterized by the displacement of freshwater in some aquifer layers by saltwater or brackish water from the Bay. Classic seawater intrusion is often induced by groundwater pumping and characterized by a relatively narrow and distinct transition or front between the saline groundwater (often called a saltwater wedge) and fresh groundwater, with the aquifers outcropping offshore in most cases (Figure 2-9). The transition from saline to fresh groundwater is called the "zone of dispersion" (Figure 2-9) and is influenced by tidally driven hydrodynamic dispersion. The most inland extent of the zone of dispersion was defined by Iwamura (1980) as the 100 mg/L chloride isocontour. Classic seawater intrusion is characterized by saline groundwater (the saltwater wedge) flowing inland and displacing fresh groundwater (Figure 2-8). The saltwater wedge shape is a function of the less dense freshwater that floats on the denser saltwater.

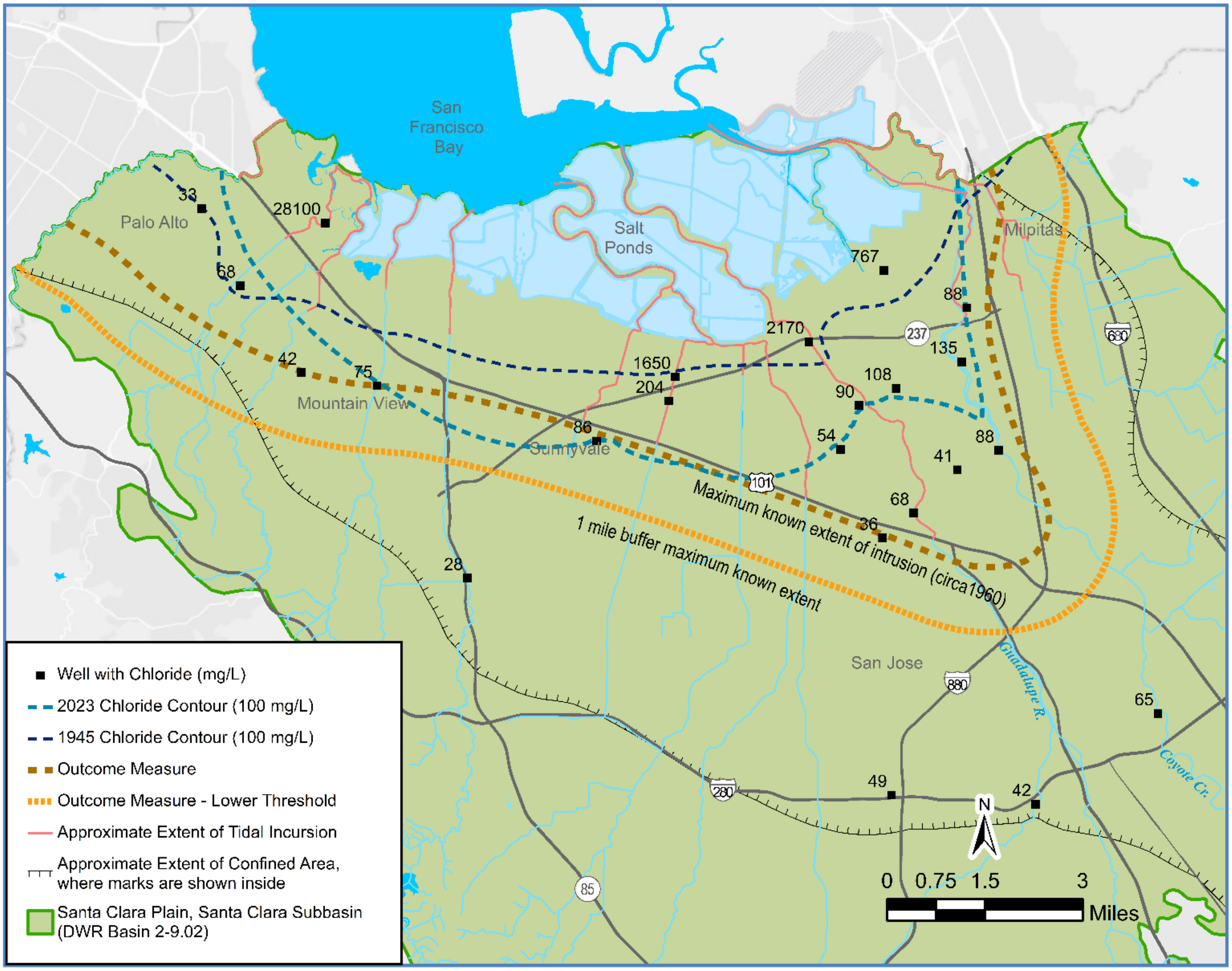
Prior to human development in the Santa Clara Subbasin, the natural hydraulic gradient in the aquifer caused groundwater to flow naturally toward the Bay. However, the historic (pre-1970s) groundwater overdraft reversed that hydraulic gradient such that it was landward, causing some classic seawater intrusion in the shallow aquifer zone. The natural (pre-development) hydraulic gradient toward the Bay was restored by the early 1970s due to Valley Water investments and efforts that halted chronic overdraft and permanent subsidence. Today, Valley Water's groundwater management activities continue to maintain the natural hydraulic gradient toward the Bay, minimizing classic seawater intrusion.

Valley Water's groundwater quality monitoring data used to create the recent 100 mg/L chloride isocontours (Figure 2-10) indicates that the spatial extent of the classic seawater intrusion front is likely limited to some aquifer layers beneath the Bay, and, to a lesser extent, the salt evaporation ponds (Figure 2-11). These locations can be inferred from the chloride concentrations from monitoring wells, as shown in Figure 2-10. There are four monitoring wells with chloride concentrations above 500 mg/L. One of those wells had a 28,100 mg/L chloride concentration (Figure 2-10) and is likely influenced by entrapped connate water, as described in subsequent sections. The other three monitoring wells have chloride concentrations that range from 767 to 2,170 mg/L and are located inland a relatively short distance (about one mile) from the salt evaporation ponds. Seawater typically has chloride concentrations of about 19,000 mg/L, Bay water has 10,000 to 17,000 mg/L chloride concentrations (Iwamura, 1980), and brackish water in tidal estuaries can have chloride concentrations on the order of 500 to 5,000 mg/L (Drever, 1982; Hem, 1989; Barlow, 2003).

The seawater intrusion front (zone of dispersion) is likely to have higher chloride concentrations than the three monitoring wells with chloride ranging from 767 to 2,170 mg/L, thus indicating that the seawater intrusion front is likely farther to the north and beneath the Bay and/or salt evaporation ponds (Figure 2-11). Figure 2-11 also illustrates that the shallowest aquifer layers beneath the Bay, such as the Newark Aquifer, likely have seawater intrusion and elevated chloride concentrations (ACWD, 2021). However, deeper aquifers, such as the Centerville Aquifer (sometimes called the "180-foot aquifer") and Deep Aquifer, may have freshwater and/or lower chloride concentrations than the Bay (ACWD, 2021; Iwamura, 1980). One of Valley Water's former monitoring well sites located on the northeast corner of salt pond A-

7, Don Edwards San Francisco Bay National Wildlife Refuge had deeper wells (06S01W05L002 and 06S01W05L003) likely screened in the Centerville-Fremont Aquifer with generally freshwater and low chloride, typically less than 10 mg/L. However, the shallow well at the site (06S01W05L001, screened around 80 feet bgs and likely in the Newark Aquifer) appeared to have trapped connate water or water affected by resolubilized evaporite deposits because the chloride concentrations were higher than Bay water, ranging from about 18,000 to 21,000 mg/L.

Figure 2-10. Extent of seawater intrusion during select years in the Santa Clara Plain shallow aquifer zone



Note: The historical maximum extent of the 100 mg/L chloride isocontour occurred around 1960. The wells with chloride shown on the map (black squares) are chloride concentrations measured in 2023 and do not reflect concentrations from 1945. Figure taken from the Annual Groundwater Report for Calendar Year 2023.

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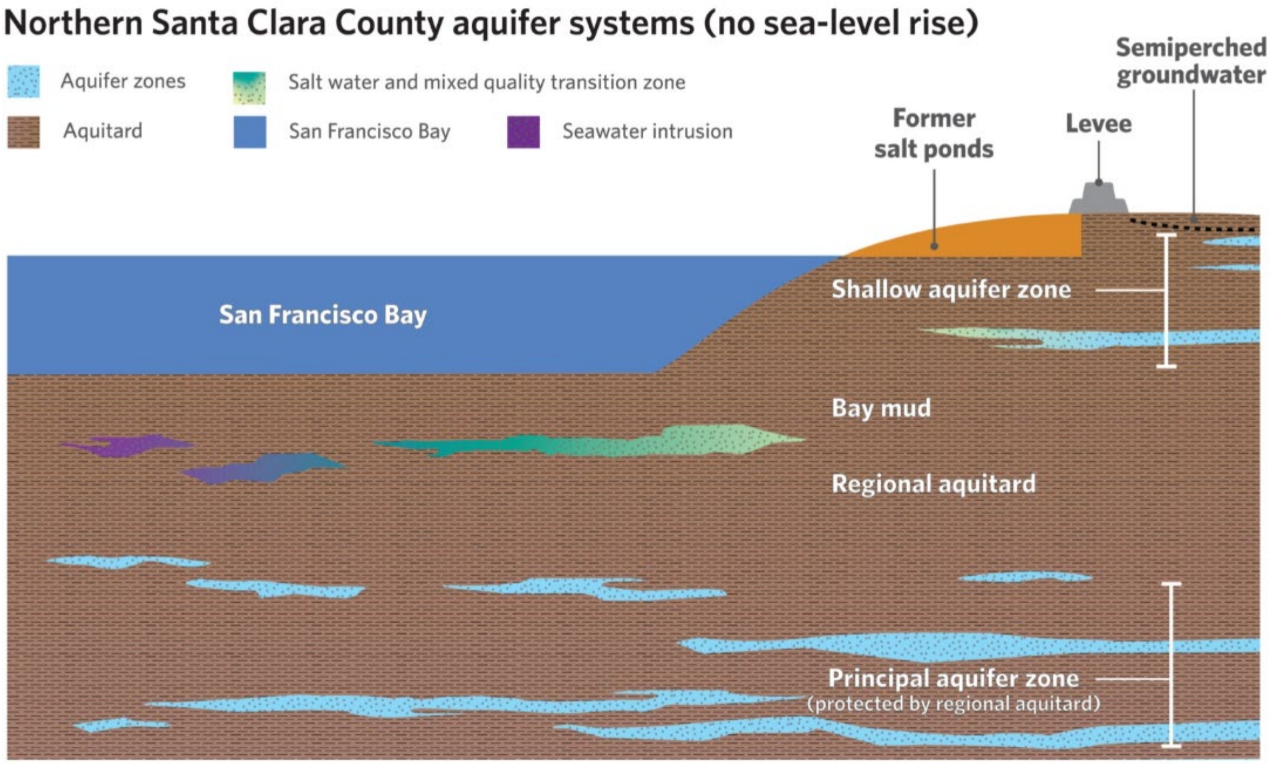
Figure 2-11. Conceptual diagram illustrating classic seawater intrusion limited to beneath the south San Francisco Bay and former salt evaporation ponds



Note: Figure taken from the 2021 Groundwater Management Plan.

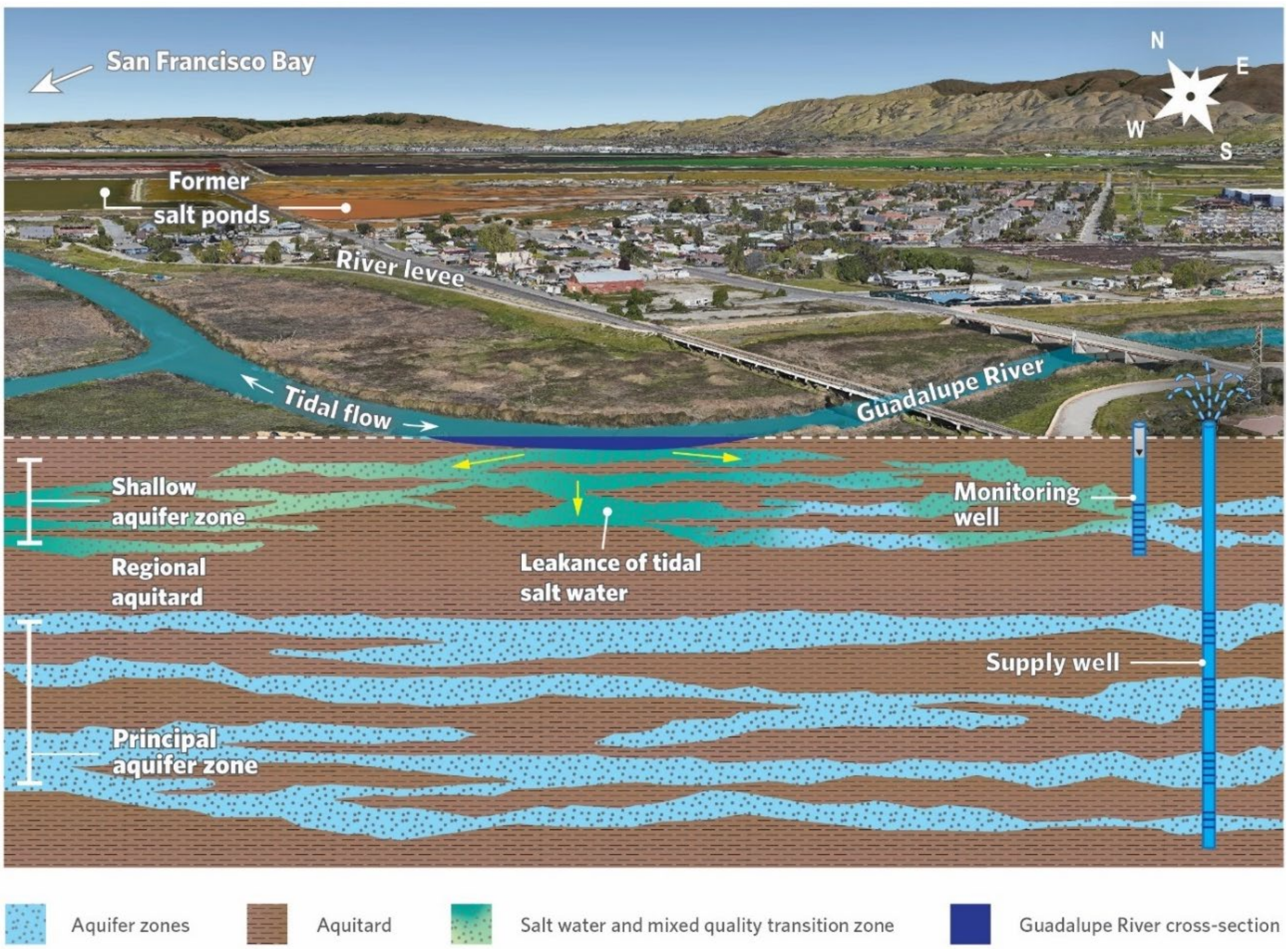
Valley Water does not currently monitor groundwater quality within the semiperched zone (Figure 2-11), nor has it been monitored historically except in a few locations near the edges of the saltwater marshlands, according to Iwamura (1980). However, some shallow monitoring wells installed for leaking underground storage tank or other GeoTracker sites are screened within the semiperched zone. Iwamura (1980) observed a difference in water chemistry in the semiperched groundwater as compared to the shallow groundwater zones. The limited groundwater quality samples in the semiperched zone had a higher salt content, including chloride concentrations as high as 5,000 mg/L, which were hypothesized by Iwamura (1980) to originate from degradation of historical agricultural wastewater or evapoconcentration processes that are not necessarily attributed to seawater intrusion. The high clay content and poor drainage conditions of the semiperched sediments could have contributed to the accumulation of agricultural wastewater and increased salt concentrations in the soil and semiperched groundwater. However, it is possible that seawater intrusion in the semiperched groundwater could be occurring only in areas that are either in contact with saltwater bodies at the bayfront, the salt evaporation ponds, or at locations along stream channels where tidal incursion of saltwater occurs (Iwamura, 1980), as described below. Elevated boron concentrations have been observed in some localized areas of the semiperched groundwater (Iwamura, 1980), which could indicate the presence of seawater intrusion because of the elevated concentration of boron in seawater (on the order of 4 to 5 mg/L in seawater and 3.8 mg/L in Bay water (Iwamura, 1980)).

Based on current and historical groundwater monitoring data, the classic seawater intrusion mechanism has a relatively minor influence on the spatial extent of seawater intrusion and the 100 mg/L chloride isocontour in the shallow aquifer zone of the Baylands (Figure 2-10). The following sections describe other mechanisms that may influence seawater in the shallow aquifers of the Baylands.

Leakance of Saltwater Beneath Tidal Stream Flow

Building off findings from Iwamura (1980), the concept that saltwater and brackish water leakance beneath tidal streams (Figure 2-12) is likely a major influence on the extent and inland migration of the 100 mg/L chloride isocontour in the Santa Clara Subbasin was described in Valley Water's 2016 Groundwater Management Plan then elaborated in the 2021 Groundwater Management Plan. Similarly, the Hingst et al. (2024) study in coastal Delaware supports tidal streams as an important mechanism of seawater intrusion, concluding that tidal streams can be possible sources of salinization in coastal aquifers but have not been widely considered in the scientific literature. Therefore, the conceptual model and study results presented here advance both understanding for the Santa Clara Subbasin as well as other coastal aquifers globally.

Figure 2-12. Conceptual diagram of seawater intrusion in the Santa Clara Subbasin by the mechanism of leakance of saltwater beneath tidal streamflow.



Note: Figure taken from the 2021 Groundwater Management Plan and modified from Iwamura (1980)

The historic groundwater overdraft prior to the 1970s caused land subsidence in the Santa Clara Plain, which created a land surface depression and enabled ocean tides to extend farther upstream in rivers than would have occurred without subsidence (Iwamura, 1980). This land subsidence, in combination with vast estuarine mudflats preventing Bay water from directly entering the principal aquifer system, has resulted in the shallow groundwater having a wide, mixed quality transition zone (Figure 2-12). This zone has moderate seawater intrusion of shallow aquifers (as defined by the 100 mg/L chloride isocontour) extending farther inland than the typical classic seawater intrusion front. The term "mixed quality transition zone" was first used by Iwamura (1980) and refers to the inland areas and much of salt ponds within the 100 mg/L chloride isocontour that have mixing of fresh groundwater and salty or brackish water from the Bay or tidal streams.

The greatest inland intrusion of the mixed quality transition zone occurs along the Guadalupe River and Coyote Creek (Iwamura, 1980). Areas near the stream channels tend to have a relatively thin clay (Bay mud) cap and greater density of shallow aquifers. The spatial extent of the mixed quality transition zone is largely caused by the tidal saltwater flows within the streams that leak through the streambed and clay cap into the shallow aquifer zone, particularly when the shallow aquifer zone is pumped. Higher historical shallow aquifer zone pumping may have contributed to the lateral spreading of the seawater intrusion that leaks beneath the tidally influenced streambeds. For example, Iwamura (1980) observed seasonal patterns in chloride concentrations during the 1960s and 1970s in two wells screened in the shallow aquifer zone near the Guadalupe River area south of Alviso. These wells had the highest seasonal chloride concentrations during the fall, near the end of the groundwater pumping season, and the lowest seasonal chloride concentrations during the spring and wetter part of the year, prior to the groundwater pumping season. Groundwater pumping likely induced lateral seawater intrusion from the tidal saltwater flow up the nearby Guadalupe River that had infiltrated downward through the streambed (Iwamura, 1980).

Based on current and historical groundwater monitoring data, leakance of saltwater from tidal stream flow has a relatively major influence on the spatial extent of seawater intrusion and the 100 mg/L chloride isocontour in the shallow aquifer zone of the Baylands. Additional details are presented in Chapter 3, which describes ocean tides and Valley Water's current groundwater monitoring.

By-Pass Down Improperly Constructed or Destroyed Wells

The Santa Clara Plain regional aquitard is relatively thick and impermeable and thus prevents downward flow of classic seawater intrusion or leakance from tidal streams from the shallow aquifer to the principal aquifer zone. Valley Water maintains robust managed aquifer recharge in the Santa Clara Plain that helps to create artesian pressures in the principal (confined) aquifer. Both the regional aquitard and upward hydraulic gradient help to minimize the downward flow of poor water quality from the shallow aquifer to the deeper principal aquifer. Iwamura (1980) identified a few isolated and seasonal occurrences of elevated chloride in the principal aquifer that may be attribute to downward by-pass flow through improperly constructed, maintained, or abandoned wells. However, as explained in Valley Water (2021), more recent water quality monitoring indicates very few Bayland wells in the principal aquifer have elevated TDS or chloride concentrations that would be indicative of seawater intrusion or by-pass flow.

Entrapped Connate Water

Iwamura (1980) first noted localized and high salt concentrations within the shallow aquifer zone in the Palo Alto and southeast San Jose bayfront area. Because these concentrations were much higher than seawater and indicative of brines, Iwamura (1980) concluded that the water is likely from "entrapped connate water that has undergone a process of concentration (by evaporation) in the geologic past". Connate water refers to the water that was trapped in the pores of the sediments and sedimentary rocks, typically of marine origin, as they were deposited, and connate water is not attributed to present-day seawater intrusion (Jiao and Post, 2019). The salinity from connate water can diffuse into or mix with more modern and fresh groundwater.

Connate water is also different than paleo-seawater that may have intruded into a coastal aquifer when the seawater and fresh groundwater circulation patterns were different in the geologic past (Jiao and Post, 2019). Paleo-seawater is younger than the rocks it flows through and represents a different source and process of salinity than connate water. Another source of elevated salinity in many regions of the world is the formation of hyper-saline water by evaporation and concentration (evapoconcentration) of seawater under current conditions or in the geologic past (Jiao and Post, 2019). This hyper-saline water typically occurs in arid- or semi-arid regions, but also in more temperate climates where strong evapoconcentration in salt marshes during summer months creates a high-salinity groundwater that can pool at the bottom of aquifer units because of density-driven flow (Jiao and Post, 2019).

The area that Iwamura (1980) suspected as connate water is indicated by the well with 28,100 mg/L chloride concentration in Figure 2-10. This well is also located near Byxbee Park, which is a reclaimed 60-year landfill[17]. Because connate water is not associated with present-day seawater intrusion and found only in localized areas, it is not an important mechanism for seawater intrusion and likely has a low influence on the spatial extent of the 100 mg/L chloride isocontour throughout the Baylands. However, to improve on the conceptual model and help identify the source of the elevated chloride, the aqueous geochemistry of the suspected connate water is evaluated in Appendix A and Chapter 3 by comparing chloride trends and the ratios of select ions (e.g., sodium to chloride) in groundwater of the seawater intrusion monitoring wells.

2.5 Sea-Level Rise Projections

Global sea-level rise from climate change has occurred and will continue to occur well into the future. Higher sea levels will amplify the effects from high tides, king tides, and storm surges, which all have implications for sea-level rise in the Bay and the risk of seawater intrusion and groundwater rise/ emergence in adjacent aquifers of Santa Clara County. The rise of global mean sea level is a climate change-driven response to the thermal expansion of warming ocean waters and the addition of water from melting glaciers and ice sheets (Sweet et al., 2022), and to a much lesser extent, from the overdraft of global aquifers (Taylor et al., 2012). The rates of regional and local sea-level rise can be considerably different than the global mean rise for a variety of reasons, which is why local tide gauges, including those in the Bay are most appropriate for establishing local trends and projections of future sea-level rise (Sweet et al., 2022).

Valley Water's responsibility and authority to manage groundwater requires the use and reliance on sea-level rise projections in the Bay made by other scientific organizations and agencies. The following projections are summarized from the 2024 California Sea-Level Rise Guidance by the California Ocean Protection Council (OPC)[18]. These projections are based on probabilistic projections from the Intergovernmental Panel on Climate Change Sixth Assessment report (IPCS AR6) and thus represent the most up-to-date scientific understanding of sea-level rise. These sea-level rise projections are based on five scenarios, which are summarized below and explained in more detail in OPC (2024):

- **Low**: 0.3 meter (1.0 feet) sea-level rise by 2100. This scenario assumes the current rate of sea-level rise continuing, which is inconsistent with current observations of accelerating sea-level rise. This scenario is on the lower bound of plausibility given current global warming and sea level trajectories.

- **Intermediate-Low**: 0.5 meter (1.6 feet) sea-level rise by 2100. Given current sea level observations and estimates of future warming, this scenario is a reasonable estimate of the lower bound for the most likely sea-level rise by 2100.

[17] The City of Palo Alto's history of the landfill at Byxbee Park: https://www.cityofpaloalto.org/Departments/Public-Works/Zero-Waste/About-Us/History-of-Waste-And-The-Baylands
[18] https://opc.ca.gov/

- **Intermediate**: 1.0 meter (3.3 feet) sea-level rise by 2100. This scenario provides a reasonable upper bound for the most likely range of sea-level rise by 2100.

- **Intermediate-High**: 1.5 meter (4.9 feet) sea-level rise by 2100. This scenario corresponds to other scientific estimates of plausible high-end projection of sea-level rise by 2100.

- **High**: 2.0 meter (6.6 feet) sea-level rise by 2100. This scenario only arises from high future emissions and high warming with a large potential contribution from rapid ice sheet loss and includes deep uncertainties. OPC (2024) explains this scenario should be used with caution and consideration of the underlying assumptions, and states that it is not possible to characterize the likelihood of reaching this scenario.

OPC (2024) recommends using the Intermediate, Intermediate-High, and High scenarios to inform appropriate sea-level rise planning and project decisions in California. This recommendation guides the maps presented in Chapter 4 of this report that illustrate groundwater response to future sea-level rise. OPC (2024) recommends using sea-level rise projections from the tide gauge nearest the project location. The San Francisco and Alameda tide gauges are within the Bay and about equidistant to Santa Clara County. However, the sea-level rise scenarios for the San Francisco tide gauge are presented here because they are generally similar but somewhat more conservative (higher) than the sea-level rise scenarios for Alameda. Sea-level rise scenarios for the San Francisco tide gauge from 2020 to 2150 are presented in Table 2-1 for low to high scenarios.

Table 2-1. Sea-level rise scenarios for San Francisco

Year	Low	Int-Low	Intermediate	Int-High	High
2020	0.2	0.2	0.2	0.3	0.3
2030	0.3	0.4	0.4	0.4	0.4
2040	0.4	0.5	0.6	0.7	0.8
2050	0.5	0.6	0.8	1.0	1.3
2060	0.6	0.8	1.1	1.5	2.0
2070	0.7	1.0	1.4	2.2	2.9
2080	0.8	1.2	1.8	3.0	4.1
2090	0.9	1.4	2.4	3.8	5.3
2100	1.0	1.6	3.1	4.8	6.5
2110	1.0	1.8	3.8	5.6	7.8
2120	1.1	2.0	4.4	6.4	9.0
2130	1.2	2.2	4.9	7.0	9.9
2140	1.3	2.4	5.4	7.6	10.8
2150	1.3	2.6	6.0	8.1	11.7

Note: The table presents the median value of sea-level rise, in feet, for each decade from 2020 to 2150, with a baseline of 2000. All median scenario values incorporate the local estimate of vertical land motion. These scenarios are taken from OPC (2024).

2.6 Sea-Level Rise Effects on Groundwater

Climate change and sea-level rise are expected to impact groundwater resources. In some locations near the Bay front, groundwater rise and emergence above land surface may occur as a response to sea-level rise. Groundwater rise generally refers to groundwater levels moving upward toward land surface and could be a temporary response to storms, high tide, and king tides, or a longer-term response to sea-level rise. For unconfined aquifers that are in direct hydraulic connection with an ocean or bay, sea-level rise may contribute to groundwater rise as it raises the interface between intruding seawater and overlying fresh groundwater (Figure 2-13A and 2-13B). As the denser seawater intrudes inland, the saltwater wedge pushes the overlying fresh groundwater upward toward land surface. Transient (temporary) groundwater rise also occurs in response to rising tides and storms. Groundwater rise above land surface is called groundwater emergence and is more likely in low-lying areas (Figure 2-13b), including natural streams or man-made drainage channels, basements, or any other feature that has a relatively lower elevation than the surrounding land surface.

For unconfined aquifers that are hydraulically connected to an ocean or bay, the effects of sea-level rise on the groundwater system may occur over a continuum of two endmembers within the conceptual model called flux-controlled and topography-limited systems (Michael et al., 2013). This range in conditions may vary geographically across a coastal aquifer and over time due to changes in groundwater pumping, recharge, and sea-level rise.

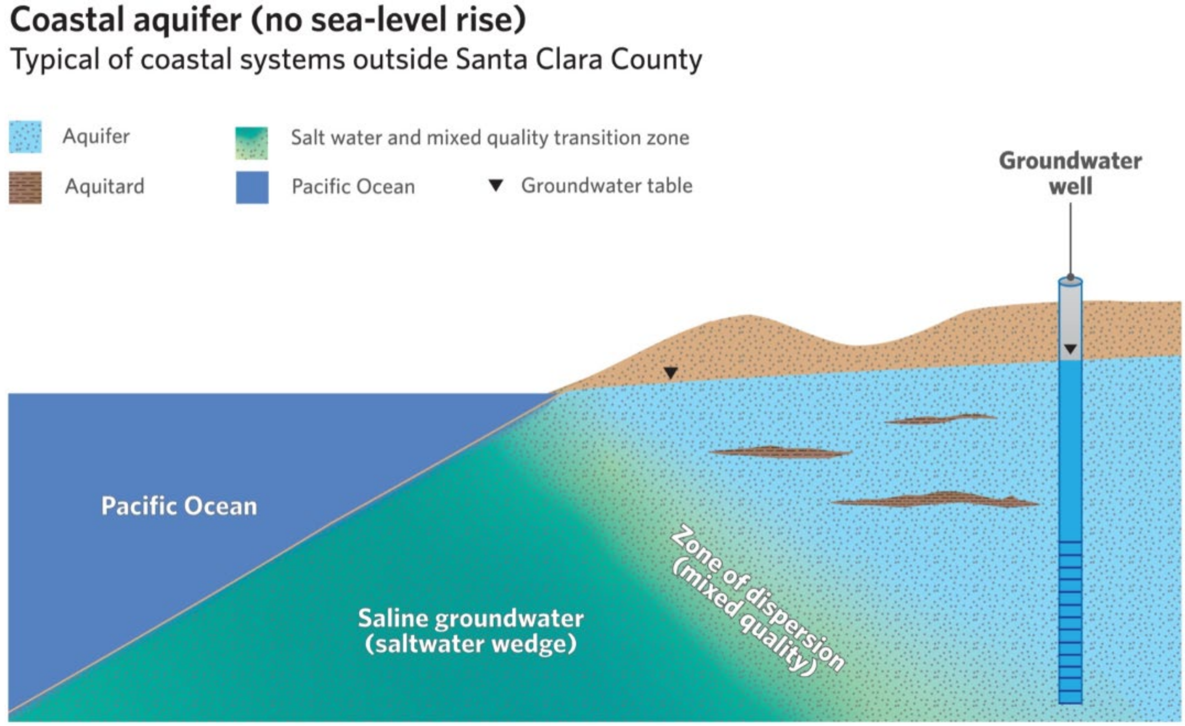
A flux-controlled (also called recharge-limited) system is an aquifer that has sufficient unsaturated zone thickness to accommodate the additional groundwater storage as the water rises in response to sea-level rise (Michael et al., 2013). In this type of system, as sea-level rise occurs, the water table in the aquifer rises at a similar rate and maintains both the position of the seawater-freshwater interface (shown as the zone of dispersion in Figure 2-13) and groundwater discharge into the ocean or bay. Sea-level rise driven seawater intrusion and groundwater rise and emergence would be relatively less in a flux-controlled groundwater system compared to a topography-limited system.

A topography-limited (also called head-controlled) system is an aquifer that does not have sufficient unsaturated zone thickness to accommodate the additional groundwater storage from sea-level rise (Michael et al., 2013). In this system, the water table rises less than sea levels and instead discharges some of the original groundwater storage to drainage networks (i.e., streams, lakes, drainage cannels, low-lying areas, salt ponds, etc.) and the intruded seawater displaces the fresh groundwater. Because these drainage networks control the inland water level, creating a constant hydraulic head condition[19], there is a reduction in the groundwater discharge into the ocean or bay. Sea-level rise driven seawater intrusion and groundwater rise and emergence would be relatively greater in a topography-limited system compared to a flux-controlled system.

Given the gently sloping topography of the Baylands and the relatively shallow groundwater (Figure 2-7), much of the shallow aquifer near the Bay likely functions as a topography-limited system. In contrast, farther inland in the Santa Clara Plain, where the land surface elevations increase and depths to water increase (Figure 2-7), the shallow groundwater system is a flux-controlled system. However, the aquifer systems of the Baylands are generally not unconfined or in direct hydraulic connection with the Bay.

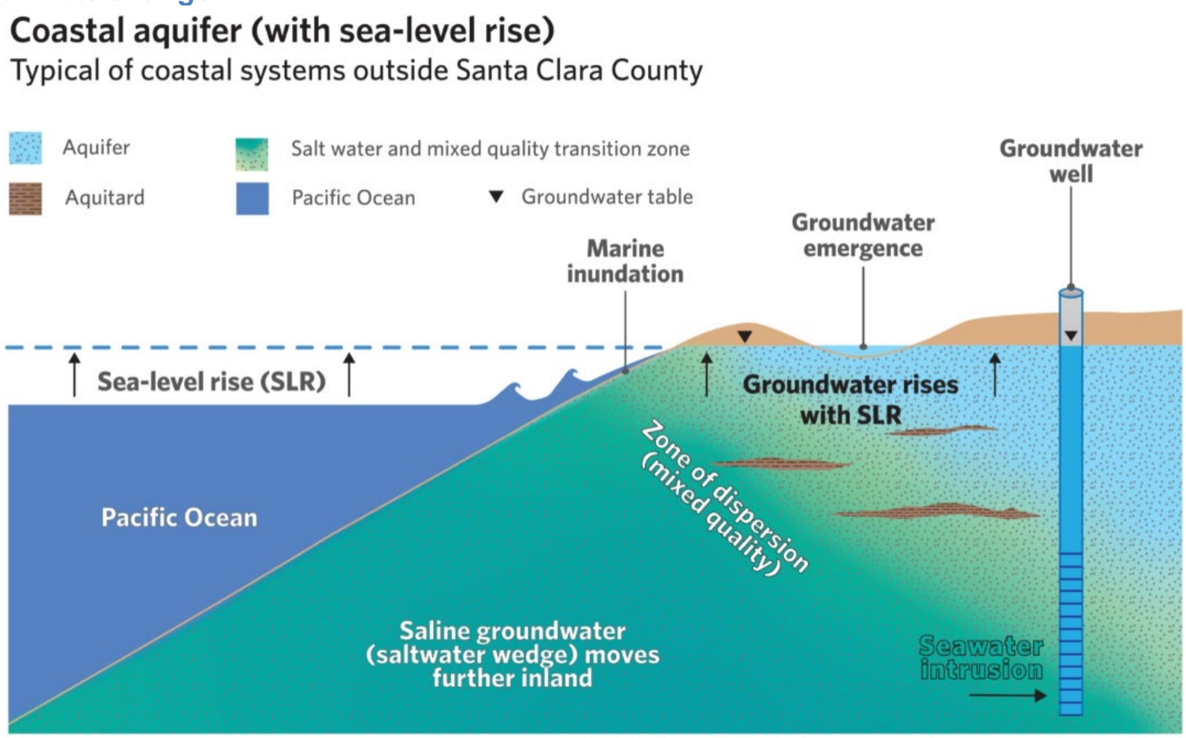
[19] Hydraulic head is the driving force of groundwater flow in an aquifer.

Figure 2-13A. Typical unconfined coastal aquifer outside Santa Clara County under natural conditions with no sea-level rise



Note: Figure taken from the 2021 Groundwater Management Plan

Figure 2-13B. Typical unconfined coastal aquifer outside Santa Clara County with sea-level rise from climate change



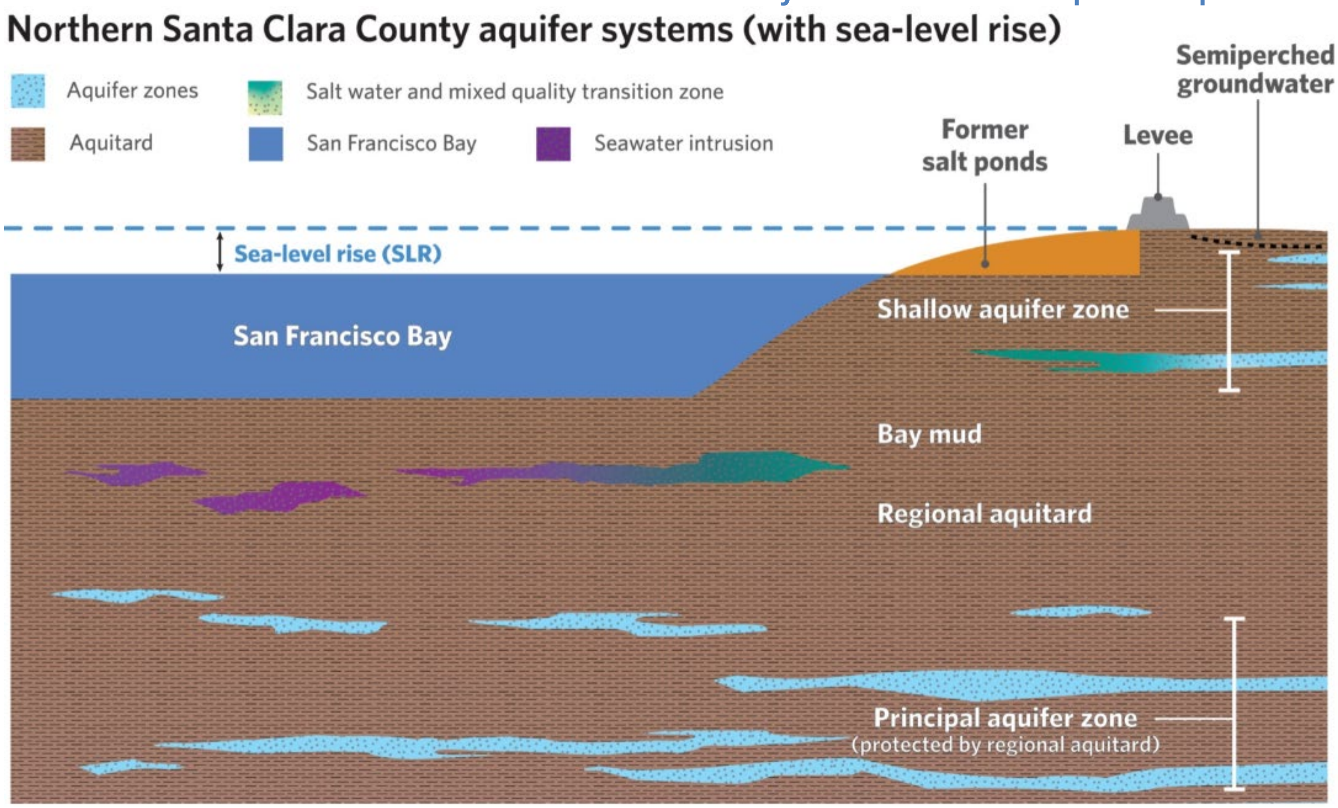
Note: Figure taken from the 2021 Groundwater Management Plan

Groundwater Response to Tides, Seawater Intrusion, and Sea-Level Rise

While sea-level rise driven sea-water intrusion and groundwater emergence may affect many unconfined aquifers in California, the hydrogeologic conditions of the Baylands in the Santa Clara Subbasin are likely to mitigate such responses to sea-level rise (Valley Water, 2021). Because of the extensive Bay mud and clay layers, sea-level rise may increase classic sea-water intrusion and chloride concentrations in limited parts of the aquifer systems beneath the Bay and short distances inland from the bayfront, estuaries, and salt evaporation ponds (Figure 2-14). As outlined in Valley Water's 2021 Groundwater Management Plan, this conceptual model suggests that sea-level rise-driven groundwater emergence may occur in the semiperched groundwater and shallow aquifer zone on the inland side of the levee system. However, the very low hydraulic conductivity of the Bay mud and clay layers are likely to mitigate some effect of groundwater rise and emergence. The conceptual model further asserts that assuming unconfined aquifer conditions and connectivity between the Bay, while also neglecting the very low hydraulic conductivity of the Bay mud and clay will likely overestimate the magnitude and extent of sea-level rise-driven groundwater emergence of the Santa Clara Subbasin (Valley Water, 2021).

Valley Water (2021) recommended that additional analysis was needed to better understand the connection between Bay water and the shallow aquifer zone and sea-water intrusion and groundwater emergence response to sea-level rise. To meet this need, aspects of this hydrogeologic conceptual model (Chapter 2) are refined and understanding about groundwater response to sea-level rise is improved based on analysis of tidally influenced shallow groundwater (Chapter 3) and groundwater rise and emergence in response to king tides (Chapter 4).

Figure 2-14. Conceptual diagram illustrating sea-level rise effects on groundwater and seawater intrusion limited to beneath the south San Francisco Bay and former salt evaporation ponds



Note: Figure taken from the 2021 Groundwater Management Plan

2.7 Changes to the Bay Shoreline

Valley Water, other agencies, and stakeholders are currently involved in several regional-scale projects that will create substantial changes to the Bay shoreline in Santa Clara County (Figure 2-15). These projects may have implications for seawater intrusion and sea-level rise. This section provides a brief overview of these projects and sources for additional information. However, it is beyond the scope of this report to evaluate how these projects may affect groundwater response to seawater intrusion and sea-level rise. This report summarizes recommendations and next steps (see Chapter 5), including potential groundwater monitoring near these projects to better understand how changes to the shoreline may affect sea-level rise, seawater intrusion, and groundwater rise and emergence.

Figure 2-15. Aerial view of the south San Francisco Bay shoreline in Santa Clara County[20]

South San Francisco Bay Shoreline Protection Project: This is a multi-agency partnership with Valley Water, California State Coastal Conservancy, U.S. Army Corps of Engineers (USACE), U.S. Fish and Wildlife Service, and other regional partners and stakeholders to provide tidal flood protection from rising sea levels, restore and enhance nearly 3,000 acres of tidal marsh and related habitats, and provide recreational and public access opportunities along Santa Clara County's Bay shoreline. The tidal marsh will be restored and enhanced using a combination of flood protection levees, restoration of tidal flows, and creation of upland transitional zone habitat ecotones, which provide a protective buffer for the levees and allow marsh habitat to migrate upslope as the sea level rises. This project will create a resilient and adaptable flood protection system using natural infrastructure that can evolve over time. Additional information including project schedule, location maps, and updates are available on the project website: https://www.valleywater.org/shoreline.

South Bay Salt Pond Restoration Project: This is a multi-agency partnership with Valley Water, California State Coastal Conservancy, U.S. Army Corps of Engineers (USACE), U.S. Fish and Wildlife

[20] Image is taken from Valley Water's South San Francisco Bay Shoreline Project video, available at: https://youtu.be/o3neVxYY7M0

Services, California Department of Fish and Wildlife, and other partners and stakeholders to restore 15,100 acres of industrial salt ponds to tidal wetlands and other habitats, making this project the largest tidal wetland restoration project on the West Coast[21]. The goals of the project include restoration, recreation, and flood protection. The project will restore and enhance a mix of wetland habitats, provide wildlife-oriented public access and recreation, and provide flood risk management in the South Bay. Additional information including project schedule, location maps, and updates are available on the project website: https://www.southbayrestoration.org/.

Local-Scale Projects: In addition to the larger, regional-scale projects, there are some local-scale projects that will create changes to the Bay shoreline and may have implications for local groundwater conditions. The Calabazas/San Tomas Aquino Creek-Marsh Connection Project will restore up to 1,800 acres of tidal marsh habitat at the A8 Ponds and Pond A4, enhance about 50 acres of freshwater and brackish marsh habitat at Harvey Marsh, and improve more than four miles of riparian habitat. The project is being led by Valley Water in partnership with the South Bay Salt Pond Restoration Project. Additional information including project schedule, location maps, and updates are available on the project website: https://www.valleywater.org/project-updates/calabazas-san-tomas-aquino-creek-marsh-connection-project

As a related project, Valley Water's Pond A4 Resilient Habitat Restoration Project will restore about 40 acres of shallow water shorebird foraging habitat along the southern portion of Pond A4 by beneficially reusing sediment from Valley Water's Stream Maintenance Program and other soil/sediment sources. Additional information is available on the project website: https://www.valleywater.org/project-updates/pond-a4-resilient-habitat-restoration-project.

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[21] https://www.southbayrestoration.org/

Tide gate on the Bay side of salt ponds AB1 and AB2 during low tide, exposing a channel in the Bay Mud that has formed from water flowing in and out through the tide gate. Photo credit: Scott Elkins, Valley Water, taken September 16, 2024 during a spring tide (see Chapter 3).

CHAPTER 3

Valley Water staff, Scott Elkins, evaluating a well for the seawater intrusion monitoring network, Don Edwards San Francisco Bay National Wildlife Refuge. Photo credit: Jason Gurdak (Valley Water), taken October 9, 2023.

CHAPTER 3 – TIDAL INFLUENCE ON STREAMS AND GROUNDWATER

This chapter describes the tidal dynamics of San Francisco Bay (Bay) and evaluates tidal influence on streams and shallow groundwater of the Santa Clara Subbasin. This analysis is based on Valley Water's groundwater monitoring network near the Bay that is designed to identify tidal influence on groundwater and provide an early warning of seawater intrusion and groundwater rise and emergence. Groundwater level response to other factors, such as rainfall and king tides is discussed. Finally, groundwater quality data from the seawater intrusion network are summarized here to support the tidal analysis and identify areas of seawater intrusion in the shallow aquifer.

3.1 San Francisco Bay Tides

The Bay is the largest estuary in the western U.S. and drains water from about 40% of California. Freshwater flows into the estuary from a 60,000 square-mile watershed, including California's two largest rivers, the Sacramento and San Joaquin, and mixes with tides and saltwater from the Pacific Ocean. Given the large area of 460 square miles, the Bay has a complex bathymetry[22] and tidal pattern around its nearly 300 miles of shoreline. The Santa Clara Subbasin is immediately adjacent to the southern Bay (known as the South Bay), as shown in Chapter 1 (Figures 1-1 and 1-2).

Historically, the National Oceanic and Atmospheric Administration (NOAA) has recorded the observed tides at 60 stations within the Bay, but only seven stations are currently active and just three stations have a 30-year record or longer (AECOM, 2016). Observed tide data from these stations have been used to calibrate and validate a hydrodynamic[23] model used by NOAA, the U.S. Army Corps of Engineers (USACE), and other agencies to predict tides at more than 50 locations around the Bay. At these stations, the tide datums are standard elevations defined by a certain phase of the tide, such as mean high tide or mean low tide. Tidal datums are used as references to measure and define local water levels and are not easily extended to other areas of the Bay (AECOM, 2016).

The Bay is influenced by both astronomical tides and extreme tides (AECOM, 2016). Astronomical tides are the daily rise and fall of the ocean surface caused by the gravitational attraction between the earth, moon, and sun. Extreme tides are increases in ocean level caused by weather and atmospheric conditions, such as storm surge, El Niño or other oceanic cycles, local wind, or streamflow conditions. These factors can cause differences between the predicted astronomical tide from the hydrodynamic model and observed tides at tidal stations. AECOM (2016) provides additional information about extreme tides in the Bay. Unless otherwise stated, tides are used here to include astronomical and extreme tides.

Tidal waves in the ocean flow horizontally into and out of the Bay, creating tidal currents. The rising tide causes the tidal current to flow into the Bay, called the "flood tide", while the falling tide causes the tidal current to flow out of the Bay, called the "ebb tide". As these tides reverse, there are short periods called "slack tides" when there is little or no tidal current or flow.

Tides follow a regular cycle based on the lunar orbit, which takes 24 hours and 50 minutes. Therefore, high tide occurs about every 12 hours and 25 minutes (Figure 3-1). The California coast, including the Bay has a mixed semidiurnal tide with two high tides and two low tides each day and each of the four tides reaching different elevations (AECOM, 2016) (Figure 3-1).

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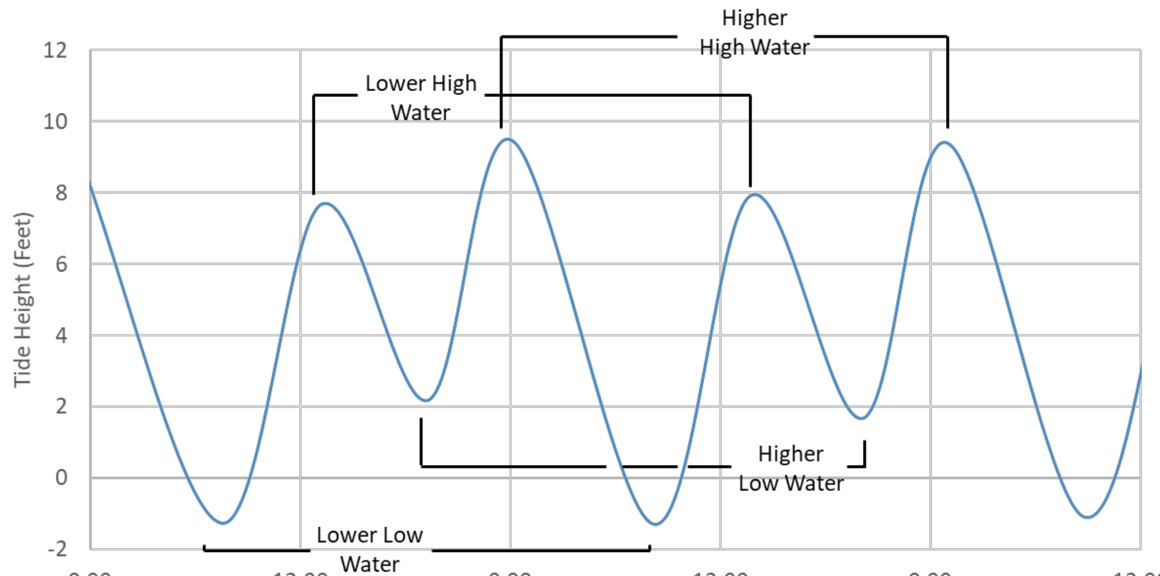
[22] Bathymetry refers to the depth of water relative to sea level and includes the shape and elevation of features beneath the water.

[23] Hydrodynamics refers to the movement of water. In general, the Bay hydrodynamics are influenced by the tides, inflow of freshwater from streams, wind, and bathymetry.

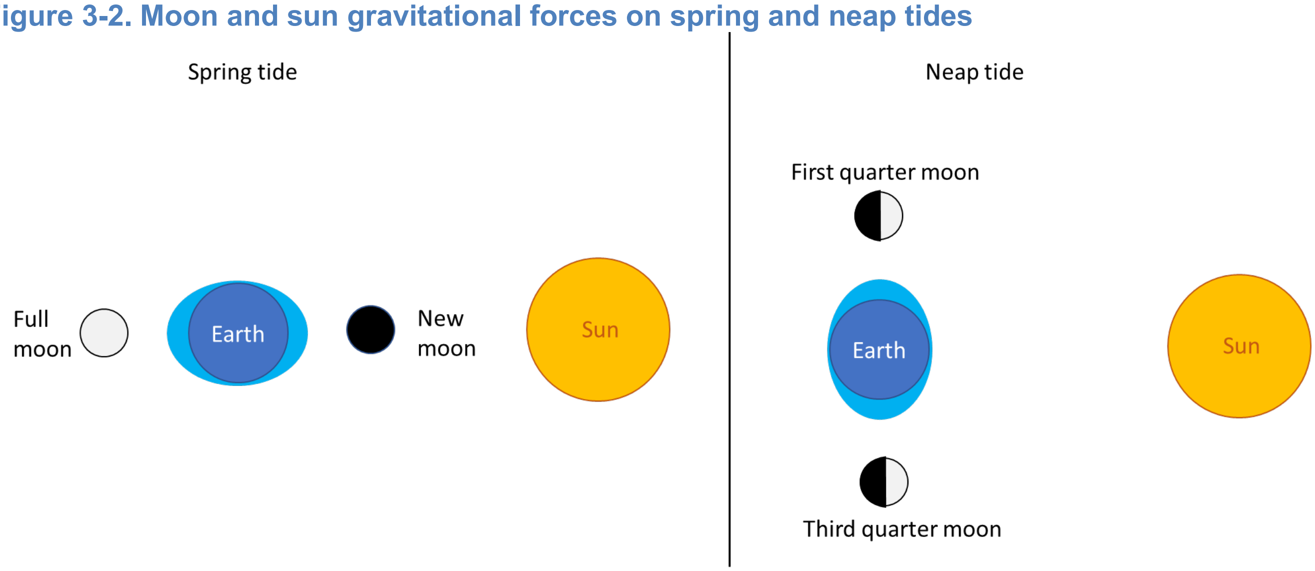
The full and new moons cause spring tides because the orientation of the moon and sun are aligned with the earth (AECOM, 2016) (Figure 3-2). During spring tides, the high tides are particularly high and low tides are particularly low (Figure 3-3). In the Bay, the tidal range for a typical spring tide is 5 to 8 feet, depending on the location. During the quarter moons, when the gravitational forces of the sun and moon are opposed (Figure 3-2), smaller than average tidal range result in neap tides (Figure 3-3).

Figure 3-1. Example of a mixed semidiurnal tide from the Bay



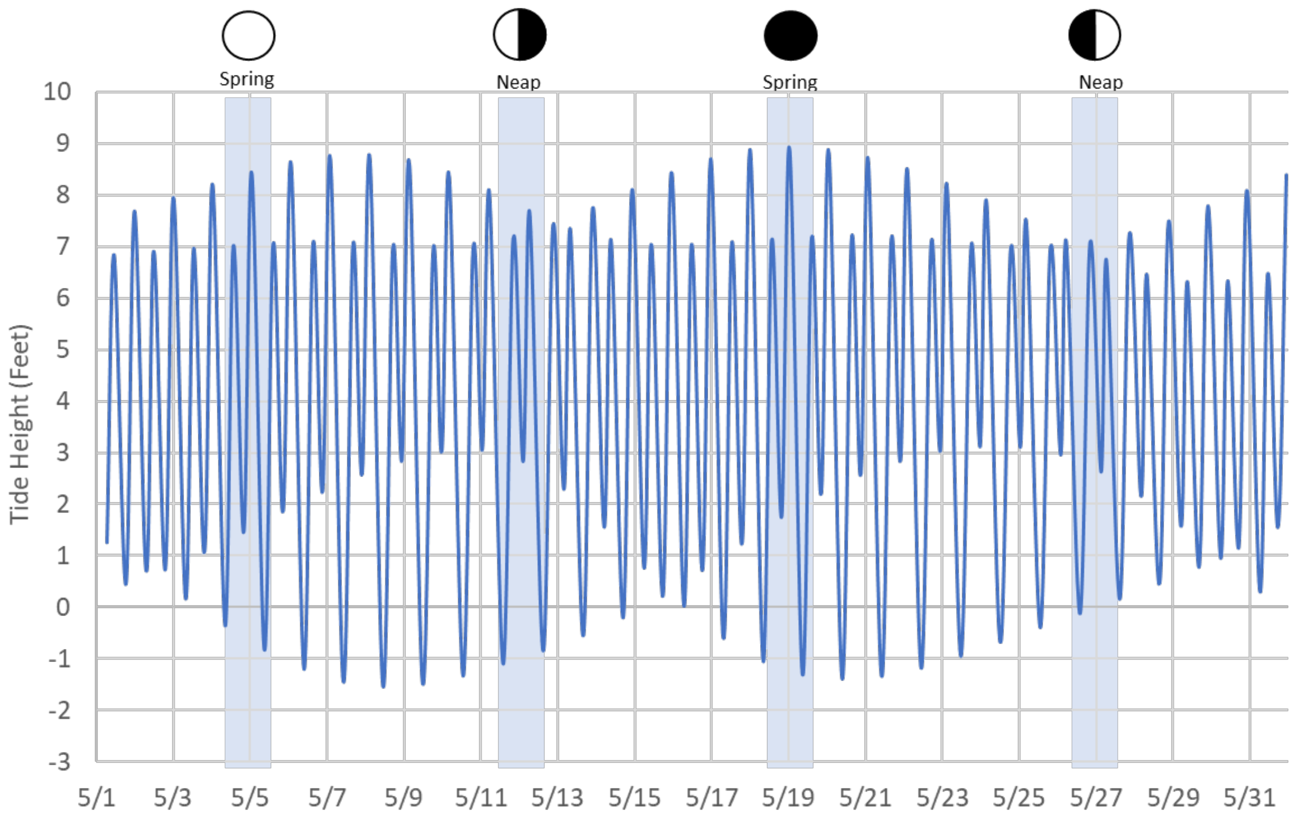
Note: Tide data from Coyote Creek Tributary #1 tide station (ID 94145561)[24], August 28 to 31, 2023. Coyote Creek flows through the Santa Clara Subbasin into the Bay.

Figure 3-2. Moon and sun gravitational forces on spring and neap tides



[24] The Coyote Creek Tributary #1 station information and data is available from the NOAA Tides & Current page: https://tidesandcurrents.noaa.gov/stationhome.html?id=9414561

Figure 3-3. Example of spring and neap tidal patterns in the Bay



Note: Tide data from Coyote Creek Tributary #1 tide station (ID 94145561)[25], May 1 to 31, 2023.

The Bay also has king tides, which is a non-scientific term used to describe some spring tides that occur when the earth is particularly close to the moon and sun. King tides have some of the highest high tides and lowest low tides of the year and are well-known for causing over-topping of the shoreline and flooding in low-lying areas surrounding the Bay (AECOM, 2016). In the Bay, king tides are typically one to two feet higher than the average high tide, ranging from about 7 to 10 feet.

While king tides are unusually large tides, they are not necessarily the largest tides of a given year. Some astronomical and meteorological factors can create tides larger than king tides along the California coast and Bay during summer months. These factors include perigean spring tides[26], the summer solstice[27], and meteorological factors, such as thermal expansion of the ocean and certain summer weather patterns with onshore winds and lower atmospheric pressures that can enhance high tides. For example, tides during July and August 2023 were higher than the subsequent king tides in January and February 2024. For this reason, this study evaluated groundwater response to both the highest tides in July and August 2023 and the king tides in January and February 2024.

The Bay tides have general spatial patterns caused by the bathymetry and geography of the Bay shoreline (AECOM, 2016). The South Bay typically has greater tidal amplification than the North Bay, with an average tidal range greater than 7.5 feet south of San Mateo Bridge and only 5.8 feet at the Golden Gate Bridge (AECOM, 2016). This amplification is caused by shallow mudflats, salt ponds, and

[25] The Coyote Creek Tributary #1 station information and data is available from the NOAA Tides & Current page: https://tidesandcurrents.noaa.gov/stationhome.html?id=9414561

[26] The perigean spring tides occur when the moon is either new or full and closest to the Earth.

[27] The summer solstice around June 21 affects the sun's position relative to the Earth.

tidal wetlands in the South Bay, which lead to large areas of the South Bay being exposed during low tides (AECOM, 2016). The South Bay also has both standing and progressive waves[28]. Due to these different tidal waves and patterns in the North versus South Bay, the South Bay begins to ebb while the North Bay is still flooding and begins to flood while the North Bay is still ebbing (AECOM, 2016). Because of these spatial tidal patterns, this study used tidal stations near Santa Clara County and the Santa Clara Subbasin.

In addition to known spatial patterns, there are also long-term temporal patterns in the tide. Tide levels in the Bay have not been stable over the past century and are projected to change in the future (AECOM, 2016). In the Bay, mean sea level has risen, extreme tides have become more frequent and larger in recent decades, and the annual maximum tide levels are rising faster than average sea-level rise, based on the San Francisco Presidio tide station, located east of the Golden Gate Bridge (AECOM, 2016). These changes in tidal patterns are, in part, motivation for Valley Water implementation of a high-resolution groundwater monitoring network and analysis outlined in this report.

3.2 Tidally Influenced Streams

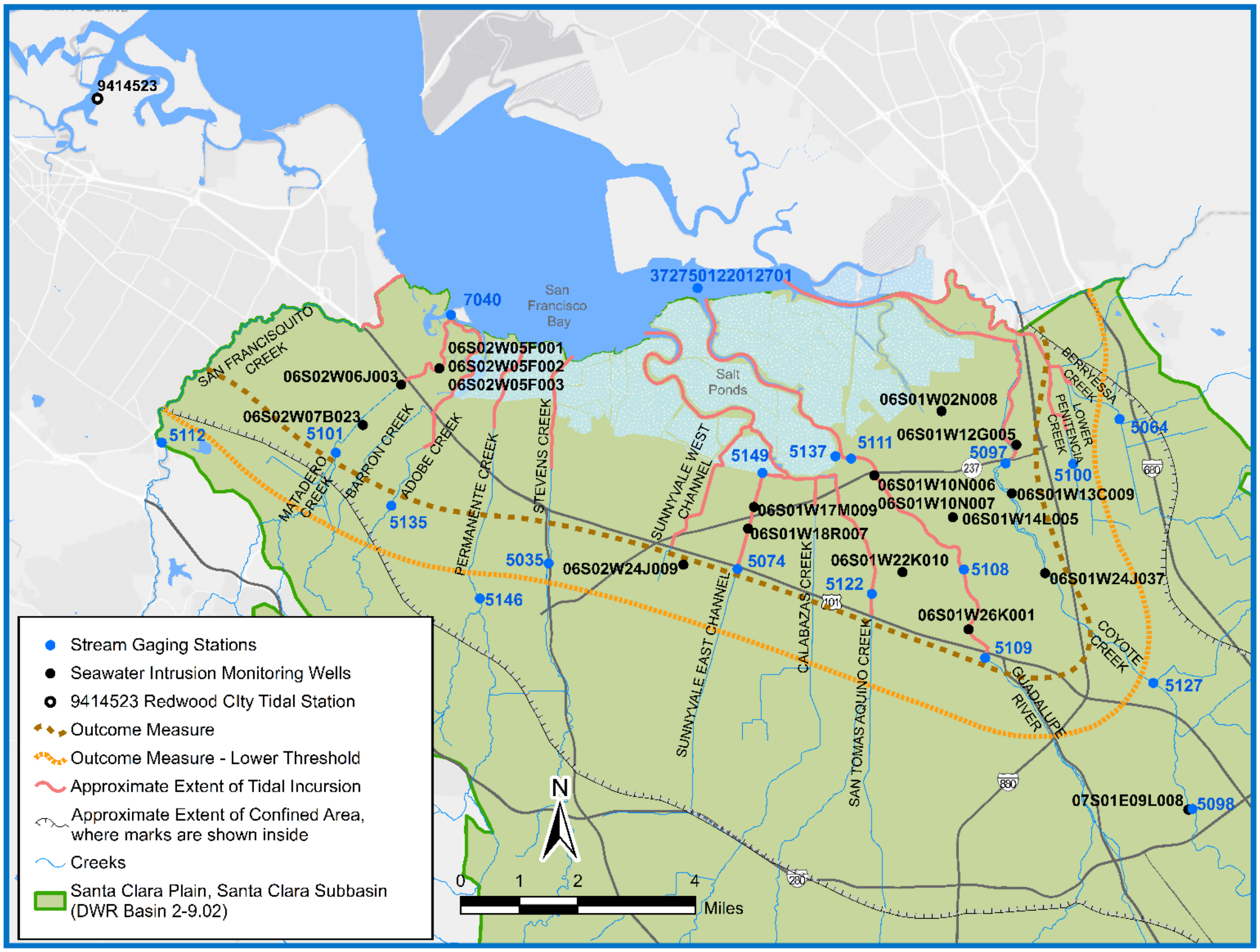
As described in the conceptual model (Chapter 2), the leakance of saltwater and brackish water beneath tidal streams has a relatively strong influence on the spatial extent of seawater intrusion and the 100 mg/L chloride isocontour in the shallow aquifer zone of the Baylands. This section describes the tidally influenced stream reaches and quantifies the tidal variability and ranges in stream stage[29]. Quantifying the connection between tides and stream stage is an important first step to better understand and forecast the relation between tides, sea-level rise, and shallow groundwater conditions near the Bay.

A total of 19 stream gaging stations[30] are within or just outside Valley Water's seawater intrusion outcome measure–lower threshold, and many of these stations are located near the 18 seawater intrusion monitoring wells (Figure 3-4). The stream gaging stations and seawater intrusion monitoring well network have a similar spatial distribution throughout the Baylands, representing a relatively uniform and random sampling of the hydrologic system near the Bay. All tidal analyses were based on observed tide data from the NOAA Redwood City, CA tidal station (9414523)[31] (Figure 3-4). Appendix A provides additional details about the tidal analysis approach and methods, including descriptions of the stream gaging stations, seawater intrusion monitoring well network, and Redwood City tidal station 9414523.

During the three-month period (July 1, 2023 to September 30, 2023) used for this tidal analysis, the variance in stream stage attributed to the tides ranged from 0 to 99% and the average daily stage range was 0 to 9 feet, with a station average of 26% and 1.3 feet, respectively (Table A-1 in Appendix A). These averages indicate a relatively modest influence of tides on steam stage variance at most stations. The amount of variance largely depends on station proximity to the Bay, with stations closer to the Bay having greater tidal variance in stream stage (Figure 3-5). Appendix A provides additional details about specific results that characterize tidal influence on stream stage variance and range.

[28] As explained by AECOM (2016), progressive tidal waves dissipate as they move upstream due to friction in the shallow area, interaction with the shoreline, and attenuation from river flow. Standing waves are caused by interference between the incoming progressive tidal waves and the wave reflection back from the shoreline.
[29] Stream stage is the water level height above a measurement point, reported in feet.
[30] Stream gaging data is available at Valley Water's Surface Water Data Portal: https://alert.valleywater.org/
[31] Redwood City, CA Station 9414523 website: https://tidesandcurrents.noaa.gov/waterlevels.html?id=9414523

Figure 3-4. Stream gaging stations, seawater intrusion monitoring wells, and tide station

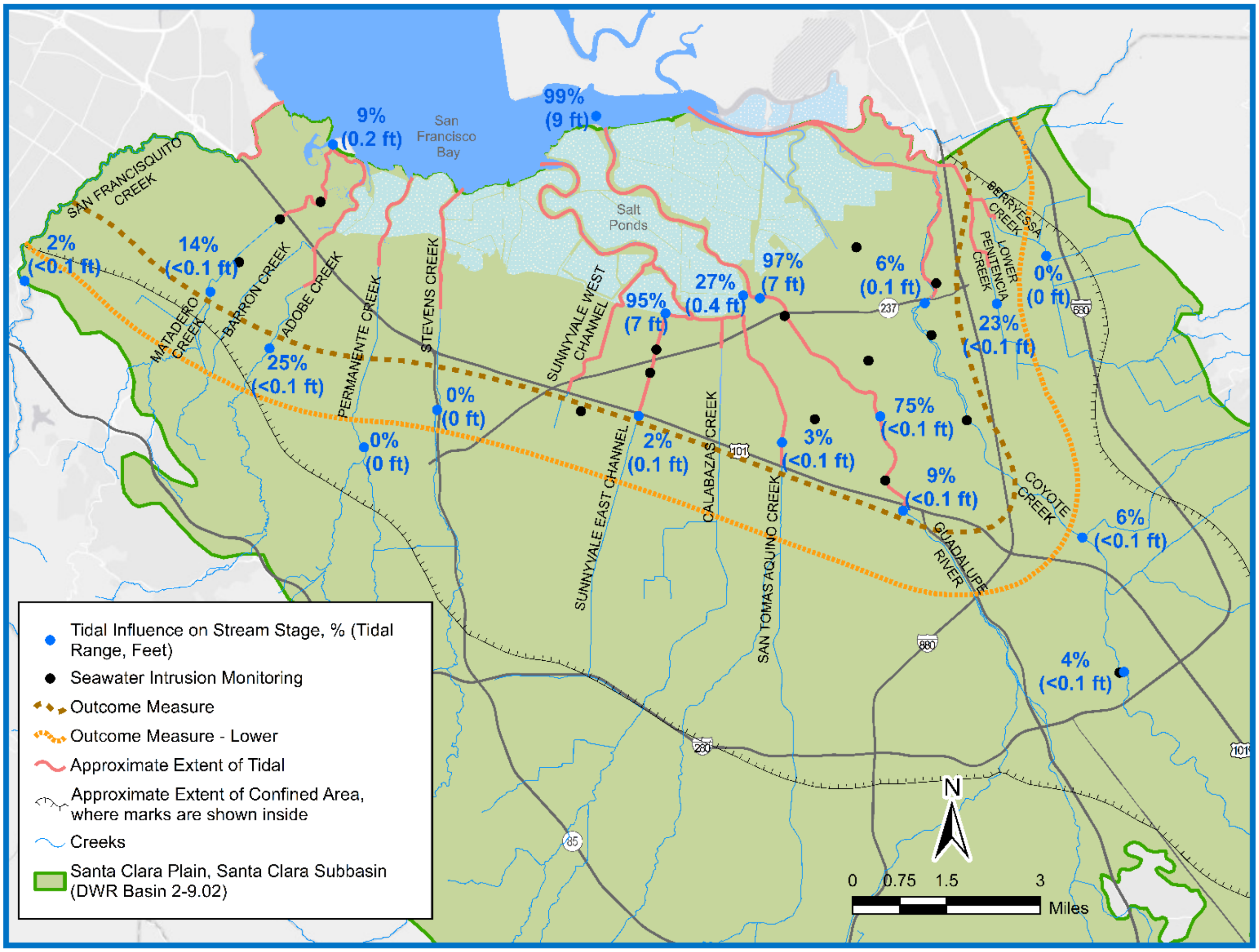


Note: Chapter 1 defines Valley Water's seawater intrusion outcome measure and outcome measure–lower threshold.

Generally, the stream reaches with the greatest tidal influence are within the approximate extent of tidal incursion[32] and closest to the Bay (Figure 3-5). The extent of tidal incursion shown in Figure 3-5 and used throughout this report is based on a head of tide study (Dusterhoff et al., 2014) and a four-year salinity study of tidal streams in Santa Clara County (Porcella, 2005). The inland extent of tidally influenced stream reaches is also generally consistent with the extent of the seawater intrusion outcome measure (Figure 3-5). The streams with the greatest extent of tidal incursion are Guadalupe River, San Tomas Aquino Creek, Sunnyvale East Channel, Sunnyvale West Channel, and Coyote Creek (Figure 3-5). Iwamura (1980) described the area with the greatest inland intrusion of the mixed transition water along Guadalupe River and Coyote Creek, suggesting a relation between seawater intrusion and the tidal incursion inland along the stream channels, which overlie the greatest abundance of shallow aquifers and the thinnest clay cap near land surface within the Baylands. According to Iwamura (1980), land subsidence has aggravated the condition of seawater intrusion by allowing farther inland incursion of saltwater up tidally influenced stream channels.

[32] The extent of tidal incursion is synonymous with head of tide (HoT), which is the inland limit of the effects of average high tides on tributary stream flows and water surface elevations and thus represents the transition zone between tidal (saltwater) and fluvial (freshwater river) processes and conditions (Dusterhoff et al., 2014). The HoT is a variable zone that depends on freshwater inflows and tidal dynamics, and thus the HoT zone shifts seasonally and interannually.

Figure 3-5. Tidally influenced stream stage variance and tidal range



The observed tidal variance in stream stage indicates the mapped extent of tidal incursion might underestimate the inland spatial extent of tidally influenced streams (Figure 3-5). For example, the tidal variance in stream stage at stations 5101 along Matadero Creek and 5135 along Adobe Creek are 14% and 25%, respectively. These stations are located near the outcome measure extent and are farther inland than the extent of tidal incursion (Figure 3-5). Long segments downstream of those stream stations on Adobe and Matadero (and Barron) creeks are concrete-lined channels, which would likely mitigate against the leakance of brackish water into the shallow aquifer. Similarly, Lower Penitencia Creek stage at station 5100 has 23% tidal variance, which is also farther inland than the mapped extent of tidal incursion (Figure 3-5). The mapped extent of tidal incursion on Coyote creek ends notably near station 5097. However, upstream stations 5127 and 5098 have 6% and 4% tidal variance in stage, respectively, despite being located inland of the outcome measure–lower threshold (Figure 3-5). These differences illustrate that the mapped extent of tidal incursion is approximate and may vary seasonally or on longer time scales, depending on the hydrology and patterns in stream discharge to the Bay. However, an important observation is that the mapped extent of tidal incursion and spatial patterns in tidal influence at stream gaging stations are generally consistent with the extent of the seawater intrusion outcome measure and outcome measure–lower threshold (Figure 3-5). These finding support the conceptual model in Chapter 2.

In summary, tidally influenced stream reaches extend considerable distances inland within the shallow aquifer zone. In general, stations with the strongest lag correlations and shortest lags with tides are located closer to the Bay, with the strength of the lag correlation typically decreasing upstream along creeks. This inland extent of tidally influenced streams has important implications for the spatial extent of shallow groundwater response to tides and sea-level rise, which may, in turn, affect the spatial patterns of groundwater rise and emergence, as described in subsequent sections.

3.3 Groundwater Monitoring Network

1 Valley Water's seawater intrusion monitoring well network is designed to identify tidal influence on shallow groundwater and provide an early warning of seawater intrusion and groundwater rise and emergence (Figure 3-4) in response to sea-level rise. This network currently includes 18 wells that are screened from 10 to 200 feet below ground surface (bgs), primarily within the shallow aquifer and above the confined aquifer of the Santa Clara Plain (Figure 3-4 and Table 3-1). The average depth of wells in the network is 63 feet bgs. The shallowest well is screened from 10 to 15 feet bgs, with most wells screened within the upper 50 feet of the shallow aquifer (Table 3-1). Well 06S02W05F003 is the deepest and is screened from 190 to 200 feet bgs, likely below the regional aquitard. The network includes two sites with co-located wells that are screened at multiple depths, including wells 06S02W05F001, 06S02W05F002, and 06S02W05F003 near Matadero Creek and wells 06S01W10N006 and 06S01W10N007 near Guadalupe River.

Table 3-1. Valley Water's seawater intrusion monitoring well network location and depth

Well Number	Latitude	Longitude	Well Depth (ft bgs)	Well Screen Depth (ft bgs)	Ground Surface Elevation (ft NAVD88)
06S01W02N008	37.43450	-121.94790	35	10 to 15	9.75
06S01W10N006	37.41825	-121.96847	37	27 to 32	12.6
06S01W10N007	37.41825	-121.96847	82.5	73 to 78	12.6
06S01W12G005	37.42634	-121.92450	37	30 to 35	16.8
06S01W13C009	37.41118	-121.92285	65	40 to 46	36.3
06S01W14L005	37.40819	-121.94380	47	37 to 47	12.0
06S01W17M009	37.40997	-122.00550	45	20 to 45	12.8
06S01W18R007	37.40458	-122.00720	45	20 to 45	12.8
06S01W22K010	37.39443	-121.95910	100	60 to 65	25.8
06S01W24J037	37.39561	-121.91556	51	40 to 46	46.1
06S01W26K001	37.38035	-121.93843	65	55 to 60	35.8
06S02W05F001	37.44037	-122.11360	31	21 to 31	6.76
06S02W05F002	37.44037	-122.11360	50	40 to 50	6.76
06S02W05F003	37.44037	-122.11360	200	190 to 200	6.76
06S02W06J003	37.43873	-122.11557	70	60 to 65	8.00
06S02W07B023	37.42867	-122.12174	45	28 to 45	14.5
06S02W24J009	37.39529	-122.02722	55	30 to 50.5	34.6
07S01E09L008	37.33638	-121.86871	72	62 to 72	88.0
		Average:	63	52[1]	22
		Median:	51	43[1]	13

Note: Latitude and longitude are in decimal degrees; bgs, below ground surface; ft, feet; and NAVD88, North American Vertical Datum of 1988. [1] based on midpoint of well screen depth.

The hydrogeologic properties of the aquifer and confining layers at the seawater intrusion monitoring wells are summarized in Table 3-2 and confirm the conceptual model outlined in Chapter 2. The aquifer properties characterize the ability to store and transmit groundwater, while the confining (clay and silt) layer properties characterize barriers that prevent groundwater from easily flowing into or out of the aquifer. Most seawater intrusion monitoring wells are screened in relatively shallow and thin aquifer units that are typically separated from the Bay and streams by relatively thick overlying clay layers (Table 3-2). For wells in the monitoring well network, the average aquifer depth is 54 feet bgs, the average aquifer thickness is about 12 feet, and the average thickness of the overlying clay and silt layers is 46 feet (Table 3-2). In nearly all cases, except for locations with multiple well completions, the wells are screened in the uppermost (first-encountered) aquifer unit at each location.

The hydraulic conductivity and other aquifer and confining layer properties at the seawater intrusion monitoring wells (Table 3-2) were estimated in 2023 by a slug test using the Bouwer-Rice (1976) method with rising head (slug-out) data and confined aquifer assumptions. The average hydraulic conductivity value is 75 feet/day (Table 3-2), consistent with silty sands, fine sands, and gravels (Fetter, 2001), which are the sediment types identified in the driller logs for these wells. For comparison, the smallest hydraulic conductivity values of these aquifer sediments are about three to four orders of magnitude larger than hydraulic conductivity of Bay mud, which ranges from 1.7×10^{-4} feet/day to 1.13×10^{-3} feet/day (U.S. Army Corps of Engineers, 1999; Burns and McDonnell Waste Consultants, 1996), with an average vertical hydraulic conductivity of 4.75×10^{-4} feet/day (Nguyen, 2007). These large differences in hydraulic conductivity values indicate that groundwater flows much easier through the sand and gravel aquifer sediments, whereas groundwater flow is restricted by the clay.

Valley Water also conducted a slug test at well 06S02W06J003, which was inadvertently partially screened within a clay layer instead of the intended sand or gravel aquifer sediment. Well 06S02W06J003 is located adjacent to Matadero Creek in Palo Alto, near other seawater intrusion monitoring wells, specifically 06S02W05F001, 06S02W05F002, and 06S02W05F003. The hydraulic conductivity at well 06S02W06J003 is 0.005 feet/day, which is consistent with the characteristics of clay (Fetter, 2001) and is approximately three to five orders of magnitude lower than the hydraulic conductivity of aquifer sediments at the other seawater intrusion monitoring wells (Table 3-2). In general, the very low hydraulic conductivity of clay reduces the flow of saltwater from the Bay or brackish water from tidally influenced streams into the shallow aquifer sediments.

The seawater intrusion monitoring wells are located at various distances from rivers, streams, and channels, ranging from 10 feet to more than 5,000 feet, and 61% (11 of 18 wells) are located 150 feet or less from a surface-water body (Table 3-3). Nearly all (16 of 18) of the monitoring wells are located near surface water reaches that are in direct hydraulic connection with the Bay and are tidally influenced (Table 3-3). The next section describes tidally influenced groundwater levels and conductivity at the seawater intrusion monitoring wells.

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Table 3-2. Aquifer and confining layer properties at the seawater intrusion monitoring wells

Well Number	Hydraulic Conductivity (ft/day)	Aquifer Depth (ft bgs)	Aquifer Thickness (ft)	Depth of Clay Layers Overlying the Aquifer [2] (ft bgs)	Thickness of Clay Layers Overlying the Aquifer [3] (ft)
06S01W02N008	143	12 to 15	3	0 to 12	12
06S01W10N006	8.18	28 to 32	4	0 to 28	28
06S01W10N007	7.38	70 to 79	9	0 to 30 33 to 70	67
06S01W12G005	140	18 to 37	19	0 to 18	18
06S01W13C009	50.9	47 to 60	13	0 to 47	47
06S01W14L005	89.9	NA	NA	NA	NA
06S01W17M009	30.7	24 to 43	19	0 to 24	24
06S01W18R007	123	39 to 47	8	0 to 39	39
06S01W22K010	98.5	53 to 66	13	0 to 15 18 to 39 41 to 53	48
06S01W24J037	330	37 to 53	16	0 to 37	37
06S01W26K001	64.9	50 to 60	10	0 to 20 33 to 50	37
06S02W05F001	17.6	27 to 28 29 to 30	2	0 to 27	27
06S02W05F002	34.9	40 to 46	6	0 to 27 28 to 29 30 to 40	38
06S02W05F003	NA	190 to 197	7	0 to 27 28 to 29 30 to 40 46 to 67 68 to 142 144 to 181 183 to 190	177
06S02W06J003	0.005	60 to 65	5	0 to 28 29 to 45 50 to 60	54
06S02W07B023	52.7	23 to 45	22	0 to 23	23
06S02W24J009	1.71	30 to 49	19	0 to 30	30
07S01E09L008	NA	70 to 100	30	0 to 70	70
Average:	75	54[1]	12	--	46
Median:	52	43[1]	10	--	37

Note: Aquifer characteristics were determined from well logs. ft, feet. bgs, below ground surface. NA, not available. --, not calculated. [1] based on midpoint of aquifer depth. [2] these confining layers include clay and silt. [3] this is the total thickness of all clay and silt layers overlying the aquifer unit.

Table 3-3. Proximity of seawater intrusion monitoring wells to streams and tidal incursion extent

Well Number	Nearest River, Stream, Slough, or Channel		Within Extent of Tidal Incursion[1]
	Name	Distance (feet)	
06S01W02N008	Mallard Slough	1,560	Yes[2]
	Coyote Creek	5,750	Yes[2]
06S01W10N006	Guadalupe River	150	Yes
	Stormwater retention pond[3]	150	
06S01W10N007	Guadalupe River	150	Yes
	Stormwater retention pond[3]	150	
06S01W12G005	Coyote Creek	380	Yes
06S01W13C009	Coyote Creek	65	Yes[2]
06S01W14L005	Guadalupe River	2,420	Yes
06S01W17M009	Sunnyvale East Channel	30	Yes
06S01W18R007	Sunnyvale East Channel	10	Yes
06S01W22K010	San Tomas Aquino Creek	2,460	Yes
06S01W24J037	Coyote Creek	122	Yes[2]
06S01W26K001	Guadalupe River	110	Yes
06S02W05F001	Mayfield Slough	45	Yes
06S02W05F002	Mayfield Slough	45	Yes
06S02W05F003	Mayfield Slough	45	Yes
06S02W06J003	Matadero Creek	20	Yes[2]
06S02W07B023	Matadero Creek	1,620	Yes[2]
	Barron Creek	1,310	No
06S02W24J009	Sunnyvale West Channel	1,820	No
07S01E09L008	Coyote Creek	220	No
	Average:	810	--
	Median:	150	--

Note: [1] is based on the mapped extent of tidal incursion (Figures 3-4 and 3-5), and [2] indicates wells not within mapped extent of tidal incursion but within the area of stream gaging stations influenced by tides (Figure 3-5). [3] this large stormwater retention pond is more than 5 acres. --, not calculated. Distances were determined from GIS and represent best estimates. Note that Matadero Creek drains into Mayfield Slough and then into the Bay through a tide gate structure.

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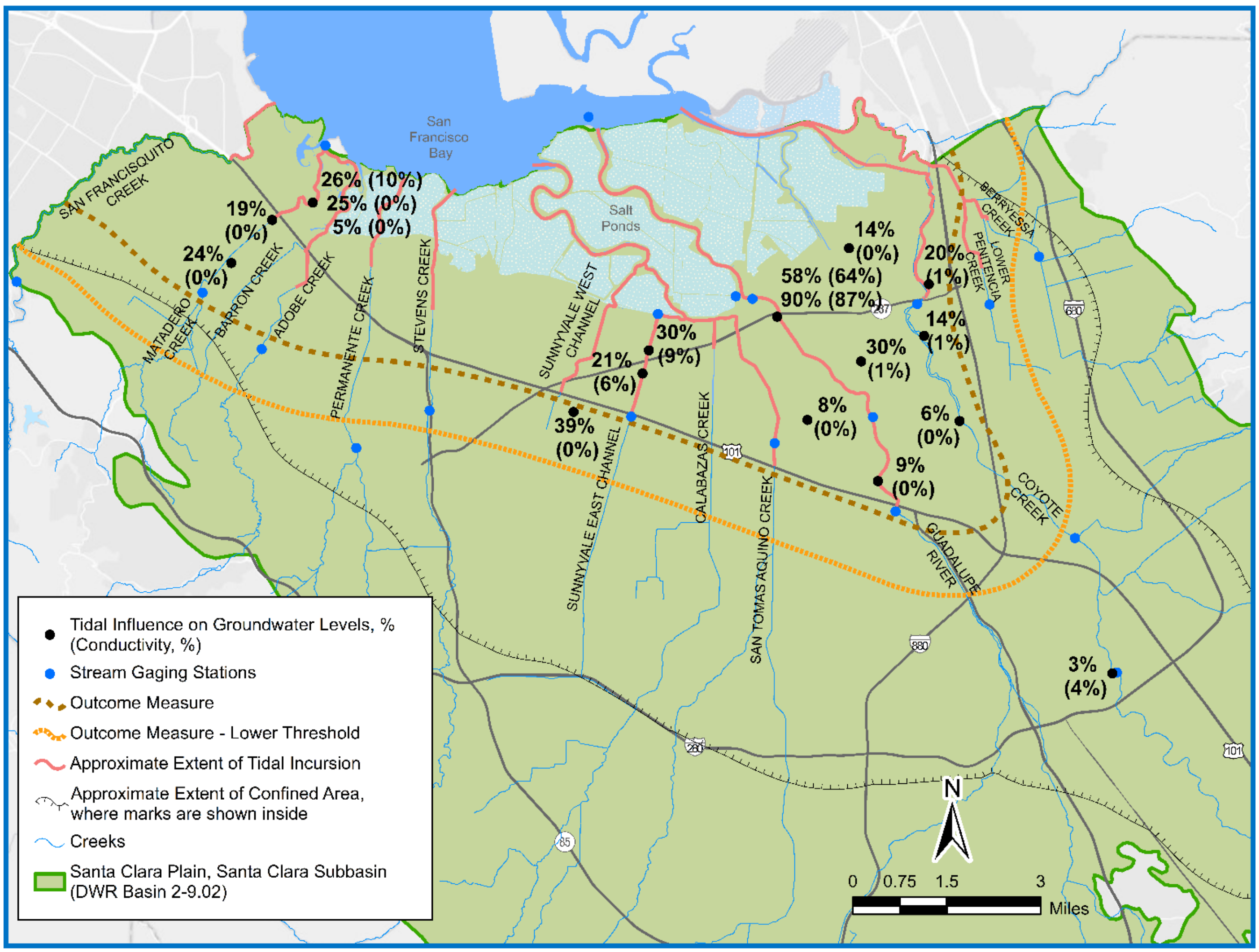
3.4 Tidally Influenced Groundwater

This section describes the seawater intrusion monitoring wells that are tidally influenced and quantifies the tidal variability and lag correlation in groundwater levels and groundwater conductivity[33] as measured in microSiemens per centimeter (µS/cm). Quantifying the link between tides and shallow groundwater provides insight into how and where future sea-level rise may affect shallow groundwater rise and emergence near the South Bay.

The seawater intrusion monitoring wells are located within the outcome measure extent, except for well 06S02W24J009, which is just outside the outcome measure, and well 07S01E09L008, which is about two miles south of the outcome measure–lower threshold extent (Figure 3-4). During a three-month period of analysis (July 1, 2023 to September 30, 2023), the variance in groundwater level and conductivity attributed to the tides ranged from 3% to 90% and 0% to 87%, respectively, depending on the proximity of the well to the Bay and nearest tidally influenced surface-water bodies (Figure 3-6, Table A-2 in Appendix A). Appendix A provides additional details about the methods and results used to quantify the tidal influence on groundwater levels and conductivity.

Figure 3-6. Tidally influenced groundwater levels and conductivity



[33] Also referred to as specific conductance, conductivity is a water quality property that is directly proportional to the concentration of dissolved ions in the water.

All 18 seawater intrusion monitoring wells, even those outside the outcome measure and outcome measure–lower threshold, have statistically significant tidal variance in groundwater levels (Figure 3-6). Similar to the spatial patterns of tidally influenced streams, the wells with the greatest groundwater level variance from tides are near the Guadalupe River, Sunnyvale East Channel, Matadero Creek, and Coyote Creek. However, only 50% (9 of 18) of the wells have statistically significant tidal variance in groundwater conductivity (Figure 3-6). The two wells with the greatest tidal variance in conductivity are 06S01W10N007 and 06S01W10N006 (87% and 64%), which are about 150 feet from the Guadalupe River (Table 3-3). All other monitoring wells have 10% or less tidal variance in conductivity (Figure 3-6, Table A-2).

There is no statistical difference between the percent tidal variance in stream stage and percent tidal variance in groundwater levels (Appendix A). Tidal forcings have similar spatial patterns on stream stage and groundwater levels, indicating that tidal variability in groundwater levels is a response to tidal variability in stream stage. Any future changes to stream stage tidal dynamics, whether from climate change or other anthropogenic factors, are likely to result in changes to groundwater level dynamics. Because of the complex hydrogeology and tidal dynamics, this lack of statistical difference does not necessarily indicate that groundwater levels will have a linear (1:1) response to sea-level rise, as discussed below.

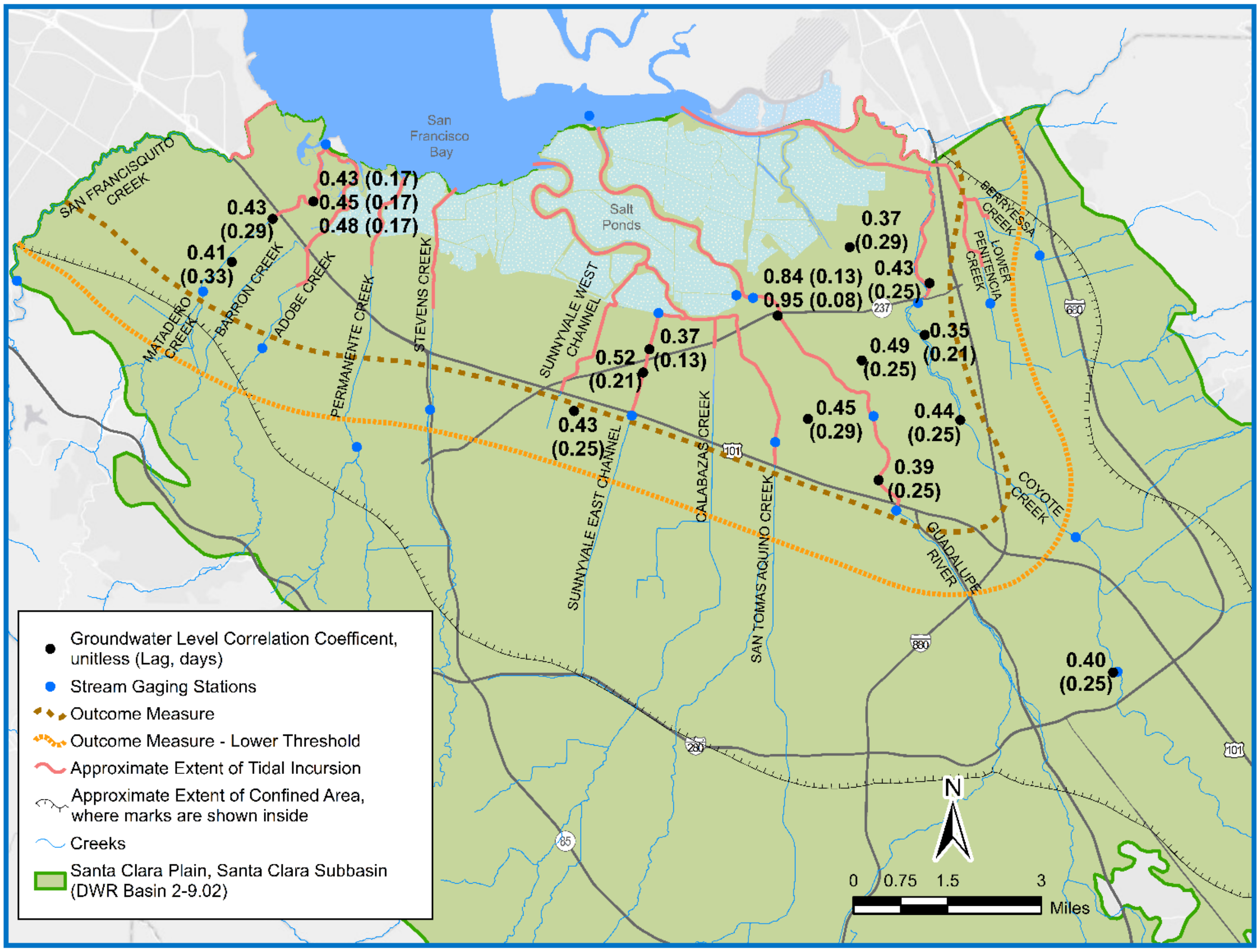
In coastal aquifers, tidal signals in groundwater levels can propagate as pressure waves hundreds of feet or more inland, and these pressure waves attenuate as a function of hydrogeologic properties of the aquifer, including whether an aquifer is unconfined or confined (Carrera et al., 2010), the period of the tidal cycle, and the well distance from the tidal boundary (e.g., Habel et al., 2024; Jiao and Post, 2019; Elad et al., 2017) (Appendix A). Results from this study indicate that tidal signals from tidally influenced stream stages can propagate thousands of feet within the shallow aquifer and be detected in the groundwater levels of the seawater intrusion monitoring network. For example, well 06S02W24J009 is 1,820 feet from Sunnyvale West Channel and has 39% tidal variance in groundwater levels. Similarly, well 06S01W14L005 is 2,240 feet from Guadalupe River and has 30% tidal variance in groundwater levels (Table 3-3 and Figure 3-6). Additional details are presented in Appendix A.

The time lag between tidal signals in stream stage from the nearest stream gage to each well and groundwater levels ranges from 0.08 days at 06S01W10N007 (150 feet to Guadalupe River) to 0.33 days at 06S02W07B023 (1,620 feet to Matadero Creek), with an average of 0.22 days (Figure 3-7 and Table A-2). Monitoring wells with relatively shorter lags tend to be located closer to tidally influenced surface-water bodies, while wells with longer lags tend to be located further away (Figures 3-7 and A-4).

The tidal signals in groundwater conductivity attenuate at much shorter distances than in the groundwater levels (Figure 3-6), and the time lags in groundwater conductivity are generally longer than the corresponding lags in groundwater levels at the same monitoring wells (Table A-2). Results support the conceptual model that tidal fluctuations in steam stage produce relatively fast pressure waves in groundwater levels, especially through the deeper and more confined aquifer units of the shallow aquifer zone in the Baylands. These tidally driven pressure waves in groundwater levels propagate much faster than the actual infiltration of seawater beneath tidal stream flow into the shallow aquifer and corresponding advective transport of seawater in groundwater, which are slower because the tidally driven changes in hydraulic head driving advective transport are attenuated in the unsaturated zone near the stream bed and water table (Elad et al., 2017). This helps explain why only about half of the wells have statistically significant tidal variance in groundwater conductivity, but all wells have statistically significant variance in groundwater level. The regional and local hydraulic gradients and overlying clay layers also act to attenuate the advective transport of seawater in shallow groundwater (Appendix A).

To reinforce the points described above, tidally driven pressure waves that propagate through stream stage and groundwater levels are not the same process as actual leakance of seawater beneath streams and groundwater flow and transport of seawater in the shallow aquifer. These findings are important additions to the conceptual hydrogeologic model of the Baylands (Chapter 2) and have important implications for the spatial extent of shallow groundwater levels and quality response to sea-level rise, including the spatial patterns of groundwater rise and emergence (Chapter 4). Additional details are presented in Appendix A.

Figure 3-7. Lag correlations in tidally influenced groundwater levels



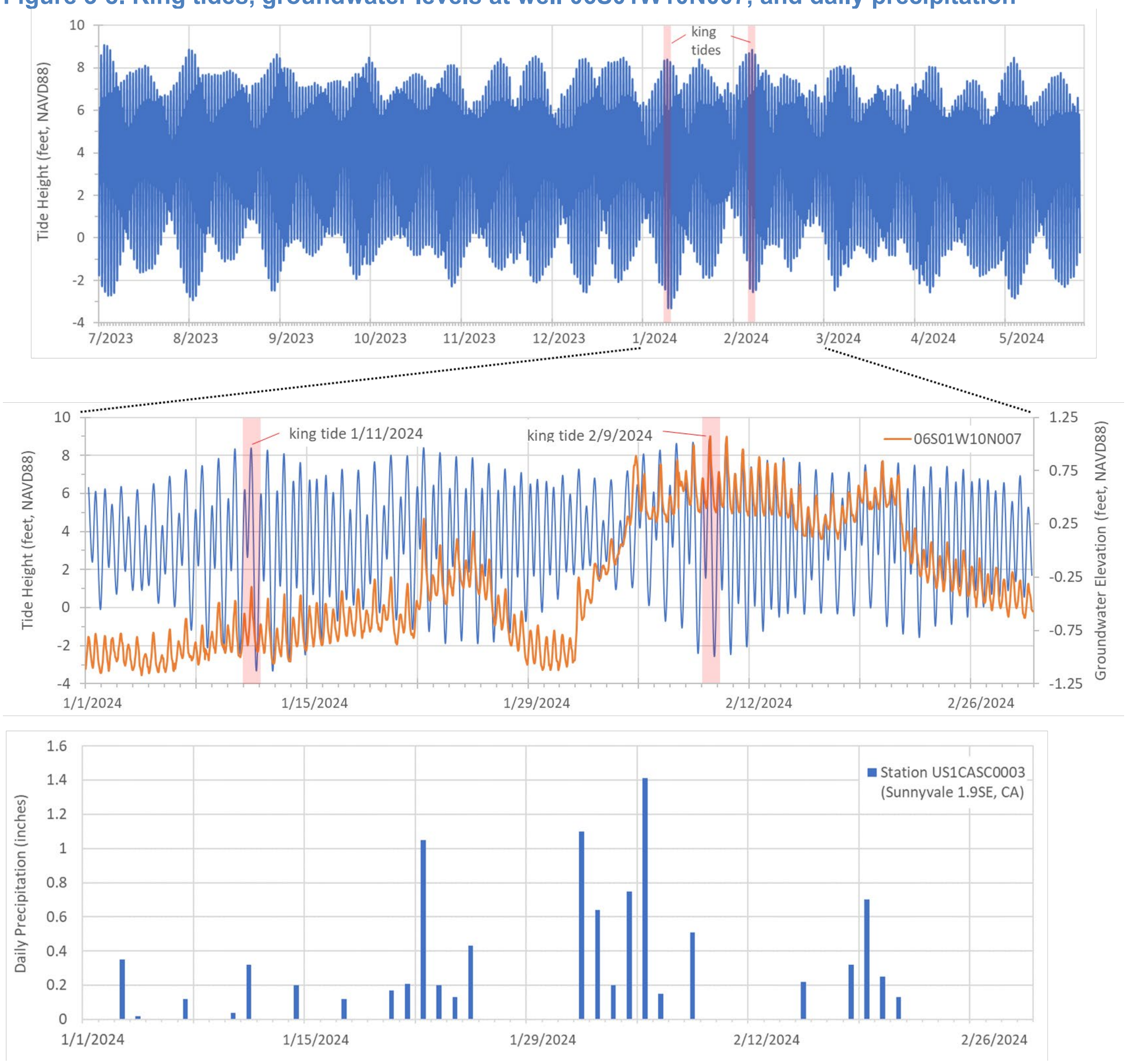
Note: The map shows groundwater level lag correlations to tides (Appendix A).

3.5 King Tides

In early 2024, king tides occurred on January 11 and February 9 and produced some of the largest ranges in higher high water and lower low water levels between July 2023 and May 2024 (Figure 3-8). While king tides often have a large range between high and low tides in the Bay, other tidal patterns can produce higher high tides than king tides. For example, the higher high water levels in July and August 2023 were higher than the January 11 and February 9, 2024 king tides (Figure 3-8). Groundwater level response to the tides in July and August 2023 was previously discussed and shown for select wells from July 1 to September 30, 2023 (Figures A-2 and A-3).

Groundwater level response to king tides is generally similar to tidal patterns during other periods, such as July 1 to September 30, 2023, but with some important differences (Figure 3-8). Well 06S01W10N007 is used to illustrate groundwater level response to king tides because it has the greatest percent variance and strongest lag correlation to tides (Table A-2). Similar to the July to September 2023 period, groundwater level variability at well 06S01W10N007 also closely followed the mixed semidiurnal tidal pattern during the king tide periods, with a typical time lag of less than 0.08 days (2 hours) (Figure 3-8). For example, during the several days leading up to the king tides on January 11 and February 9, the higher high levels in the tides and groundwater levels progressively increased, and conversely, both high tides and groundwater levels progressively decreased in the days following the king tide (Figure 3-8).

Figure 3-8. King tides, groundwater levels at well 06S01W10N007, and daily precipitation



Note: The tide height is from Redwood City, CA station 9414523 and shown as daily higher high water, lower high water, higher low water, and lower low water from 7/1/2023 to 5/31/2024. Groundwater level and precipitation data from 1/1/2024 to 3/1/2024. Negative groundwater elevations indicate groundwater levels are below mean sea level.

While there are many similarities in groundwater level response during the king tides compared to other higher tides during July and August 2023, there are some striking differences caused by precipitation patterns. Most king tides along the California coast and in the Bay typically occur during the wet winter months. For example, there was about 4.75 inches of precipitation during the week before the February 9 king tide, which resulted in a sharp, almost 2-feet increase in groundwater levels and a corresponding muting of the mixed semidiurnal tidal pattern in the groundwater levels (Figure 3-8). Following the king tide, groundwater level reached a maximum on February 10, which was not only the highest water level between July 2023 and May 2024 but also the highest water level over the entire period of record for the well (2008 to present). The record high water level at well 06S01W10N007 was more of a response to the historically wet winter and storms immediately preceding February 9, 2024, rather than a response to the king tide.

Figure 3-8 illustrates that during the wetter winter months, most variability in the groundwater levels at well 06S01W10N007 is attributed to precipitation and, to a lesser extent, to tidal patterns. Because there is 67 feet of overlying clay (Table 3-2) and small storativity values (Table A-3), well 06S01W10N007 is screened in either a confined or semiconfined aquifer. Therefore, the immediate response in water levels at well 06S01W10N007 is not likely caused by the infiltration of precipitation and subsequent flux of recharge into the aquifer at 70 to 79 feet bgs (Table 3-2). Rather, the immediate response in the water levels is more likely caused by confined aquifer "loading" from rainfall and soil moisture (Maliva et al., 2011; van der Kamp and Schmidt, 2017). Similar to how changes in barometric pressure or tides create pressure waves in groundwater levels, confined aquifer loading can occur as rainwater accumulates at the land surface and in soil moisture, increasing the mechanical stress that is instantaneously transmitted to the pore-pressure of the underlying confined aquifer. This loading induces an increase in pressure in the confined aquifer, resulting in rising groundwater levels in wells (Figure 3-8), rather than actual flow of recharge into the aquifer. The rainfall loading process also explains why groundwater levels fall rapidly once the rainfall ends (Figure 3-8), because the mechanical stress is lessened as surface water is removed by evaporation, evapotranspiration, or runoff. As Maliva et al. (2011) warn, "The water management implications of the loading effect on confined aquifers can be profound if the hydrographs are misinterpreted…". Loading from rainfall and soil moisture is an important factor to evaluate when interpreting the groundwater levels in the seawater intrusion monitoring network.

Given the highly heterogeneous hydrogeologic conditions near the Bay, some of the seawater intrusion monitoring wells are screened in shallow aquifers that behave more like unconfined aquifers, with groundwater levels that respond to recharge flux from rainfall, while most other wells in the network are screened in more confined or semiconfined aquifers with groundwater levels that respond more to rainfall- or soil moisture-loading and less to recharge flux (actual flow) from rainfall. These findings help illustrate how groundwater levels near the Bay respond to changes in pressure from tides, stream stage, and rainfall- and soil moisture-loading, and have important implications for how groundwater conditions may respond to future changes in sea level, tides, and precipitation patterns from climate change. Additionally, these findings further support the conceptual model that the "classic" seawater intrusion mechanism likely has a relatively minor role in the spatial extent of seawater intrusion and similarly, may have a limited role in contributing to sea-level rise driven groundwater rise and emergence in the Santa Clara Subbasin.

The California Coastal Commission's California King Tide Project[34] uses citizen science to help visualize future sea levels by observing today's king tides. While king tides are naturally occurring and are not caused by climate change, they provide a regular opportunity during winter months to temporarily experience future conditions that are representative of climate change-induced sea-level rise. King tides approximate future average sea levels because one to two feet of sea-level rise is expected over the coming decades (see Chapter 2). King tides typically occur in winter months and thus coincide with the wet season, winter storms, and rainfall that can increase groundwater levels in the shallow aquifer zone

[34] https://www.coastal.ca.gov/kingtides/

near the Bay. Therefore, Valley Water staff followed a similar rationale as the King Tide Project and used king tides to help ground-truth and verify the estimated groundwater conditions under future conditions. Because of the higher tides in summer 2023, observed groundwater levels from both July and August 2023 and January 11 and February 9, 2024 king tides were used to help verify the groundwater rise and emergence maps for future climate change. Chapter 4 describes these methods, results, and appropriate uses and uncertainty of the groundwater rise and emergence maps.

3.6 Groundwater Quality

Select groundwater quality data collected between 2000 to 2023 from the seawater intrusion monitoring network are summarized here to support the tidal analysis and identify areas of seawater intrusion in the shallow aquifer. These data support the findings that most seawater intrusion monitoring wells are not directly affected by brackish water from tides or show evidence of seawater intrusion. However, at least one well (06S01W10N007) is affected by seawater intrusion and two others (06S02W05F001 and 06S02W05F002) are affected by elevated salinity from evapoconcentration of salts during the geologic past. The following summary is supported by a detailed analysis presented in Appendix A.

In general, the wells with low (<5%) or no tidally influenced groundwater conductivity (Figure 3-6 and Table A-2) have chloride concentrations less than 100 mg/L, which supports the findings from the tidal analysis that groundwater quality in these wells is not influenced by Bay water from tides or seawater intrusion. Four wells have statistically significant decreasing chloride concentration trends, and four wells have statistically significant increasing chloride concentration trends. The remaining ten wells have no trends in chloride concentrations. Most wells with decreasing and increasing chloride trends have no tidally influenced groundwater conductivity and chloride concentrations less than about 200 mg/L.

A notable exception is well 06S01W10N007 that has the greatest tidal signal in water levels and conductivity and the greatest rate of increasing chloride concentrations (86 mg/L per year) of any of the seawater intrusion monitoring wells with water quality data. The 67 feet of overlying clay (Table 3-2) would likely be sufficient to prevent the downward migration of brackish water from the nearby and tidally influenced Guadalupe River based on other wells in the network. However, a reasonable explanation is that the nearby Highway 237 bridges (located within 200 feet) have dozens of subsurface piles and piers that were constructed (and some abandoned) down to depths equivalent to the well screen, which have created preferential flow paths for brackish water from the Guadalupe River to reach well 06S01W10N007. If the bridge construction is causing these water quality trends, it highlights the importance of clay layers in protecting the groundwater quality from brackish or salt water and the need to consider the impacts of subsurface construction on groundwater quality in the shallow aquifer during environmental review and planning.

The three co-located wells (06S02W05F001, 06S02W05F002, and 06S02W05F003) provide unique insight into the vertical heterogeneity of chloride concentrations and sources within the shallow aquifer. The wells are only about 45 feet from the tidally influenced Mayfield Slough (Table 3-3) and are among the closest seawater intrusion monitoring wells to the Bay (Figure 3-4). However, these three wells have substantial differences in groundwater quality. Well 06S02W05F003 is screened in a deeper confined (and artesian) aquifer unit within the shallow aquifer system and shows no evidence of connection with the Bay, while 06S02W05F001 and 06S02W05F002 have elevated chloride not from present-day Bay water but from evapoconcentration of salts from the geologic past. These results illustrate the discontinuous nature of the aquifer units and that the source of chloride (connate, evapoconcentration, or Bay water) can be localized within the shallow aquifer. Additional details are found in Appendix A.

Mouth of Stevens Creek in the Bay during low tide, exposing a channel in the Bay Mud that winds north across the intertidal mud flats. Photo credit: Scott Elkins, Valley Water, taken September 16, 2024 during a spring tide.

CHAPTER 4

Suspected groundwater emergence at Baylands Park during the January 2024 king tide. Photo credit: Jason Gurdak (Valley Water), taken January 8, 2024.

CHAPTER 4 – GROUNDWATER RISE AND EMERGENCE

This chapter evaluates groundwater rise (also called groundwater shoaling) and emergence above land surface, which may occur in some areas of the Santa Clara Subbasin due to tides and sea-level rise. Groundwater emergence refers to groundwater rising above land surface, which is more likely to occur in low-lying areas or surface depressions with existing shallow groundwater in proximity to the San Francisco Bay (Bay).

First, this chapter provides an overview of recent studies and current understanding of groundwater rise and emergence in response to sea-level rise, with a focus on aquifers adjacent to the Bay. Next, new maps are presented that estimate areas near the Bay in Santa Clara County that may experience groundwater rise and emergence under existing conditions and future climate change scenarios. This chapter also describes field observations made by Valley Water staff, which help validate the accuracy of the groundwater rise and emergence maps. Finally, the inherent uncertainties, limitations, and appropriate use of these maps are discussed.

4.1 Recent Studies

Climate change and sea-level rise are expected to have wide-ranging impacts on freshwater resources, including groundwater (Treidel et al., 2012). As understanding of human-induced climate change has grown, the number of scientific publications about climate change effects on groundwater has increased exponentially since the late 1990s and early 2000s (Green et al., 2011). For example, studies show that changes in precipitation and evapotranspiration patterns will directly affect natural recharge patterns (Taylor et al., 2012), and climate change will indirectly affect groundwater by altering water demand and groundwater pumping trends (Gurdak, 2017). Such changes to recharge and pumping may affect groundwater resources that support human water supply and groundwater dependent ecosystems (Klove et al., 2014). While seawater intrusion is a well-known and extensively studied process for more than a century (e.g., Chesnaux, 2015; Werner and Simmons, 2009), climate change and sea-level rise may also exacerbate seawater intrusion caused by groundwater overdraft in coastal and island aquifers (e.g., Zamrsky et al., 2024) and from declining future recharge in some coastal regions (Adams et al., 2024). More recent scientific publications (e.g., Bosserelle et al., 2022; Habel et al., 2024) and related coverage in news outlets and popular press (e.g., KQED, 2023; LA Times, 2023; Science News, 2023; San Francisco Examiner, 2024) have increasingly described groundwater rise and emergence in response to climate change-driven sea-level rise and seawater intrusion.

One of the first studies on California coastal groundwater rise and emergence was published in 2017 by the U.S. Geological Survey (USGS) (Hoover et al., 2017). This study evaluated sea-level rise effects on groundwater rise and emergence at select coastal aquifers in northern, central, and southern California. Hoover et al. (2017) concluded that many areas along coastal California may be vulnerable to sea-level rise-driven groundwater rise and emergence and recommended that improving understanding of the response of California coastal aquifers to sea-level rise will help inform mitigation and adaptation planning.

Applying methods from Hoover et al. (2017), Plane et al. (2019) presented a rapid assessment method to identify sea-level rise-driven groundwater rise and emergence in unconfined and shallow coastal aquifers. They applied this rapid assessment to the Bay Area, including a small part of Santa Clara County, assuming the shallow coastal and unconfined aquifers have a direct connection to the Bay and a linear relation (1:1 response) between sea-level rise in the Bay and groundwater rise. Using a projected sea-level rise of one meter (3.28 feet), Plane et al. (2019) estimated that 2.3 km^2 (0.89 mi^2) of groundwater emergence could occur in some areas of Santa Clara County near the Bay.

Groundwater Response to Tides, Seawater Intrusion, and Sea-Level Rise

Using regional groundwater modeling, Befus et al. (2020) evaluated sea-level rise scenarios to assess the response of shallow groundwater in unconfined aquifers along the California coast, including low-lying areas around the Bay. The groundwater models were developed assuming unconfined aquifers, and the authors note:

> "Along with the increasing exposure of coastal communities to overland flood risk, rising sea levels will cause unconfined coastal groundwater levels (that is, water table) to rise, leading to inland flooding hazards via subsurface connections to the sea." and "Unconfined aquifers in hydraulic connection with rising seas experience shoaling of water tables as the higher sea level and the intrusion of denser marine water force water tables higher."

Because of the regional nature of this modeling study, all aquifers near the Bay were assumed to be unconfined with homogeneous hydrogeologic properties. This assumption likely overestimates actual groundwater rise and emergence. As explained in Chapter 2, the shallow aquifer near the Bay is not an unconfined aquifer because of the abundance of Bay mud and clay layers that create locally confined and semiconfined aquifer conditions. Befus et al. (2020) acknowledged it is critical to constrain the model properties of the aquifer, such as hydraulic conductivity and thickness, to reduce the uncertainty of model-predicted groundwater rise and emergence. Befus et al. (2020) also estimated locations of flux-controlled versus topography-controlled systems, which are concepts described in Chapter 2 of this report.

May et al. (2020) evaluated shallow groundwater in the City of Alameda and explored the links between sea-level rise, precipitation, and shallow groundwater, as well as the location of existing contaminants and emergent groundwater as potential areas of concern. The shallow groundwater in the City of Alameda is hydrologically connected to the Bay and responds to tides. May et al. (2020) included a series of maps showing where groundwater could rise and become emergent under seven sea-level rise scenarios (12 to 108 inches) that are consistent with the Adapting to Rising Tides[35] sea-level rise mapping (Vandever et al., 2017). May et al. (2020) provided an important point about current conditions:

> "…at present, emergent groundwater is not a serious concern for the City of Alameda, apart from groundwater seepage into basements and other subterranean areas."

The report outlined several potential adaptation strategies to address groundwater rise and emergence in response to sea-level rise.

As mentioned in Chapter 1, Valley Water's 2021 Groundwater Management Plan (Valley Water, 2021) presents a seawater intrusion outcome measure and outcome measure–lower threshold based on the 100 mg/L chloride isocontour line (Figure 1-3) from monitoring wells in the shallow aquifer of the Santa Clara Subbasin near the south Bay in Santa Clara County. Appendix H of the 2021 Groundwater Management Plan presents a detailed description of the hydrogeologic conditions and conceptual model of shallow groundwater response to seawater intrusion and sea-level rise. This chapter builds on the concepts and monitoring outlined in Appendix H of the 2021 Groundwater Management Plan.

Similar to the City of Alameda, several cities in Santa Clara County near the Bay, such as Palo Alto, are in relatively low-lying areas with naturally occurring shallow groundwater (see Chapter 2, Figure 2-7). In 2022, the City of Palo Alto published a sea-level rise vulnerability assessment that considers the response of shallow groundwater rise and emergence to future projections of Bay sea-level rise, from 12 to 84 inches, coupled with scenarios of high tide, 100-year storm tide, and wet-weather groundwater conditions (City of Palo Alto, 2022). With 36 inches of sea-level rise, the study concluded that groundwater could rise up to within six feet of land surface at nearly 8,000 residential parcels, three city facilities, eight schools, and other community infrastructure. Under the 36 inches of sea-level rise, groundwater emergence was predicted at about 770 residential parcels in Palo Alto.

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[35] Adapting to Rising Tides is a program developed by the San Francisco Bay Conservation and Development Commission (BCDC) and NOAA's Office for Coastal Management, https://www.adaptingtorisingtides.org/.

In 2022, Pathways Climate Institute and San Francisco Estuary Institute published a report (May et al., 2022) about sea-level rise-driven shallow groundwater rise and emergence in Alameda, Marin, San Francisco, and San Mateo Counties, which generally surround much of the north, east, and west Bay. This study used a slightly modified method from Plane et al. (2019), but similarly assumed that shallow coastal and unconfined aquifers have a direct connection to the Bay and a linear relation (1:1 response) between sea-level rise in the Bay and groundwater rise. May et al. (2022) acknowledged that a 1:1 response is reasonable for some planning purposes but likely produces a higher than anticipated future groundwater rise and emergence in some areas because it simplifies local hydrogeologic conditions that control groundwater flow. Additionally, the study noted that a simplistic 1:1 response does not capture future climate change-induced changes to precipitation and evaporation that may affect future recharge, groundwater pumping, or management actions that affect groundwater conditions and flow direction. May et al. (2022) concluded that:

> "…resultant mapping is not intended to replace the need for site-specific analyses where groundwater flow directions, flow rates, and the interactions with subsurface infrastructure may be important considerations."

The partnership between Point Blue Conservation Science and the USGS Pacific Coastal and Marine Science Center called Our Coast, Our Future[36] has developed a web-based Future Hazard Map interactive tool[37] for exploring modeling results for sea-level rise and storms across California, including groundwater emergence. As with other similar studies, the Our Coast, Our Future hazard maps of groundwater emergence are provided for informational purposes and are "…intended for use as a screening tool to identify locations that may experience increasing groundwater hazards as seas rise."[3] The groundwater emergence maps are based on the USGS Coastal Storm Modeling System (CosMoS) that can be used to project coastal flooding and shoreline change. Because shallow subsurface coastal geologic data is not available for much of California, the CoSMoS groundwater model uses three generalized scenarios to represent the subsurface hydrogeology, including a less permeable, moderate, and more permeable subsurface geology. Due to the generalized assumptions about hydrogeologic conditions, the "…results are sensitive to the choice of geology and do not reflect geologic variability at the local scale; thus, individual regions may vary significantly from predictions."[38]. As an example, under current conditions with 0 feet of sea-level rise, the Our Coast, Our Future groundwater hazard map shows groundwater emergence in large areas of the Baylands that do not currently have groundwater emergence based on Valley Water staff observations from the field and groundwater rise and emergence maps, as presented in Chapter 4 and Appendix D. The CoSMoS groundwater model was also used to estimate shallow and emergent groundwater for coastal flood hazard maps in the San Francisco Bay Conservation and Development Commission (BCDC) Regional Shoreline Adaptation Plan (BCDC, 2024). Similarly, these CoSMoS derived maps likely overestimate emergent groundwater conditions based on field observations and groundwater rise and emergence maps presented in Chapter 4 and Appendix D.

Hill et al. (2023) compared the location of known U.S. Superfund and state-managed contaminated sites in coastal aquifers to areas of projected groundwater rise and emergence from sea-level rise, with a particular focus on Bay Area aquifers. Environmental regulators and remediation practitioners are recognizing the risk of sea-level rise effects on groundwater rise and emergence because of the potential to alter the geochemical, physical, and biological conditions that affect the fate and transport of contaminants in the soil and groundwater at these sites. For example, the San Francisco Regional Water Quality Control Board, as of 2022, requires landfill operators to consider rising coastal groundwater, and California's Department of Toxic Substances Control (DTSC) has developed draft rule changes to require managers of contaminated sites to consider the impact of rising coastal groundwater by early 2023 (Hill et al., 2023). The DTSC requires a sea-level rise vulnerability assessment to be conducted at each stage

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[36] https://ourcoastourfuture.org/

[37] https://ourcoastourfuture.org/hazard-map/

[38] https://ourcoastourfuture.org/science-and-modeling/

of the remediation process to evaluate the resilience of wastes and remedy at the site to future sea-level rise impacts[39]. The Hill et al. (2023) study identified more than 5,000 open and closed sites in the greater Bay Area that may be exposed to groundwater rise and emergence with one meter (3.28 feet) of sea-level rise. Current and future groundwater levels from the Befus et al. (2020) study were used to estimate the locations of groundwater rise from one meter of sea-level rise. Given the previously described uncertainties with the regional scale groundwater model in Befus et al. (2020), more sub-regional and local studies are needed with higher-resolution data, maps, and models to better constrain the impact on contaminated sites, as noted by Hill et al. (2023).

In 2024, Nuestra Casa, a community-based organization serving Latinx families, and San Francisco Bay Area Planning and Urban Research Association (SPUR), a nonprofit public policy organization, published a case study for equitable adaptation to groundwater rise and potential policy responses for the City of East Palo Alto in San Mateo County (Atkinson, 2024). The report identified the need for "short- and long-term strategic and equity-focused planning" and provided five recommendations for policymakers in East Palo Alto and San Mateo County. These planning and policy recommendations were based on the previously published maps of current and future groundwater rise and emergence by May et al. (2022).

In summary, this brief literature review of groundwater rise and emergence studies identifies a clear gap and need to improve the localized understanding, modeling, and mapping of sea-level rise-driven groundwater rise and emergence in the shallow aquifer of the Santa Clara Subbasin, south of the Bay in Santa Clara County. Previous studies also identify a clear need to better understand the physical hydrogeologic system and local-scale controls on groundwater rise and emergence. These knowledge gaps are the primary motivation for the detailed hydrogeologic conceptual model and groundwater tidal analysis presented in Chapters 2 and 3. Additionally, the purpose of this chapter is to fill the gap in mapping groundwater rise and emergence using Valley Water's extensive knowledge of local hydrogeologic and groundwater conditions from groundwater management activities and programs, including data from the seawater intrusion monitoring network described in Chapter 3. As shown in the review of recent studies, proactive communities are beginning to use groundwater rise and emergence maps for planning and policy decisions. Therefore, this chapter also stresses the importance of identifying and discussing the inherent uncertainties, limitations, and appropriate use of maps of current and future groundwater rise and emergence to support informed planning and policymaking decisions.

4.2 Impacts

In general, groundwater rise and emergence have the potential to impact both the built environment and natural systems. Groundwater rise may damage surface infrastructure and/or subgrade structures, such as building foundations, basements, underground parking structures, on-site septic systems, sewer lines, and other underground utilities. According to several studies and press articles (e.g., May et al., 2022), if groundwater rise continues and results in groundwater emergence, aboveground flooding from groundwater emergence could occur even before marine inundation from sea-level rise that overtops the shoreline. Some studies suggest this could happen years to decades before marine inundation and shoreline overtopping in some locations (e.g., Habel et al., 2024).

Before groundwater emergence at land surface, groundwater rise may initially affect sub-grade infrastructure. This rise in groundwater may increase the need for basement sump pumps and other shallow groundwater dewatering activities. Groundwater rise could cause the scour of building foundations and soil erosion, making buildings more susceptible to localized soil sinking, structural damage, and reductions in carrying capacity (May et al., 2020; Habel et al., 2024). Additionally, groundwater rise may increase the risk of groundwater seeping into storm sewer systems, reducing their

[39] California's Department of Toxic Substances Control (DTSC) sea-level rise guidance: https://dtsc.ca.gov/climate-change/

conveyance capacity during storm events. Similarly, underground electrical utilities may also be flooded by rising groundwater.

As groundwater rise approaches land surface, the soil will become saturated and limit infiltration and drainage, impacting natural and built drainage systems (Rotzoll and Fletcher, 2013). Groundwater rise and emergence also have the potential to affect other natural systems, including the quantity and quality of water flowing to groundwater dependent ecosystems (GDEs). As described in Chapter 2 and shown in Figure 2-8, GDEs overlie the Santa Clara Subbasin near the Bay.

This report is not intended to evaluate the impacts to the built environment and natural systems, including GDEs, due to future groundwater rise and emergence above the Santa Clara Subbasin within Santa Clara County. However, as an example of a detailed, city-scale evaluation of potential impacts, the City of Palo Alto's Sea Level Rise Vulnerability Assessment identifies possible impacts to city and community facilities, residential parcels, emergency response, natural resources and open space, transportation, and utilities and flood management (City of Palo Alto, 2022). Additionally, some news articles have focused on potential impacts to specific types of Bay Area infrastructure, like schools, based on the previously described Our Coast, Our Future hazard maps (KQED, 2024a,b). On a broader scale, Habel et al. (2024) provide a comprehensive review of sea-level rise influenced groundwater impacts and management needs for various components of critical infrastructure in coastal regions, including roadways, buildings, conveyance infrastructure (water, waste, and stormwater), on-site sewage disposal, and additional sources of urban and coastal groundwater contamination. As noted by Habel et al. (2024), most sea-level rise vulnerability assessments to date have focused on marine inundation affecting aboveground infrastructure and rarely consider groundwater-related impacts to below- and aboveground infrastructure.

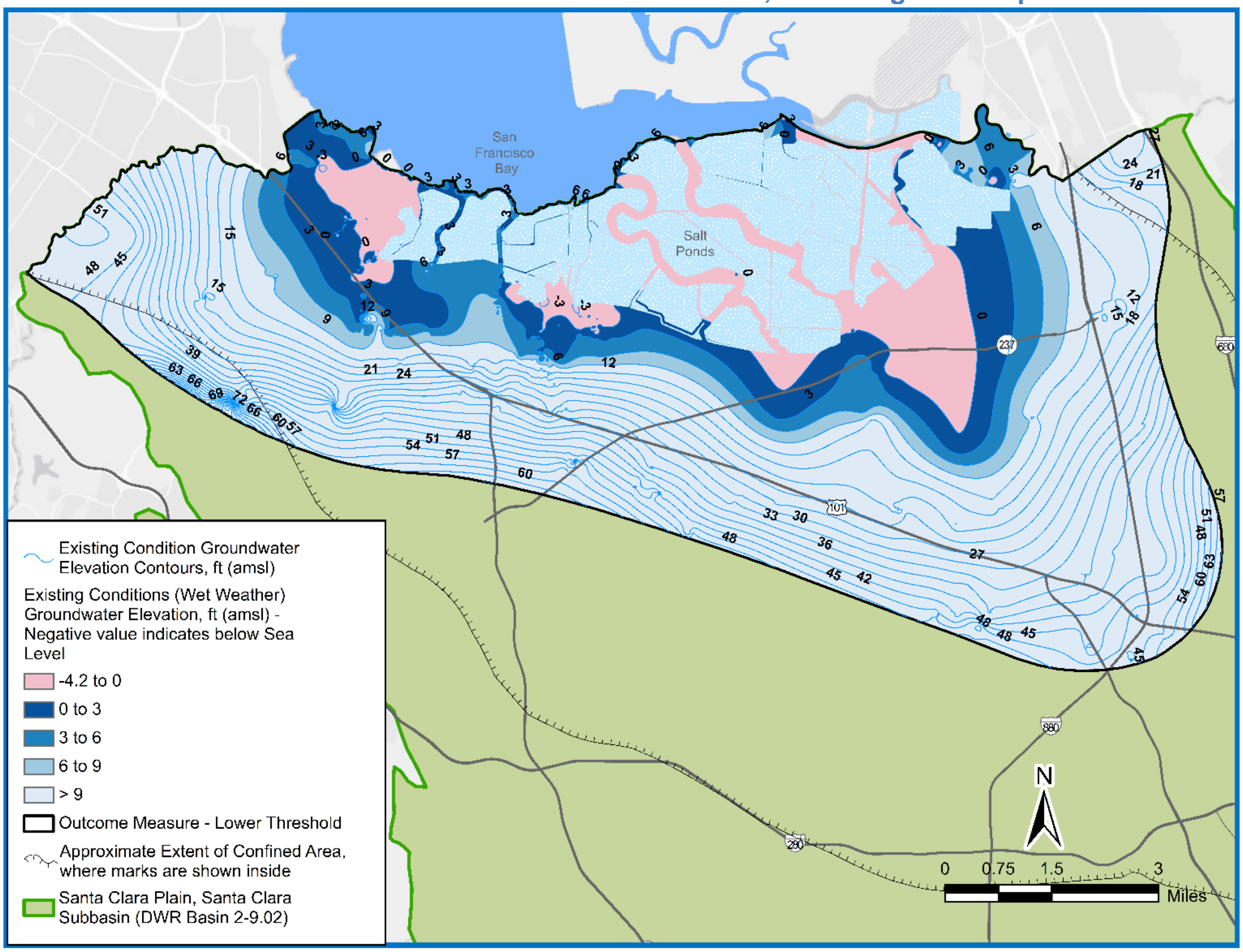
As evidenced by this report and referenced studies, groundwater-related impacts from sea-level rise are being increasingly acknowledged and addressed. The number of future scientific and engineering studies, planning and management actions, and related policies and regulations addressing groundwater-related impacts to the built environment and natural systems are likely to continue growing, given increasing sea-level rise and its intersection with low-lying coastal regions that are home to the largest concentrations of urban development, not only in California and the U.S. but across the globe.

4.3 Existing Highest Groundwater Conditions

For this study, Valley Water created existing highest groundwater conditions maps using methods generally similar to those in Hoover et al. (2017), Plane et al. (2019), and May et al. (2022) to promote consistency with previously published groundwater rise and emergence maps. Detailed information about these methods is provided in Appendix B. The spline interpolation method in ArcGIS Spatial Analyst was used with minimum depth to water well data and control points to create maps of existing highest groundwater conditions, shown as both groundwater elevations relative to mean sea level (Figures 4-1 to 4-3) and as depth to water relative to ground surface, including areas of emergent groundwater (Figures 4-4 and 4-5). These maps represent a temporal composite of the highest recorded groundwater levels at each well between 2000 and 2020, providing a theoretical highest-case scenario for shallow groundwater conditions near the Bay. Given actual variability in recharge and discharge to the shallow groundwater, it is unlikely that all wells would simultaneously have the highest recorded water levels under real-world conditions.

In Figures 4-1, 4-3, and 4-4, the estimated groundwater conditions are excluded (not shown) across the salt pond area to clearly identify the salt pond locations. The salt ponds lack built infrastructure that could be affected by shallow or emergent groundwater. Therefore, Figure 4-2 shows the existing highest groundwater condition, including the area within the salt ponds. Several of these former salt ponds are already in direct connection to the Bay and many more will be breached in the coming decade, as mentioned in Chapter 2. However, it is important to note that Valley Water's 81 square mile seawater intrusion outcome measure–lower threshold area includes 14 square miles of salt ponds. Figure 4-2 shows the existing highest groundwater condition, including the salt pond area, and indicates 2.9 square miles of emergent groundwater, which represents 3.6% of the seawater intrusion outcome measure–lower threshold area. The shallow and emergent groundwater beneath the salt ponds may have implications for the ecosystem and salt pond restoration projects, which are mentioned in Chapter 2. Figure 4-2 indicates that many salt ponds likely have shallow (0 to 3 feet bgs) or emergent groundwater conditions, which is supported by the salt ponds' proximity to the Bay and land surface elevations either at or below mean sea level.

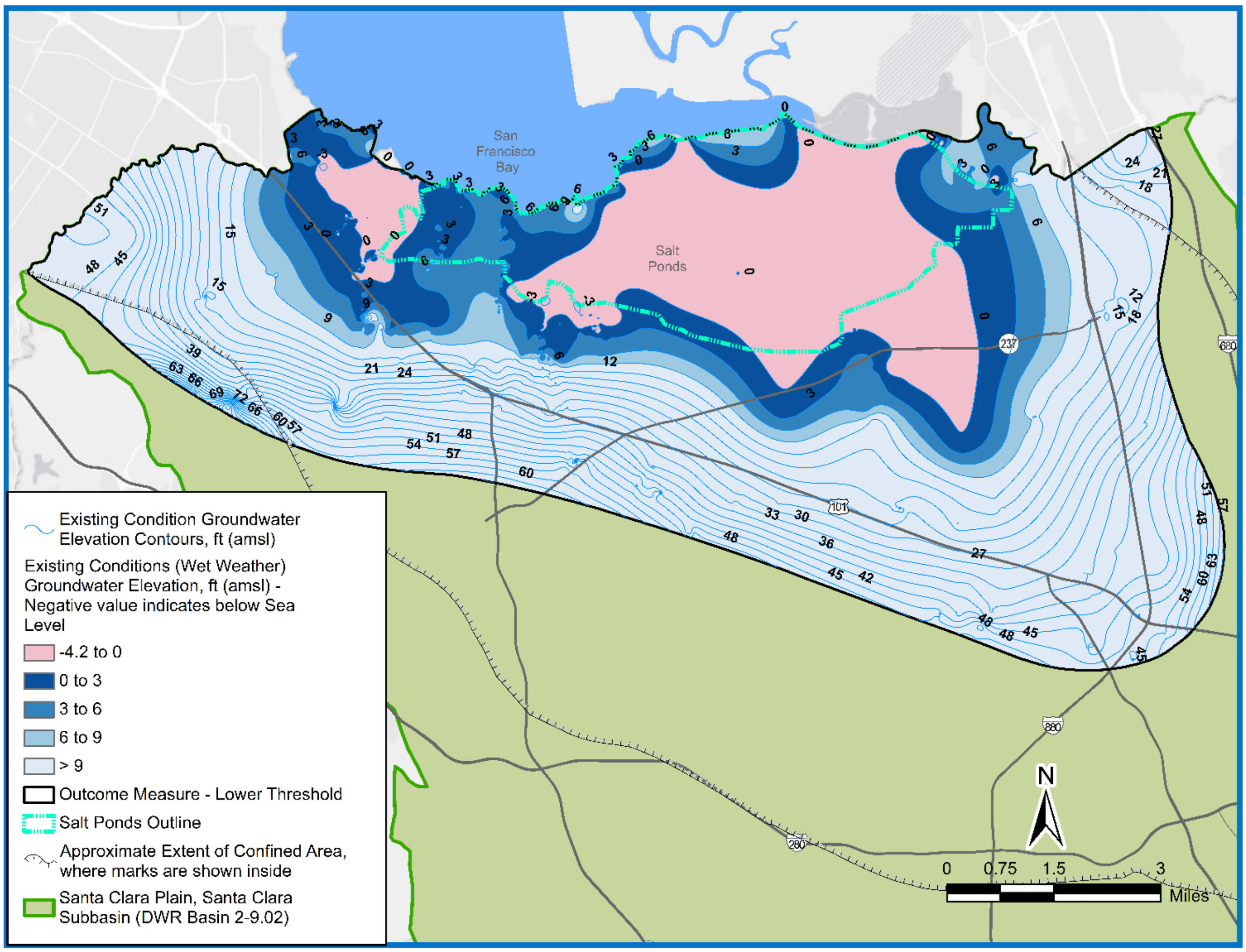
Figure 4-1. Existing highest groundwater elevation conditions within the seawater intrusion outcome measure – lower threshold area from 2000 to 2020, excluding the salt pond area



Note: ft (amsl), feet above mean sea level. This map is a temporal composite of the highest recorded groundwater levels at individual wells between 2000 and 2020 and thus is a theoretical highest case scenario for shallow groundwater. Under real-world conditions, it is unlikely that all wells would simultaneously have the highest recorded water levels.

Maps of existing highest groundwater elevation conditions (Figures 4-1 and 4-2) indicate a relatively low hydraulic gradient[40] for groundwater flow in the shallow aquifer toward the Bay, consistent with the relatively flat land of Santa Clara Valley. In general, the hydraulic gradient is lower in the eastern Baylands and higher in parts of the western Baylands. Most of the seawater intrusion outcome measure–lower threshold area has groundwater elevation contours that are substantially greater than 9 feet above mean sea level, making those areas unlikely to be directly affected by seawater intrusion or sea-level rise because the groundwater elevations are much higher than current or future sea level and tides. However, existing highest groundwater elevations are below mean sea level across nearly 11 square miles (13% of the outcome measure–lower threshold), including about 7 square miles beneath the salt ponds and 4 square miles inland of salt ponds (Figures 4-1 and 4-2). These areas are more likely to be affected by seawater intrusion and sea-level rise because the groundwater elevations are lower than the current mean sea level.

Figure 4-2. Existing highest groundwater elevation conditions within the seawater intrusion outcome measure – lower threshold area from 2000 to 2020

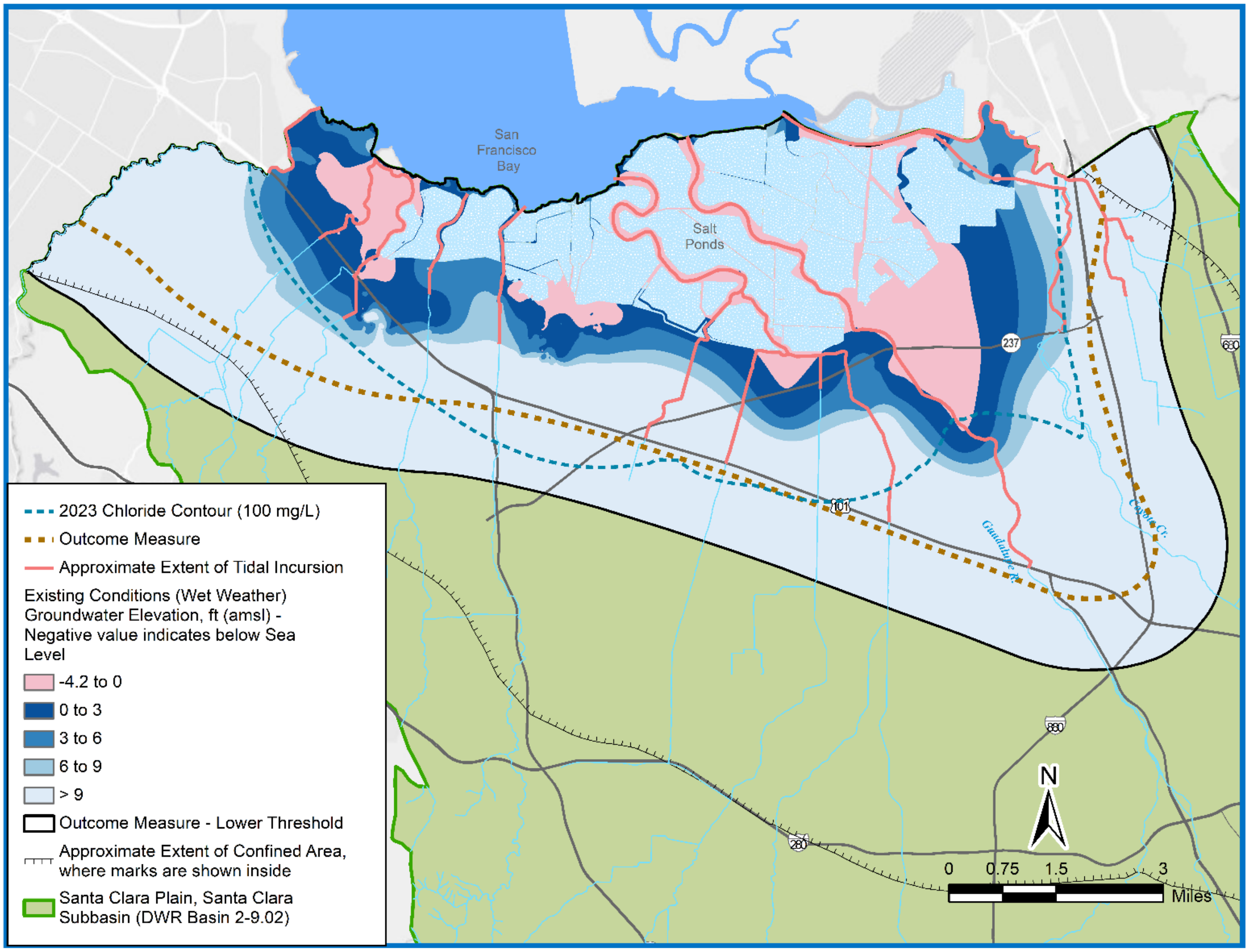


Note: ft (amsl), feet above mean sea level. This map is a temporal composite of the highest recorded groundwater levels at individual wells between 2000 and 2020 and thus is a theoretical highest case scenario for shallow groundwater. Under real-world conditions, it is unlikely that all wells would simultaneously have the highest recorded water levels.

[40] Areas with groundwater elevation contours spread further away have a relatively lower hydraulic gradient than areas with groundwater elevation contours closer together. Groundwater flows from areas of relatively higher elevation contours toward areas of relatively lower elevation contours.

The area with groundwater elevations below mean sea level generally corresponds to the historic subsidence area (see Chapter 2) and the approximate extent of tidal incursion, especially inland along the Guadalupe River (Figure 4-3). The co-location of groundwater elevations below mean sea level and tidally influenced creeks and rivers (Figure 4-4 and see Chapter 3) further supports the conceptual model that the leakance of seawater and brackish water beneath tidal stream flow (Chapter 2) is likely a dominant mechanism that affects seawater intrusion and the 100 mg/L chloride isocontours in the shallow aquifer. The existing highest groundwater elevation maps (Figures 4-1 to 4-3) also have important implications for the uncertainty and appropriate interpretation of future groundwater conditions maps, as discussed in subsequent sections of this chapter.

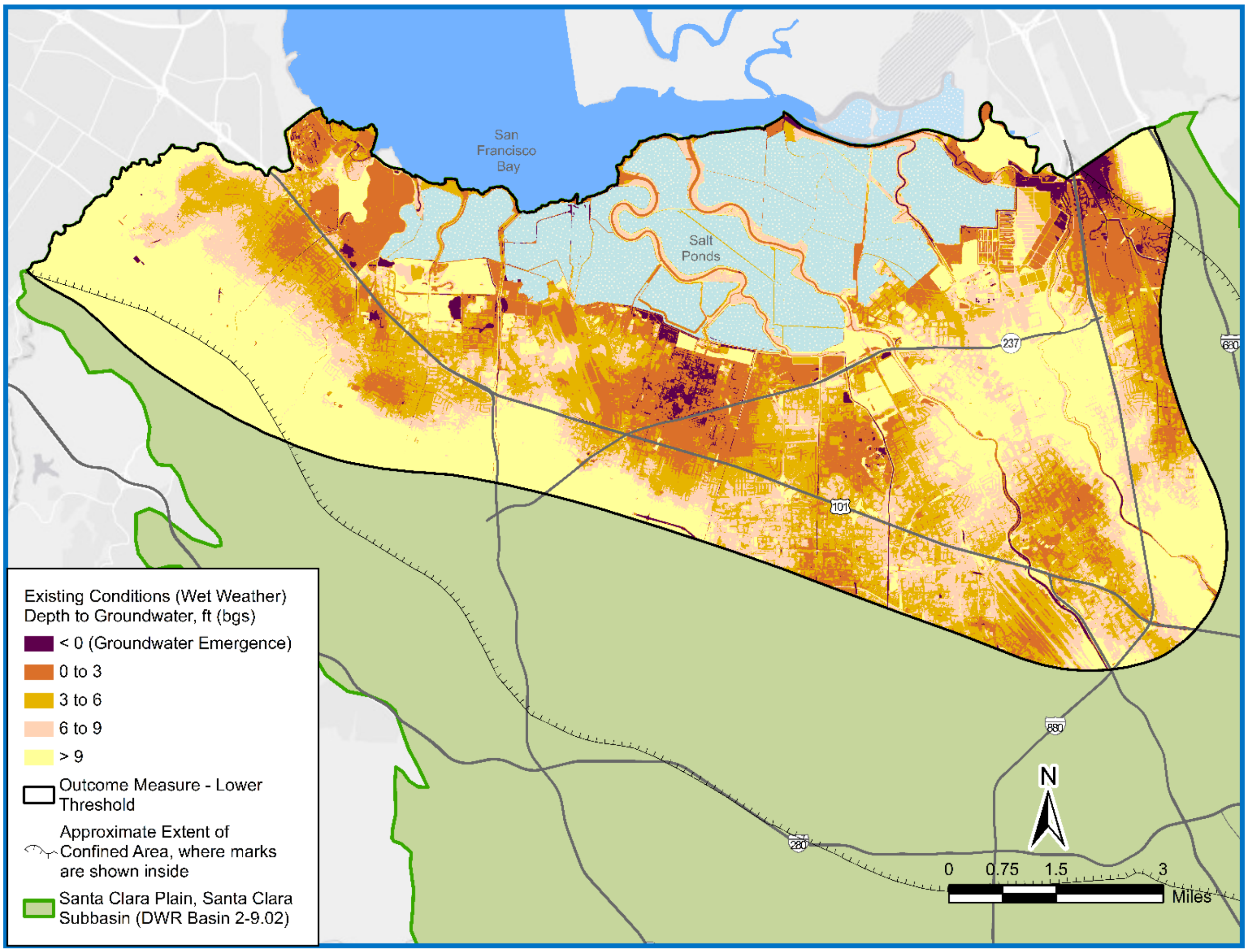
Figure 4-3. Approximate extent of tidal incursion, chloride contours, and existing highest groundwater elevation conditions within the seawater intrusion outcome measure – lower threshold from 2000 to 2020, excluding the salt ponds



Note: ft (amsl), feet above mean sea level. This map is a temporal composite of the highest recorded groundwater levels at individual wells between 2000 and 2020 and thus is a theoretical highest case scenario for shallow groundwater. Under real-world conditions, it is unlikely that all wells would simultaneously have the highest recorded water levels.

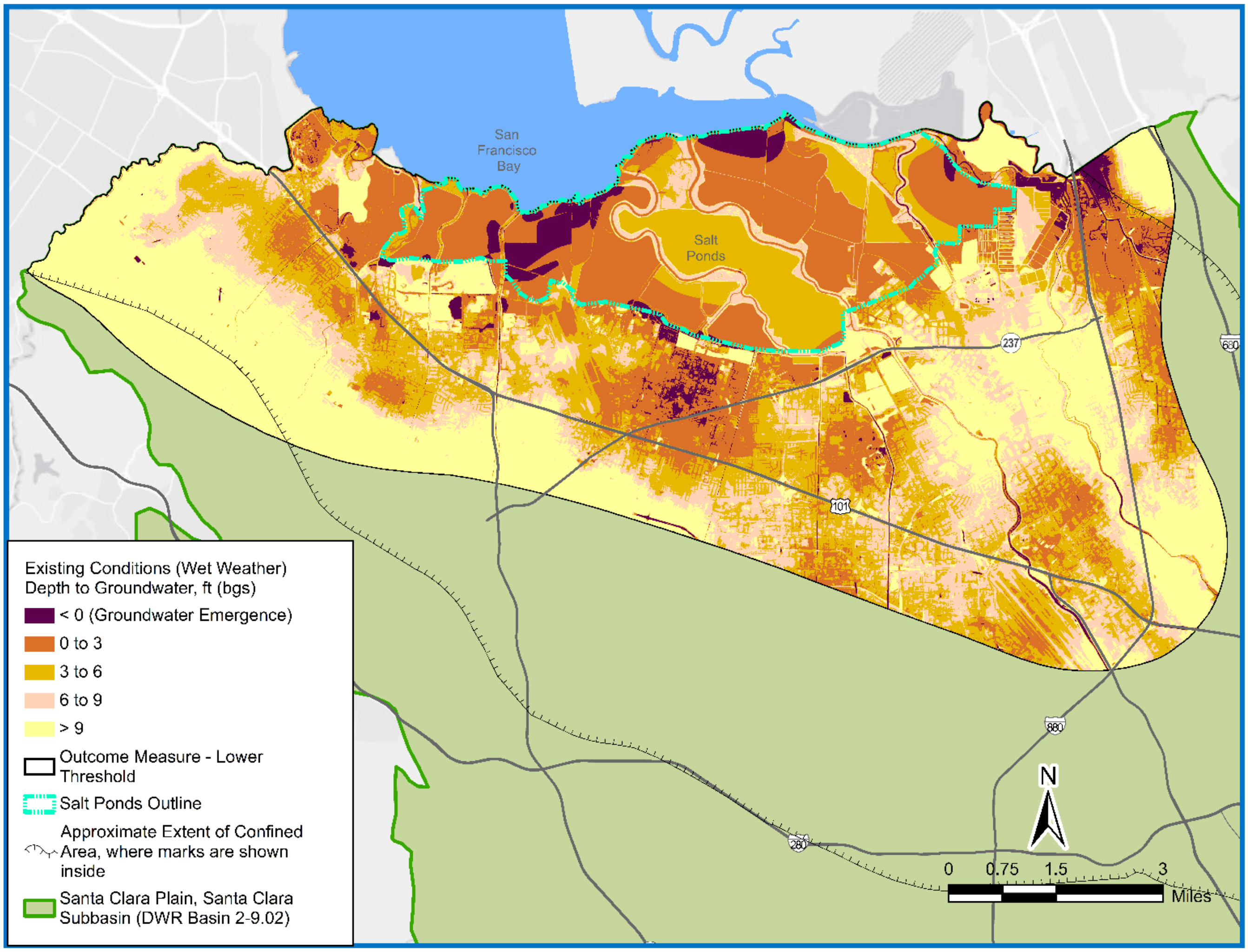
Maps of existing highest groundwater conditions, shown as depth to water relative to ground surface (Figures 4-4 and 4-5), indicate that a considerable area has relatively shallow groundwater below ground surface (bgs). About 12 square miles (15%) of the outcome measure–lower threshold area (81 square miles) have shallow groundwater less than 3 feet bgs, excluding the salt ponds (Figure 4-4). Including the salt ponds, the area with shallow groundwater (0 to 3 feet bgs) is 20 square miles (25%) of the outcome measure–lower threshold area (Figure 4-5). Some areas with shallow groundwater (0 to 3 feet bgs) are in the southern Baylands, far from the Bay, and based on groundwater elevations (Figures 4-1 to 4-3), are not likely to be affected by tides or seawater intrusion. Areas of emergent groundwater tend to be closer to or beneath the salt ponds (Figures 4-4 and 4-5). About 1.7 and 2.9 square miles (2.1% and 3.6%) of the outcome measure–lower threshold area have estimated groundwater emergence, excluding and including salt ponds, respectively (Figures 4-4 and 4-5). However, these interpolated areas of shallow and emergent groundwater are likely overestimates of actual conditions, as discussed in subsequent sections of this chapter.

Figure 4-4. Existing highest groundwater conditions, shown as depth to water below ground surface, within the seawater intrusion outcome measure – lower threshold from 2000 to 2020, excluding the salt ponds



Note: ft (bgs), feet below ground surface. This map is a temporal composite of the highest recorded groundwater levels at individual wells between 2000 and 2020 and thus is a theoretical highest case scenario for shallow groundwater. Under real-world conditions, it is unlikely that all wells would simultaneously have the highest recorded water levels. This map tends to overestimate the presence of shallow and emergent groundwater.

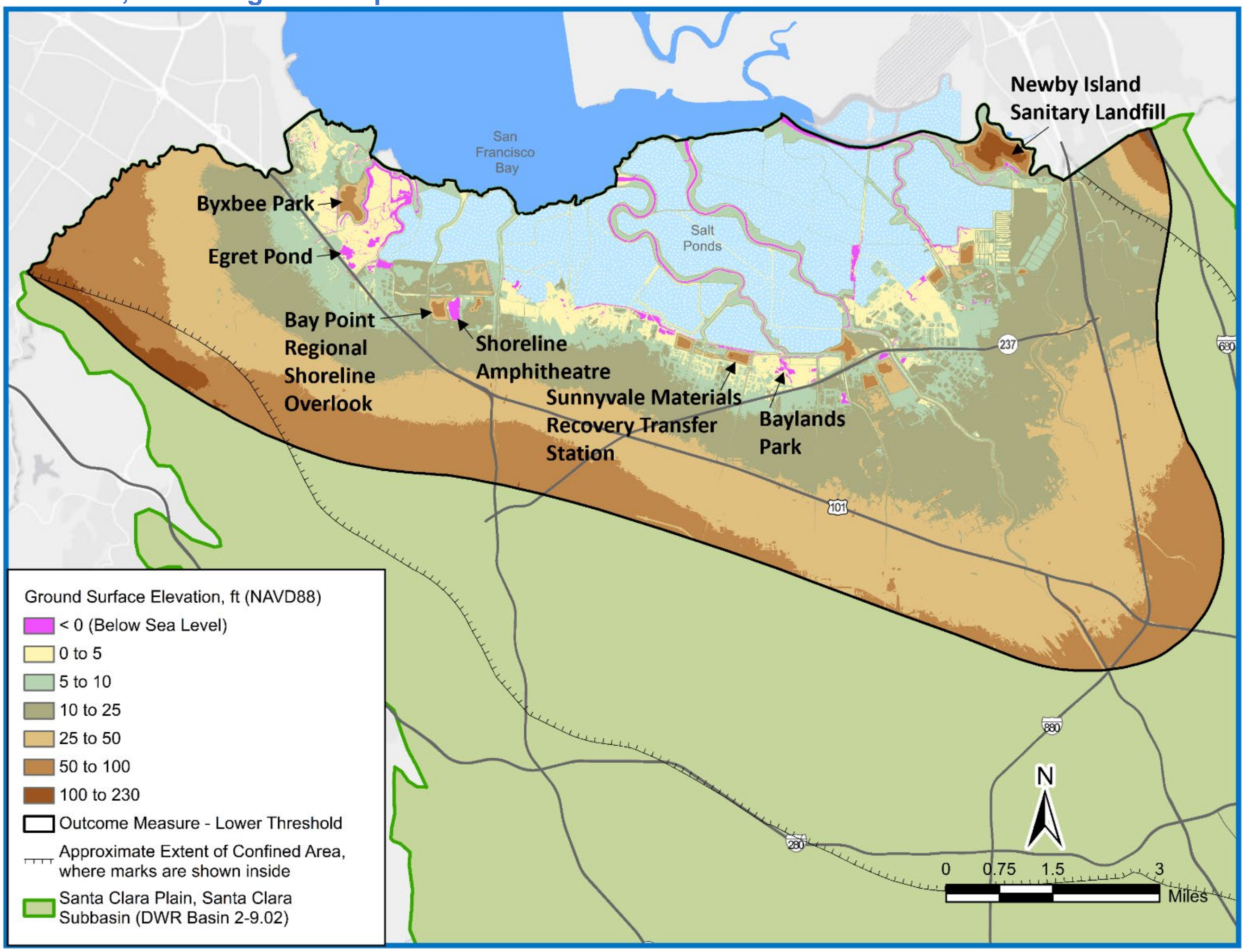
Figure 4-5. Existing highest groundwater conditions, shown as depth to water below ground surface, within the seawater intrusion outcome measure – lower threshold from 2000 to 2020



Note: ft (bgs), feet below ground surface. This map is a temporal composite of the highest recorded groundwater levels at individual wells between 2000 and 2020 and thus is a theoretical highest case scenario for shallow groundwater. Under real-world conditions, it is unlikely that all wells would simultaneously have the highest recorded water levels. This map tends to overestimate the presence of shallow and emergent groundwater.

The existing highest groundwater conditions maps (Figures 4-1 to 4-5) were reviewed for potential inconsistencies caused by data or interpolation errors. Ground surface elevations (Figure 4-6) at specific locations were compared to areas mapped as having shallow and emergent groundwater within known wetlands and field observations by Valley Water staff. For example, the Baylands Park wetlands in Sunnyvale have ground surface elevations below sea level (Figure 4-6) and corresponding 0 to 3 feet mapped depth to groundwater (Figures 4-4 and 4-5). Other areas with low ground surface elevation, such as Egret Pond and Shoreline Amphitheatre (Figure 4-6), also have areas mapped as having shallow or emergent groundwater (Figures 4-4 and 4-5). Valley Water staff conducted field investigations at many of these low-lying areas with mapped shallow or emergent groundwater during recent king tides, as described in subsequent sections of this chapter. Conversely, some areas of relatively deep mapped groundwater (>9 feet bgs) near the salt ponds (Figures 4-4 and 4-5) are consistent with known elevated land masses, such as Byxbee Park in Palo Alto, the City of Sunnyvale Materials Recovery Transfer Station, and Newby Island Sanitary Landfill in Milpitas (Figure 4-6). This comparison of ground surface elevation at specific locations with existing highest groundwater conditions maps generally confirmed expectations and the conceptual model (Chapter 2). Areas with low-lying ground surface, especially those below sea level, tend to have shallow or emergent groundwater, while areas with elevated ground surface tend to have deeper, non-emergent groundwater. However, there are other, more spatially extensive uncertainties and errors associated with the existing highest groundwater conditions map, as described next.

Figure 4-6. Ground surface elevation within the seawater intrusion outcome measure – lower threshold, excluding the salt ponds



Note: Ground surface elevation based on 1 x 1 feet resolution LiDAR. Locations highlighted on the map are examples of low-lying (below sea level) and elevated ground surface elevations.

Valley Water used spline interpolation in ArcGIS to create Figures 4-1 to 4-5 because this method typically generates groundwater elevation and depth to groundwater maps that are reasonably smooth and representative of actual groundwater conditions. The spline interpolation method uses a mathematical function that minimizes overall surface curvature, resulting in a smooth surface that precisely honors the input data points. Valley Water has applied the spline interpolation method in most other published groundwater level maps, such as the previously mentioned annual groundwater elevation maps and depth to first groundwater maps (Figure 2-7).

Other common interpolation methods include kriging and inverse distance weighting (IDW), while May et al. (2022) used a multi-quadratic radial basis interpolation method. Each of these methods uses known data points and different mathematical functions to predict unknown values across a given geographic area, which inherently introduces uncertainty into maps by underestimating or overestimating the interpolated values. To illustrate this uncertainty, Appendix C includes four versions of the existing highest groundwater condition map, each produced using spline, kriging, IDW, and multi-quadratic radial basis interpolation methods. As detailed in Appendix C, each method results in substantially different locations and areas of shallow and emergent groundwater. The spline method produced the smallest areas of shallow and emergent groundwater, while the other three methods resulted in 2.5 to 3 times greater areas of emergent groundwater and incorrectly identified large areas that do not have groundwater emergence based on historical or current observations (Appendix C). The analysis in Appendix C supports a best-use practice of using the spline interpolation method for creating maps of existing highest groundwater conditions.

Given the inherent uncertainties of the interpolation method used to produce the existing highest groundwater conditions maps (Figure 4-1 to 4-5), an independent data set was used to help validate the maps. The exceptionally wet winter of 2022 to 2023 resulted in historical high groundwater levels in many wells throughout Santa Clara County, including the index well 07S01W25L001 (Figure B-1). The highest groundwater levels from January 2023 to May 2023 were compared to the map of existing highest groundwater elevation conditions (Appendix C). This validation indicates that the existing highest groundwater conditions map tends to overestimate the locations of shallow and emergent groundwater, with observed depth to water generally being deeper (lower elevation) than estimated on the map. Additional details of the validation are provided in Appendix C, offering important insight into the proper interpretation and appropriate use of the existing highest groundwater conditions maps (Figures 4-1 to 4-5). Because these maps tend to overestimate the presence of shallow and emergent groundwater, the maps of future groundwater conditions assuming sea-level rise also likely overestimate future conditions of shallow and emergent groundwater, as discussed in the next section.

The maps of existing highest groundwater condition are based on interpolating groundwater levels from shallow wells (<50 feet bgs) in the shallow aquifer, which may be screened in confined or semiconfined aquifers. As discussed in Chapter 3, the shallow aquifer has complex and heterogeneous vertical sequences of Bay mud and clay layers that tend to restrict direct hydraulic connection between Bay water and shallow groundwater. While some wells used for interpolation may have direct hydraulic connection with tidally influenced streams or the Bay, most wells are screened in semiconfined or confined aquifers and have water levels that are more responsive to changes in pressure from tides, stream stage, and rainfall- and soil moisture-loading (Chapter 3).

Given the complex hydrogeology and the lack of driller's logs for most wells in the shallow aquifer zone, it is very difficult to quantify the relative degree of direct hydraulic connection with sources of saltwater from tidal streams or the Bay. Based on findings from Chapter 3, it is likely that a relatively large percentage of wells used for the interpolation have water levels that respond significantly to pressure changes (from tides, stream stage, or rainfall), rather than direct hydraulic connections. Therefore, many of the water levels used for interpolation are more representative of the potentiometric surface[41] of the confined or semiconfined aquifers and not the water table of an unconfined aquifer. While water in a well may rise above the top of a confined aquifer due to the pressure changes, the actual groundwater in the confined aquifer will not necessarily rise above the top of the confined aquifer because the groundwater is restricted (or confined) by the overlying clay layers. The implication is that many areas within the maps of the existing highest groundwater conditions (Figures 4-4 and 4-5) may be more representative of the

[41] The potentiometric surface refers to the level of water rise in wells above the top of a confined or semiconfined aquifer unit. If no wells are screened within a confined aquifer, the potentiometric surface represents the theoretical elevation that groundwater would rise above the confined aquifer if not trapped or restricted by the overlying confining clay layers. Potentiometric surface is the total hydraulic head of groundwater in the confined or semiconfined aquifer.

potentiometric surface of underlying confined or semiconfined aquifers and less representative of water levels in an unconfined aquifer that are responsive to sea-level rise or changing hydrology with rapidly rising water levels or emergence at land surface. Additionally for these reasons, the maps of existing highest groundwater conditions likely overestimate the locations of shallow and emergent groundwater. These concepts have important implications for interpreting how groundwater rise and emergence may respond to future changes in sea level, tides, and precipitation patterns from climate change.

4.4 Future Groundwater Rise and Emergence

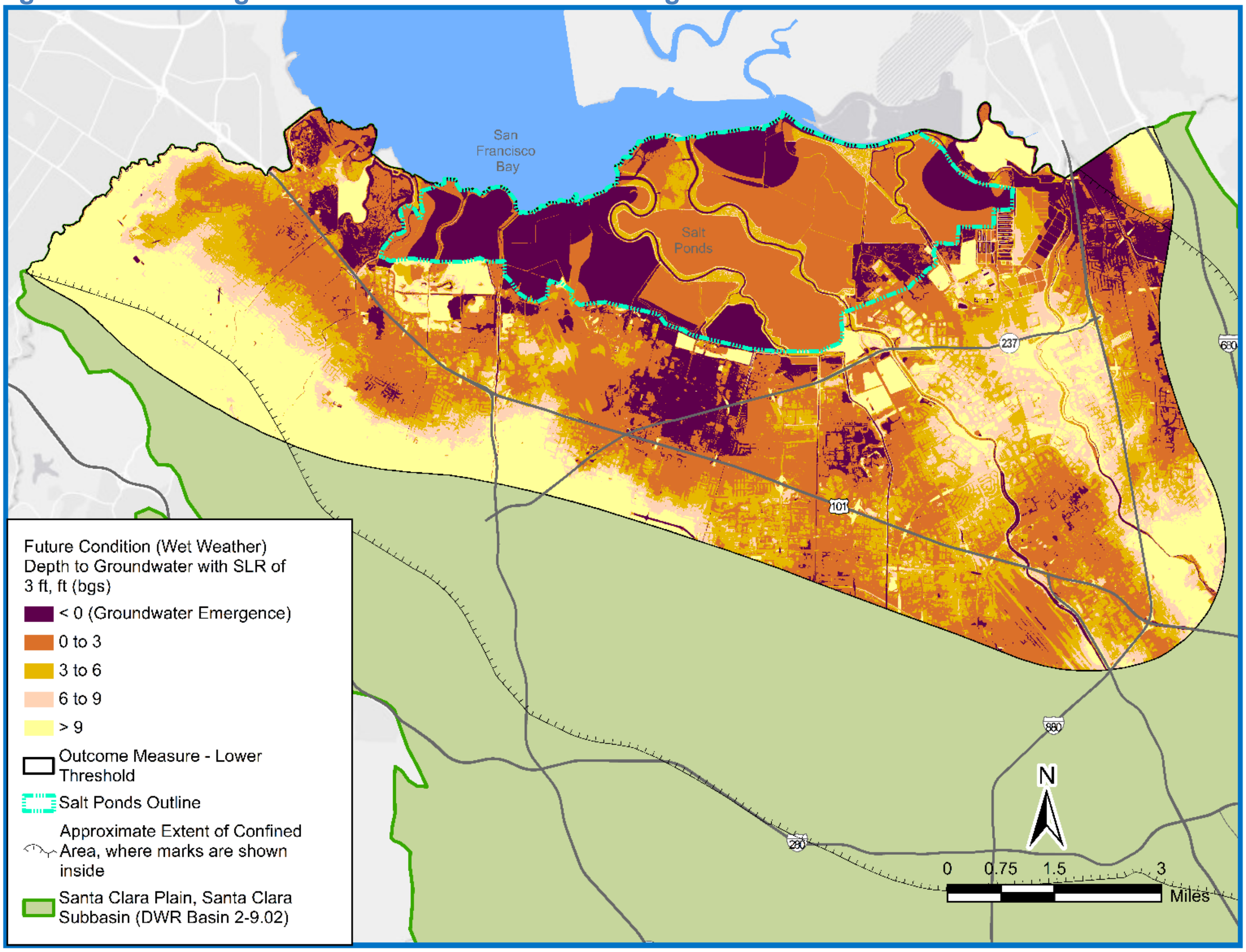
Previous studies that have evaluated the potential for groundwater rise and emergence in response to sea-level rise in the Bay have assumed a 1:1 relation between sea-level rise and water table rise (Hoover et al., 2017; Plane et al., 2019; Befus et al., 2020; May et al., 2020, 2022). However, the rate of groundwater rise in response to sea-level rise is unlikely to be exactly linear (1:1) unless a groundwater system behaves like a flux-controlled system. As explained in Chapters 2 and 3, the shallow groundwater system near the Bay in Santa Clara County is highly complex and likely behaves more like a topography-limited system, rather than a flux-controlled system. However, to maintain consistency with previously published studies, this study created future groundwater rise and emergence maps using the same linear (1:1) assumption, which likely overestimates the occurrence.

To illustrate the potential groundwater rise and emergence response to climate change, maps were created assuming sea-level rise of 0.5, 1.0, 3.0, 5.0, and 6.5 feet, with a linear (1:1) response between sea-level rise and groundwater rise and emergence. These maps and related analysis are summarized here with detailed information in Appendix D. As explained in Chapter 2 and Appendix D, these five sea-level rise scenarios were selected because they correspond to OPC (2024) recommended Intermediate, Intermediate-High, and High scenarios for San Francisco Bay. For example, 0.5 feet of sea-level rise corresponds to about the year 2030 under the Intermediate, Intermediate-High, and High scenarios (Table D-1). By 2100, the projected sea-level rise is approximately 3.0 feet for Intermediate, 5.0 feet for Intermediate-High, and 6.5 feet for High scenarios (Table D-1).

Maps of future groundwater conditions assuming 3.0 feet of sea-level rise indicate that a considerable area surrounding and beneath the salt ponds will have shallow groundwater (0 to 3 feet bgs) and groundwater emergence (Figure 4-7). Under this scenario, excluding the salt pond area, 23 square miles are estimated to have shallow groundwater and 7 square miles with groundwater emergence, which correspond to 28% and 8.6%, respectively, of the 81 square mile saltwater intrusion outcome measure–lower threshold area (Table D-2). Figures 4-7 indicates substantial areas of groundwater emergence in parts of Palo Alto, Sunnyvale, and Milpitas, including infrastructure such as Highways 237 and 880. Generally, the projected areas of future groundwater emergence (Figures 4-7) are similar to the estimated areas of existing groundwater emergence (Figure 4-4 and 4-5). However, Figure 4-8 illustrates that these areas are projected to expand in the future.

The maps of future groundwater conditions assuming sea-level rise, including Figures 4-7 and others in Appendix D, likely overestimate future conditions of shallow and emergent groundwater because they are based on the maps of existing highest groundwater conditions that tend to overestimate the presence of shallow and emergent groundwater, as previously discussed in Chapter 4 and Appendices C and D. Additionally, other factors that will affect future groundwater conditions, such as changes to rainfall patterns, are not considered in these maps. To characterize the uncertainty and likely overestimate of future groundwater conditions, a field study was conducted during the January and February 2024 king tides to help validate the maps of future groundwater rise and emergence, which is discussed in the next section.

Figure 4-7. Future groundwater conditions assuming 3.0 feet of sea-level rise



Note: bgs, below ground surface. This map assumes a linear (1:1) response between 3.0 feet of sea-level rise and groundwater level rise. Because the map of existing highest groundwater condition tends to overestimate the presence of shallow and emergent groundwater, this map may also overestimate future shallow and emergent groundwater.

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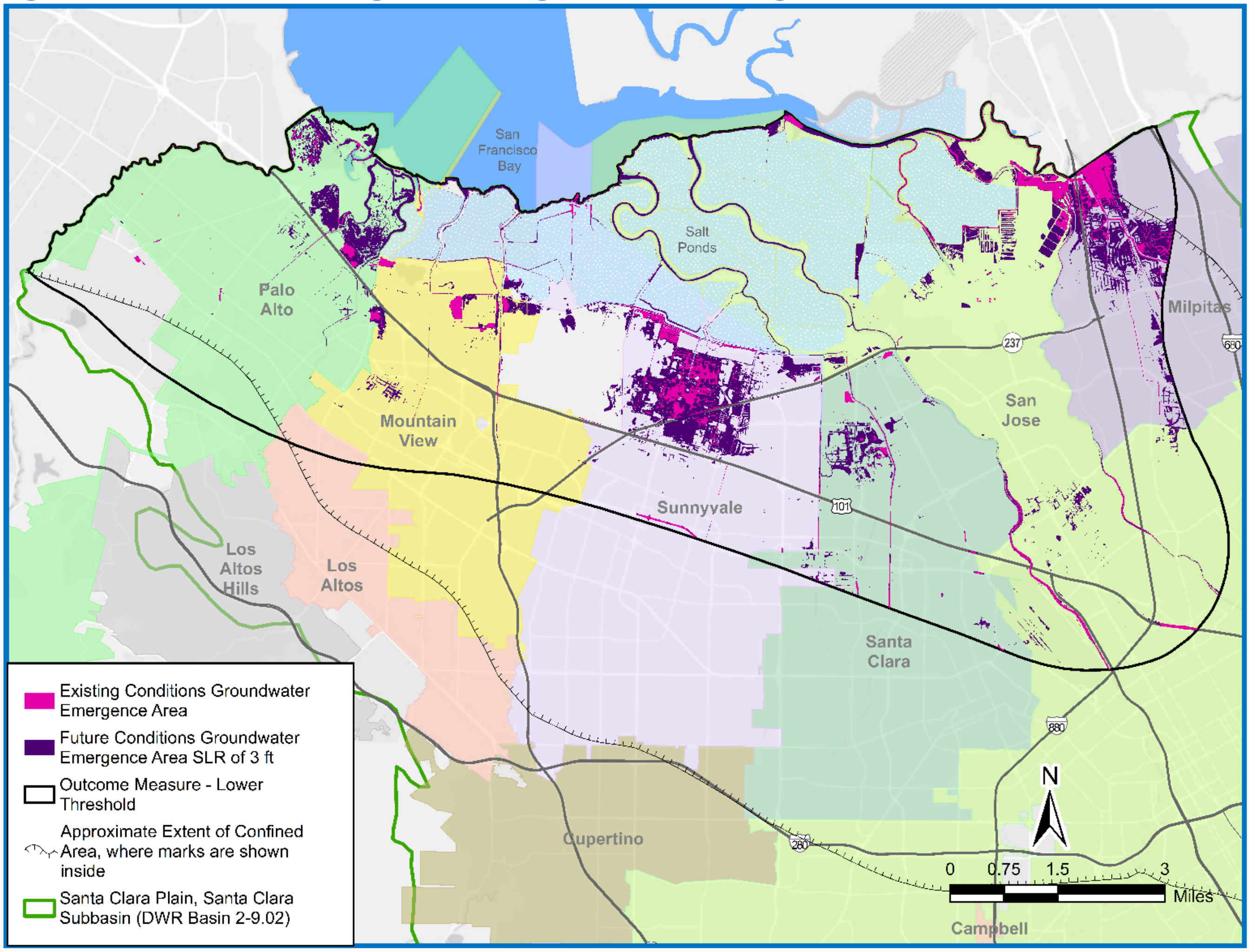
Figure 4-8. Estimated existing and future groundwater emergence with 3.0 feet of sea-level rise



Note: SLR, sea-level rise. This map assumes a linear (1:1) response between 3.0 feet of sea-level rise and groundwater level rise. Because the map of existing highest groundwater condition tends to overestimate the presence of shallow and emergent groundwater, this map may also overestimate future shallow and emergent groundwater.

4.5 Field Validation of Groundwater Rise and Emergence During King Tides

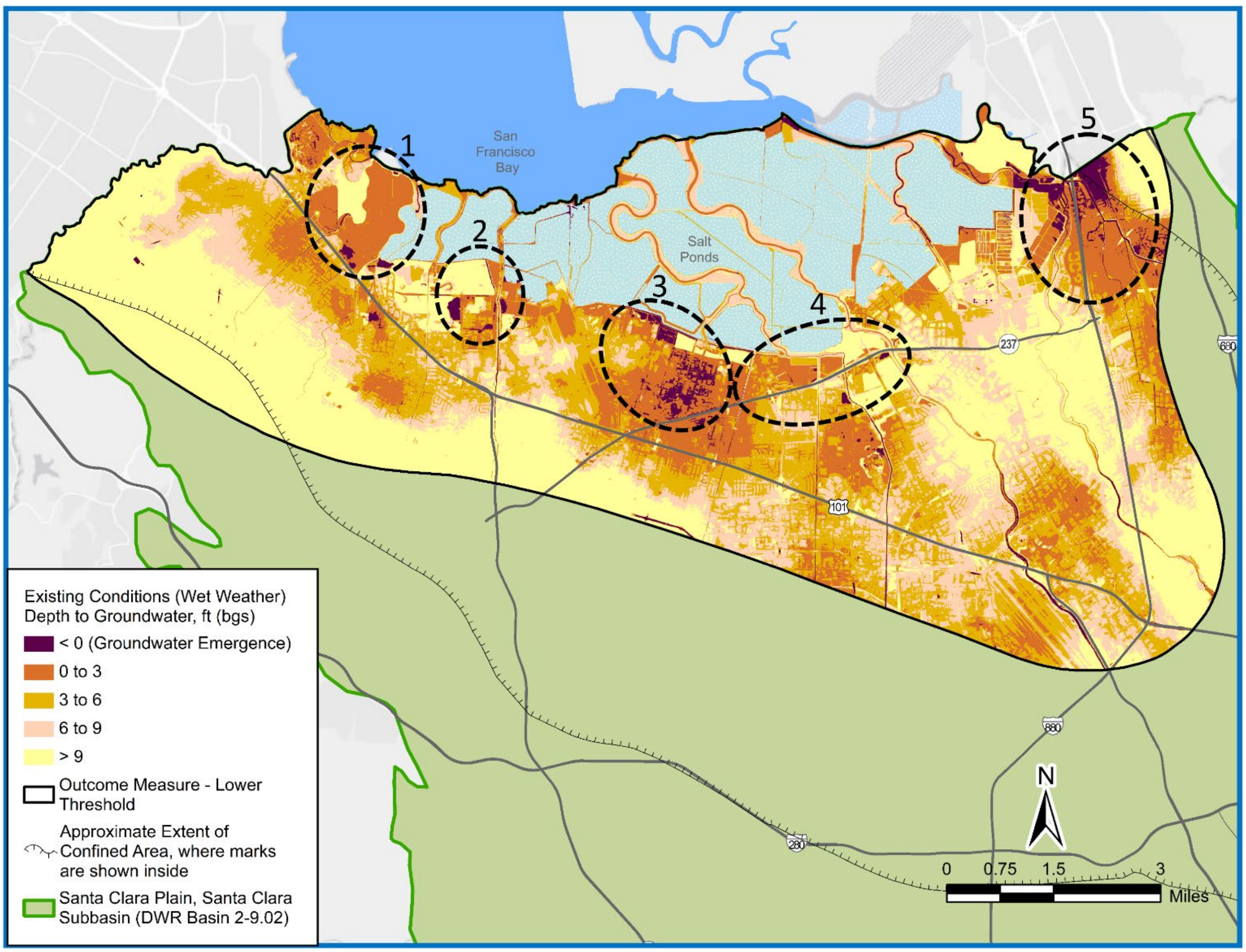
Valley Water staff made field observations during the winter 2024 king tides to help validate the maps of existing and future groundwater rise and emergence. As discussed in Chapter 3, king tides in the Bay are typically one to two feet higher than the average high tide and therefore approximate projected future sea-level rise for the Intermediate to High scenarios by the middle to late twenty-first century. The California Coastal Commission's California King Tide Project uses king tide events to help the public visualize future sea levels and related impacts by observing today's king tides. In much the same way, Valley Water staff conducted a field study during the January 11 and February 9, 2024 king tides to observe and document any groundwater emergence and help validate the groundwater rise and emergence maps for future sea-level rise scenarios. These two king tides occurred during one of the wettest winters in recent record when many groundwater elevations were at their highest over the past several decades, as described in Chapter 3 and Appendix B. Tide height and select groundwater level response during these king tides were previously discussed in Chapter 3 (Figure 3-8 and related text), including the general finding that groundwater levels from the seawater intrusion monitoring wells responded in varying degrees to king tides and other higher tides in 2023, with some notable differences.

Field observations during the king tides were conducted at five general locations (Figure 4-9), which were selected because they all have areas mapped (interpolated) as having existing conditions of shallow groundwater (0-3 feet bgs) and groundwater emergence at land surface:

- Location 1 is the area surrounding Byxbee Park and Egret Pond in Palo Alto.
- Location 2 is the area surrounding Shoreline Amphitheatre in the City of Mountain View.
- Location 3 includes the City of Sunnyvale Water Pollution Control Plant and neighborhoods south to Highway 237.
- Location 4 includes the areas surrounding the City of Sunnyvale Materials Recovery Transfer Station, Twin Creeks Sports Complex, and Baylands Park.
- Location 5 includes areas in the City of Milpitas, south of Newby Island Sanitary Landfill, near Highway 880.

These five locations also include many of the previously discussed areas where ground surface elevation is below sea level (Figure 4-6). Appendix D provides additional details about site selection, observations, and photos during the king tides.

Figure 4-9. Five locations of field observations during the January 11 and February 9, 2024 king tides, modified from Figure 4-4



Note: ft (bgs), feet below ground surface.

Valley Water staff observed groundwater emergence in some very localized areas, as illustrated in Figure 4-10 and detailed in Appendix D (Table D-4). However, most areas mapped (interpolated) as having groundwater emergence on Figures 4-4 and 4-5 either had direct connection to tidally influenced surface water or did not show any evidence of groundwater emergence during the king tide events. Within the five locations observed, a total of 42 areas that are mapped as having groundwater emergence (Figure 4-9) were observed by Valley Water staff during the king tides or evaluated using Google satellite images[42] to help visually identify the presence of direct connection to surface water because not all areas were accessible in the field. As summarized in Table 4-1, of the 42 areas mapped (interpolated) as having groundwater emergence, field observations showed that only 3 (7%) were confirmed groundwater emergence and 11 (26%) were suspected groundwater emergence, for a combined 33% of the areas mapped (interpolated) as having groundwater emergence. The confirmed and suspected groundwater emergence areas covered about 0.007 and 0.176 square miles, respectively, for a total of about 0.183 square miles. Of the remaining areas with field observations (Table 4-1), 19 (45%) had direct connection to surface water or the Bay but may have unknown groundwater emergence and 9 (22%) showed no evidence of groundwater emergence and are likely overestimates of mapped (interpolated) groundwater emergence. Additionally, Valley Water staff observed suspected groundwater emergence in two areas that were not mapped (interpolated) as having groundwater emergence in Figure 4-9. While these field observations confirm some groundwater emergent areas have transient responses to king tides, other areas with direct subsurface connection to the Bay may require a longer or more persistent rise in sea level to show groundwater emergence. See Chapter 5 for recommended monitoring.

Table 4-1. Summary of field observations during the January and February 2024 king tides in 42 areas mapped (interpolated) as having groundwater emergence (based on Figure 4-9)

Results of Field Observations	All 42 Areas Mapped as having Groundwater Emergence						
	Location 1	Location 2	Location 3	Location 4	Location 5	Total	
Confirmed groundwater emergence	1	0	0	2	0	3 (7%)	14 (33%)
Suspected groundwater emergence	3	3	1	2	2	11 (26%)	
Direct connection to surface water or Bay	4	1	1	6	7	19 (45%)	28 (67%)
No evidence of groundwater emergence	0	4	1	0	4	9 (22%)	
Total	8	8	3	10	13	42 (100%)	

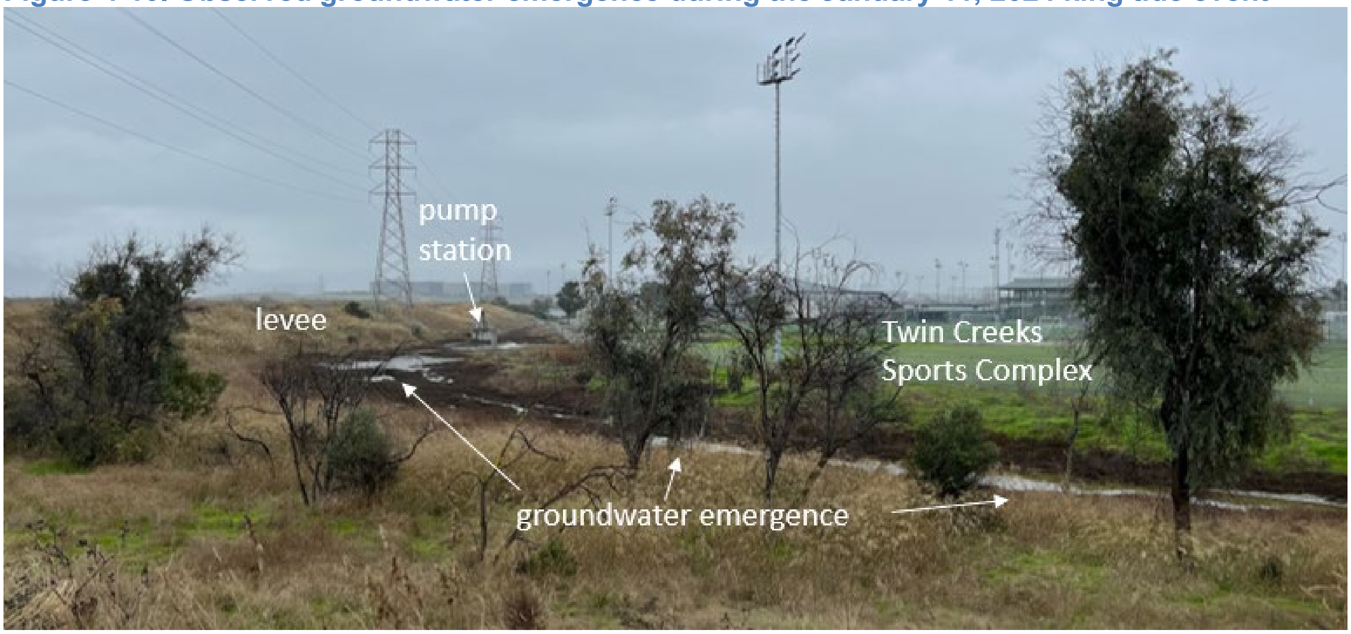
Note: This table is a summary of the details in Table D-4.

In all cases of confirmed or suspected groundwater emergence, the areas were in undeveloped locations near the Bay, such as wetlands, preserves, or parks. Most areas of confirmed and suspected groundwater emergence appear in long-term natural features, like ephemeral ponds, wetlands, and depressions in the land surface. Nearly all areas of confirmed or suspected groundwater emergence were far from developed commercial or residential areas or infrastructure. In the one case where

[42] The dates of the Google satellite images are unknown but likely to do not correspond with the same time period as the field observations in January and February 2024. Therefore, the satellite images were used primarily to help visually identify the presence of direct connection to surface water in areas that were not accessible in the field and based on the reasonable assumption that changes to the landscape have not change dramatically in between the time of the satellite images and the field observations.

groundwater emergence was adjacent to development and infrastructure (Figure 4-10), a pump station is actively being operated to address the groundwater emergence.

Figure 4-10. Observed groundwater emergence during the January 11, 2024 king tide event



Note: Groundwater emergence in Location 4 (Figure 4-9) immediately adjacent to the levee on the south side of Sunnyvale East Channel, south of saltpond A4 near Twin Creeks Sports Complex (photo by Jason Gurdak, Valley Water, taken on January 10-12, 2024). Appendix D provides additional details about groundwater emergence in this area.

The land surface elevation is an important control on observed groundwater emergence. Within the outcome measure–lower threshold area, excluding the salt ponds, about 1.4 square miles (1.7%) and 4.8 square miles (5.9%) have land surface elevations below sea level (< 0 feet) and 0 to 5 feet above sea level, respectively (Figure 4-6). All areas of confirmed groundwater emergence have land surface elevations below sea level (Table D-4). Similarly, all areas of suspected groundwater emergence occurred where land surface elevation was below sea level, except in Location 2 that has suspected areas with 0 to 5 feet and 5 to 10 feet above sea level and Location 5 that has suspected areas with 5 to 10 feet above sea level (Table D-4). Nearly all areas of mapped groundwater emergence with direct connections to tidally influenced streams are below sea level, except for areas in Locations 2 and 5 that are 0 to 5 feet and 5 to 10 feet above sea level (Table D-4). Conversely, most areas that lack observed groundwater emergence have land surface elevations greater than 5 feet above sea level (Table D-4). The field observations confirm that land surface elevation, particularly elevation below sea level is an important predictive factor that should be considered during monitoring and mapping of existing and future groundwater emergence. For example, the total area of mapped groundwater emergence under existing conditions assuming a 1:1 rise with sea level (1.7 square miles, Figure 4-4) is about 20% greater than the total area below sea level (1.4 square miles, Figure 4-6). This may indicate the maps tend to overestimate groundwater emergence conditions given the close agreement with observed and suspected groundwater emergence in land below sea level (Table D-4).

Because only 33% of the areas mapped (interpolated) as having groundwater emergence areas had confirmed or suspected groundwater emergence (Table 4-1), results of the field observations further support the findings that the maps of existing highest groundwater conditions tend to overestimate actual conditions. The remaining 67% of the areas mapped as having groundwater emergence areas either had direct connection to tidally influenced surface water or had no observed groundwater emergence during the king tides (Table 4-1). King tides approximate one to two feet of future sea-level rise and the field observations were conducted during one of the wettest years on record. Additionally, the king tides occurred after rainfall events, which could have either further contributed to groundwater rise and emergence or created localized puddles at land surface and the illusion of groundwater emergence. Therefore, the general lack of observed groundwater emergence supports the conclusions that the maps of existing and future groundwater rise and emergence tend to overestimate conditions, especially the areas of estimated groundwater emergence during 3 feet of sea-level rise highlighted in Figure 4-8.

Several important insights can be drawn from the field observations that are relevant for groundwater rise and emergence in Santa Clara County and potentially other areas surrounding the Bay:

- Given the complexities of the Bay shoreline and surrounding land use and infrastructure, field observations are necessary to properly evaluate and validate mapped groundwater rise and emergence under existing conditions.
- Field observations are particularly important during wet winters and king tides, especially if these maps of groundwater rise and emergence will be used to support management and policy decisions.
- The field observations, along with other lines of evidence (Appendices C and D) support the conclusion that these maps are more likely to overestimate, rather than underestimate, the presence of groundwater rise and emergence in most areas of Santa Clara County.
- Based on field observations, communities and land-use planners appear to be generally aware of existing conditions of groundwater emergence because nearly all confirmed and suspected areas of groundwater emergence were in undeveloped areas, wildlife preserves, and parks.
- Based on geologic evidence (Appendix D), field observations during the king tides (Appendix D), and groundwater quality results (Chapter 3 and Appendix A), the groundwater emergence phenomenon is not likely a new process caused solely by present-day tides or climate change induced sea-level rise, but rather a geologically persistent and endemic process of the south Bay shoreline and associated shallow groundwater system. Localized groundwater emergence has likely occurred throughout the geologic past and will likely continue in the future.
- As a follow-up field investigation, Valley Water staff visited the same 42 areas during the November 2024 king tide. Valley Water staff observed groundwater emergence in only one of the 42 areas (at Location 1, The Bowl, Appendix D), highlighting the temporal variability of areas with field-observed groundwater emergence. The nearly complete lack of observed groundwater emergence in these 42 areas during the November 2024 king tide further highlights the tendency of the maps to overestimate the existing and future groundwater rise and emergence in the Santa Clara Subbasin.

The field observations during the January, February, and November 2024 king tides represent a snapshot in time and a baseline for existing conditions. Longitudinal field observations over time at these five locations and 42 areas, particularly those below sea level, will likely help track how conditions change with rising sea levels. For example, any future expansion of groundwater emergence in one of the confirmed or suspected areas of groundwater emergence may provide a relatively early warning, possibly before other areas begin to have groundwater emergence. See Chapter 5 for monitoring recommendations.

4.6 Uncertainty, Limitations, and Appropriate Use

This chapter and associated appendices present maps of current and future groundwater rise and emergence. These maps are a type of groundwater model. All models have inherent uncertainty and limitations because they are representations of the real world. Dr. Eileen Poeter modified the famous

George Box quote[43] and posed the question "If all [groundwater] models are wrong, how do we know which are useful?"[44] This question is addressed by the information presented throughout this chapter and summarized below. Discussing model uncertainty and limitations is crucial because they directly affect the appropriate uses and interpretations of the groundwater rise and emergence maps presented here.

The usefulness of the maps of current and future groundwater rise and emergence depends on both the map maker and map user. The map maker should clearly explain how the maps were created and describe the inherent uncertainties and limitations, even if this involves presenting technically challenging information to the public and non-experts. The map user should understand how the maps were made and their inherent uncertainties and limitations and evaluate how those factors may impact related management, planning, or policy decisions. This section summarizes the previously described uncertainties and limitations of the maps presented in this chapter and offers some insights into the appropriate uses and interpretations. Users of these maps may have different goals or needs and should carefully evaluate the appropriate uses and make their own interpretations.

First, it is important for the map user to understand that the existing groundwater condition maps represent a temporal composite of the highest recorded groundwater level at each well between 2000 and 2020 and therefore show a theoretical highest-case scenario for shallow groundwater conditions near the Bay. However, given actual variability in recharge and discharge to the shallow groundwater, it is unlikely that all wells would have the highest recorded water levels simultaneously under actual, real-world conditions.

As described in chapters 3 and 4, many wells used to create these maps are likely screened in confined and semiconfined aquifers. While some wells used to create the maps may have direct hydraulic connection with tidally influenced streams or the Bay, many wells are screened in confined or semiconfined aquifers and thus have water levels that are more responsive to changes in pressure from tides, stream stage, and rainfall- and soil moisture-loading. The confined and semiconfined aquifers have limited direct contact with Bay water, and thus have relatively less response to water flow from tides, rainfall, or sea-level rise that could otherwise lead to rapidly rising groundwater levels or emergence at land surface in an unconfined aquifer. A pressure-driven potentiometric surface rise in a monitoring well screened in a confined or semiconfined aquifer does not necessarily indicate that groundwater will also rise and emerge from these aquifers because the thick clay layers restrict the upward flow of groundwater. For these reasons, the maps of existing highest groundwater conditions may also overestimate shallow and emergent groundwater in some areas. These concepts have important implications for interpreting how groundwater rise and emergence in the shallow aquifer may respond to future changes in sea level, tides, and precipitation patterns from climate change.

The validation process using independent groundwater level data and field observations during king tides provides important insight into the proper interpretation and appropriate use of the maps of existing highest groundwater conditions. It is important for the user to understand the maps represents estimated (interpolated) highest groundwater conditions. In some locations, the actual highest groundwater may be shallower (closer to land surface) than shown in the map, but in most locations, the actual highest groundwater is likely deeper (farther from land surface) than shown in the map.

Importantly, the map of existing highest groundwater also tends to overestimate the areas of groundwater emergence, based on field observations during king tides. Only 33% of areas mapped (interpolated) as having groundwater emergence areas had confirmed or suspected groundwater emergence (Table 4-1).

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[43] "All models are wrong, but some are useful." George Box (1978), https://en.wikipedia.org/wiki/All_models_are_wrong

[44] Dr. Eileen Poeter, 2006 Darcy Lecture, "All models are wrong: how do we know which are useful?", https://www.ngwa.org/events-and-education/groundwater-lecture-series/past-lecturers-darcy

Conversely, 67% of the areas mapped as having groundwater emergence areas either had a direct connection to tidally influence surface or had no observed groundwater emergence during the king tides. The results of these field observations further support the findings that the maps of existing highest groundwater conditions (Figures 4-4 and 4-5) tend to overestimate actual conditions. Additional field observations may be warranted in some areas before local planning or policy decisions to further validate the maps. In general, field validation is a crucial first step before these maps of groundwater rise and emergence are used solely to inform important management, planning, or policy decisions.

This study presents maps created using the spline interpolation method (Figures 4-2 and C-9) because other interpolation methods (kriging, inverse distance weighting (IDS), and multi-quadratic radial basis) tend to produce even greater overestimates of shallow groundwater and groundwater emergence, and in many cases, very unrealistic spatial extents of groundwater emergence based on direct observations (Figure C-3 to C-8). Given the wide range of estimated groundwater emergence among the four methods (Appendix C), the choice of interpolation method is likely to have considerable bearing on the accuracy and reliability of maps of groundwater rise and emergence. For example, the resulting planning or policy decisions might have very different outcomes if based on maps created using spline interpolation versus multi-quadratic radial basis interpolation.

The map of existing highest groundwater conditions (Figure 4-3) is used to project how future sea-level rise will impact shallow groundwater and groundwater emergence. Because the map of existing highest groundwater conditions (Figure 4-3) tends to overestimate the presence of shallow groundwater and groundwater emergence, the maps of projected future groundwater conditions with sea-level rise are also likely to overestimate future conditions of shallow groundwater and groundwater emergence. Longitudinal field observations at confirmed and suspected groundwater emergence under existing conditions may help to better constrain how groundwater emergence conditions change under future sea-level rise.

To maintain consistency with the previously published studies, future groundwater condition maps were created using a linear (1:1) assumption with sea-level rise based on the map of existing highest groundwater conditions. Therefore, the maps of future groundwater rise and emergence do not account for future conditions in other factors that affect groundwater levels, including future patterns in precipitation, evapotranspiration, streamflow, natural recharge, managed recharge, and groundwater pumping. Additionally, these maps do not consider future changes in land use or operations of the salt ponds, levees, or other infrastructure around the south Bay.

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A dry groundwater emergence area from Location 1 (Figure 4-9) south of Byxbee Park about 100 feet west of Mayfield Slough. The white evaporative salts are deposited here from the cycles of groundwater emergence of brackish water and subsequent evaporation. Appendix D provides additional details about this groundwater emergence area. Photo by Scott Elkins, Valley Water, taken on October 30, 2024.

CHAPTER 5

Valley Water staff, Dana Kilsby, measuring groundwater levels at a monitoring well. Photo credit: Cheyne Hirota (Valley Water), taken October 26, 2023.

CHAPTER 5 – SUMMARY AND CONCLUSIONS

This chapter summarizes the major findings and conclusions. These findings are organized by current and future groundwater conditions, with recommendations and next steps outlined below.

5.1 Current Groundwater Conditions

The hydrogeologic conceptual model in Chapter 2 has been updated and improved based on new results and findings presented in Chapters 3, 4, and the associated appendices. These findings represent a major advancement in the understanding of the shallow aquifer system in the Santa Clara Subbasin near the Bay. This updated conceptual model will help Valley Water refine groundwater monitoring, modeling, and other groundwater management programs and actions, as outlined in the next steps section.

Seawater Intrusion Management Metrics

Valley Water has developed and implemented quantifiable goals (outcome measures) to track the performance of sustainable management practices and comply with SGMA, including the following seawater intrusion outcome measure and outcome measure–lower threshold:

> **Outcome Measure:** In the Santa Clara Subbasin shallow aquifer, the 100 milligram per liter (mg/L) chloride isocontour area is less than the historical maximum extent area (57 square miles).
>
> **Outcome Measure–Lower Threshold:** In the Santa Clara Subbasin shallow aquifer, the 100 mg/L chloride isocontour area is less than 81 square miles, which represents a one-mile radial buffer of the historical maximum extent area.

Outcome measure–lower thresholds are used to define undesirable results and are functionally equivalent to minimum thresholds under SGMA. The outcome measure–lower thresholds account for a reasonable margin of operational flexibility below the outcome measures that accommodates drought, climate change, conjunctive water management, and other groundwater management activities.

Protective Clay Layers

Valley Water's extensive seawater intrusion groundwater monitoring network confirms the conceptual model that aquifer units near the Bay are relatively thin and typically separated from the Bay and streams by thick clay layers. At these monitoring wells, new hydraulic conductivity estimates of the aquifer units are three to four orders of magnitude larger than the clay and Bay mud. These results indicate the clay layers and Bay mud largely restrict the inflow of Bay water into the shallow aquifer. Additionally, due to the gently sloping land surface and the relatively shallow groundwater near the Bay, the shallow aquifer likely functions as a topography-limited system where the water table rise is less pronounced than sea level rise because the excess groundwater discharges into drainage networks, such as rivers, creeks, and unlined canals. This has implications for future groundwater conditions, as groundwater levels may not rise in a linear relation (1:1 response) with rising sea levels.

Seawater Intrusion Mechanisms

Currently, at least four mechanisms[45] may contribute to varying degrees to seawater intrusion in the shallow aquifer. Among these, the leakance of saltwater and brackish water beneath tidal stream flow is likely the most important mechanism that affects the overall spatial extent and inland migration of

[45] As explained in Chapter 2, these mechanisms are classic seawater intrusion, leakance of saltwater beneath tidal stream flow, by-pass flow down improperly constructed or destroyed wells, and entrapped connate water.

seawater intrusion. Tidally influenced stream reaches extend considerable distances inland, generally aligning with the inland extent of the seawater intrusion outcome measure, supporting the conceptual model that tidal stream flow leakance is a key mechanism of seawater intrusion in the shallow aquifer. Similar to flow down improperly constructed or destroyed wells, findings from this study indicate that construction activities, such as bridge piles or piers, that pierce the protection Bay mud and clay layers may create preferential pathways that contribute to localized seawater intrusion in the shallow aquifer.

Groundwater Responds to Pressure Changes from Tides, Streams, and Precipitation

An important new finding is that all seawater intrusion monitoring wells have statistically significant tidal variance in groundwater levels, while only about half have statistically significant tidal variance in groundwater conductivity. Tidal signals from tidally influenced stream stages propagate thousands of feet within the shallow aquifer and are detected in the groundwater levels of the seawater intrusion monitoring network. These tidally driven pressure waves in groundwater levels propagate much faster than the actual infiltration of seawater beneath tidal stream flow into the shallow aquifer and subsequent movement of seawater in groundwater. This may explain why only about half of the wells have statistically significant tidal variance in groundwater conductivity while all have significant tidal variance in groundwater levels. Tidally driven pressure waves that propagate through stream stages and groundwater levels are not the same as actual leakance of seawater and brackish water beneath streams and subsequent flow in the shallow aquifer.

Groundwater level variability in the shallow aquifer closely corresponds to the mixed semidiurnal tidal pattern. However, rainfall events can cause an immediate rise in groundwater levels in wells screened in confined or semiconfined aquifers, likely indicating a pressure response due to increased rainfall and soil moisture, rather than actual infiltration and recharge from the rainfall. Groundwater levels near the Bay respond to various factors, including changes in pressure from tides, stream stage, and rainfall- and soil moisture-loading. These responses have important implications for understanding and forecasting how groundwater conditions may respond to future changes in sea level, tides, and precipitation patterns due to climate change. Given the complex hydrogeology of the shallow aquifer, interpreting groundwater levels near the Bay requires careful consideration of all these factors. Findings from the tidal analysis of groundwater levels further support the conceptual model that the “classic” seawater intrusion mechanism likely plays a relatively minor role in the spatial extent of seawater intrusion and may also have a limited role in contributing to sea-level rise-driven groundwater rise and emergence in the Santa Clara Subbasin.

Existing Highest Groundwater Conditions

This report presents maps of existing highest groundwater conditions, which represent a temporal composite of the highest recorded groundwater levels at each well between 2000 and 2020. Therefore, these maps show a theoretical, highest-case scenario for shallow groundwater conditions near the Bay. Most of the seawater intrusion outcome measure – lower threshold area (81 square miles) has groundwater elevation contours substantially greater than 9 feet above mean sea level. Because the groundwater elevations are much greater (>9 feet) than current or future sea levels, these areas are unlikely to be affected by seawater intrusion or sea-level rise. However, the existing highest groundwater elevations are below mean sea level across nearly four-square miles inland of the salt ponds, which is equivalent to about 5% of the outcome measure – lower threshold area. These areas are more likely to be affected by seawater intrusion and sea-level rise because the groundwater elevations are lower than current mean sea level.

The finding that groundwater elevations below mean sea level tend to be co-located with tidally influenced creeks and rivers further supports the conceptual model that the leakance of seawater and brackish water beneath tidal stream flow is a dominant mechanism affecting seawater intrusion and the extent of the elevated chloride in the shallow aquifer. Additionally, many salt ponds likely have shallow (0 to 3 feet bgs) or emergent groundwater due to their proximity to the Bay and land surface elevations at or below mean sea level. The shallow and emergent groundwater beneath the salt ponds may have implications for salt pond restoration or other shoreline projects.

Groundwater Rise and Emergence is Not Widespread in Santa Clara County

A major finding is that under current conditions, groundwater rise and emergence is not a substantial or widespread concern for much of Santa Clara County, particularly near the Bay. This finding is consistent with other recent studies, such as May et al. (2020), which concluded that groundwater emergence is not a serious concern for the City of Alameda under present conditions, apart from groundwater seepage into basements and other subterranean areas. As noted in Chapter 2, shallow groundwater is a naturally occurring feature of the Santa Clara Subbasin and presents challenges for the urban built environment. Similarly, shallow groundwater seeps into basements in some parts of Santa Clara County, particularly during wet winters, such as the historic winters of 2022-2023 and 2023-2024. Shallow groundwater seeping into basements typically decreases during the dry summer and fall months and does not usually occur during average rainfall and drought years. Under current conditions, groundwater rise in the shallow aquifer typically follows seasonal and annual patterns in rainfall and tides, and groundwater emergence is not a widespread concern, as it has been observed only in localized areas near the Bay, typically in undeveloped lands, open spaces, wildlife preserves, and parks, almost exclusively in locations where the land surface elevation is below mean sea level.

Maps of Shallow and Emergent Groundwater Overestimate Actual and Future Conditions

Based on measured groundwater levels from the exceptionally wet winter of 2022 to 2023, the existing highest groundwater conditions map (interpolated) tends to overestimate locations of shallow and emergent groundwater because observed depths to water tend to be greater (deeper) than estimated by the map. Additionally, many of the wells in the shallow aquifer system used to create this map are likely screened in confined or semiconfined zones. Therefore, many areas of the existing highest groundwater conditions map may be more representative of the potentiometric surface of locally confined or semiconfined aquifers within the complex shallow aquifer system and less representative of water levels from unconfined aquifers. The confined and semiconfined aquifers have limited direct contact with Bay water, and thus have relatively less response to flows from tides, rainfall, or sea-level rise that could otherwise lead to rapidly rising groundwater levels or emergence at the land surface in an unconfined aquifer. A pressure-driven potentiometric surface rise in a monitoring well screened in a confined or semiconfined aquifer does not necessarily mean that groundwater will also rise and emerge from that aquifer because the thick clay layers restrict the upward flow of groundwater through the subsurface. For these reasons, the maps of existing highest groundwater conditions may also overestimate shallow and emergent groundwater in some areas. These concepts have important implications for interpreting how groundwater rise and emergence in the shallow aquifer may respond to future changes in sea level, tides, and precipitation patterns due to climate change.

5.2 Future Groundwater Conditions

Climate change and sea-level rise are expected to impact future groundwater conditions in some areas of the Santa Clara Plain near the Bay. Monitoring and understanding current groundwater responses to present-day variability in tides, including king tides, rainfall, and seawater intrusion can help inform how and where groundwater may respond to future sea-level rise.

Expansion of Localized Groundwater Emergence in Response to Future Sea-Level Rise

Some localized areas currently have groundwater emergence, which may continue under future conditions and potentially expand as a response to future sea-level rise. However, not all areas of the Santa Clara Plain are likely to be impacted by future groundwater rise and emergence.

To illustrate the potential for future groundwater rise and emergence in response to climate change, maps were developed using future sea-level rise scenarios of 0.5, 1.0, 3.0, 5.0, and 6.5 feet, assuming a linear (1:1) response between sea-level rise and groundwater rise and emergence. This approach is consistent with previous Bay area studies. These sea-level rise scenarios correspond to the California Ocean Protection Council's 2024 recommended Intermediate, Intermediate-High, and High scenarios in San Francisco Bay. For example, under the 3.0-feet sea-level rise scenario, excluding the salt pond area, these maps indicate that 23 square miles will have shallow groundwater (<3 feet bgs) and 7 square miles will have emergent groundwater, corresponding to 28% and 8.6%, respectively, of the 81-square-mile seawater intrusion outcome measure–lower threshold area. However, these maps of future groundwater conditions likely overestimate the presence of shallow and emergent groundwater because they are based on the maps of existing highest groundwater conditions, which tend to overestimate these conditions. Additionally, these maps do not consider other factors that will affect future groundwater conditions, such as changes to rainfall patterns or projects that change the Bay shoreline.

Localized Groundwater Emergence Before Marine Inundation or Shoreline Overtopping

As noted in Chapter 4, some previous studies have warned that groundwater emergence due to sea-level rise may occur in some areas potentially years to decades before marine inundation and shoreline overtopping. Field observations and other findings from this study of the Santa Clara Plain support some aspects of that warning. For example, during the king tides of 2024, a year with historically high groundwater levels, Valley Water staff identified localized groundwater emergence (either confirmed or suspected) in about 33% of observed areas estimated by the map of future groundwater rise and emergence. The confirmed and suspected groundwater emergence areas covered about 0.007 and 0.1765 square miles, respectively, for a total of about 0.183 square miles. These identified areas of groundwater emergence are primarily in open space, parks, and undeveloped land, and inland of the shoreline levees, and many have tidally driven groundwater emergence, as some areas were observed to be wet during high tide and dry during low tide. The tidally driven wetting and drying cycles, along with elevated conductivity measurements at many areas, indicate that these areas appear to have direct subsurface connections with the Bay. Therefore, these observations confirm that groundwater emergence is happening today in some localized areas, well before sea-level rise has approached marine inundation or shoreline overtopping, particularly given the levees that protect much of the south Bay.

Based on field observations during the king tides, groundwater quality results, and geologic evidence, the groundwater emergence phenomenon is not likely a new process caused solely by present-day tides or climate change induced sea-level rise. Instead, this phenomenon is likely a geologically persistent and endemic process of the south Bay shoreline and associated shallow groundwater system. An important finding of this study is localized groundwater emergence has likely occurred throughout the geologic past and will likely continue in the future.

Windows into Future Groundwater Response to Sea-Level Rise

The areas of present-day and tidally driven groundwater emergence provide an important window into forecasting future groundwater conditions. As sea-level rise continues in the Bay, the areas of present-day tidally driven groundwater emergence are likely to have more persistent periods of emergence and each area of emergence will likely grow and expand over time. The increasing persistence and expansion of individual tidally driven groundwater emergent areas may occur before other areas with higher land surface elevations begin to experience noticeable groundwater rise and emergence. Therefore, present-day tidally driven groundwater emergent areas provide an opportunity for monitoring and forecasting how groundwater rise and emergence may expand or increase in other areas as sea-level rise continues in the 21st century.

5.3 Recommendations and Next Steps

A holistic framework for mitigating and adapting to climate change-driven sea-level rise requires a wide range of planning and policy sectors, beyond the scope of local groundwater management of coastal aquifers. Therefore, the following recommendations and next steps focus on groundwater management programs and activities within Valley Water's scope and authority under SGMA and the District Act to provide safe and reliable groundwater supply to Santa Clara County.

Adaptative Groundwater Management

Valley Water uses an adaptative groundwater management approach (Valley Water, 2021), which is driven by sustainability goals and strategies in accordance with the District Act, Board policy, and SGMA (see Chapter 1). Valley Water implements basin management programs and activities in accordance with these strategies to achieve sustainability goals. Groundwater monitoring is conducted, the results are analyzed by Valley Water, and then compared to outcome measures and corresponding lower thresholds. If these measures indicate the need for improvement, Valley Water will modify existing programs or develop new strategies and tools to achieve sustainability goals. Many key findings from this study will be integrated into Valley Water's adaptive groundwater management, particularly in maintaining adequate monitoring programs and modeling tools, as described below.

Seawater Intrusion Outcome Measure

The study confirms that the seawater intrusion outcome measure and outcome measure–lower threshold are based on a sound hydrogeologic conceptual model of the Santa Clara Subbasin near the Bay. Study findings provide important updates to this model that will benefit Valley Water's groundwater management. Moreover, this study confirms that neither the seawater intrusion outcome measure nor outcome measure–lower threshold have been exceeded. Valley Water will continue to evaluate the seawater intrusion outcome measure and lower threshold annually and present results in the annual SGMA Water Year report, due April 1 to DWR.

Groundwater Monitoring

Groundwater monitoring is a key component of Valley Water's adaptive groundwater management, particularly regarding the seawater intrusion outcome measure and outcome measure–lower threshold. Study findings are being used by Valley Water to update and improve the groundwater monitoring network near the Bay. For example, based on preliminary findings and evaluation of the network's spatial coverage, Valley Water installed two additional groundwater monitoring wells (well IDs 05S01W36K013 and 06S02W08C004) during the summer of 2024 near Penitencia Creek and Adobe Creek, respectively. These locations were selected to fill spatial gaps in the existing network near tidally influenced streams. Slug tests were conducted in these newly installed wells to estimate local hydrogeologic parameters. Although not included in the analysis presented in this report, data from these two new monitoring wells, as well as other monitoring wells that Valley Water will install in the future, will be included in Valley Water's annual evaluation of the seawater intrusion outcome measure and associated lower threshold.

New Monitoring Program – Groundwater Emergent Areas

As with all Valley Water groundwater monitoring networks, the seawater intrusion groundwater monitoring network will be evaluated regularly to identify gaps and install new monitoring wells as needed. As a new element to the monitoring program, Valley Water will regularly monitor and evaluate the tidally driven groundwater emergent areas to track if these conditions become more permanent or expand. While monitoring will occur annually, this evaluation of groundwater emergent areas will occur every five years and be included in each periodic evaluation of the Groundwater Management Plan, which is Valley Water's DWR-approved Alternative to a Groundwater Sustainability Plan under SGMA. Valley Water is also considering the regional shoreline projects mentioned in Chapter 2 and evaluating if and where additional groundwater monitoring wells are needed to better understand and track how changes to the shoreline may affect groundwater conditions.

Modeling

Maintaining calibrated groundwater flow models that can reasonably forecast groundwater conditions is an important part of Valley Water's comprehensive groundwater management strategy (Valley Water, 2021). As described in Chapter 3, slug tests were conducted at the seawater intrusion groundwater monitoring wells to collect new data about the local hydrogeologic parameters and to better constrain the hydrogeologic conceptual model of the aquifer systems near the Bay. Valley Water is actively using these new hydrogeologic parameters and the improved conceptual model to evaluate the need and feasibility of developing a new groundwater flow model near the Bay. This evaluation will consider whether a new model can improve the map estimates of groundwater rise and emergence (Chapter 4) and help minimize the overestimation of groundwater rise and emergence shown by these maps.

Currently, Valley Water uses a regional-scale and calibrated MODFLOW[46] groundwater model of the entire Santa Clara Plain to assist with water supply operations and decisions. However, this model was not designed to evaluate the shallow aquifer system near the Bay, including processes related to tides, seawater intrusion, or sea-level rise. The development of such a new model is hindered by the complex hydrogeologic framework and lack of sufficient hydrogeologic parameters. In addition to the new slug test results and water level data from the seawater intrusion monitoring network, Valley Water staff have also evaluated the potential for using geophysical data to fill gaps in the hydrogeologic framework and parameters. As noted in the 2021 Groundwater Management Plan, such data collection from the shallow aquifer near the Bay is a necessary first step in Valley Water's ongoing efforts to identify and implement modeling improvements that enhance simulation capabilities, including the effects of sea-level rise on groundwater conditions.

Careful Consideration of Dewatering as Mitigation to Groundwater Emergence

As noted in Chapter 4, the naturally occurring shallow groundwater in some areas of Santa Clara County currently necessitates dewatering activities by some property owners, typically during building construction and infrastructure maintenance, including along some highways by the California Department of Transportation. Under current conditions, dewatering of shallow groundwater can be temporary, typically lasting several months during building construction, or more permanent for some highway underpasses. Local cities and the Regional Water Board are the permitting authorities for dewatering shallow groundwater in Santa Clara County, and some cities have published dewatering protocols and construction guidelines for waterproofing subsurface structures.

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[46] MODFLOW is the U.S. Geological Survey's (USGS) modular hydrologic model, which is considered an international standard for simulating and predicting groundwater conditions and groundwater/surface-water interactions. Additional information about MODFLOW is available on the USGS webpage: https://www.usgs.gov/mission-areas/water-resources/science/modflow-and-related-programs

Some studies mentioned in the literature review (see Chapter 4) have identified dewatering shallow groundwater as a potential approach to mitigate the risk of groundwater rise and emergence from future sea-level rise (e.g., Rotzoll and Fletcher, 2013). However, findings outlined in Chapter 2, 3, and 4 of this report highlight the complexities of the subsurface hydrogeologic conditions and connections to the Bay. These findings support the need for careful site-specific investigations before communities in Santa Clara County use dewatering as a mitigation measure against sea-level driven groundwater rise and emergence because of the potential for other undesirable outcomes. Such site investigations should evaluate the local subsurface connections to the Bay and the potential for dewatering activities to exacerbate seawater intrusion, which is a concern given the topography-limited nature of the shallow aquifer system near the Bay. Similarly, Habel et al. (2024) cautioned that aquifer pumping as a primary flood-mitigation approach could result in subsidence, further increasing the risk of marine inundation and groundwater emergence. Other studies have suggested that seawater intrusion could advance a great distance inland if dewatering and drainage controls are used to mitigate groundwater rise and emergence from sea-level rise, particularly in topography-limited aquifer systems (Werner and Simmons, 2009; Bjerklie et al., 2012). As discussed in this report, the Bay mud and clay layers provide some protection from seawater intrusion in the shallow aquifer. However, some localized areas have tidally driven groundwater emergence with likely subsurface connections to the Bay. Dewatering of shallow groundwater in these areas could exacerbate seawater intrusion into the shallow aquifer.

Stakeholder Engagement

Valley Water will remain engaged with local communities and other agencies in Santa Clara County as they consider groundwater rise and emergence for land-use planning, policy, and regulatory decisions under future climate change and sea-level rise. Whether using groundwater rise and emergence maps, like those presented in Chapter 4, or other types of models, it is important to understand the inherent uncertainties, limitations, and appropriate use of such tools to support best-informed planning and policy decisions about future sea-level rise. Valley Water will continue to provide local groundwater management expertise to support these important efforts in Santa Clara County.

San Francisco Bay and tide marker near Santa Clara County. Photo credit: California King Tides Project (available for public use at https://www.coastal.ca.gov/kingtides/gallery.html).

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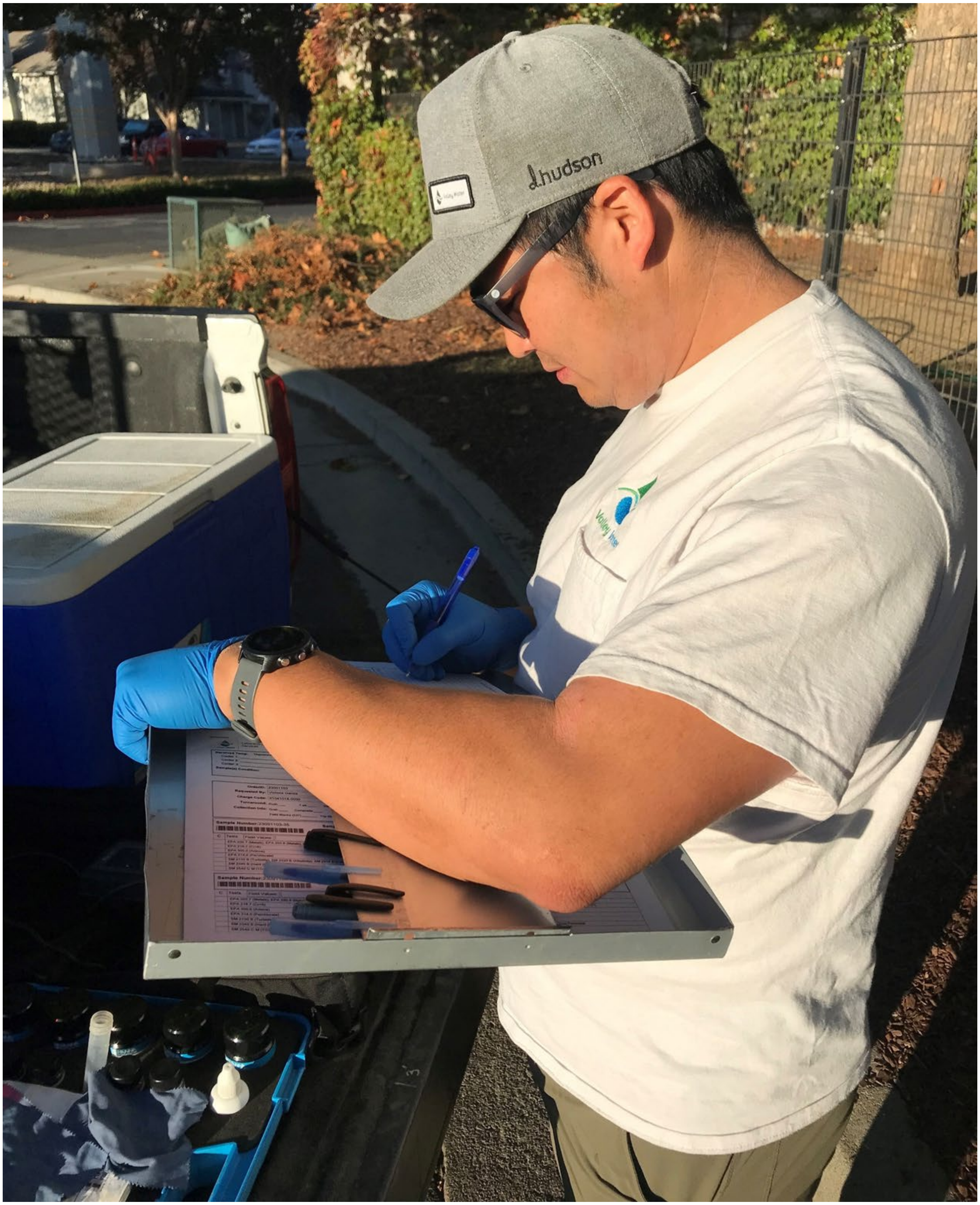

Valley Water staff, Cheyne Hirota, collecting a groundwater quality sample at a monitoring well. Photo credit: Dana Kilsby (Valley Water), taken October 26, 2023.

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GLOSSARY

A

Acre-Foot
The volume of water necessary to cover one acre to a depth of one foot; equal to 43,560 cubic feet or 325,851 gallons.

Alluvium (or alluvial)
A general term for clay, silt, sand, gravel, or similar unconsolidated detrital material, deposited during comparatively recent geologic time by a stream or other body of running water, as a sorted or semi-sorted sediment in the bed of the stream, on its floodplain or delta, or as a cone or fan at the base of a mountain slope.

Aquifer
A body of rock or sediment that is sufficiently porous and permeable to store, transmit, and yield significant or economic quantities of groundwater to wells and springs.

Aquitard
A confining bed and/or formation composed of rock or sediment that retards but does not prevent the flow of water to or from an adjacent aquifer. It does not readily yield water to wells or springs but stores groundwater.

Artesian Aquifer
A body of rock or sediment containing groundwater that is under greater than hydrostatic pressure; that is, a confined aquifer. When an artesian aquifer is penetrated by a well, the water level will rise above the top of the aquifer.

B

Basin
A groundwater basin or subbasin identified and defined in the California Department of Water Resources Bulletin 118.

Bathymetry
The depth of water relative to sea level in a body of water, such as the San Francisco Bay. Similar to a topographic map, a bathymetric map illustrates the shape and elevation of features beneath the water.

Baylands (Santa Clara County Baylands)
The broad alluvial plain surrounding the southern extent of the Bay shoreline within Santa Clara County, from Palo Alto in the west to Milpitas in the east, extending south-southeast into Sunnyvale and Santa Clara. The Baylands are the northern extent of the Santa Clara Subbasin. Salt evaporation ponds are located adjacent to the Bay and are separated from the Bay and adjacent Baylands by levee systems.

Bay Mud
Soft, water-saturated estuarine deposits of clay and silt less than 10,000 years old that underlie the southern part of the San Francisco Bay and the present salt ponds and former marshlands that border the Bay. These low permeable sediments underlie the relatively shallow Bay and help isolate the Bay water from the underlying aquifers.

Beneficial Use
One of many ways that water can be used either directly by people or for their overall benefit. The State Water Resources Control Board recognizes 23 types of beneficial use with water quality criteria for those uses established by the Regional Water Quality Control Boards.

C

Cone of Depression
In an unconfined aquifer, this is an actual depression of the water levels. In confined aquifers (artesian), the cone of depression is a reduction in the pressure head surrounding the pumped well.

Confined Aquifer
An aquifer that is bounded above and below by formations of distinctly lower permeability than that of the aquifer itself. An aquifer containing confined groundwater. See artesian aquifer.

Conjunctive Management/Use
The coordinated and planned management of both surface and groundwater resources to maximize the efficient use of the resource; that is, the planned and managed operation of a groundwater basin and a surface water storage system combined through a coordinated conveyance infrastructure. Water is stored in the groundwater basin for later and planned use by intentionally recharging the basin with available surface water supplies.

E

Estuary (or estuarine)
The mouth of a river where the ocean or bay tides meets the stream.

G

General Circulation Model (or global climate model)
Numerical models representing physical processes in the atmosphere, ocean, cryosphere and land surface, are the most advanced tools currently available for simulating the response of the global climate system to increasing greenhouse gas concentrations.

Groundwater
Water beneath the surface of the earth within the zone below the water table in which the soil is completely saturated with water but does not include water that flows in known and definite channels.

Groundwater Basin
An alluvial aquifer or a stacked series of alluvial aquifers with reasonably well-defined boundaries in a lateral direction and having a definable bottom.

Groundwater Budget
A numerical accounting of the recharge, discharge and changes in storage of an aquifer, part of an aquifer, or a system of aquifers. The groundwater equation for mass conservation or balance for an aquifer, part of an aquifer, or a system of aquifers.

Groundwater Charge Zone
A zone in which groundwater production charges are levied to fund District activities that protect and augment groundwater supplies.

Groundwater Demand
The quantity of groundwater within the subbasin needed for beneficial use.

Groundwater Dependent Ecosystem
An ecological communities of species that depend on groundwater emerging from aquifers or on groundwater occurring near the ground surface.

Groundwater Emergence
The flow groundwater at or above land surface caused by groundwater rise (or shoaling), ocean tides, storms, or sea-level rise.

Groundwater Gradient
A measure of the change in groundwater head over a given distance. Groundwater flows from areas of high hydraulic head (high water level elevation) to areas of low head (low water level elevation).

Groundwater Recharge
The natural or intentional infiltration of surface water into the zone of saturation.

Groundwater Rise (also called groundwater shoaling)
The process of rising fresh groundwater caused by tides, storms, sea-level rise, or other factors. For example, sea-level rise can contribute to seawater intrusion that raises the interface between the intruding and underlying saltwater and the overlying fresh groundwater. As the denser seawater intrudes inland, it pushes upward the overlying freshwater toward land surface. Transient groundwater rise also occurs in response to rising or high tides and storms. Groundwater rise can cause groundwater emergence if the rising groundwater flows above land surface.

Groundwater Shoaling
See Groundwater Rise.

Groundwater Subbasin
A subdivision of a groundwater basin created by dividing the basin using geologic and hydrologic conditions or institutional boundaries.

Groundwater Sustainability Agency
One or more local agencies that implement the provisions of the Sustainable Groundwater Management Act. The Santa Clara Valley Water District is the groundwater sustainability agency for Santa Clara Subbasin and Llagas Subbasin.

Groundwater Sustainability Plan (GSP)
A plan of a groundwater sustainability agency proposed or adopted pursuant to the Sustainable Groundwater Management Act.

H

Hydraulic conductivity
The ability of geologic media (e.g., sand, gravel, clay, and rock) in aquifers to transmit groundwater. Groundwater flows easier in geologic media, such as gravel or sand, with relatively higher hydraulic conductivity. Conversely, geologic media with relatively low hydraulic conductivity, such as clay, restricts groundwater flow.

Hydraulic connection
In the context of sea-water intrusion and sea-level rise, hydraulic connection refers to a hydrogeologic condition where a highly permeable aquifer material allows free movement of fresh or salt water between the ocean (or bay) and adjacent aquifer.

Hydraulic gradient
The difference in hydraulic head measured at two or more locations in an aquifer and represents the driving force of groundwater flow through an aquifer.

Hydraulic head
Hydraulic head is the height of groundwater measured in reference to a datum, typically sea level, and represents the total available energy available to move groundwater through an aquifer. In an unconfined aquifer, the water table represents hydraulic head, while in a confined aquifer, the potentiometric surface represents hydraulic head (Taylor and Alley, 2001). Groundwater flows from locations of higher to lower hydraulic head.

I

Imported Water
Non-local source of water. Water is purchased from the State and Federal Water Projects and others outside the groundwater basin’s geographical boundaries and transported into the basin for use as surface water or for recharge into the basin.

In-Lieu Recharge
The practice of providing surplus surface water or recycled water to historic groundwater users, thereby

leaving groundwater in storage for later use. Water conservation programs also serve as in-lieu recharge by reducing demands, thereby increasing storage.

L

Land Subsidence
The lowering of the natural land surface due to groundwater extraction.

LIDAR
Lidar (Light Detection and Ranging) is a remote sensing method that uses lasers to measure distances (or elevations) of the Earth.

Long-Term Overdraft
The condition of a groundwater basin where the average annual amount of water extracted for a long-term period, generally 10 years or more, exceeds the long-term average annual supply of water to the basin, plus any temporary surplus. Overdraft during a period of drought is not sufficient to establish a condition of long-term overdraft if extractions and recharge are managed as necessary to ensure that reductions in groundwater levels or storage during a period of drought are offset by increases in groundwater levels or storage during other periods.

M

Managed Recharge
The addition of water to a groundwater reservoir by human activity, such as putting surface water into dug or constructed spreading basins or injecting water through wells.

Marine Inundation
In coastal settings, wave runup and overwash onto land can lead to the shift of the coastline landward, erode beaches, accelerate cliff failure, degrade coastal habitats, damage coastal infrastructure, and increase recharge of seawater into shallow unconfined aquifers, increasing groundwater levels over longer timescales. Marine inundation is often used in the longer-term context of climate change and sea-level rise but can also be used for transient effects from storms.

Maximum Contaminant Level (MCL)
The highest drinking water contaminant concentration allowed under federal and State Safe Drinking Water Act regulations. Health based MCLs are referred to as Primary MCLS. Secondary MCLs are established for contaminants that may affect aesthetic properties of drinking water such as taste, color, and odor.

N

Natural Recharge
Natural replenishment of an aquifer, generally from runoff, through seepage from the surface.

O

Operational Storage
The usable storage within an aquifer system or groundwater basin that accounts for the avoidance of adverse impacts. It is a dynamic quantity that must be determined from a set of alternative groundwater management decisions subject to goals, objectives, and constraints of the groundwater management plan.

Outcome Measures
Specific, quantifiable goals for the maintenance or improvement of the specified groundwater conditions included in the Plan to achieve the sustainability goal for the basin. The outcome measure is functionally equivalent to a measurable objective under SGMA.

Outcome Measures–Lower Threshold
A quantifiable value used to define an undesirable result and is functionally equivalent a minimum threshold under SGMA.

P

Public Water System

As defined in Section 116275 of the Health and Safety Code, a public water system is a system for the provision of water for human consumption through pipes or other constructed conveyances that has 15 or more service connections or regularly serves at least 25 individuals daily at least 60 days out of the year. A public water system includes the following:

(1) Any collection, treatment, storage, and distribution facilities under control of the operator of the system that are used primarily in connection with the system.

(2) Any collection or pretreatment storage facilities not under the control of the operator that are used primarily in connection with the system.

(3) Any water system that treats water on behalf of one or more public water systems for rendering it safe for human consumption.

R

Recharge Area

The area that supplies water to an aquifer in a groundwater basin.

Representative Concentration Pathway

A greenhouse gas concentration trajectory adopted by the Intergovernmental Panel on Climate Change (IPCC). Four pathways were used for climate modeling for the IPCC fifth Assessment Report (AR5) (RCPs 2.6, 4.5, 6, and 8.5). The pathways describe different climate futures, all of which are considered possible depending on the volume of greenhouse gases emitted in the future. RCP 8.5 was used in this 2021 GWMP and refers to a radiative forcing value of 8.5 W/m^2. RCP 8.5 is generally taken as the basis for the worst-case climate change scenarios.

S

Saltwater Wedge

As conceptualized in the classic case of seawater intrusion, the saltwater wedge refers to the denser saltwater or saline groundwater that has intruded beneath the overlying fresh groundwater. The saltwater wedge is often characterized by a relatively narrow and distinct transition (or front) between underlying saltwater and overlying fresh groundwater.

Seawater Intrusion (or salt-water intrusion)

The movement of salt water into a body of fresh water. It can occur in either surface water or groundwater bodies.

Shoaling

See Groundwater Shoaling.

Sustainable Groundwater Management Act (SGMA)

Legislation signed into state law in 2014 with the intent for groundwater to be managed sustainably in California's groundwater basins by local public agencies and newly-formed groundwater sustainability agencies.

T

Tide

The alternating rise and fall f the oceans with respect to land. In this report, the tide refers to rise and fall of water levels in the San Francisco Bay.

U

Unconfined Aquifer

An aquifer that is not bounded on top by an aquitard. The upper surface of an unconfined aquifer is the water table.

Undesirable Result
As defined in SGMA (Water Code Section 10721), an undesirable result is one or more of the following effects caused by groundwater conditions occurring throughout the basin:

1. Chronic lowering of groundwater levels indicating a significant and unreasonable depletion of supply if continued over the planning and implementation horizon. Overdraft during a period of drought is not sufficient to establish a chronic lowering of groundwater levels if extractions and recharge are managed as necessary to ensure that reductions in groundwater levels or storage during a period of drought are offset by increases in groundwater levels or storage during other periods.
2. Significant and unreasonable reduction of groundwater storage.
3. Significant and unreasonable seawater intrusion.
4. Significant and unreasonable degraded water quality, including the migration of contaminant plumes that impair water supplies.
5. Significant and unreasonable land subsidence that substantially interferes with surface land uses.
6. Depletions of interconnected surface water that have significant and unreasonable adverse impacts on beneficial uses of the surface water.

W

Water Budget
An accounting of the total groundwater and surface water entering and leaving a basin including the changes in the amount of water stored. See groundwater budget.

Water Year
The period from October 1 through the following September 30, inclusive.

Z

Zone of Dispersion
The transition from saline to fresh groundwater in the classic case of seawater intrusion. The zone of dispersion is influenced by tidally driven hydrodynamic dispersion (mixing within the aquifer) and represents the leading front of the saltwater wedge during seawater intrusion.

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ACRONYMS AND ABBREVIATIONS

AF: acre-feet

AFY: acre-feet per year

Bay: San Francisco Bay

BGS: below ground surface

Board: Santa Clara Valley Water District Board of Directors

County: Santa Clara County

CY: Calendar Year

District: Santa Clara Valley Water District

District Act: Santa Clara Valley Water District Act

DWR: California Department of Water Resources

EC: electrical conductivity

ft: feet

GCM: General Circulation Model (or Global Climate Model)

GDE: Groundwater Dependent Ecosystem

GIS: Geographic Information System

GSA: Groundwater Sustainability Agency

GSP: Groundwater Sustainability Plan

GWMP: Groundwater Management Plan

InSAR: Interferometric Synthetic Aperture Radar

LIDAR: Light Detection and Ranging

m: meter

MCL: Maximum Contaminant Level

NAVD 88: North American Vertical Datum of 1988

NGVD 29: National Geodetic Vertical Datum of 1929

NTU: Nephelometric Turbidity Unit

OM: outcome measure

OM-LT: outcome measure – lower threshold

PPT: parts per trillion

PSI: pounds per square inch

RCP: Representative Concentration Pathway

SFEI: San Francisco Estuary Institute

SFPUC: San Francisco Public Utilities Commission

SGMA: Sustainable Groundwater Management Act

SMCL: Secondary Maximum Contaminant Level

State Water Board: State Water Resources Control Board

SWI: seawater intrusion

TDS: Total Dissolved Solids

TMDL: Total Maximum Daily Load

USGS: United States Geological Survey

Water Board: Regional Water Quality Control Board

Water Code: California Water Code

WSCP: Water Shortage Contingency Plan

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APPENDICES

APPENDIX A
Tidal Analysis

APPENDIX A – TIDAL ANALYSIS

Appendix A details methods and results summarized in Chapter 3 that were used to evaluate tidally influenced stream stage and shallow groundwater levels and conductivity near the Bay. Additionally, groundwater quality data from the seawater intrusion monitoring network are compiled and analyzed here to support the tidal analysis and identify areas of seawater intrusion in the shallow aquifer.

A.1 Methods

Time series of tides, stream stage, groundwater levels, and groundwater conductivity were analyzed using the U.S. Geological Survey (USGS) Hydrologic and Climate Analysis Toolkit (HydroClimATe) (Dickenson et al., 2014). HydroClimATe is a computer program for evaluating relations between hydrologic and climatic time series that vary in time and space. This study used HydroClimATe to pre-process the data, perform Singular Spectrum Analysis (SSA) (Ghil et al., 2002; Vautard et al., 1992), and calculate lag correlations between time series. In addition to HydroClimATe, the R statistical software was used for other statistical analyses, including the rank-sum test described below.

Unless otherwise noted, all tidal analyses were conducted using data from the three-month period of July 1 to September 30, 2023. A July through September analysis period was chosen because it provides sufficient time to identify tidal signals in hydrologic time series and it is the dry season. Rainstorms that typically occur during winter months can mask tidal signals in some hydrologic time series, which complicates the interpretation of some results. As described in Chapter 3, this three-month period also coincided with some of the highest tides in the Bay during the study period, producing tides even higher than the king tides of January 11 and February 9, 2024.

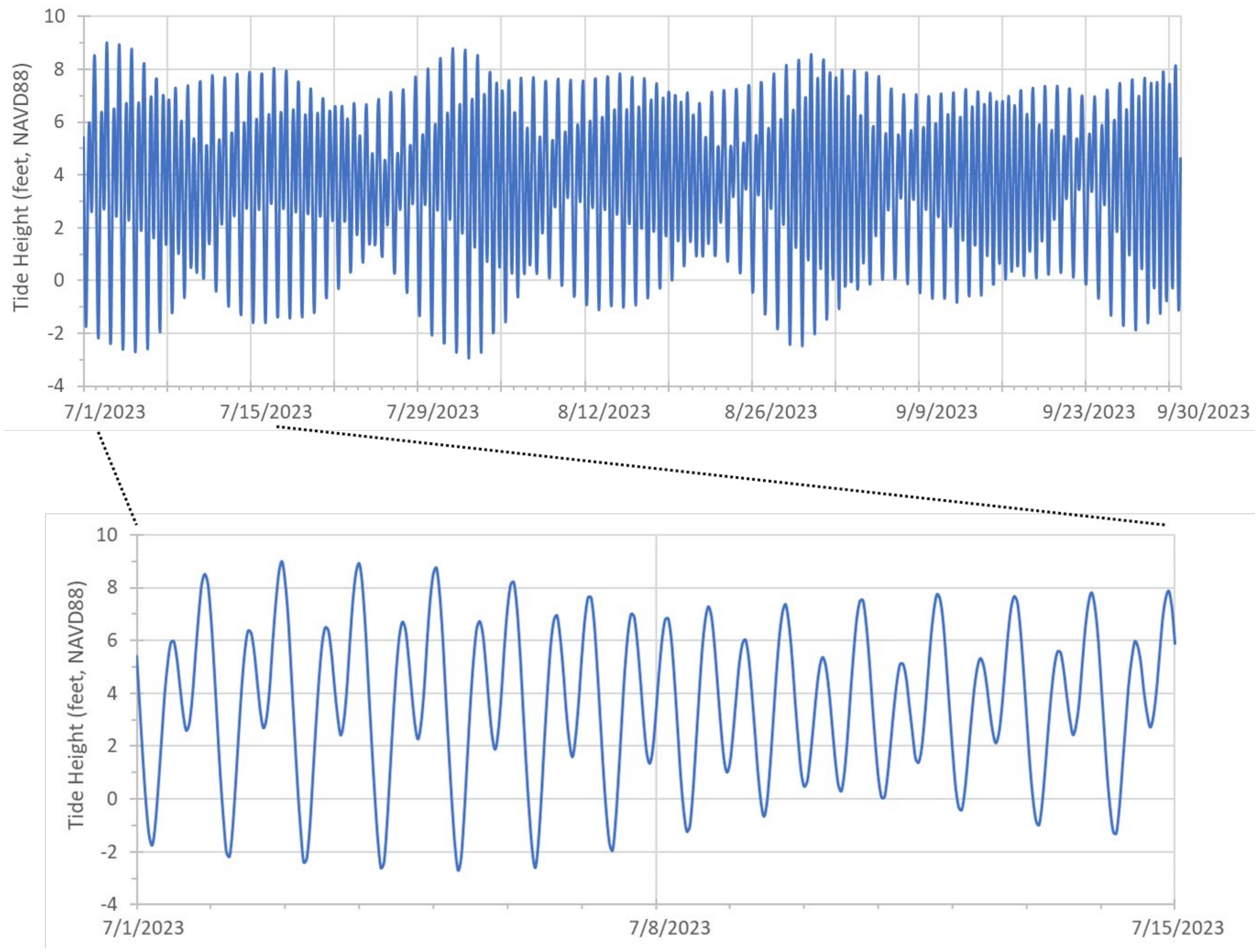
All tidal analyses were based on observed tide data from the National Oceanic and Atmospheric Administration (NOAA) Redwood City, CA tidal station (9414523)[1] (Figure 3-4). While other tidal stations are closer to the Santa Clara Subbasin, these stations have only predicted tide data and no verified, observed data. Station 9414523 is the closest station with verified, observed tide data. This study used one-hour interval tide data, and all tide, stream stage and groundwater level data are based on the topographic datum NAVD88, which is the current national standard vertical datum and establishes the elevation of zero across North America. Station 9414523 has a mixed semidiurnal tide that is characteristic of the Bay, and between July 1 to September 30, 2023 had a daily tide range minimum of 5.5 feet, maximum of 11.7 feet, and average of 8.4 feet (Figure A-1).

A.1.a Pre-processing

This study generally followed many of the pre-processing methods outlined by Velasco et al. (2017) and Dickinson et al. (2014), including the following steps. A linear interpolation was used to fill any gaps in the time series. The time series were standardized by the historic mean to create normalized departures (unitless), which enabled statistical comparisons between different types of data. Finally, the time series were detrended using a regression-fitted low-order (cubic) polynomial that was subtracted from the time series to obtain the residual series. This detrending of the time series eliminated lower frequency cycles that were not of interest in this study and would otherwise dominate the variance of the time series. Because the focus was on tidal analysis, the detrending removed lower frequency signals or cycles that may be caused by seasonal or longer trends in precipitation, recharge, or pumping. In general, these pre-processing steps were necessary to remove human influence, non-periodic and non-tidal effects from the time series.

[1] Redwood City, CA Station 9414523 website: https://tidesandcurrents.noaa.gov/waterlevels.html?id=9414523

Figure A-1. Tide height at Redwood City, CA station 9414523 from July 1 to September 30, 2023.



A.1.b. Singular spectrum analysis (SSA)

Singular spectrum analysis (SSA) was used to identify and quantify tidal signals in the time series. SSA is a nonparametric spectral estimation method that has been used to analyze variations in short and noisy geophysical and hydrologic time series, including groundwater levels (e.g., Velasco et al., 2017; Kuss and Gurdak, 2014; Gurdak et al., 2007; Dickinson et al., 2004; and Hanson et al., 2004).

Following the pre-processing steps, SSA was applied to the normalized, residual time series using the Vautard and Ghil significance test to determine the series reconstructed components (RCs) that were statistically significant against a red-noise null hypothesis (Dickinson et al, 2014). The RCs are linear combinations of the phase information, oscillatory modes, and noise of each time series. Therefore, the RCs represent the dominant frequencies, as quantified by the variance that each RC contributes to the overall variability of the time series. The variability in most hydrologic time series can be entirely described using the first 10 RCs (Hanson et al., 2004). For each time series in this study, composite RCs were created using only the statistically significant RCs and grouping and summing them according to the known periods (about 12 and 24 hours) of the Bay's mixed semidiurnal tide. The composite RCs represent statistically significant oscillatory modes within each of the hydrologic time series that have periods consistent with Bay tides. Therefore, this method quantifies the percent variance of a given time series that is tidally influenced. These SSA methods are similar to those used in other studies that have isolated tidal signals in coastal aquifers (e.g., Elad et al., 2017).

A.1.c. Lag correlations

When a part of a hydrologic system has a delayed response to a forcing, like a tide, lag correlations can help quantify the strength of association between the two variables at different time shifts (Helsel and Hirsch, 2002). HydroClimATe's lag correlation two-tailed significance test, with a significance level (also called alpha level) of 0.05, was used to calculate the maximum forward lag correlation between tides and each unique pair of data types. Based on the conceptual model of the system (Chapter 2), this study reports the maximum forward lag correlation coefficient within a 24-hour lag period between tides and stream stage or within a period generally consistent with calculated time lags (Equation 1) between tides and groundwater levels and tides and groundwater conductivity. All lag correlation analyses were done using the composite RCs, as described in the SSA methods, and similar to previous studies (e.g., Velasco et al., 2017; Kuss and Gurdak, 2014). Prior to lag correlation analyses, the composite RCs from each data type were truncated to the same starting (July 1, 2023) and ending dates (September 30, 2023). The lag correlation analysis is valuable in providing insight into the system without using a dynamic, numerical groundwater model.

In addition to the statistically based lag correlations using HydroClimATe, tidal lags were also calculated at select seawater intrusion monitoring wells with available hydrogeologic parameters (Tables 3-2 and A-3) using the following equation (Jiao and Post, 2019):

$$t_{lag}=x\sqrt{\tau S/4\pi T} \qquad \text{(Equation 1)}$$

where: t_{lag} (days) is the time between the peak of high tide and the corresponding peak of the groundwater level, x (feet) is the distance from the tidal boundary (i.e., tidal stream or Bay) to the monitoring well (Table 3-3), τ (days) is the period of the tidal harmonic oscillation, S (unitless) is the aquifer storage coefficient of the aquifer sediments, and T (feet^2/day) is the transmissivity of the aquifer sediments. Assumptions used to derive Equation 1 are explained in Jiao and Post (2019). Equation 1 was only applied to monitoring wells with available S and T estimates based on the 2023 slug test results (Table A-3). Results from Equation 1 were used to confirm the statistically based lag correlations coefficients between tides and groundwater levels.

A.1.d. Other statistical analyses

R statistical software was used to run the unpaired two-sample Wilcoxon rank-sum test, which is a non-parametric test used commonly in the hydrologic sciences (Helsel and Hirsch, 1992). The Wilcoxon rank-sum test with an alpha-level of 0.05 was used in this study to determine statistically significant differences between two independent groups, specifically the differences in the percent tidal variance in stream stage versus the percent tidal variance in groundwater levels. The Wilcoxon rank-sum test null hypothesis is that the two groups have the same median and distribution. The null hypothesis is rejected when the p-value is less than the alpha-level (0.05), which indicates the two groups of data are statistically different. A p-value greater than 0.05 fails to reject the null hypothesis and indicates the two groups of data are not statistically different.

As a direct comparison to the daily tide range (8.4 feet) at the Redwood City, CA station (9414523), the daily range in stream stage was calculated at each stream gaging station and reported here as the average daily range between July 1 and September 30, 2023. Because the daily stage range was calculated using the original stage data from each station, and not the composite RCs from the SSA, the range may include variance caused by factors other than the tides. However, the percent variance calculated by SSA provides insight into the magnitude of the daily stage range that is tidally driven.

A.2. Results

The results show that nearly all stream gauging stations and groundwater monitoring wells in this study are tidally influenced. In general, the monitoring locations with the greatest tidal influence are within the approximate extent of tidal incursion, with relatively greater influence in proximity to the Bay and tidally influenced streams. The tidal analysis results are presented in subsequent sections by data type: stream stage and groundwater levels and conductivity.

A.2.a. Streams

A.2.a.i. Tidally influenced stage variance and range

The SSA results indicate that 16 (of 19) stream gauging stations have stage variance with statistically significant oscillations related to tides, ranging from 2% to 99% variance from tidal influence (Table A-1, Figure 3-5). The average and median percent variance are 26% and 9% (Table A-1), respectively, which indicates a relatively modest influence of tides on steam stage variance at most stations. Similarly, the median and average daily range are modest (1.3 feet and <0.1 feet) (Table A-1), as compared to the average daily tide range of 8.4 feet at the Redwood City, CA station (9414523).

The stream gauging stations with the greatest variance from tidal influence, ranging from 75% to 95% variance and <0.01 feet to 9 feet stage range, are closest to the Bay (Table A-1). These stations include stations 372750122012701 at the mouth of Coyote Creek near Alviso, station 5111 Guadalupe River at Gold Street, station 5149 Sunnyvale East Channel at Baylands Park, and station 5108 Guadalupe River at Montague Expressway, which is about six miles inland from the Bay (Figure 3-4).

Coyote Creek and Guadalupe River have the greatest inland extent of tidal influence, reaching station 5098 on Coyote Creek, about 11 miles inland from the Bay, and station 5109 on Guadalupe River, over 7.5 miles inland from the Bay (Figure 3-5). As described in Chapter 2, historic groundwater overdraft and subsidence prior to the 1970s created a land surface depression along the axis of the Santa Clara Valley near Coyote Creek and Guadalupe River, which has enabled tides to propagate further upstream in these rivers than other locations in the valley (Iwamura, 1980). As discussed in subsequent sections, subsidence and tidal propagation upstream in Coyote Creek and Guadalupe River are major factors that influence the spatial extent of the seawater intrusion in shallow groundwater and associated outcome measure and outcome measure–lower threshold.

Conversely, stream gaging stations without tidal influence (0% variance) are generally located furthest inland from the Bay, either outside the outcome measure extent, such as station 5035 on Stevens Creek, or outside the outcome measure–lower threshold extent, such as stations 5146 on Permanente Creek and 5064 on Berryessa Creek (Figure 3-5). These three stations are located outside the approximate extent of tidal incursion (Figure 3-5).

The tidal variance in stream stage indicates the mapped extent of tidal incursion may underestimate the inland spatial extent of tidally influenced streams. For instance, on Matadero and Barron creeks, the tidal variance in stream stage is 14% and 25%, respectively, at stations 5101 and 5135, near the outcome measure extent and further inland than the extent of tidal incursion (Table A-1, Figure 3-5). Lower Penitencia Creek has 23% variance in stream stage associated with tides at station 5100, which is further inland than the mapped extent of tidal incursion (Figure 3-5). On Coyote Creek, the mapped extent of tidal incursion ends near station 5097, but upstream stations 5127 and 5098 have 6% and 4% tidal variance, respectively, although they are located inland of the outcome measure–lower threshold (Figure

3-5). These differences illustrate that the mapped extent of tidal incursion is approximate and may vary seasonally or over longer time scales, depending on the hydrology and patterns in stream discharge to the Bay.

Table A-1. Tidally influenced stream stage variance and range at stream gaging stations.

Station ID and Name	Variance from Tidal Influence (%)	Average Daily Stage Range (feet)	Lag Correlation	
			Coefficient (unitless)	Lag (hours)
372750122012701, Coyote Creek near Alviso, CA (USGS)	99	9	0.98	<1 hr
5111, Guadalupe River at Gold Street	97	7	0.99	1
5149, Sunnyvale East Channel at Baylands Park	95	7	0.98	1
5108, Guadalupe River at Montague Expressway	75	<0.1	0.36	21
5137, Pond A8 Stage	27	0.4	0.86	4
5135, Adobe Creek downstream of El Camino Real	25	<0.1	0.22	16
5100, Lower Penitencia Creek at Machado Ave	23	<0.1	0.21	7
5101, Matadero Creek at Lambert Ave	14	<0.1	0.38	17
5109, Guadalupe River at US-101 (USGS)	9	<0.1	0.35	17
7040, Palo Alto Flood Basin	9	0.2	0.63	2
5097, Coyote Creek at CA-237 (USGS)	6	0.1	0.20	8
5127, Coyote Creek at Berryessa Road	6	<0.1	0.25	17
5098, Coyote Creek at William Street	4	<0.1	0.25	22
5122, San Tomas Aquino Creek at Mission College Blvd	3	<0.1	0.21	22
5112, San Francisquito Creek at Stanford (USGS)	2	<0.1	0.21	24
5074, Sunnyvale East Channel at Baylands Park	2	0.1	0.18	24
5035, Stevens Creek above CA-85 near Central Ave	0	0	NA	NA
5064, Berryessa Creek above Calaveras Blvd	0	0	NA	NA
5146, McKelvey Park Pump Sensor	0	0	NA	NA
Average:	26	1.3	0.45	13
Median:	9	<0.1	0.30	17

Note: Stream gaging stations are sorted by variance from tidal influence (%). Results for station 5074 are from August 17 to September 30, 2023 because a step change in stage data on August 16, 2023 (results are similar for the period July 1 to August 16, 2023).

A.2.a.ii. Lag correlations with tides

The stream gauging stations with statistically significant tidal variance in stream stage have a range from weak (0.18 coefficient and 24 hr lag) to strong (0.99 coefficient and 1 hr or less) lag correlations with tides (Table A-1). While several stations (372750122012701, 5111, and 5149) have strong correlations (>0.98 coefficient) with stream stage that lag tides by 1 hr or less, most stations have relatively modest lag correlations based on the average and median correlations coefficients (0.45 and 0.30) and lags (13 and

17 hrs) (Table A-1). In general, stations with the strongest lag correlations and shortest lags with tides are located closer to the Bay, with the strength of the lag correlation typically decreasing upstream along creeks. For example, on Coyote Creek, downstream station 5097 has an 8 hr lag, station 5127 has a 17 hr lag, and upstream station 5098 has a 22 hr lag.

The SSA and lag correlation results support the conceptual model that along the South Bay, tidally influenced stream reaches extend considerable distances inland within the extent of the shallow aquifer zone. As described in subsequent sections, the inland extent of tidally influenced streams has important implications for the spatial extent of shallow groundwater response to tides and sea-level rise, which may, in turn, affect the spatial patterns of groundwater rise and emergence.

A.2.b. Groundwater

The hydraulic gradient in an aquifer affects groundwater flow rates and direction. The hydraulic gradient is influenced by recharge and groundwater pumping, as well as by the elevation of surface water in hydraulically connected areas of the Bay and streams. Therefore, Bay tides and tidally influenced streams, like the Guadalupe River and Coyote Creek, can influence groundwater levels to varying degrees in the shallow aquifer near the Bay. Tidal signals from the Bay and streams propagate through groundwater at a rate that is a function of aquifer hydrogeologic properties and period of the tidal cycle (Jiao and Post, 2019). The tidal signals attenuate in groundwater as the amplitude dampens and becomes more delayed in time further inland from the Bay or further away from a tidal stream. Depending on the hydrogeologic properties, like transmissivity and storativity, tidal signals in groundwater levels have been observed and reported in the scientific literature many hundreds of feet or more inland in coastal aquifers (Jiao and Post, 2019). These hydrogeologic concepts are supported by the following results from SSA and lag correlations.

A.2.b.i. Tidally influenced levels and conductivity

The SSA results indicate that all 18 seawater intrusion monitoring wells have statistically significant groundwater level variance related to the tides, while only 50% (9 of 18) of wells have statistically significant tidal variance in conductivity (Table A-2, Figure 3-6). The five wells with the greatest groundwater level variance from tidal influence, ranging from 90% to 30% variance, are closest to the Bay. These include wells 06S01W10N007 and 06S01W10N006 (90% and 58%) (Figure A-2), which are about 150 feet from the Guadalupe River; well 06S02W24J009 (39%) near Sunnyvale West Channel; well 06S01W14L005 (30%) near the Guadalupe River; and well 06S01W17M009 (30%) near Sunnyvale East Channel (Table A-2). All other wells have 26% or less tidal variance in groundwater levels (Table A-2).

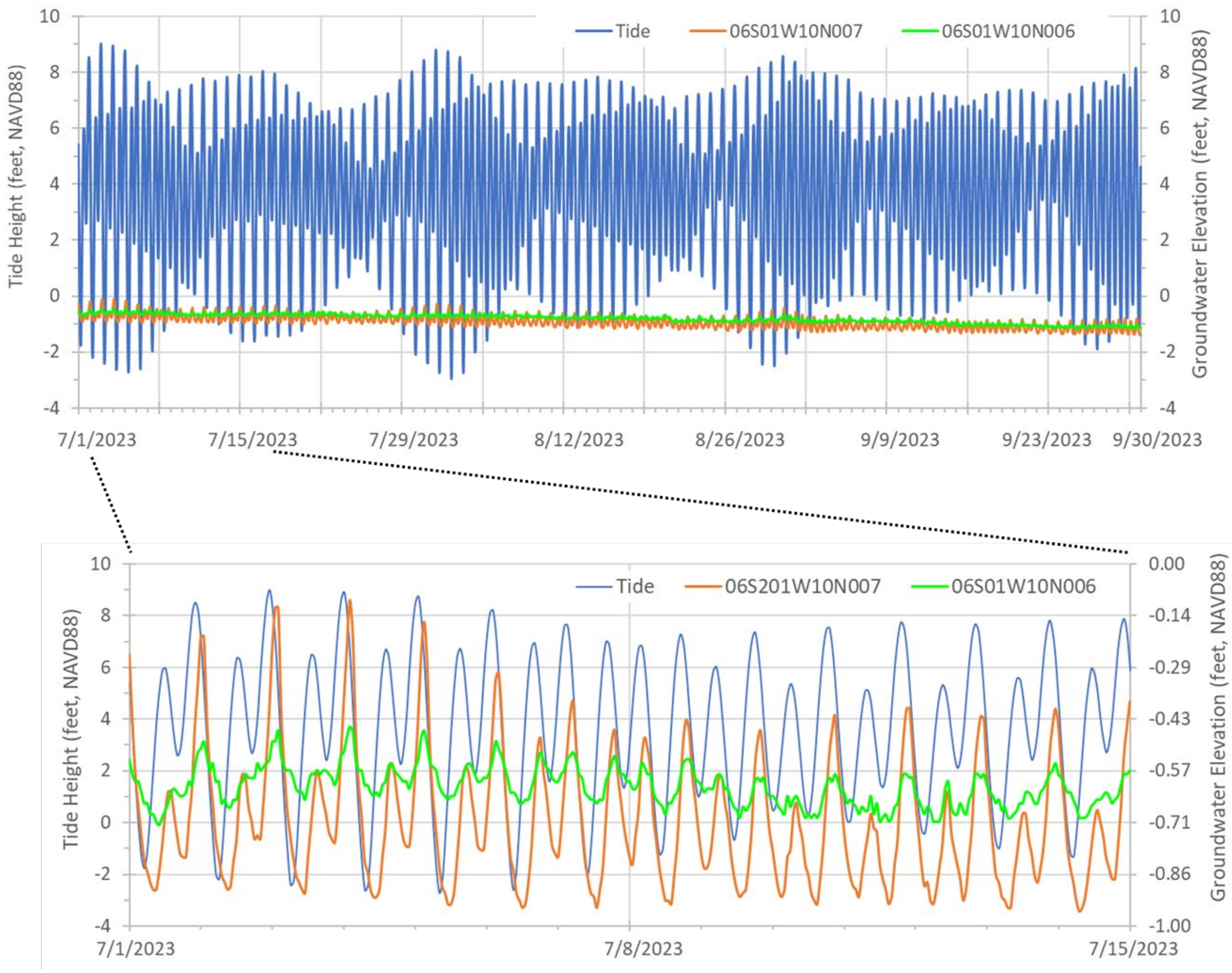
Similar to the stream gaging stations, wells with the greatest inland extent of tidal influence are near the Guadalupe River and Coyote Creek. The most inland well (06S01W26K001) along the Guadalupe River has 9% variance in groundwater levels (Figure A-3), which is the same percent variance (9%) as nearby stream gauging station 5109, located over 7.5 miles inland from the Bay (Figures 3-5 and 3-6). The most inland well (07S01E09L008[2]) along Coyote Creek has 3% variance in groundwater levels, which is nearly the same percent variance (4%) as nearby stream gaging station 5098 that is about 11 miles inland from the Bay (Figures 3-5 and 3-6).

The Wilcoxon rank-sum test results (p-value = 0.196; alpha-level = 0.05) indicate there is no statistical difference between the percent tidal variance in stage at the stream gaging stations and percent tidal variance in groundwater levels at the seawater intrusion monitoring wells. These results indicate that tidal

[2] This well typically has artesian conditions for much of the year. This well is capped and prevents groundwater from flowing from the well. See glossary for artesian aquifer.

forcings have similar spatial patterns on stream stage and groundwater levels and support the finding that tidal variability in groundwater levels are a response to the tidal variability in stream stage. Any future changes to stream stage tidal dynamics, whether from climate change or other anthropogenic factors, are likely to result in changes to groundwater level dynamics.

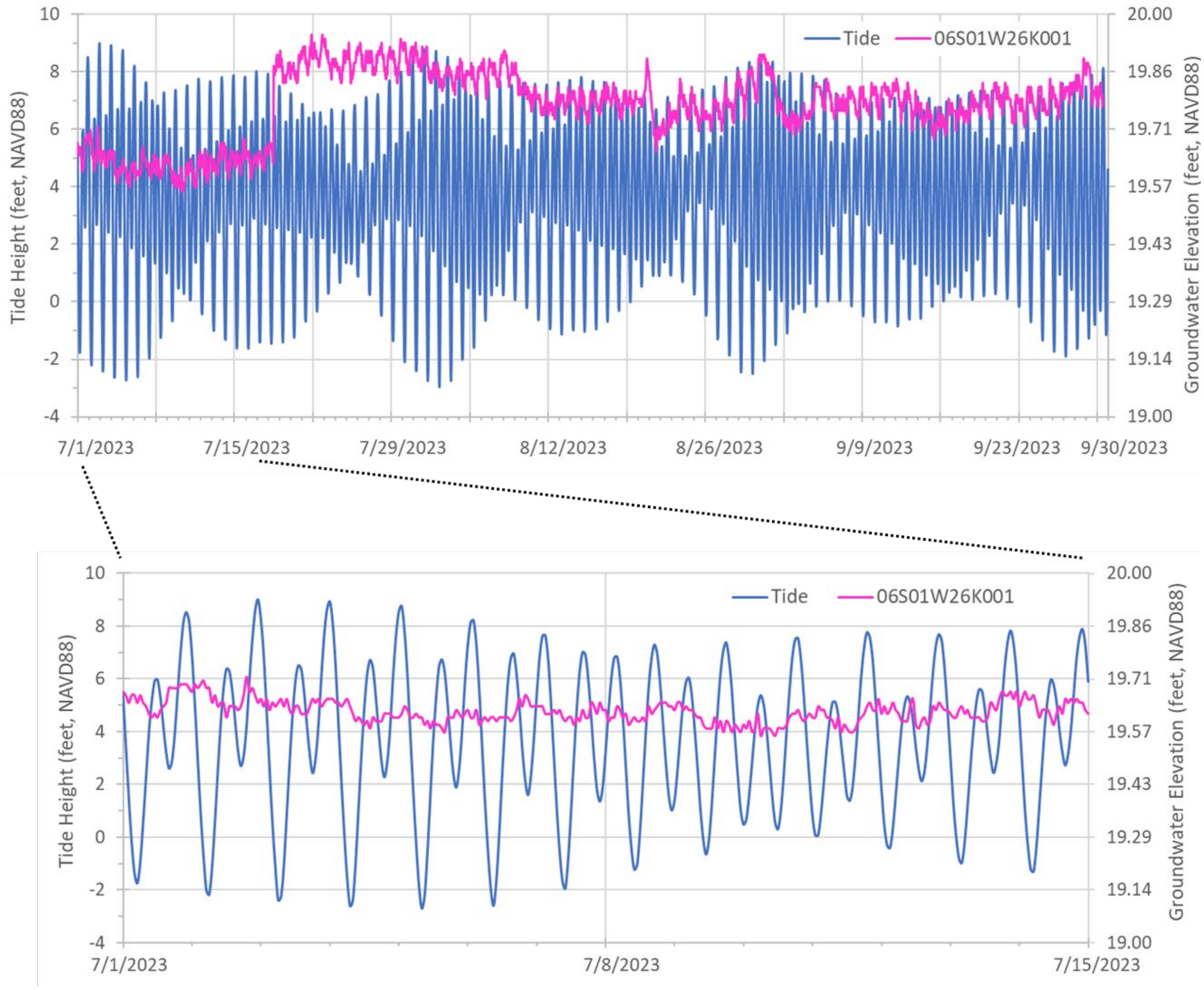
Figure A-2. Tide height and groundwater elevation at wells 06S01W10N006 and 06S01W10N007.



Note: The groundwater elevation scales are different on the two graphs. Negative groundwater elevations indicate groundwater levels are below mean sea level.

The tidal variance in groundwater levels further indicates that the mapped extent of tidal incursion may underestimate the inland spatial extent of tidally influenced streams. Near Matadero Creek, the variance in groundwater levels associated with tides is 19% and 24% at wells 06S02W06J003 and 06S02W07B023, respectively, which are further inland than the mapped extent of tidal incursion (Table A-2, Figure 3-6). Most notably along Coyote Creek, wells 06S01W13C009, 06S01W24J037, and 07S01E09L008 have 14%, 6%, and 3%, respectively, tidal variance in groundwater levels and are located much further inland than the mapped extent of tidal incursion along Coyote Creek (Figure 3-6). These differences illustrate that the mapped extent of tidal incursion is approximate and may vary seasonally or on longer time scales, depending on the hydrology and patterns in stream discharge to the Bay.

Figure A-3. Tide height and groundwater elevation at well 06S01W26K001.



Note: The tide height and groundwater elevation have different scales.

The SSA results indicate that tidal signals from tidally influence stream stage can propagate thousands of feet within the shallow aquifer zone. For example, well 06S02W24J009 is located 1,820 feet from Sunnyvale West Channel and has 39% tidal variance in groundwater levels, and well 06S01W14L005 is 2,240 feet from Guadalupe River and has 30% tidal variance in groundwater levels (Tables 3-3 and A-2). The SSA results show that tidal signals in groundwater levels propagate further inland and away from tidal streams as compared to tidal signals in groundwater conductivity (Table A-2). Only 9 wells have tidal variance in conductivity, with an average and median variance of 10% and 1%, respectively (Table A-2). Tidal signals from tidally influenced stream stage propagate in groundwater levels considerably greater distances inland within the shallow aquifer zone as compared to groundwater conductivity, which has tidal signals that attenuate at relatively shorter distances inland. The tidal signals in groundwater levels propagate further inland and attenuate at much longer distance than groundwater conductivity because the tidal fluctuations propagate as pressures wave in the water levels that travel more efficiently through the aquifer than the actual groundwater flow and advective transport[3] of chloride and salinity from the Bay seawater.

Table A-2. Tidally influenced groundwater levels and conductivity at the seawater intrusion monitoring well network.

Well Number	Groundwater Level			Groundwater Conductivity		
	Variance from Tidal Influence (%)	Lag Correlation		Variance from Tidal Influence (%)	Lag Correlation	
		Coefficient (unitless)	Lag (days)		Coefficient (unitless)	Lag (days)
06S01W10N007	90	0.95	0.08	87	0.98	0.04
06S01W10N006	58	0.84	0.13	64	0.93	0.21
06S02W24J009	39	0.43	0.25	0	NA	NA
06S01W14L005	30	0.49	0.25	1	0.40	45
06S01W17M009	30	0.37	0.13	9	0.79	0.08
06S02W05F001	26	0.43	0.17	10	0.36	0.21
06S02W05F002	25	0.45	0.17	0	NA	NA
06S02W07B023	24	0.41	0.33	0	NA	NA
06S01W18R007	21	0.52	0.21	6	0.33	0.88
06S01W12G005	20	0.43	0.25	1	0.12	24
06S02W06J003	19	0.43	0.29	0	NA	NA
06S01W02N008	14	0.37	0.29	0	NA	NA
06S01W13C009	14	0.35	0.21	1	0.41	36
06S01W26K001	9	0.39	0.25	0	NA	NA
06S01W22K010	8	0.45	0.29	0	NA	NA
06S01W24J037	6	0.44	0.25	0	NA	NA
06S02W05F003	5	0.48	0.17	0	NA	NA
07S01E09L008	3	0.40	0.25	4	0.40	43
Average:	25	0.48	0.22	10	0.52	17
Median:	21	0.44	0.25	1	0.40	1

Notes: NA, not applicable because the well had 0% variance from tidal influence.

A.2.b.ii. Lag correlations with tides

The lag correlations support the SSA results and indicate that all monitoring wells have groundwater levels that are statistically lag correlated with the tides (Table A-2). The lag correlation coefficients range from 0.35 to 0.95, and average of 0.48, indicating generally moderate to strong lag correlations between tides and groundwater level variance. The time lag between tidal signals and groundwater level effects ranges from 0.08 days (about 2 hours) at 06S01W10N007 (150 feet to Guadalupe River) to 0.33 days (8 hours) at 06S02W07B023 (1,620 feet to Matadero Creek), with an average of 0.22 days (5 hours) (Table A-2). In general, time lags in groundwater levels are faster in monitoring wells closer to the tidal

[3] Advection is the process that chemicals are transported by flowing fluid, such as groundwater, in response to a hydraulic gradient.

boundaries and longer in monitoring wells further from the tidal boundaries (Figures A-4 and 3-7), which is a finding consistent with other studies (e.g., Elad et al., 2017).

The time lags in groundwater levels (Table A-2) are short but reasonable based on findings from studies of unconfined coastal aquifers. These studies report time lags ranging from 0.25 to 2.50 hrs for wells about 30 to 330 feet from the shoreline (Elad et al., 2017) and from 2.00 to 8.25 hrs for wells about 200 feet from the shoreline (Opatz and Dinicola, 2018). The time lags from this study are shorter than those reported in studies of unconfined aquifers because the storativity values from the shallow aquifer zone (Table A-3) are several orders of magnitude smaller than the typical range of storativity values (0.01 to 0.3) for unconfined aquifers. Equation 1 illustrates that the time lags are directly proportional to storativity values.

Table A-3. Calculated time lags in groundwater levels based on Equation 1.

Well Number	x (feet)	τ (days)	S (unitless)	T (feet^2/day)	t_{lag} (days)	t_{lag} (hours)
06S01W02N008	1,560	0.5	3.00E-05 [1]	429	0.08	1.97
06S01W10N006	150	0.5	1.0E-06 [1]	33	0.01	0.13
06S01W10N007	150	0.5	2.47E-05	66	0.02	0.44
06S01W12G005	380	0.5	9.9E-04 [1]	2,660	0.05	1.11
06S01W13C009	65	0.5	4.50E-07	662	3.4E-04	0.01
06S01W14L005	2,420	0.5	4.00E-06 [2]	NA	NA	NA
06S01W17M009	30	0.5	2.8E-03	583	1.3E-02	0.32
06S01W18R007	10	0.5	1.0E-04	984	6.5E-04	0.02
06S01W22K010	2,460	0.5	1.3E-05 [2]	1,281	4.9E-02	1.19
06S01W24J037	122	0.5	7.8E-04	5,280	9.4E-03	0.23
06S01W26K001	110	0.5	1.0E-04 [1]	649	8.6E-03	0.21
06S02W05F001	45	0.5	3.5E-06 [1]	35	2.8E-03	0.07
06S02W05F002	45	0.5	1.02E-05 [1]	209	2.0E-03	0.05
06S02W05F003	45	0.5	NA	NA	NA	NA
06S02W06J003	20	0.5	5.0E-06 [2]	0.025	5.6E-02	1.35
06S02W07B023	1,620	0.5	2.2E-05 [2]	1,159	4.5E-02	1.07
06S02W24J009	1,560	0.5	3.85E-07	32	0.03	0.81
07S01E09L008	220	0.5	NA	NA	NA	NA

Note: these variables are explained in Equation 1:

x is the distance from the tidal boundary (i.e., tidal stream, see Table 3-3) to the monitoring well.

τ is the period of the tidal harmonic oscillation (12 hours).

S (storativity) values were determined using AQTESOLV software[4] with the 2023 slug test data and confined aquifer assumptions with the Cooper-Bredehoeft-Papadopulos, rising head data, unless otherwise specified as [1] KGS method (where S = specific storage x b) or [2] Cheremisinoff (1997) method (where S = 1.0×10^{-6} x b).

T (transmissivity) is calculated using hydraulic conductivity (K) and aquifer thickness (b) (Table 3-2), where T = Kb.

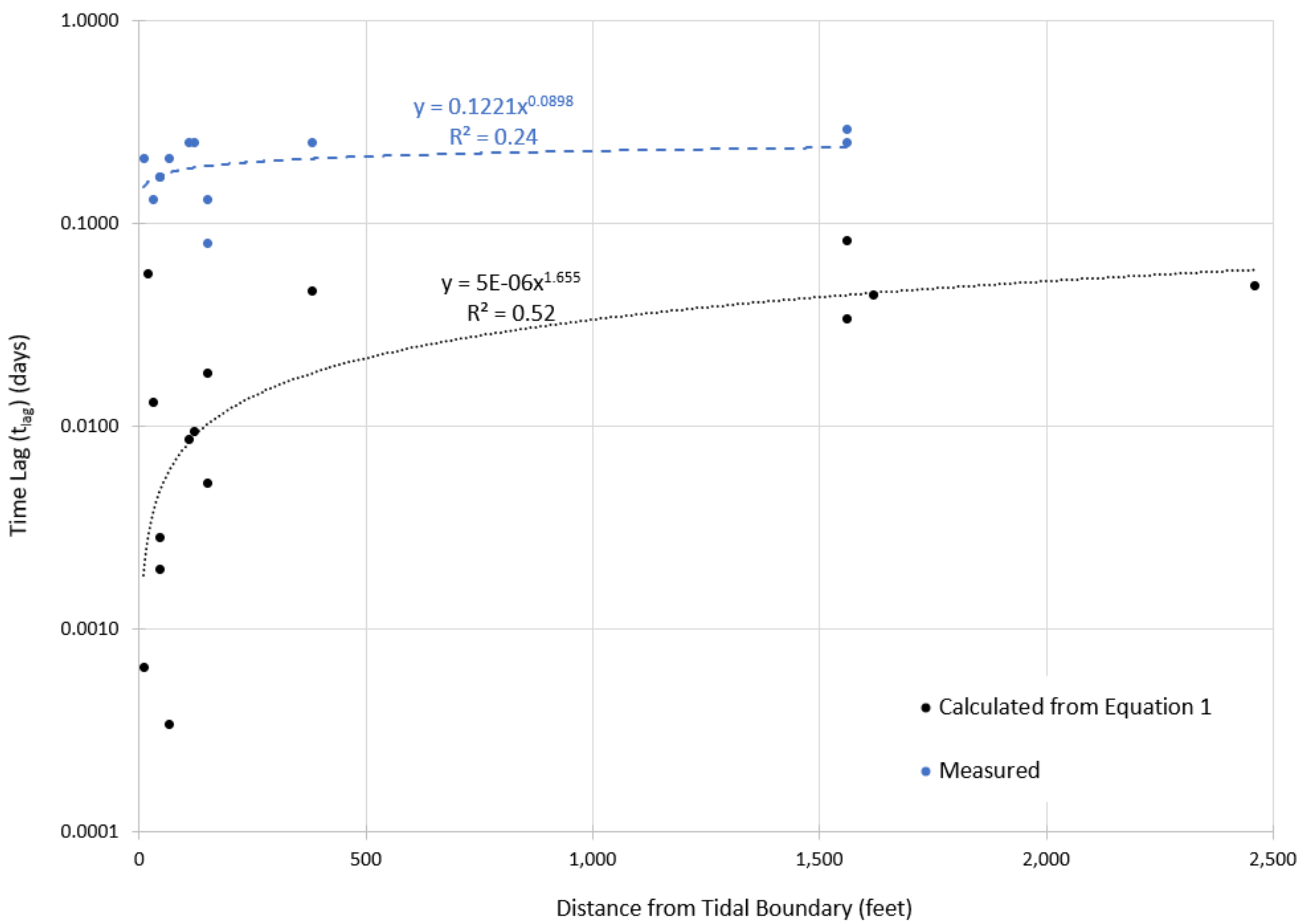
t_{lag} is the time lag between the peak of high tide and the corresponding peak of the groundwater level.

NA, not available from results of the slug test.

[4] http://www.aqtesolv.com/

The statistically based time lags from the measured groundwater levels (Table A-2) are generally comparable but tend to be longer than the theoretical time lags calculated from Equation 1 (Table A-3, Figure A-4). The difference between the measured (Table A-2) and calculated (Table A-3) time lags (Figure A-4) are attributed to the heterogeneities of the hydrogeologic properties in the actual aquifers, while Equation 1 assumes a homogeneous aquifer.

Figure A-4. Time lags in groundwater levels versus distance from tidal boundary.



The time lags in groundwater conductivity are considerably longer than the corresponding time lags in groundwater levels at the same monitoring well (Table A-2). While five wells have time lags in conductivity less than one day, including wells 06S01W1N006 and 06S01W1N007, the other four wells with tidal variance in conductivity have time lags from 24 to 45 days, and the average time lag in groundwater conductivity was 7 days longer than in groundwater levels (Table A-2). The relative differences in SSA and lag correlation results between groundwater levels and conductivity (Table A-2) are similar to other coastal aquifers (e.g., Elad et al., 2017).

The lag correlation results here support the conceptual model that tidal fluctuations in stream stage produce relatively fast pressure waves in groundwater levels, especially through the deeper and more confined aquifer units. These pressure waves in groundwater levels propagate much faster than the actual infiltration of seawater beneath tidal stream flow into the shallow aquifer and corresponding advective transport of seawater in groundwater, which is slower because the tidally driven changes in hydraulic head that drive advective transport are attenuated in the unsaturated zone near the stream bed and water table (Elad et al., 2017). Based on theory and observations by other studies, tidally driven pressure waves propagate through the porous media of aquifers faster and farther inland than that of solute transport (e.g., Jiao and Post, 2019; Guo et al., 2023), Additionally, the regional groundwater flow gradient in the Santa Clara Subbasin is north toward the Bay and many streams in the Baylands are likely groundwater dependent ecosystems (GDEs) because they are gaining streams (see Chapter 2) (Valley Water, 2021). These regional and local-scale hydraulic gradients help attenuate the leakance of saltwater beneath tidal streamflow and the associated advective transport of seawater in groundwater of the shallow aquifer. While pressure waves can travel through the clay layers overlying the aquifer units at most monitoring well locations (Table 3-2), the clay layers act to restrict the actual groundwater flow and advective transport of seawater that leaks beneath tidal stream flow. For example, well 06S02W06J003 (20 feet from Matadero Creek) that was inadvertently screened in the clay has 19% variance groundwater levels and 0.29-day tidal lag but has 0% tidal variance in groundwater conductivity.

Tidally driven pressure waves that propagate through stream stage and groundwater levels are not the same process as actual leakance beneath streams and groundwater flow and transport of seawater through the shallow aquifer. These findings are important additions to the conceptual hydrogeologic model of the Baylands and have important implications for the spatial extent of shallow groundwater levels and groundwater quality responses to sea-level rise, including the spatial patterns of groundwater rise and emergence (Chapter 4).

A.3 Groundwater Quality

This section presents results of Valley Water's groundwater quality sampling of the seawater intrusion monitoring network between 2000 and 2023. Valley Water routinely publishes results of the groundwater quality sampling in the Annual Groundwater Reports and Groundwater Management Plans. The water quality data are compiled and analyzed here to support the tidal analysis and identify areas of seawater intrusion.

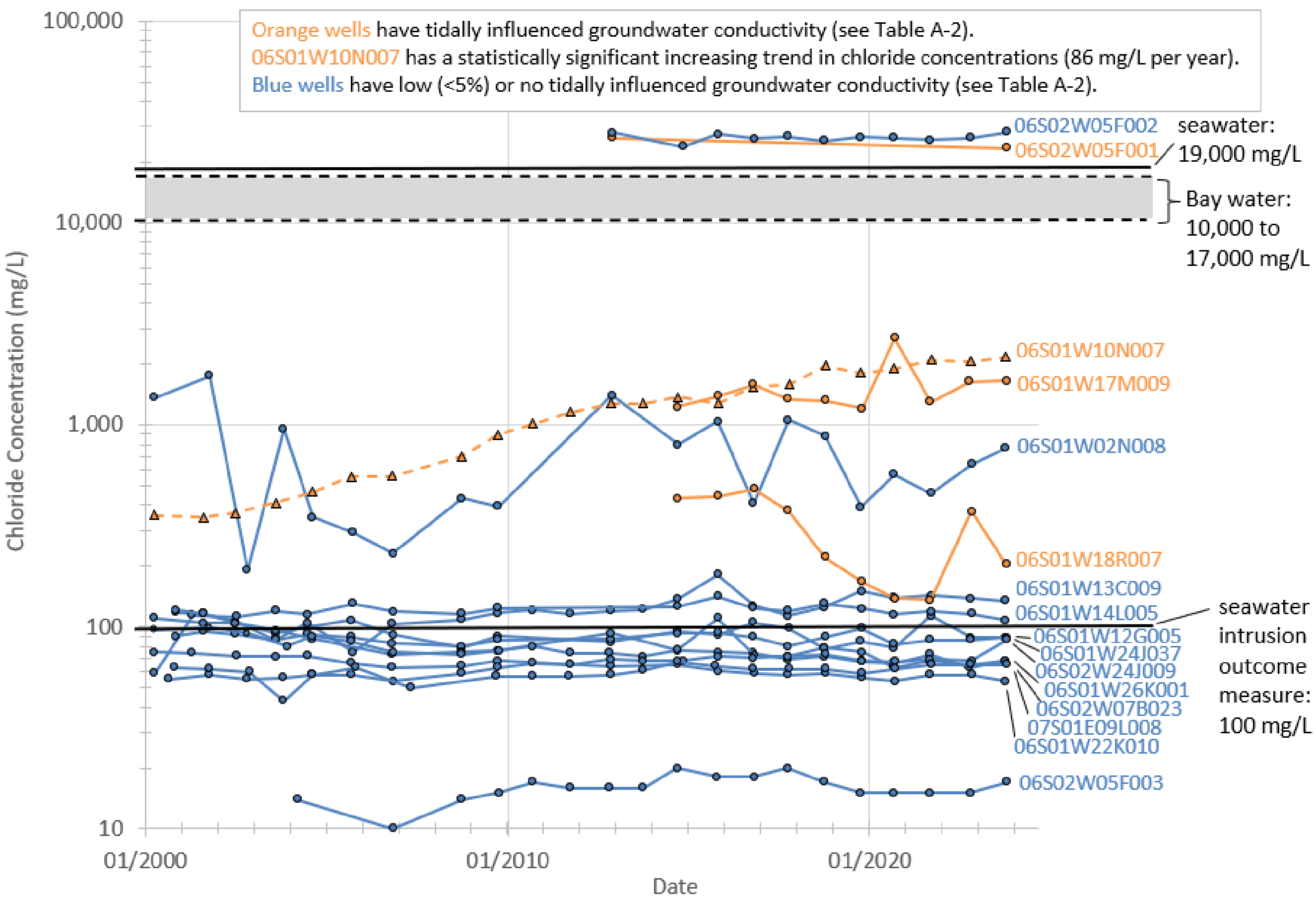
Groundwater quality can be an indicator of tidal influence and seawater intrusion because there are often increases in salinity and other systematic changes in the geochemical composition of groundwater as seawater intrudes into freshwater aquifers (Jiao and Post, 2019). The following sections focus on chloride concentrations (Figures A-5 and A-6) and molar ratios of other ions (Figures A-7 and A-8) in groundwater quality samples from the seawater intrusion monitoring wells between 2000 and 2023. All supporting groundwater quality data are compiled in Table A-4.

A.3.a Chloride

Chloride concentrations in groundwater are a useful indicator of tidal influence and seawater intrusion, particularly if seawater is the only source of groundwater chloride. Chloride is a conservative (i.e., nonreactive) water quality constituent, which makes it relatively straightforward to interpret as an indicator of seawater intrusion. For these reasons, Valley Water and other agencies use chloride as an indicator of seawater intrusion (see Chapter 1 for information about Valley Water's 100 mg/L chloride-based seawater intrusion outcome measure). Many aquifers with seawater intrusion have a positive relation between chloride concentrations and other parameters of salinity, such as specific conductance (conductivity) (Jiao and Post, 2019), which are easily measured with in-situ sensors. This is why Valley Water uses sensors in the seawater intrusion monitoring network wells to monitor changes in water levels and specific conductance as an indicator of tidal influence and seawater intrusion.

Figure A-5 shows available chloride concentration data from the seawater intrusion monitoring wells between 2000 and 2023 and identifies wells with tidally influenced groundwater conductivity, which was previously described in Table A-2. Generally, the wells with low (<5%) to no tidally influenced groundwater conductivity have chloride concentrations less than 100 mg/L (Figure A-5), which Valley Water uses as the seawater intrusion outcome measure. These low chloride concentrations further support the conclusions from the tidal analysis that the groundwater quality in these wells is not influenced by Bay water from tides or seawater intrusion. Wells 06S01W14L005 and 06S01W13C009 do not have tidally influenced conductivity but have chloride concentrations between 100 mg/L and 200 mg/L, which are below the secondary MCL of 250 mg/L (note - water may have a salty taste above this concentration) and could indicate a relatively minor influence from seawater intrusion. Well 06S01W02N008 has no tidal influence in conductivity but chloride concentrations range from 190 to 1,750 mg/L (average 719 mg/L), which likely indicates an elevated chloride source from the Bay via nearby Mallard Slough. Similarly, well 06S02W05F002 has no tidal signal in conductivity but has very elevated chloride concentrations that range from 23,800 to 28,100 mg/L (average 26,400 mg/L), which exceeds concentrations typical of both Bay water (10,000 to 17,000 mg/L) and seawater (19,000 mg/L) and likely indicates a connate or evapoconcentration source of chloride.

Figure A-5. Chloride concentrations in seawater intrusion monitoring wells (2000 to 2023).



The four wells with elevated chloride and tidally influenced conductivity are 06S01W18R007, 06S01W17M009, 06S01W10N007, and 06S02W05F001 (Figure A-5). Wells 06S01W18R007 and 06S01W17M009 are located along Sunnyvale East Channel and within the approximate extent of tidal incursion (Figure 3-4). Well 06S01W17M009 has chloride concentrations that exceed 1,000 mg/L, while 06S01W18R007 are generally less than 500 mg/L, which is a difference that may be attributed to relatively greater tidal influence (Table A-2) and a slightly higher sand fraction (less overlying clay, Table 3-2) at 06S01W17M009 compared to 06S01W18R007.

Four of the seawater intrusion wells have statistically significant decreasing chloride concentration trends and four wells have statistically significant increasing trends from 2000 to 2023, based on the Mann-

Kendall test, alpha-level = 0.05. The remaining ten wells have no trends in chloride concentrations. All wells with a decreasing trend (06S01W22K010 (p-value = <0.01), 06S01W26K001 (p-value = <0.01), and 06S02W07B023 (p-value = <0.01)) except 06S01W18R007 (p-value = 0.03) have low or no tidally influenced groundwater conductivity and chloride concentrations less than 100 mg/L (Figure A-5). The average rate of decreasing chloride is 2 mg/L per year or less at these wells, except 06S01W18R007 that has an average 30 mg/L per year decrease. Similarly, all wells with an increasing trend (06S01W13C009 (p-value = <0.01), 06S02W24J009 (p-value = <0.01), and 07S01E09L008 (p-value = 0.02)) except 06S01W10N007 (p-value = <0.01) have low or no tidally influenced groundwater conductivity and chloride concentrations less than 200 mg/L (Figure A-5). The average rate of increasing chloride is 2 mg/L per year or less at these wells, except 06S01W10N007 that has an average 86 mg/L per year increase (Figure A-5).

The large rate of increasing chloride concentrations at well 06S01W10N007, coupled with the greatest tidal signal in water levels and conductivity of all the monitoring wells (Table A-2), is unexpected given the relatively thick 67 feet of clay overlying the well screen (Table 3-2). These unique groundwater quality conditions and chloride trend at well 06S01W10N007 may be explained by the construction of the nearby Highway 237 bridges over Guadalupe River that are only about 200 feet north of wells 06S01W10N006 and 06S01W10N007. Historical chloride data are not available for the shallower well, 06S01W10N006, however conductivity data indicates elevated chloride concentrations similar to or greater than 06S01W10N007. According to the as-built engineering plans, the original bridges from the mid-1990s were replaced between 2008 and 2010. Dozens of concrete piles and piers were installed to depths around 70 to 80 feet bgs during the original construction, many of which were abandoned in-place and new piles driven to depths of about 80 to 90 feet bgs during the replacement bridge construction starting in 2008. The screen depth of well 06S01W10N007 is 73 to 78 feet bgs (Table 3-1) and consistent with total depth of the bridge piles and piers, which may indicate that the piles and piers act as a preferential flow path for tidally driven brackish water from Guadalupe River to reach the well. The timing of the 2008 bridge replacement is also consistent with a notable increase in the rate of the chloride concentration trend (Figure A-5). If the bridge piles and piers are the reason for the increasing chloride trend at well 06S01W10N007, it illustrates how important the clay layers are in preventing seawater from migrating deeper into the shallow aquifer because no other seawater intrusion monitoring wells have such large increasing trends in chloride concentrations. This also illustrates that construction activities near the Bay that pierce through the protective clay layers could negatively impact the groundwater quality of the shallow aquifer and thus should be considered during environmental planning prior to construction. The concept that seawater intrusion caused by construction activities that pierce the protective clay layers dates to at least the 1940s when Tolman and Poland (1940) suggested that the construction of the Dumbarton Bridge and Hetch-Hetchy pipeline may have punctured the clay layers and enabled seawater intrusion.

Well 06S02W05F001, like the co-located well 06S02W05F002, has very elevated chloride concentrations above typical seawater (Figure A-5), which likely indicates a connate or evapoconcentration source of chloride. However, well 06S02W05F001 has tidally influenced groundwater, possibly because it has a shallower screen depth (Table 3-1) and considerably less overlying clay (Table 3-2) than well 06S02W05F002.

Figure A-6 shows a strong positive relation between chloride and specific conductance in the seawater intrusion monitoring wells between 2000 and 2023 and illustrates a mixing-line between relatively fresh groundwater and increasing influence by seawater. Most of the wells with low to no tidally influenced groundwater conductivity cluster in the same general location on the fresh end of the mixing line and have a moderate R^2 (coefficient of determination) of 0.5 (Figure A-6). Compared to these nine wells, the wells with elevated chloride and tidally influenced conductivity (06S01W18R007, 06S01W17M009, and 06S01W10N007) plot higher along the mixing line, closer to the Bay water chloride concentrations. Similar to these three wells, well 06S01W02N008 plots higher along the mixing line, although it does not have tidally influenced conductivity (Figure A-5). The elevated chloride and lack of tidal signal may somehow be influenced by the proximity of well 06S01W02N008 to Mallard Slough, which is the discharge outfall channel for the San Jose-Santa Clara Regional Wastewater Facility.

In Figure A-6, the three co-located wells (06S02W05F001, 06S02W05F002, and 06S02W05F003) are highlighted because they provide unique insight into the vertical heterogeneity of chloride concentrations and sources within the shallow aquifer. These co-located wells are only about 45 feet from the tidally influenced Mayfield Slough (Table 3-3) and are among the closest seawater intrusion monitoring wells to the Bay (Figure 3-4). However, these wells have substantial differences in groundwater quality. Well 06S02W05F003 has the lowest chloride and specific conductance concentrations of any of the seawater intrusion monitoring wells. Coupled with the lack of tidal influence in conductivity (Figure A-5), this indicates this well has no influence from Bay water. However, wells 06S02W05F001 and 06S02W05F002 have the greatest concentrations of chloride and specific conductance, nearly one order of magnitude larger than the next greatest concentrations in well 06S01W17M009 (Figure A-6). The source of chloride in wells 06S02W05F001 and 06S02W05F002 is likely from a connate or evapoconcentration source that is different than present day Bay water because the chloride concentrations are much larger than Bay water and seawater and plot well above the mixing line of all the other seawater intrusion wells (Figure A-6). These differences are attributed to the local hydrogeologic conditions since 06S02W05F003 is screened deeper at 190 to 200 feet bgs with 177 feet of overlying clay, while wells 06S02W05F001 and 06S02W05F002 are screened shallower at 21 to 31 and 40 to 50 feet bgs, with only 27 and 38 feet, respectively, of overlying clay (Tables 3-1 and 3-2). These results illustrate the discontinuous nature of the aquifer units and that the source of chloride (connate, evapoconcentration, or Bay water) can be localized within the shallow aquifer.

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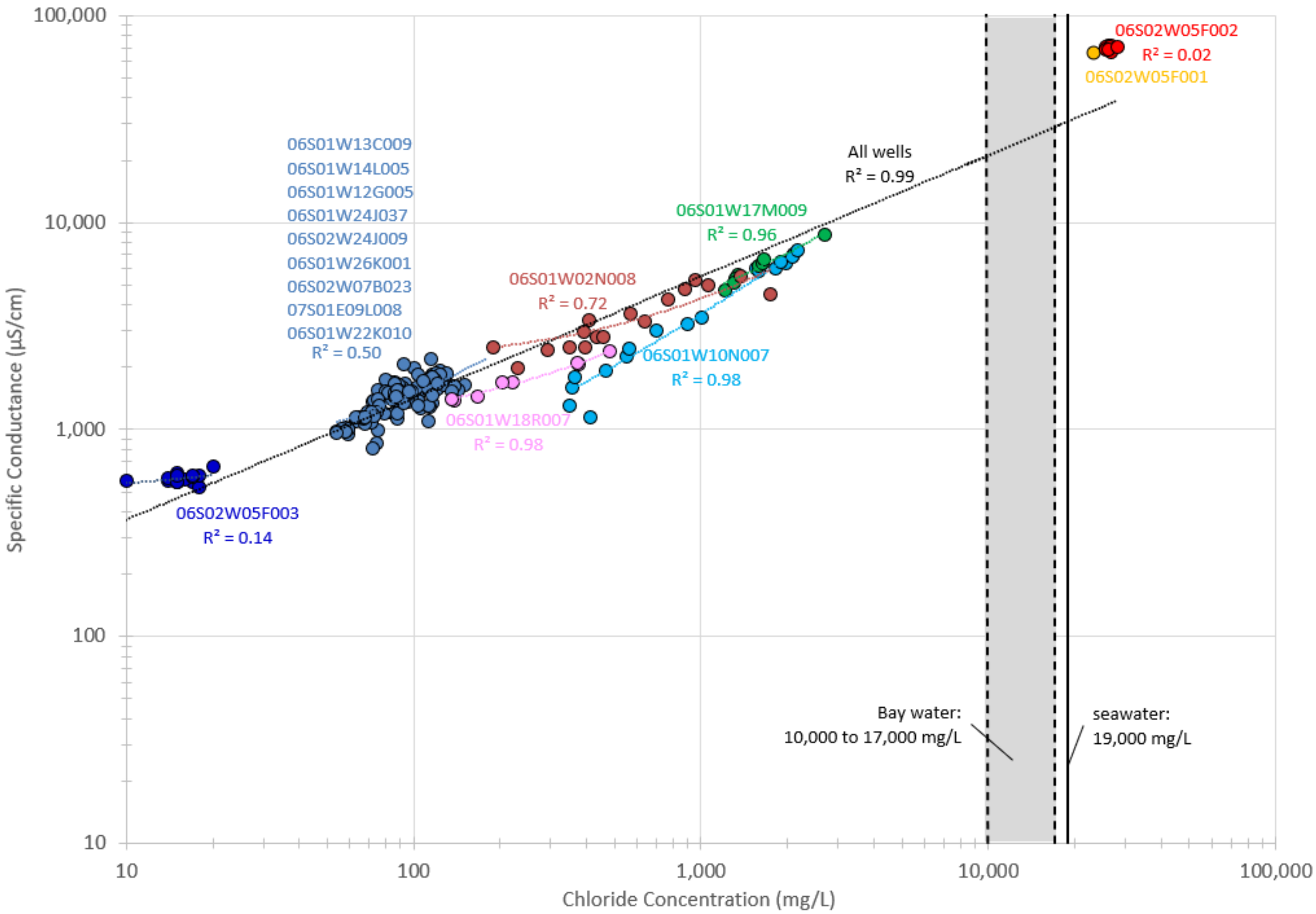
Figure A-6. Chloride and specific conductance in seawater intrusion monitoring wells (2000 to 2023).



Note: The nine wells (06S01W13C009 to 06S01W22K010) clustered together have low (<5%) to no tidally influenced groundwater conductivity (as shown in Figure A-5).

A.3.b Molar Ratios

In aquifers with other potential sources of salt concentrations, elevated salinity or chloride concentrations may not be conclusive of seawater intrusion (Jiao and Post, 2019). Because seawater has relatively constant ratios of several constituents (e.g., Na^+/Cl^-), these ratios can be evaluated in groundwater to help confirm if the salinity is from seawater intrusion or some other source (Jiao and Post, 2019). In the following sections, all ratios are presented as molar ratios based on concentration data in Table A-4.

Because seawater has a Na^+/Cl^- molar ratio of 0.86 and fresh groundwater typically has a higher ratio, a groundwater Na^+/Cl^- ratio of less than 0.86 can be used as an indicator of seawater intrusion (Jiao and Post, 2019). A decrease in the Na^+/Cl^- ratio occurs during seawater intrusion because Na^+ tends to adsorb on aquifer sediment, lowering the concentration in the water. The time series of chloride concentration and Na^+/Cl^- from well 06S01W10N007 illustrate changes that are characteristics of seawater intrusion (Figure A-7). As chloride concentrations increase over time, the Na^+/Cl^- decreases from about 0.84 to 0.33. This inverse relation between chloride concentrations and the Na^+/Cl^- ratio further supports the interpretation that the increasing chloride trend at this well is from seawater intrusion, likely from the nearby tidally influenced Guadalupe River, as previously discussed.

Although well 06S02W24J009 has no tidally influenced conductivity, chloride concentrations less than 100 mg/L, and an increasing chloride trend (0.9 mg/L per year) that is much less than well

06S01W10N007 (86 mg/L per year), the down trending Na^+/Cl^- ratios may indicate early stages of seawater intrusion (Figure A-7). Over the last decade at well 06S02W24J009, many of the Na^+/Cl^- ratios have been less than 0.86, which can indicate seawater intrusion, including the most recent data from 2023 that accompanied a substantial increase in chloride concentrations (Figure A-7). As noted by Jiao and Post (2019), the Na^+/Cl^- ratio can be a more sensitive indicator than chloride concentrations during the early stages of seawater intrusion because the increases in salinity (chloride) can often be subtle.

Conversely, the patterns with chloride concentrations and Na^+/Cl^- ratios can be reversed if an aquifer with saltwater intrusion receives freshwater (a process called groundwater freshening) (Jiao and Post, 2019). Although both wells 06S01W10N007 and 06S01W18R007 have tidally influenced conductivity (Figure A-5), well 06S01W18R007 has a statistically significant decreasing trend in chloride concentrations, as previously discussed. Figure A-7 illustrates the inverse relation between chloride and Na^+/Cl^- at well 06S01W18R007; as the chloride concentrations decrease over time, the Na^+/Cl^- ratio increases. This increase in the Na^+/Cl^- ratio occurs because the sorbed Na^+ is released from the aquifer sediments, increasing the Na^+ concentration in the water.

Only time series from 06S01W10N007, 06S02W24J009, and 06S01W18R007 are presented in Figure A-7 because no other wells have clear temporal patterns in the Na^+/Cl^- ratios that indicate either seawater intrusion or groundwater freshening. However, the previous discussions regarding chloride concentrations and trends (Figures A-5 and A-6) support the conclusion that several other wells are likely influenced by either seawater intrusion (06S01W13C009 and 07S01E09L008) or groundwater freshening (06S01W22K010, 06S01W26K001, and 06S02W07B023).

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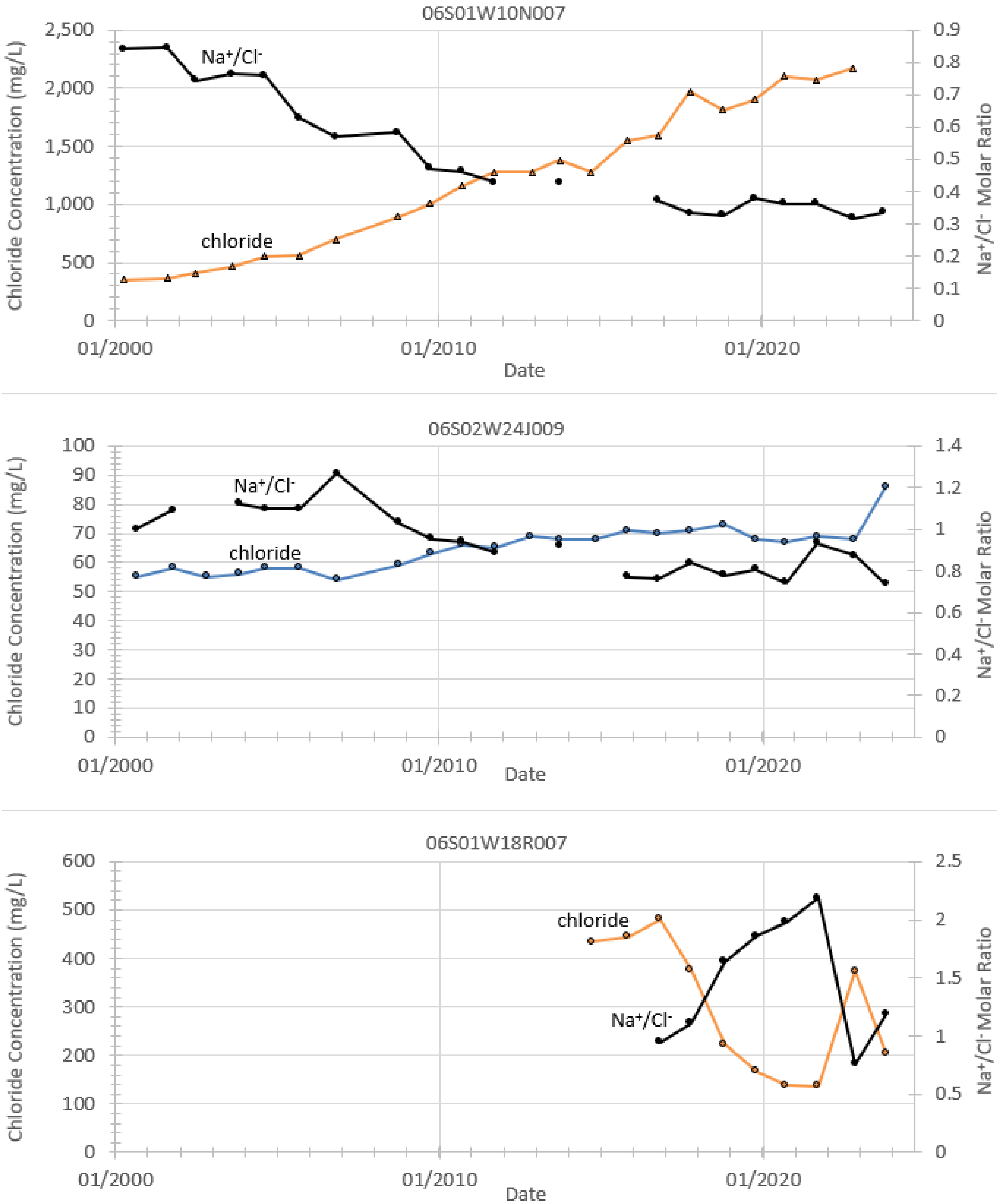
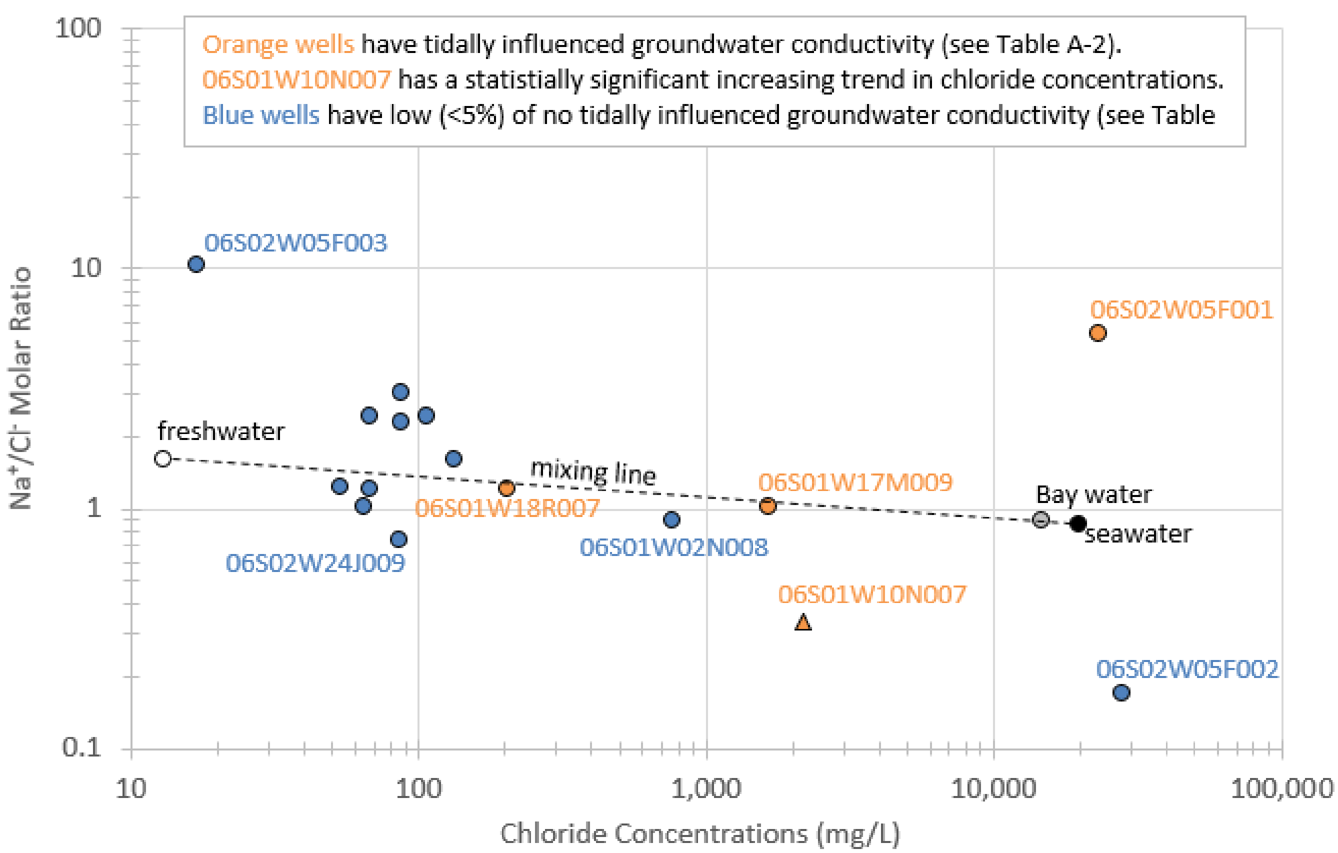
Figure A-7. Chloride and Na^+/Cl^- at wells 06S01W10N007 and 06S01W18R007 (2000 to 2023).



Note: Gaps in the Na^+/Cl^- molar ratio timeseries because sodium data are not available.

In Figure A-8, chloride concentrations and Na^+/Cl^- ratios for all seawater intrusion monitoring wells with available data from 2023 are compared to representive freshwater (surface water), Bay water, and seawater. Many of the wells have values near the mixing line between freshwater and seawater (Figure A-8). The wells with more elevated chloride concentrations (06S01W10N0007, 06S01W17M009, 06S01W02N008, and 06S01W18R007) tend to plot along the mixing line closer to Bay water and somewhat near or below the Na^+/Cl^- ratio of 0.86 that indicates seawater intrusion. Similarly, well 06S02W24J009 has a Na^+/Cl^- ratio of less than 0.86 that may be an early indicator of seawater intrusion (Figure A-8). However, the notable exceptions are the three co-located wells (06S02W05F001, 06S02W05F002, and 06S02W05F003) that plot well above and below the mixing line and other seawater intrusion monitoring wells (Figure A-8). As previously noted, wells 06S02W05F001 and 06S02W05F002 have chloride much greater than seawater and likely indicates a connate or evapoconcentration source different than present day Bay water. Prior to 2023, the Na^+/Cl^- ratio of well 06S02W05F002 was greater than 0.86 and closer to previous values for well 06S02W05F001. The elevated Na^+/Cl^- ratio of well 06S02W05F003 further indicates the unique geochemical signature and evolution of groundwater in that relatively deeper aquifer unit near the Bay, which is considerably different than all other samples from the seawater intrusion monitoring network.

Figure A-8. Chloride and Na^+/Cl^- at the seawater intrusion monitoring wells (2023).



Notes: The freshwater data point is a 2019 surface-water sample from Valley Water's Camden 2 managed recharge pond and represents surface water chemistry prior to recharge within the aquifer. The Bay water data is from Iwamura (1980) and the seawater data is from Jiao and Post (2019).

The water quality data, including the chloride trends and molar ratios, do not support a definitive conclusion as to the source of salinity at the co-located wells 06S02W05F001 and 06S02W05F002, other than it is likely from either a connate source or an evapoconcentration process. Chapter 2 provides additional explanation of the differences between a connate source or evapoconcentration process. While the water quality data is not definitive, observations made during the 2024 king tides at areas of groundwater emergence tend to support a conclusion that the source is from an evapoconcentration process similar to today's tidal marshes, rather than an entrapped connate water of marine origin (see

Appendix D and Chapter 4 for additional explanation). From these observations, the groundwater emergence in localized areas that is currently evapoconcentrating salts at land surface may be interpreted as the same process from the geologic past that created the elevated salinity conditions found today in groundwater from the co-located wells 06S02W05F001 and 06S02W05F002. As explained in Chapter D, this interpretation is supported by geologic evidence that the Bay shoreline has not migrated substantially during the past 1 to 1.5 million years, despite fluctuations in sea level highstand[5] because sedimentation rates of the Santa Clara Valley kept pace with relatively uniform subsidence rates[6] (Langenheim et al., 2015).

Table A-4. Groundwater quality data from Valley Water's seawater intrusion monitoring wells.

Well ID	Date	Chloride (mg/L)	Bicarbonate (as HCO3) (mg/L)	Boron (ug/L)	Bromide (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Sodium (mg/L)	Specific Conductance (uS/cm)	Sulfate (mg/L)	Total Dissolved Solids (TDS) (mg/L)
06S01W02N008	4/10/2000	1,370	1,647	1,460	0.1	48	95	1,040	5,550	146	4,200
06S01W02N008	10/17/2001	1,750	1,530	2,010	1.93	58.8	120	1,262	4,480	13.6	3,900
06S01W02N008	10/30/2002	190	230	1,560	1.05	13.7	25.5	448	2,510	169	1,300
06S01W02N008	10/29/2003	957	392	989	1.66	67.9	120	620	5,240	337	2,300
06S01W02N008	8/19/2004	350	384	835	0.85	27.2	54.3	319	2,510	314	1,160
06S01W02N008	10/5/2005	292	438	929	0.89	43	74.5	297	2,430	212	1,260
06S01W02N008	11/8/2006	230	440	912	0.58	43.9	57.1	274	1,980	158	1,070
06S01W02N008	10/2/2008	433	427	736	1.13	67.7	74	332	2,800	229	1,470
06S01W02N008	10/5/2009	394	454	818	0.99	68.5	86.7	294	2,490	228	1,380
06S01W02N008	11/27/2012	1,400	1,650	1,620	6.92	131				162	3,720
06S01W02N008	9/24/2014	795									2,700
06S01W02N008	10/26/2015	1,040									
06S01W02N008	10/19/2016	407	1,080	1,620	2	123	95.9	430	3,380	299	2,000
06S01W02N008	10/10/2017	1,060	541	1,130		111	84.5	651	4,950		2,720
06S01W02N008	10/16/2018	883		1,560		163	98.6	617	4,790		2,800
06S01W02N008	10/8/2019	392	1,070	1,440	2.5	188	103	350	2,980	217	1,810
06S01W02N008	9/10/2020	566	803	1,480		175	89.9	437	3,610		
06S01W02N008	9/13/2021	457	527	1,040		86.7	61.7	395	2,790		1,580
06S01W02N008	11/2/2022	637	554	1,170	3.11	80.1	59.9	493	3,320	293	1,920
06S01W02N008	10/4/2023	767		1,460		244	129	437	4,240		
06S01W10N007	4/10/2000	356	290	354	0.1	74	58	194	1,590	36	1,000
06S01W10N007	8/21/2001	350	285	415	1.31	67.4	64.6	192	1,310	35.2	860
06S01W10N007	7/9/2002	365		490	1.04	78.2	63.8	176	1,800	35.2	940
06S01W10N007	8/13/2003	410		462	1.11	80.2	64.1	203	1,150	36.2	960
06S01W10N007	8/18/2004	466	290	496	1.37	81.6	70.4	229	1,920	36.1	1,020
06S01W10N007	9/13/2005	553	310	446	1.83	87.5	74	225	2,250	41.2	1,180
06S01W10N007	11/2/2006	561	249	487	2.22	112	93.5	207	2,460	43.2	1,310
06S01W10N007	9/30/2008	700	238	437	1.99	135	88.6	264	2,990	46.8	1,760

[5] A sea-level highstand refers to times in the geologic past when sea levels were at their highest and typically higher than present-day levels.
[6] This type of subsidence is from tectonic processes over the geologic past and not from modern groundwater pumping.

06S01W10N007	10/1/2009	895	240	450	2.94	154	131	273	3,210	54.2	1,600
06S01W10N007	9/20/2010	1,010	233	498	3.24	160	141	303	3,480	55.3	1,850
06S01W10N007	9/26/2011	1,160	274	455	3.67	210	173	322		64	1,980
06S01W10N007	11/20/2012	1,280	275	479	4.2	233				72.3	2,340
06S01W10N007	10/3/2013	1,280	272	422	4.18	253	211	354		78.7	2,710
06S01W10N007	9/24/2014	1,380									2,700
06S01W10N007	10/29/2015	1,280									
06S01W10N007	10/19/2016	1,550	252	447	0.05	297	246	374	6,040	94.1	3,600
06S01W10N007	10/11/2017	1,590	265	467		309	262	343	5,820		2,880
06S01W10N007	10/17/2018	1,970		439		384	315	418	6,350		4,200
06S01W10N007	10/8/2019	1,810	321	453	6.9	385	316	443	6,030	115	3,720
06S01W10N007	9/10/2020	1,900	285	492		400	335	446	6,500		
06S01W10N007	9/13/2021	2,100	254	521		466	379	494	7,000		4,850
06S01W10N007	10/27/2022	2,070	252	473	7.41	406	341	426	6,830	141	3,940
06S01W10N007	10/4/2023	2,170		452		451	381	473	7,320		
06S01W12G005	4/10/2000	110	673	1,500	0.1	52	73	281	1,640	273	1,500
06S01W12G005	8/21/2001	104	522	1,370	0.42	60.2	77.6	219	1,440	189	898
06S01W12G005	7/9/2002	104							1,390		
06S01W12G005	8/13/2003	93							1,660		
06S01W12G005	6/30/2004	100							1,980		
06S01W12G005	9/9/2005	108							1,680		
06S01W12G005	11/7/2006	91	544						1,590		
06S01W12G005	9/30/2008	79							1,420		
06S01W12G005	9/30/2009	90	506	1,060	0.34	48	69.5	155	1,340	119	754
06S01W12G005	11/7/2012	84	557	964	0.31	47.9	75.1	155	1,410	112	740
06S01W12G005	9/15/2014	95									696
06S01W12G005	11/3/2015	91									
06S01W12G005	10/19/2016	105	531	852	0.42	55.3				156	906
06S01W12G005	10/11/2017	98	576	830		55.9	77.1	155	1,440		796
06S01W12G005	10/11/2018	78		853		51.9	69.6	147			690
06S01W12G005	10/8/2019	85	517	702	0.4	46.6	62.8	126	1,200	102	702
06S01W12G005	9/10/2020	79	529	764		48.9	66.9	134	1,200		
06S01W12G005	9/13/2021	113	525	752		48.4	66	135	1,090		692
06S01W12G005	10/27/2022	88	486	657	0.5	42	57.2	116	1,130	88.6	666
06S01W12G005	10/2/2023	88		660		52.1	70.5	131	1,200	229	964
06S01W13C009	11/16/2000	118							1,540		
06S01W13C009	8/21/2001	116							1,350		
06S01W13C009	7/9/2002	106							1,260		
06S01W13C009	8/12/2003	86							1,560		
06S01W13C009	6/30/2004	104							1,850		
06S01W13C009	9/30/2005	75	452						1,550		
06S01W13C009	10/31/2006	103	469	586	0.5	112	69	149	1,600		
06S01W13C009	9/30/2008	109							1,680		
06S01W13C009	9/30/2009	117	548	567	0.45	112	75.3	144	1,630	203	954
06S01W13C009	9/20/2010	121	527	616	0.44	108	73.2	145	1,580	198	944
06S01W13C009	9/26/2011	116	602	557	0.38	108	69.2	144		175	922
06S01W13C009	11/8/2012	120	601	609	0.43	112				175	824
06S01W13C009	10/3/2013	122	600	585	0.41	134	74.9	171		201	990

06S01W13C009	9/15/2014	137									976
06S01W13C009	10/26/2015	181									
06S01W13C009	10/18/2016	127	579	568	0.44	106	73	145	1,640	209	1,060
06S01W13C009	10/10/2017	113	595	607		100	69.2	148	1,570		890
06S01W13C009	10/11/2018	125		635		118	80	157			940
06S01W13C009	10/17/2019	150	660	588	0.5	117	78.5	138	1,640	202	996
06S01W13C009	9/10/2020	139	651	590		119	80.6	140	1,620		
06S01W13C009	9/13/2021	143	651	612		128	81.3	158	1,560		1,010
06S01W13C009	10/27/2022	138	672	595	0.51	113	74.9	146	1,620	175	1,010
06S01W13C009	10/4/2023	135		531		101	70.2	140	1,530		
06S01W14L005	4/11/2000	59	428	134	0.1	100	40	59	950	92	620
06S01W14L005	4/23/2001	114							1,290		
06S01W14L005	7/9/2002	112							1,310		
06S01W14L005	8/13/2003	120							1,730		
06S01W14L005	6/30/2004	115							2,180		
06S01W14L005	10/5/2005	130							1,840		
06S01W14L005	11/6/2006	119	488	527	0.6	139	79.5	149	1,800	313	1,120
06S01W14L005	9/30/2008	116							1,850		
06S01W14L005	10/1/2009	124	520	459	0.57	138	78	164	1,780	301	1,110
06S01W14L005	9/15/2014	126									1,190
06S01W14L005	10/27/2015	142									
06S01W14L005	10/19/2016	124	696	524	0.6	136	76.1	171	1,920	312	1,230
06S01W14L005	10/5/2017	120	649	542		153	86.9	187	1,880		1,170
06S01W14L005	10/9/2018	130		526		125	72	152	1,870		1,200
06S01W14L005	10/22/2019	123	718	545	0.8	158	87.9	177	1,850	312	1,190
06S01W14L005	9/10/2020	115	698	505		141	81	160	1,790		
06S01W14L005	9/13/2021	119	683	553		157	85.7	178	1,730		1,170
06S01W14L005	11/2/2022	116	724	518	0.67	142	78.1	162	1,780	307	1,190
06S01W14L005	10/5/2023	108		503		140	78.2	168	1,720		
06S01W17M009	9/15/2014	1,230									2,700
06S01W17M009	10/27/2015	1,390									
06S01W17M009	10/24/2016	1,580	519	593	5.56	196	149	861	6,140	231	3,710
06S01W17M009	10/3/2017	1,340	522	609		168	149	770	5,620		3,120
06S01W17M009	10/16/2018	1,320		650		172	147	675	5,320		2,900
06S01W17M009	10/21/2019	1,210	590	608	6.1	170	139	697	4,730	193	2,800
06S01W17M009	9/14/2020	2,700	480	657		296	248	1,100	8,750		
06S01W17M009	9/9/2021	1,300	508	615		200	162	717	5,130		3,200
06S01W17M009	10/12/2022	1,640	600	676	6.41	222	185	865	6,390	260	4,320
06S01W17M009	10/18/2023	1,650		753		243	204	1,080	6,660		
06S01W18R007	9/15/2014	434									1,220
06S01W18R007	10/27/2015	445									
06S01W18R007	10/25/2016	481	533	399	1.66	94	71.9	296	2,380	89.6	1,420
06S01W18R007	10/3/2017	376	486	374		85.7	66	271	2,060		1,200
06S01W18R007	10/16/2018	222		434		69.3	51.1	236	1,680		940
06S01W18R007	10/21/2019	167	534	358	0.9	63.6	46.7	201	1,440	89.5	868
06S01W18R007	9/14/2020	138	634	346		59.2	46.1	177	1,380		
06S01W18R007	9/9/2021	136	611	386		70.3	52.7	193	1,410		854
06S01W18R007	11/2/2022	373	600	365	1.34	126	90.6	184	2,110	79.9	1,210

06S01W18R007	10/18/2023	204		320		104	75.8	157	1,700		
06S01W22K010	4/11/2000	75	309	151	0.1	128	35	38	991	161	630
06S01W22K010	4/24/2001	74							864		
06S01W22K010	7/10/2002	72							808		
06S01W22K010	8/14/2003	71							1,080		
06S01W22K010	6/30/2004	72							1,360		
06S01W22K010	9/14/2005	66							1,120		
06S01W22K010	10/31/2006	63	268	200	0.17	140	40.6	42.4	1,100	206	708
06S01W22K010	10/1/2008	64							1,140		
06S01W22K010	10/1/2009	68	277	181	0.2	137	38.3	40.4	1,070	206	700
06S01W22K010	11/7/2012	64	336	213	0.26	139				201	678
06S01W22K010	9/16/2014	65									698
06S01W22K010	11/4/2015	61									
06S01W22K010	10/26/2016	59	321	192	0.18	122	34.2	40.2	1,010	19.6	684
06S01W22K010	10/3/2017	58	331	211		131	37.7	41.7	1,020		650
06S01W22K010	10/16/2018	59		202		117	33.4	39.5	1,010		670
06S01W22K010	10/21/2019	56	342	212	0.2	134	37.5	44.5	1,000	168	638
06S01W22K010	9/14/2020	54	343	182		119	34	42.6	984		
06S01W22K010	9/9/2021	58	363	198		123	33.9	42.4	977		672
06S01W22K010	11/2/2022	58	394	201	0.5	120	32.9	40.5	975	168	650
06S01W22K010	10/5/2023	54		202		120	34.3	42.4	962	196	1,000
06S01W24J037	11/16/2000	90							1,570		
06S01W24J037	8/21/2001	95							1,360		
06S01W24J037	7/9/2002	92							1,340		
06S01W24J037	8/12/2003	86							1,700		
06S01W24J037	6/30/2004	92							2,080		
06S01W24J037	9/9/2005	89	607						1,640		
06S01W24J037	10/31/2006	83	598	1,420	0.75	104	80.6	191	1,690		
06S01W24J037	9/30/2008	80							1,740		
06S01W24J037	9/30/2009	86	669	1,270	0.67	94.2	81.6	172	1,660	176	982
06S01W24J037	11/7/2012	87	718	1,340	0.6	92.5				171	930
06S01W24J037	9/16/2014	93									954
06S01W24J037	10/28/2015	94									
06S01W24J037	10/18/2016	89	679	1,240	0.54	82.5	71.7	171	1,540	151	980
06S01W24J037	10/10/2017	80	674	1,210	0.6	80.7	69.4	172	1,520		864
06S01W24J037	10/16/2018	89		1,050		77.6	66.8	150	1,480		880
06S01W24J037	10/17/2019	98	765	1,110		86.7	72.7	158	1,530	131	898
06S01W24J037	9/10/2020	82	738	1,160		87	73.1	162	1,500		
06S01W24J037	9/8/2021	86	734	1,070		83.7	68.5	151	1,450		916
06S01W24J037	10/13/2022	86	758	1,100	0.68	84.9	72.4	154	1,500	128	940
06S01W24J037	10/18/2023	88		1,060		90.2	76.6	171	1,540		
06S01W26K001	11/16/2000	121							1,660		
06S01W26K001	8/21/2001	116							1,460		
06S01W26K001	7/9/2002	104							1,310		
06S01W26K001	8/12/2003	96							1,530		
06S01W26K001	8/19/2004	87							1,450		
06S01W26K001	10/31/2006	73	366	287	0.17	180	58.2	77.6	1,390	267	930
06S01W26K001	10/1/2008	75							1,400		

06S01W26K001	10/5/2009	76	368	203	0.21	149	52.5	62.2	1,310	233	886
06S01W26K001	11/20/2012	93	436	212	0.15	152				222	854
06S01W26K001	9/17/2014	76									790
06S01W26K001	11/4/2015	75									
06S01W26K001	10/17/2016	74	415	199	0.19	128	47.2	59.4	1,220	191	832
06S01W26K001	10/4/2017	69	430	211		141	51.6	62	1,220		752
06S01W26K001	10/11/2018	71		227		115	42.7	51.4	1,210		760
06S01W26K001	10/21/2019	67	430	202	0.2	135	48	56.3	1,130	177	782
06S01W26K001	9/9/2020	66	434	189		127	47.8	54.7	1,140		
06S01W26K001	9/8/2021	73	466	213		147	52.7	58.9	1,160		796
06S01W26K001	10/11/2022	63	470	204	0.75	135	48.8	53.6	1,150	176	840
06S01W26K001	10/5/2023	68		193		131	48.2	52.9	1,150		
06S02W05F001	12/4/2012	26,400	1,470	8,730	86.6	571	1980	15100		265	46,000
06S02W05F001	10/18/2023	23,400		7,860		529	8640	80000	65,800		
06S02W05F002	12/4/2012	28,000	940	7,600	85.5	915	2600	16700		321	51,000
06S02W05F002	11/13/2014	23,800	1,130	5,640	89.3	704				3,290	51,100
06S02W05F002	10/26/2015	27,400									
06S02W05F002	10/31/2016	26,100	909	7,050	94	629	1,800	17,100	71,200	3,570	50,400
06S02W05F002	10/2/2017	26,800	913	6,460		644	1,750	16,600	71,600		49,800
06S02W05F002	10/10/2018	25,600	1,360	5,870		774	2,060	17,100	70,100		48,000
06S02W05F002	10/10/2019	26,600		5,290	94.1	716	2,210	16,800	66,400	337	51,100
06S02W05F002	9/9/2020	26,400	1,480	5,240		571	468	14,500	70,100		52,200
06S02W05F002	9/8/2021	25,700	1,150	6,040		745	2,400	18,400	68,100		
06S02W05F002	10/13/2022	26,300	2,210	5,940	116	506	2,020	15,400	68,800	3,620	94,400
06S02W05F002	10/23/2023	28,100		5,440		660	2,000	3,060	70,100		
06S02W05F003	3/15/2004	14	276	224	0.1	14.3	7.9	101	562	7.3	350
06S02W05F003	11/6/2006	10	268	322	0.11	14.9	8.7	110	569	7.3	318
06S02W05F003	10/2/2008	14	268	284	1	13.8	8.2	106	581	5.9	352
06S02W05F003	10/8/2009	15	278	271	0.11	14.1	8.2	103	556	5.6	344
06S02W05F003	9/20/2010	17	279	306	0.11	14.8	8.5	108	558	4.3	338
06S02W05F003	9/27/2011	16	338	267	0.1	13.8	7.9	102	574	4.2	340
06S02W05F003	11/6/2012	16	368	299	0.05	16.2				0.5	354
06S02W05F003	10/1/2013	16	372	298	0.13	15	8.9	107		1	370
06S02W05F003	9/17/2014	20	391	283	0.13	16.2	9.7	104		0.5	362
06S02W05F003	10/22/2015	18	379	281	0.13	16.2	9.7	109	528	0.8	372
06S02W05F003	10/27/2016	18	350	296	0.12	16.3	9.9	115	601	1.5	356
06S02W05F003	10/2/2017	20	344	274	0.11	14.6	8.6	98.7	665	1.9	348
06S02W05F003	10/10/2018	17		322	0.12	11.8	7.2	85.5	587	1.9	330
06S02W05F003	10/10/2019	15	346	282	0.1	16	9.2	106	558	6.4	338
06S02W05F003	9/9/2020	15	356	303	0.14	16.7	9.7	108	560	2.1	370
06S02W05F003	9/8/2021	15	374	308	0.13	18.7	10.5	112	616	1	382
06S02W05F003	10/13/2022	15	365	314	0.15	17.2	10.3	112	603	3.2	368
06S02W05F003	10/23/2023	17	351	291	0.13	16.6	9.6	114	598	4.8	364
06S02W07B023	4/10/2000	97	554	231	0.1	120	70	103	1,210	108	790
06S02W07B023	10/15/2001	99		264	0.46	109	79.8	97.3	913	129	810
06S02W07B023	10/30/2002	93	250	344	0.38	113	70.3	103	1,420	129	820
06S02W07B023	12/8/2003	80	490	290	0.23	117	70.5	104	1,450	119	820
06S02W07B023	8/17/2004	90	476	343	0.41	114	71.5	102	1,510	119	817

06S02W07B023	9/12/2005	85	552	311	0.62	111	69.4	98.7	1,410	136	838
06S02W07B023	11/6/2006	75	519	363	0.41	116	65.7	112	1,400	118	792
06S02W07B023	10/3/2008	73	534	307	0.36	113	60	99.8	1,480	108	830
06S02W07B023	10/20/2009	76	520	318	0.37	109	66.6	103	1,370	101	816
06S02W07B023	9/20/2010	80	550	329	0.37	108	68	106	1,360	132	800
06S02W07B023	9/27/2011	74	626	294	0.28	105	63.1	99.8		104	798
06S02W07B023	11/6/2012	74	634	313	0.34	106				105	800
06S02W07B023	10/1/2013	71	672	323	0.32	104	62.8	104		88.8	790
06S02W07B023	9/17/2014	77	604	276	0.33	93.9	59.5	93.3		104	790
06S02W07B023	10/26/2015	110	710	282	0.34	99.7	60.1	101	1,320	97	748
06S02W07B023	10/31/2016	72	677	299	0.32	102	65.1	108	1,430	99	836
06S02W07B023	10/3/2017	71	631	319	0.32	106	66.6	108	1,320	94.3	746
06S02W07B023	10/10/2018	79		341	0.3	100	62.9	103	1,350	94.5	770
06S02W07B023	10/21/2019	75	722	309	0.3	126	65.4	121	1,260	95.7	798
06S02W07B023	9/9/2020	63	689	300	0.35	127	64.7	127	1,310	98.3	804
06S02W07B023	9/8/2021	68	691	316	0.34	109	66.2	104	1,320	98.6	812
06S02W07B023	10/13/2022	65	869	317	0.38	111	68.4	108	1,330	104	818
06S02W07B023	10/12/2023	68	727	299	0.35	113	68.4	106	1,350	92.5	834
06S02W24J009	9/1/2000	55						35.7	1,110		
06S02W24J009	10/16/2001	58	304	228	0.26	135	44.8	41	855	231	730
06S02W24J009	10/30/2002	55	304	316	0.2	157	50.5		1,030	233	770
06S02W24J009	11/3/2003	56	312	270	0.21	172	50.7	40.8	1,170	212	790
06S02W24J009	8/18/2004	58	301	272	0.23	150	47.4	41.3	1,140	227	809
06S02W24J009	9/14/2005	58	330	285	0.28	163	52.3	41.3	1,160	236	784
06S02W24J009	11/6/2006	54	302	331	0.25	148	45	44.4	1,150	207	716
06S02W24J009	9/30/2008	59	302	240	0.21	146	41	39.4	1,160	182	716
06S02W24J009	10/6/2009	63	304	238	0.24	143	43.6	39	1,120	188	744
06S02W24J009	9/21/2010	66	293	226	0.21	141	42.2	40.3	1,100	146	706
06S02W24J009	9/26/2011	65	354	216	0.23	133	38.8	37.4		175	676
06S02W24J009	11/7/2012	69	366	244	0.24	142				184	676
06S02W24J009	9/30/2013	68	364	229	0.24	146	43.1	40.6		165	694
06S02W24J009	11/12/2014	68	365	225	0.25	128				171	694
06S02W24J009	10/29/2015	71	369	229	0.25	133	39.4	35.5	1,090	179	720
06S02W24J009	10/12/2016	70	344	224	0.24	126	39	34.5	1,090	145	710
06S02W24J009	10/4/2017	71	362	237	0.24	140	42.9	38.5	1,090	164	684
06S02W24J009	10/22/2018	73		228	0.24	130	39.8	36.8	1,070	155	660
06S02W24J009	10/15/2019	68	360	205	0.3	144	37.8	35.5	1,060	158	694
06S02W24J009	9/17/2020	67	357	219	0.26	114	35.6	32.2	1,050	163	670
06S02W24J009	9/7/2021	69	360	242	0.28	145	44.1	41.8	1,040	165	708
06S02W24J009	11/3/2022	68	411	235	0.27	138	41.1	38.5	1,060	156	696
06S02W24J009	10/18/2023	86	359	224	0.28	137	41.9	41.1	1,060	148	724
07S01E09L008	10/24/2000	63		163		90.6			1,090	101	658
07S01E09L008	10/17/2001	62	394	162	0.21	85.2	70.5	50	792	93.4	590
07S01E09L008	11/18/2002	60	382	142	0.17	88.6	59.8	36.7	943	91.9	580
07S01E09L008	10/30/2003	43	365	182	0.2	92.2	61.3	35.2	1,000	76.7	610
07S01E09L008	8/16/2004	58	393	198	0.21	91.4	66.1	41.4	1,270	88.5	596
07S01E09L008	11/2/2005	63	410	183	0.19	94.2	69.2	40.6	943	89.4	582
07S01E09L008	5/7/2007	50	362	170	0.05	87.6	62.4	41.4	1,000	84.5	586

07S01E09L008	9/22/2009	57	372	175	0.19	85.2	60.1	40.2	992	84.7	578
07S01E09L008	9/21/2010	57	359	162	0.17	85.8	59.6	41.9	985	79.9	576
07S01E09L008	9/19/2011	57	444	173	0.13	85.9				80.4	576
07S01E09L008	11/20/2012	58	433	173	0.21	87.9				79.1	572
07S01E09L008	9/30/2013	61	452	177	0.19	86.8	60.4	41.1		63	552
07S01E09L008	9/22/2014	67	451	147	0.19	81.4	57.5	36.6		82.7	584
07S01E09L008	10/8/2015	64	457	136	0.2	88.6	61.6	40.7	1,040	74.6	612
07S01E09L008	10/12/2016	62	429	162	0.2	83	58.8	37	1,030	66.1	620
07S01E09L008	10/24/2017	62	460	206	0.2	90	61.5	39.3	1,040	82.9	582
07S01E09L008	10/15/2018	62		173	0.19	85.5	60.8	39.9	1,050	78.3	610
07S01E09L008	10/15/2019	59	448	168	0.2	86.4	61.1	40.3	997	77.4	564
07S01E09L008	9/17/2020	62	461	174	0.23	80.6	58.1	35.7	1,010	82.8	640
07S01E09L008	9/15/2021	65	469	191	0.23	93.1	67.2	40.3	1,010	82.5	628
07S01E09L008	10/24/2022	65	471	170	0.25	92.7	65.3	41	1,050	82.1	620
07S01E09L008	10/23/2023	65	492	178	0.23	96.5	68.8	42.6	1,070	79.8	646

Note: blank cells – data not available; no groundwater quality samples available for wells 06S01W10N006 or 06S02W06J003.

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APPENDIX B
Existing Groundwater Condition Map Methods

APPENDIX B – EXISTING GROUNDWATER CONDITION MAP METHODS

Appendix B describes the methods used to evaluate and map areas in the shallow aquifer system near the Bay in Santa Clara County that may experience groundwater rise and emergence under existing conditions. To promote consistency with previously published groundwater rise and emergence maps from other counties surrounding the Bay, this study created maps using methods generally similar to Hoover et al. (2017), Plane et al. (2019), and May et al. (2022), with noted differences. Appendix B also summarizes the minimum depth to water measurements and control points used to create the existing highest groundwater conditions map.

B.1 Methods

While Valley Water publishes annual groundwater elevation maps[1] and a depth to first groundwater map for the aquifers in Santa Clara County (Chapter 2, Figure 2-7)[2], this study created a new map specifically for shallow groundwater near the Bay. Consistent with previous studies, the primary source of depth to groundwater data was the California State Water Resources Control Board (SWRCB) GeoTracker[3], a key data management system for groundwater sites with impacted groundwater quality, including sites requiring cleanup. Only sites within the Santa Clara Plain groundwater management area were used for this study (i.e., excludes Coyote Valley groundwater management area and Llagas Subbasin given their distance from the Bay). Although Valley Water has extensive groundwater level and seawater intrusion monitoring networks, GeoTracker data provide a spatially denser network of shallow monitoring wells near the Bay. Because GeoTracker includes cleanup sites, the monitoring wells tend to be relatively shallow and often screened within the shallow aquifer system of the Santa Clara Subbasin. Cleanup activities often span many years, and therefore GeoTracker data often includes groundwater levels over relatively long periods. Using GeoTracker data also allows other California coastal studies to follow the methods outlined here, promoting a consistent statewide approach to understanding groundwater rise and emergence.

Consistent with previous groundwater rise and emergence studies, several data compilation and filtering steps were applied to the depth to water data. These steps included using only depth to water data from 2000 to 2020 and between December and May, which includes the winter rainy season and spring when shallow groundwater typically reaches its seasonal high in the Santa Clara Plain. Additionally, these steps reduce the number of wells but remove potential bias from wells with depth to water measurements limited to the dry summer months. Only wells with total depths less than 50 feet below ground surface (bgs) were included. Wells with no reported total depth or well depths greater than or equal to 50 feet bgs were excluded. Using wells with depths less than 50 feet helps ensure the monitoring wells are screened in the shallow aquifer system and thus represent shallow groundwater conditions. Similarly, only depth to water measurements of less than 50 feet bgs were included. Negative depth to water measurements (above ground surface) were excluded. Wells with negative depths to water readings are usually from the deeper aquifer system and associated with artesian conditions. All depth to water measurements were normalized relative to ground surface, including monitoring wells with riser height above ground surface. The depth to water measurements were all converted to the uniform NAVD-88 topographic datum.

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[1] Annual groundwater elevation maps of the Santa Clara Subbasin principal aquifer are published in Valley Water's Annual Groundwater Report, which is available here: https://www.valleywater.org/your-water/groundwater.

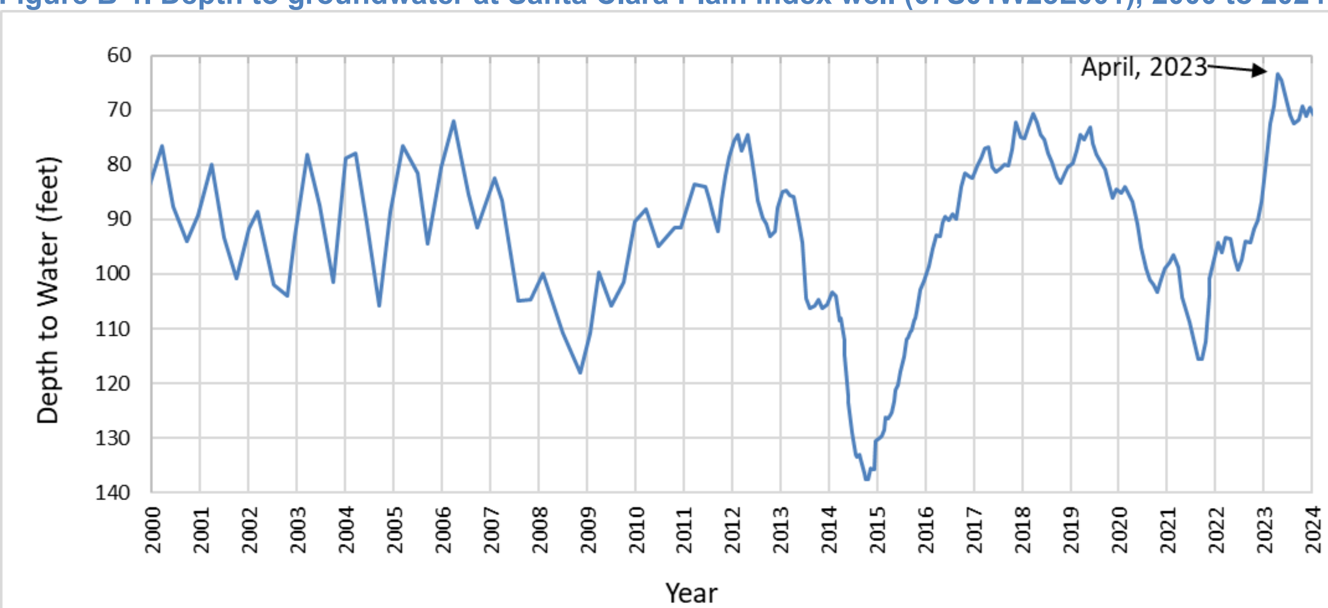
[2] The depth to first groundwater in the Santa Clara Subbasin map is available as Figure 2-17 in the 2021 Groundwater Management Plan.

[3] GeoTracker is available here: https://geotracker.waterboards.ca.gov/

Groundwater Response to Tides, Seawater Intrusion, and Sea-Level Rise

To provide context for the general groundwater and hydrologic conditions in the Santa Clara Plain from 2000 to 2020, Valley Water's index well (07S01W25L001)[4] for the Santa Clara Plain is shown in Figure B-1. Although well 07S01W25L001 is in the City of Campbell, about nine miles south of the Bay, screened in the principal aquifer, and not affected by seawater intrusion or groundwater rise and emergence, water levels in this index well reflect the general groundwater trends in the shallow and principal aquifers of the Santa Clara Plain. Site specific groundwater conditions in the shallow aquifer can vary from this index well, as illustrated in Chapters 2 and 3. From 2000 to 2006, groundwater levels were relatively stable with characteristic seasonal variability (Figure B-1). Groundwater levels declined in response to statewide droughts from 2007 to 2009, 2012 to 2016, and 2020 to 2022 (Figure B-1). Following each drought, groundwater levels quickly recovered because of a return to normal or above-normal hydrologic conditions, Valley Water's managed recharge operations, and community water conservation efforts. Relatively high groundwater levels occurred in 2006, 2012, and from 2017 to 2019 (Figure B-1). Notably absent from the 2000 to 2020 study period is the exceptionally wet winter of 2022 to 2023 and the above-average wet winter of 2023 to 2024, which resulted in the highest ever recorded groundwater level at well 07S01W25L001 in April 2023 (Figure B-1). Groundwater levels from the wet winters were used to help verify the maps of existing highest groundwater conditions, as described in the methods below.

Figure B-1. Depth to groundwater at Santa Clara Plain index well (07S01W25L001), 2000 to 2024



Note: Depth to water (DTW) reflects depth of the groundwater level below ground surface.

Following the groundwater level data compilation and filtering steps, several spatial gaps were identified near the Bay. To fill these gaps, groundwater level data from Groundwater Monitoring Reports of four cleanup sites[5] in GeoTracker that met the data requirements were added to the spatial coverage.

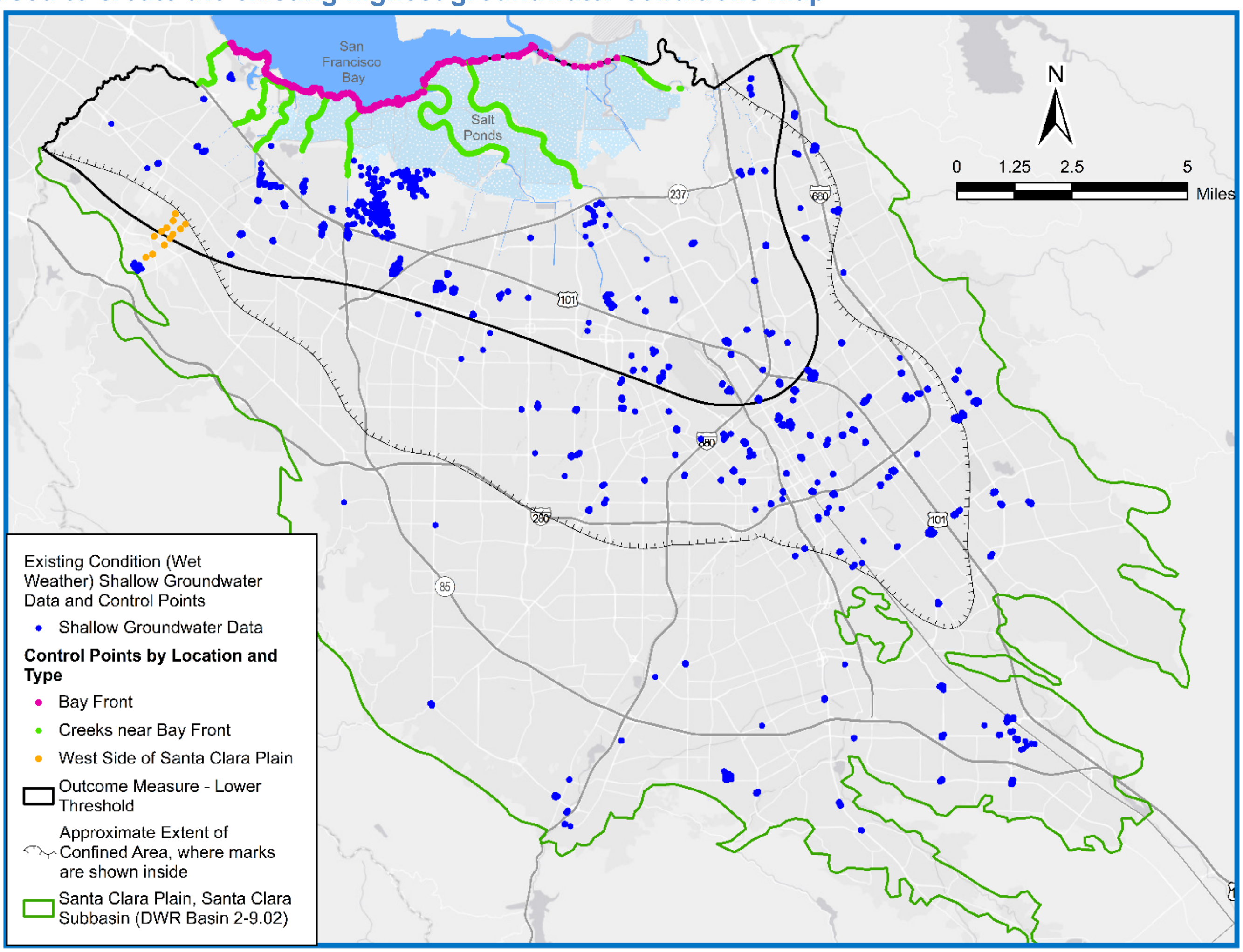
Using these selection and filtering criteria, the minimum depth to water from 2,174 wells with well depth less than 50 feet bgs across the Santa Clara Plain were compiled from GeoTracker (Figure B-2 and Table B-1). Only the minimum depth to water measurement for each well and control point was used in subsequent steps to create the existing highest groundwater conditions map. These minimum depth to water measurements reflect the highest recorded groundwater elevation at each well between 2000 and 2020. Rather than reflecting the actual spatial pattern during any given year, this method uses the

[4] Groundwater levels for the index well (07S01W25L001) are available on Valley Water's Historical Groundwater Elevation Data website: https://gis.valleywater.org/GroundwaterElevations/index.php
[5] Site IDs: SLT20365255, T10000001778, T10000003442, T10000007316

minimum depth to water measurement for each well from different years, creating a temporal composite of the minimum depth to water. This temporal composite is a theoretical condition where each well has the minimum depth to water and thus represents the highest-case scenario for shallow groundwater based on historical observations at each well. Because of actual hydrogeologic conditions that influence local-scale recharge and discharge that affect shallow groundwater, it is unlikely that all wells would simultaneously have minimum depth to water under actual, real-world conditions.

Due to limited groundwater level monitoring along the Bay shoreline, within the salt ponds, and near the creeks, a total of 2,453 control points (Figures B-2) were used to constrain land surface elevation and groundwater levels based on the 2020 digital elevation model (DEM) (1 feet x 1 feet resolution) in NAVD88 vertical datum. The control points include 307 along the Bay front, 2,134 along gaining reaches of Adobe Creek, Coyote bypass channel, Guadalupe River, Guadalupe Slough, Alviso Slough, Matadero Creek, Permanante Creek, San Francisquito Creek, and Stevens Creek, and 12 on the western edge of the Santa Clara Plain near Matadero and Barron creeks (Figure B-2). These 12 control points filled the data gap and eliminated an area of artificially created groundwater emergence that was caused by the interpolation. As a conservative estimate of groundwater conditions at the control points, groundwater elevations were assigned as land surface elevation along the shoreline control points and as streambed elevation along the stream reach control points. The spatial density of control points along the shoreline and streams matches the number of vertices of the shoreline and stream reach extent in GIS.

Figure B-2. Location of wells with minimum depth to water measurements and control points used to create the existing highest groundwater conditions map



Using the previously described minimum depth to water measurements and control points, the spline interpolation method in ArcGIS was used to create maps of existing highest groundwater elevation relative to mean sea level. These maps are shown in Chapter 4 as Figures 4-1 and 4-2. The maps of existing highest groundwater conditions, shown as depth to water relative to ground surface (Figures 4-4 and 4-5), were created using ArcGIS Spatial Analyst tools. Specifically, the depth to water map or surface was calculated by subtracting the existing highest groundwater elevation raster surface from the 2020 digital land surface elevation model (DEM) (1 feet x 1 feet resolution in NAVD88 vertical datum). As explained in Chapter 4, the existing highest groundwater conditions maps were reviewed for potential inconsistencies caused by data or interpolation errors, and ground surface elevations (Figure 4-6) at specific locations were compared to mapped shallow and emergent groundwater within known wetlands and other field observations by Valley Water staff. Other details about map verification are described in Chapter 4.

Table B-1. GeoTracker wells with minimum depth to water measurements used to create the existing highest groundwater conditions map

GeoTracker Global ID_Field Point Name	Latitude	Longitude	Ground Surface Elevation (feet NAVD88)	Well Depth (feet below ground surface)	Minimum Depth to Water (feet below ground surface)	Minimum Groundwater Level Elevation (feet NAVD88)	Date
T10000002937_MW-1	37.2217058	-121.9790499	381.746	30	10.350	371.396	1/29/2015
T10000002937_MW-2	37.2215962	-121.9787864	383.650	30	13.260	370.390	1/29/2015
T10000002937_MW-3	37.2216727	-121.9789157	381.705	30	9.880	371.825	1/29/2015
T10000002937_MW-4	37.2215128	-121.9789948	384.333	30	11.900	372.433	1/29/2015
T10000002937_MW-5	37.2214897	-121.9790902	385.213	30	12.760	372.453	1/29/2015
T10000002937_MW-6	37.2215277	-121.9792009	384.572	30	12.500	372.072	1/29/2015
T10000004547_MW-1	37.2209327	-121.9767589	379.638	35	25.190	354.448	3/26/2013
T0608501534_MW-10	37.2211267	-121.8626167	242.773	28	16.520	226.253	12/1/2008
T0608501534_MW-11	37.2210276	-121.8626002	243.151	30	17.150	226.001	12/1/2008
T0608501534_MW-12	37.2211699	-121.8623557	243.969	29	17.220	226.749	12/1/2008
T0608501534_MW-13	37.2209952	-121.8621750	245.245	30	18.130	227.115	12/1/2008
T0608500369_GT-1	37.2301335	-121.9832301	410.696	33	16.250	394.446	12/30/2003
T0608500369_MW-4	37.2302267	-121.9831631	410.895	25	16.350	394.545	12/30/2003
T0608500369_MW-5	37.2300616	-121.9829980	411.124	27	16.440	394.684	12/30/2003
T0608500369_MW-7	37.2302213	-121.9828165	409.136	33	15.730	393.406	12/30/2003
T0608500369_MW-8	37.2300008	-121.9826866	405.725	24	13.650	392.075	12/30/2003
T0608500598_MW-1	37.2304944	-121.9829892	409.922	30	18.060	391.862	3/7/2002
T0608500598_MW-2	37.2306162	-121.9829191	408.784	30	17.310	391.474	3/7/2002
T0608500598_MW-3	37.2306023	-121.9831658	411.156	30	16.920	394.236	12/13/2001
T0608500598_MW-4	37.2307284	-121.9831089	410.161	29	15.590	394.571	3/7/2002
T0608500598_MW-5	37.2307162	-121.9826635	405.862	30	15.480	390.382	3/7/2002
T0608500598_MW-6	37.2303250	-121.9818600	401.335	29	16.230	385.105	3/7/2002
T0608500598_MW-7	37.2302186	-121.9828195	409.103	30	18.280	390.823	3/7/2002
T0608591773_E-1	37.2253153	-121.9783703	346.849	18	13.820	333.029	2/14/2017
T0608591773_E-2	37.2258076	-121.9780313	342.790	22	9.880	332.910	2/14/2017
T0608591773_E-4	37.2258659	-121.9778533	342.194	19	9.080	333.114	2/14/2017
T0608591773_MW-2	37.2252210	-121.9784460	347.222	34	14.100	333.122	2/14/2017

T0608591773_MW-3	37.2253803	-121.9783526	346.115	34	13.050	333.065	2/14/2017
T0608591773_MW-4	37.2253356	-121.9782709	346.279	34	12.910	333.369	2/14/2017
T0608591773_MW-5	37.2253057	-121.9783429	346.756	35	13.530	333.226	2/14/2017
T0608500350_MW-2	37.2297840	-121.8713360	218.074	26	7.510	210.564	2/22/2002
T0608500350_MW-3	37.2298981	-121.8713482	218.430	17	8.020	210.410	2/22/2002
T0608500350_MW-4	37.2296297	-121.8715177	218.841	17	8.000	210.841	2/22/2002
T0608500350_MW-5	37.2294628	-121.8713119	217.211	14	6.950	210.261	2/22/2002
T0608501262_S-1	37.2286881	-121.8709138	220.458	26	5.910	214.548	12/23/2002
T0608501262_S-2	37.2290364	-121.8707379	218.356	27	4.560	213.796	12/30/2002
T0608501262_S-3	37.2291050	-121.8708996	217.547	27	4.600	212.947	12/23/2002
T0608501262_S-4	37.2291306	-121.8711731	217.733	17	5.160	212.573	12/23/2002
T0608501262_S-5	37.2288042	-121.8705526	219.560	13	6.300	213.260	3/15/2004
T0608500939_MW-2	37.2355796	-121.9776240	370.856	30	16.000	354.856	2/26/2004
T0608500939_MW-4	37.2356841	-121.9774212	370.177	30	14.650	355.527	2/21/2005
T0608501502_MW-10	37.2370236	-121.9141975	261.587	15	11.640	249.947	1/6/2004
T0608501502_MW-11	37.2370241	-121.9144070	261.575	26	12.280	249.295	1/6/2004
T0608501502_MW-12	37.2370204	-121.9146153	259.450	26	10.630	248.820	1/6/2004
T0608501502_MW-23	37.2368218	-121.9157013	257.027	30	9.570	247.457	4/12/2011
T0608501502_MW-24	37.2365276	-121.9138410	263.782	30	11.600	252.182	1/6/2004
T0608501502_MW-25	37.2367070	-121.9143155	264.650	30	10.390	254.260	4/12/2011
T0608501502_MW-3	37.2366511	-121.9141634	264.566	42	14.550	250.016	1/27/2003
T0608501502_MW-5	37.2367606	-121.9140054	262.587	27	12.760	249.827	1/23/2002
T0608501502_MW-7	37.2367591	-121.9142173	264.295	27	14.050	250.245	1/23/2002
T0608501502_MW-8A	37.2366933	-121.9143128	264.799	27	15.440	249.359	1/27/2003
T0608501502_MW-8B	37.2366969	-121.9143299	264.667	40	14.980	249.687	1/27/2003
T0608501502_MW-9	37.2370276	-121.9140068	260.907	29	11.130	249.777	1/6/2004
T0608501502_RW-1	37.2367070	-121.9143155	264.650	35	13.830	250.820	1/28/2005
T0608501502_VE-3	37.2368871	-121.9141285	261.488	25	11.350	250.138	1/6/2004
T0608501502_VE-4	37.2368864	-121.9142917	261.651	25	12.070	249.581	1/6/2004
T0608501502_VE-5	37.2368834	-121.9144530	261.835	25	12.380	249.455	1/6/2004
T0608501502_VE-6	37.2368804	-121.9146536	259.683	25	10.690	248.993	1/6/2004
T0608501502_VE-7	37.2368814	-121.9148168	259.628	25	11.100	248.528	1/6/2004
T0608501502_VE-9	37.2370251	-121.9149183	259.275	25	11.480	247.795	1/6/2004
T0608502449_MW-1	37.2366475	-121.9155723	259.754	35	13.030	246.724	3/17/2011
T0608502449_MW-2	37.2367179	-121.9151702	261.356	30	14.410	246.946	3/16/2011
T0608502449_MW-23	37.2368262	-121.9157045	257.084	30	12.570	244.514	3/16/2011
T0608502449_MW-25	37.2368158	-121.9151540	259.195	31	12.340	246.855	3/16/2011
T0608502449_MW-3	37.2363867	-121.9151809	262.661	30	14.480	248.181	3/26/2010
T0608502449_STMW-1	37.2366460	-121.9155732	259.730	35	18.390	241.340	2/24/2015
T0608502449_STMW-10	37.2363390	-121.9161853	258.360	30	17.290	241.070	2/24/2015
T0608502449_STMW-4	37.2364909	-121.9154980	261.283	30	14.520	246.763	3/16/2011
T0608502449_STMW-5	37.2367242	-121.9156181	258.455	30	11.760	246.695	3/17/2011
T0608502449_STMW-6	37.2365618	-121.9156371	258.953	30	13.550	245.403	3/26/2010
T0608502449_STMW-7	37.2364292	-121.9156207	259.972	30	14.020	245.952	3/26/2010

T0608502449_STMW-8	37.2365843	-121.9158325	258.948	30	13.390	245.558	3/26/2010
T0608502449_STMW-9	37.2370823	-121.9159045	257.363	30	14.500	242.863	3/16/2011
T0608500182_MW-1	37.2322727	-121.9040887	293.176	49	23.580	269.596	3/1/2005
T0608500182_MW-10	37.2325023	-121.9032962	290.514	49	27.550	262.964	3/17/2009
T0608500182_MW-11	37.2328086	-121.9033013	289.262	48	26.850	262.412	3/1/2005
T0608500182_MW-13	37.2322442	-121.9039451	293.010	45	22.820	270.190	3/17/2009
T0608500182_MW-14	37.2322442	-121.9039451	293.010	45	21.310	271.700	3/17/2009
T0608500182_MW-15	37.2322442	-121.9039451	293.010	45	25.150	267.860	3/1/2005
T0608500182_MW-16	37.2322442	-121.9039451	293.010	45	25.060	267.950	3/17/2009
T0608500182_MW-17	37.2322442	-121.9039451	293.010	44	24.290	268.720	3/17/2009
T0608500182_MW-3A	37.2322442	-121.9039451	293.010	44	23.770	269.240	3/17/2009
T0608500182_MW-5	37.2321073	-121.9037733	292.927	44	24.600	268.327	3/1/2005
T0608500182_MW-6	37.2324355	-121.9037411	291.590	43	25.450	266.140	3/1/2005
T0608500182_MW-7	37.2325282	-121.9039382	291.796	41	23.700	268.096	3/17/2009
T0608502412_MW-1	37.2374974	-121.8312818	168.164	22	8.820	159.344	3/21/2007
T0608502412_MW-10	37.2369964	-121.8317690	166.464	23	7.140	159.324	3/15/2006
T0608502412_MW-11	37.2368711	-121.8316248	167.049	25	8.830	158.219	3/21/2007
T0608502412_MW-12	37.2368587	-121.8317722	167.003	25	8.730	158.273	3/21/2007
T0608502412_MW-13	37.2367141	-121.8318420	166.228	25	7.250	158.978	3/15/2006
T0608502412_MW-14	37.2371304	-121.8312964	167.984	21	7.690	160.294	3/15/2006
T0608502412_MW-2	37.2374958	-121.8309636	168.661	22	9.360	159.301	3/15/2006
T0608502412_MW-3	37.2371882	-121.8312996	168.390	21	8.310	160.080	3/15/2006
T0608502412_MW-4	37.2372566	-121.8310218	168.393	20	8.420	159.973	3/15/2006
T0608502412_MW-5	37.2371562	-121.8314097	167.810	25	7.800	160.010	3/15/2006
T0608502412_MW-6	37.2370736	-121.8309686	167.317	30	8.450	158.867	3/15/2006
T0608502412_MW-7	37.2372292	-121.8310711	168.237	45	7.300	160.937	3/15/2006
T0608502412_MW-8	37.2371495	-121.8314057	167.815	45	8.820	158.995	3/15/2006
T0608502412_MW-9	37.2370012	-121.8313273	166.661	47	7.410	159.251	3/15/2006
T0608501533_EW-2	37.2363210	-121.8035193	186.948	40	18.000	168.948	5/13/2011
T0608501533_EW-3	37.2362531	-121.8035823	187.062	40	18.210	168.852	5/13/2011
T0608501533_EW-4	37.2362147	-121.8036374	187.150	44	18.330	168.820	5/13/2011
T0608501533_EW-5	37.2362648	-121.8035085	186.751	48	18.040	168.711	5/13/2011
T0608501533_MW-1	37.2367789	-121.8034304	188.587	32	19.470	169.117	5/13/2011
T0608501533_MW-11	37.2362569	-121.8039768	186.753	32	17.930	168.823	5/13/2011
T0608501533_MW-15	37.2361877	-121.8036547	187.752	28	0.000	187.752	3/24/2004
T0608501533_MW-21	37.2361771	-121.8034245	186.864	31	18.180	168.684	5/13/2011
T0608501533_MW-24	37.2365688	-121.8033235	189.575	38	20.430	169.145	5/13/2011
T0608501533_MW-25	37.2367197	-121.8039894	187.170	37	23.440	163.730	4/11/2002
T0608501533_MW-26	37.2363141	-121.8039770	186.858	36	18.030	168.828	5/13/2011
T0608501533_MW-29	37.2367578	-121.8032378	188.653	45	19.230	169.423	5/13/2011
T0608501533_MW-3	37.2365552	-121.8037078	187.434	28	19.070	168.364	5/13/2011
T0608501533_MW-31	37.2367772	-121.8035497	188.217	45	19.760	168.457	5/13/2011
T0608501533_MW-4	37.2364589	-121.8035883	188.497	41	19.600	168.897	5/13/2011
T0608501533_MW-5	37.2364569	-121.8036130	188.156	29	19.440	168.716	5/13/2011

T0608501533_MW-6	37.2365943	-121.8035764	188.704	29	19.480	169.224	5/13/2011
T0608501533_MW-7	37.2366606	-121.8032573	189.352	32	20.570	168.782	5/13/2011
T0608501533_MW-9	37.2363113	-121.8036813	187.481	30	19.090	168.391	5/13/2011
T0608501820_MW-1	37.2374068	-121.8033857	187.264	33	21.660	165.604	5/30/2006
T0608501820_MW-2	37.2375826	-121.8034691	187.610	34	22.720	164.890	4/10/2002
T0608501820_MW-3	37.2372131	-121.8033552	187.648	28	22.040	165.608	5/30/2006
T0608501820_MW-4	37.2376005	-121.8030705	187.994	33	23.380	164.614	5/30/2006
T0608501820_MW-5	37.2375823	-121.8034204	187.719	41	21.870	165.849	5/30/2006
T0608501820_MW-8	37.2374063	-121.8034101	187.246	37	21.640	165.606	5/30/2006
T0608501820_SP-1/A-1	37.2376849	-121.8035101	187.484	30	22.350	165.134	4/10/2002
T0608501502_MW-13A	37.2377419	-121.9155162	254.565	30	9.060	245.505	4/20/2006
T0608501502_MW-15	37.2377480	-121.9147738	256.600	39	9.370	247.230	4/20/2006
T0608501502_MW-17	37.2383322	-121.9156374	251.377	40	8.920	242.457	4/20/2006
T0608501502_MW-19	37.2377529	-121.9140399	258.238	39	9.570	248.668	4/28/2003
T0608501502_MW-20	37.2390460	-121.9167619	248.182	40	15.530	232.652	1/6/2004
T0608501502_MW-26	37.2382307	-121.9147799	257.465	32	12.490	244.975	4/20/2006
T0608501502_MW-27	37.2377412	-121.9162198	252.216	30	12.920	239.296	1/6/2004
T0608502449_STMW-11	37.2373429	-121.9161922	254.765	30	16.740	238.025	2/24/2015
SL720561211_A-11	37.2472017	-121.8001855	192.967	41	31.900	161.067	5/31/2005
SL720561211_A-53	37.2473340	-121.7992970	194.894	46	33.180	161.714	5/31/2005
SL720561211_RA-14	37.2474530	-121.7992318	194.678	48	34.310	160.368	5/31/2005
SL720561211_A-17	37.2489966	-121.7947817	194.297	42	30.500	163.797	5/31/2005
SL720561211_RA-25	37.2491187	-121.7960976	193.212	43	26.800	166.412	5/31/2005
SL720561211_RA-26	37.2485645	-121.7978870	195.709	42	30.840	164.869	5/31/2005
T0608500398_MW-1	37.2481181	-121.9573861	309.491	39	25.730	283.761	4/20/2006
T0608500398_MW-2	37.2482361	-121.9571692	309.685	39	28.850	280.835	1/29/2002
T0608500398_MW-3	37.2482656	-121.9574067	307.490	44	22.450	285.040	1/8/2004
T0608500398_VW-1	37.2481919	-121.9573939	308.845	34	22.740	286.105	4/8/2020
T0608502069_MW-7	37.2535483	-121.9021087	206.677	49	30.100	176.577	4/28/2005
T0608501956_MW-1	37.2501675	-121.8660222	189.594	39	25.250	164.344	2/19/2009
T0608501956_MW-2	37.2501582	-121.8657784	189.311	42	25.550	163.761	2/19/2009
T0608501956_MW-3	37.2499508	-121.8659154	189.954	45	25.280	164.674	2/19/2009
T0608500386_MW-1	37.2509051	-121.8310443	170.366	18	9.050	161.316	5/11/2005
T0608500386_MW-10	37.2507672	-121.8315719	169.204	30	10.700	158.504	5/11/2005
T0608500386_MW-11	37.2506447	-121.8314718	169.983	30	10.550	159.433	5/11/2005
T0608500386_MW-12	37.2513115	-121.8314972	169.960	32	10.480	159.480	5/11/2005
T0608500386_MW-13	37.2513156	-121.8311127	170.703	33	10.150	160.553	5/11/2005
T0608500386_MW-14	37.2508456	-121.8312543	170.395	37	10.240	160.155	5/11/2005
T0608500386_MW-2	37.2507664	-121.8310559	170.000	16	9.600	160.400	5/10/2006
T0608500386_MW-6	37.2510743	-121.8314026	168.553	20	8.530	160.023	5/11/2005
T0608500386_MW-7	37.2510774	-121.8312340	169.554	19	7.800	161.754	5/11/2005
T0608500386_MW-8	37.2509756	-121.8315655	169.263	30	9.360	159.903	5/11/2005
T0608500386_MW-9	37.2506480	-121.8311861	170.073	30	9.280	160.793	5/10/2006
T0608500943_MW-7	37.2516181	-121.8306005	170.839	10	0.000	170.839	2/23/2012

SL720561211_05-A	37.2546784	-121.8146626	179.302	34	19.950	159.352	5/31/2005
T0608500348_MW-1	37.2516135	-121.8089748	184.967	34	26.060	158.907	3/5/2002
T0608500348_MW-2	37.2518337	-121.8089789	183.677	33	24.980	158.697	3/5/2002
T0608500348_MW-3	37.2517655	-121.8083388	184.344	34	25.980	158.364	3/5/2002
SL720561211_12-A	37.2526930	-121.8040953	191.202	42	32.150	159.052	5/31/2005
SL720561211_ORA-4	37.2529496	-121.8044027	191.278	46	31.150	160.128	5/31/2005
SL720561211_ORA-5	37.2525981	-121.8043708	190.021	40	30.710	159.311	5/31/2005
SL720561211_RA-02	37.2507473	-121.8025250	191.850	40	35.450	156.400	5/31/2005
SL720561211_RA-29	37.2505581	-121.8014718	191.273	45	27.600	163.673	5/31/2005
SL720561211_RA-30	37.2500572	-121.8015862	193.036	45	31.380	161.656	5/31/2005
SL720561211_RA-31	37.2528481	-121.8035250	192.837	46	33.710	159.127	5/31/2005
SL720561211_RA-32	37.2530016	-121.8034916	192.964	44	34.460	158.504	5/31/2005
SL720561211_RA-27	37.2498616	-121.7985943	195.732	49	33.060	162.672	5/31/2005
T0608500361_MW-4	37.2582153	-122.0320145	488.828	39	16.380	472.448	4/21/2006
T0608500181_A-10	37.2571004	-121.8035274	193.343	39	20.290	173.053	5/30/2006
T0608500181_A-11	37.2569504	-121.8037522	194.127	39	22.000	172.127	5/30/2006
T0608500181_A-12	37.2570043	-121.8039454	193.242	39	20.140	173.102	5/30/2006
T0608500181_A-13	37.2571960	-121.8037639	193.292	39	20.070	173.222	5/30/2006
T0608500181_A-14	37.2573376	-121.8035919	194.320	39	21.720	172.600	5/30/2006
T0608500181_A-15	37.2573845	-121.8032831	194.510	37	21.800	172.710	5/30/2006
T0608500181_A-16	37.2568430	-121.8038809	192.537	45	21.550	170.987	3/14/2007
T0608500181_A-19	37.2567760	-121.8043208	193.037	41	20.180	172.857	5/30/2006
T0608500181_A-20	37.2574777	-121.8057103	190.938	35	19.760	171.178	5/30/2006
T0608500181_A-21	37.2565712	-121.8057746	188.686	35	15.070	173.616	5/30/2006
T0608500181_A-22	37.2564171	-121.8049511	189.740	35	18.710	171.030	5/30/2006
T0608500181_A-23	37.2565132	-121.8059822	186.003	35	15.490	170.513	5/30/2006
T0608500181_A-24	37.2561332	-121.8060588	187.139	30	17.230	169.909	5/30/2006
T0608500181_A-25	37.2556280	-121.8059375	186.553	30	18.350	168.203	5/30/2006
T0608500181_A-4	37.2567700	-121.8034041	193.928	37	21.300	172.628	5/30/2006
T0608500181_A-5	37.2570085	-121.8033636	194.257	36	20.080	174.177	5/30/2006
T0608500181_A-6	37.2571249	-121.8034357	194.038	43	21.120	172.918	5/30/2006
T0608500181_A-7	37.2570141	-121.8032882	194.561	45	21.830	172.731	5/30/2006
T0608500181_A-8	37.2568324	-121.8032121	194.934	27	22.210	172.724	5/30/2006
T0608500181_A-9	37.2568090	-121.8035297	193.451	35	20.090	173.361	5/30/2006
T0608500181_AR-2	37.2571183	-121.8038402	193.095	48	20.800	172.295	5/30/2006
T0608500181_AR-3	37.2568551	-121.8039441	192.546	45	20.120	172.426	5/30/2006
T0608500361_DR-4	37.2584411	-122.0321009	487.523	47	23.230	464.293	4/21/2006
T0608500361_MW-6	37.2590493	-122.0322962	478.199	44	17.830	460.369	4/21/2006
T0608500361_MW-7	37.2588806	-122.0326979	481.149	46	24.360	456.789	4/21/2006
T0608500361_MW-8	37.2585168	-122.0319688	486.540	45	20.830	465.710	4/21/2006
T0608500361_MW-9	37.2587372	-122.0319987	482.638	44	18.110	464.528	4/21/2006
SL0608552523_MW-1	37.2618822	-121.8777193	171.964	39	22.610	149.354	5/21/2010
SL0608552523_MW-2	37.2623932	-121.8778886	173.130	30	21.080	152.050	5/21/2010
SL0608552523_MW-3	37.2623056	-121.8773769	173.527	32	21.380	152.147	5/21/2010

SL0608552523_MW-4	37.2625731	-121.8775228	174.251	32	21.610	152.641	5/21/2010
SL0608552523_MW-5	37.2623163	-121.8775657	173.574	29	21.400	152.174	5/21/2010
T0608502415_MW-1	37.2662623	-121.8314502	166.589	34	11.670	154.919	4/6/2005
T0608502415_MW-2	37.2662396	-121.8319502	164.977	28	10.100	154.877	4/19/2004
T0608502415_MW-7	37.2655997	-121.8309540	166.100	25	11.100	155.000	5/17/2006
T0608500295_WW-1P	37.2684102	-121.9443921	232.000	46	44.730	187.270	3/13/2013
T0608502415_MW-3	37.2667063	-121.8315586	166.238	34	11.480	154.758	4/6/2005
T0608502415_MW-4	37.2666827	-121.8326032	164.785	24	10.740	154.045	5/17/2006
T0608502415_MW-5	37.2670958	-121.8317907	165.964	25	10.450	155.514	1/2/2007
T0608502415_MW-6	37.2668262	-121.8310288	166.126	27	11.700	154.426	5/17/2006
T0608502415_SVE-1	37.2664640	-121.8315352	166.594	25	10.590	156.004	4/19/2004
T0608502415_SVE-2	37.2665538	-121.8316502	166.673	17	11.470	155.203	1/21/2006
T0608502415_SVE-3	37.2665197	-121.8316105	166.609	16	11.400	155.209	4/6/2005
T0608501512_PMW-1	37.2726626	-121.9324569	205.888	38	33.410	172.478	3/25/2002
T0608501512_PMW-3	37.2727025	-121.9328331	208.102	40	0.000	208.102	2/18/2011
T0608501512_PMW-4	37.2729425	-121.9327887	209.001	39	36.580	172.421	4/6/2011
T0608501512_VE-1	37.2727485	-121.9325700	207.124	42	34.490	172.634	3/25/2002
T0608501512_VE-2	37.2726758	-121.9326069	207.156	40	34.970	172.186	4/11/2006
T0608501512_VE-3	37.2724358	-121.9324898	206.674	38	34.480	172.194	1/26/2005
T0608501512_VE-4	37.2726759	-121.9326445	207.277	38	36.900	170.377	4/6/2011
T0608501512_VE-7	37.2728774	-121.9324609	205.963	35	34.190	171.773	2/18/2011
T0608501085_EW-3	37.2731966	-121.8698874	157.312	35	15.810	141.502	3/6/2007
T0608501914_MW-1	37.2933682	-121.8336570	153.086	48	42.740	110.346	12/27/2002
T0608501914_MW-3	37.2933682	-121.8336570	153.086	49	44.380	108.706	12/27/2002
T0608502333_MW-1	37.2929705	-121.8332588	153.911	48	33.100	120.811	12/1/2006
T0608502333_MW-3	37.2928380	-121.8330697	153.693	49	36.250	117.443	12/1/2006
T0608502333_MW-5	37.2926400	-121.8332849	152.832	48	37.500	115.332	12/1/2006
T0608502333_MW-7	37.2925495	-121.8335134	154.457	49	38.750	115.707	12/1/2006
SL1824F1150_PW-13A	37.3044720	-121.8667184	119.109	35	20.770	98.339	1/20/2017
SL1824F1150_PW-15A	37.3042205	-121.8669798	120.598	30	28.970	91.628	1/20/2017
SL1824F1150_PW-16A	37.3043769	-121.8668319	119.648	30	27.910	91.738	1/20/2017
SL1824F1150_PW-17A	37.3047099	-121.8665987	119.598	30	27.610	91.988	1/20/2017
SL1824F1150_PW-18A	37.3051846	-121.8637769	116.716	34	22.450	94.266	1/20/2017
SL1824F1150_PW-2A	37.3039054	-121.8675549	122.882	35	32.750	90.132	1/20/2017
SL0608503734_MW-1A	37.3071759	-121.8899498	115.755	42	22.150	93.605	4/19/2006
SL0608503734_MW-2	37.3072812	-121.8900671	115.982	41	19.910	96.072	4/19/2006
SL0608503734_MW-3	37.3070800	-121.8902228	115.875	41	19.700	96.175	4/19/2006
T0608501436_MW-A13	37.3096006	-121.8864265	112.163	44	15.640	96.523	3/31/2006
T0608501436_MW-A14	37.3095637	-121.8862754	113.196	45	16.380	96.816	3/31/2006
T0608501436_MW-A15	37.3095577	-121.8861632	113.560	42	16.720	96.840	3/31/2006
T0608501436_MW-A16	37.3094803	-121.8861613	114.059	44	17.350	96.709	3/31/2006
T0608501436_MW-A1R	37.3095092	-121.8865542	112.604	45	15.820	96.784	3/31/2006
T0608501436_MW-A4R	37.3095571	-121.8865221	112.279	45	15.600	96.679	3/31/2006
T0608535747_STMW-1	37.3087287	-121.8722322	113.465	35	16.220	97.245	3/9/2005

T0608535747_STMW-2	37.3088449	-121.8723252	113.334	35	15.040	98.294	3/9/2005
T0608535747_STMW-3	37.3088545	-121.8724757	113.446	35	15.740	97.706	3/9/2005
T0608535747_STMW-4	37.3085888	-121.8724681	114.259	35	16.100	98.159	3/9/2005
T0608535747_STMW-5	37.3086055	-121.8727193	114.025	35	15.320	98.705	3/9/2005
T0608535747_STMW-6	37.3084626	-121.8728920	114.586	35	16.880	97.706	3/9/2005
T0608535747_STMW-7	37.3084736	-121.8726958	113.939	35	0.000	113.939	2/11/2015
T0608501625_MW-10	37.3105763	-121.8497547	120.342	32	24.480	95.862	3/13/2002
T0608501625_MW-11	37.3106690	-121.8496942	120.824	32	23.800	97.024	3/13/2002
T0608501625_MW-12	37.3106127	-121.8499608	119.326	32	23.950	95.376	3/12/2004
T0608501625_MW-13	37.3105288	-121.8500069	120.282	32	24.090	96.192	3/12/2004
T0608501625_MW-14	37.3105702	-121.8500758	118.836	32	23.940	94.896	3/12/2004
T0608501625_MW-15	37.3103708	-121.8500544	118.065	32	23.700	94.365	5/19/2003
T0608501625_MW-9	37.3105055	-121.8501100	117.579	32	23.560	94.019	5/19/2003
T0608501517_MW-15	37.3080573	-121.8129897	150.455	35	17.800	132.655	3/6/2007
T0608501517_MW-16R	37.3079022	-121.8129946	150.918	35	23.180	127.738	3/31/2019
T0608501517_MW-17	37.3078762	-121.8134398	150.666	38	20.500	130.166	3/6/2007
T0608501517_MW-4	37.3087365	-121.8125899	151.659	28	15.750	135.909	3/6/2007
T0608501517_MW-4A	37.3087365	-121.8125899	151.659	28	17.930	133.729	1/29/2003
T0608501517_MW-5R	37.3082667	-121.8128518	150.645	37	17.690	132.955	3/6/2007
T0608501018_EW 1	37.3121483	-121.8631392	106.847	25	9.700	97.147	5/4/2006
T0608501018_EW-1	37.3121423	-121.8631984	106.745	24	10.920	95.825	2/15/2007
T0608501018_MW 5	37.3121483	-121.8631392	106.847	21	9.910	96.937	5/4/2006
T0608501018_MW-2A	37.3121483	-121.8631392	106.847	30	10.900	95.947	2/15/2007
T0608501018_MW-5	37.3122797	-121.8633824	106.903	21	11.130	95.773	2/15/2007
T0608500157_A-1	37.3147269	-121.8367094	125.725	24	13.280	112.445	5/8/2006
T0608500157_A-10	37.3147697	-121.8371080	126.212	37	13.920	112.292	5/8/2006
T0608500157_A-11	37.3145646	-121.8371937	125.192	36	12.800	112.392	5/8/2006
T0608500157_A-12	37.3144790	-121.8364897	126.542	30	13.280	113.262	5/8/2006
T0608500157_A-13	37.3148253	-121.8361524	126.025	32	12.500	113.525	5/8/2006
T0608500157_A-14	37.3151500	-121.8367413	125.087	31	12.590	112.497	5/8/2006
T0608500157_A-15	37.3149268	-121.8370378	125.544	32	12.750	112.794	5/8/2006
T0608500157_A-16	37.3148464	-121.8373723	126.936	32	13.400	113.536	5/8/2006
T0608500157_A-17	37.3147188	-121.8379464	127.848	25	16.740	111.108	5/8/2006
T0608500157_A-18	37.3147203	-121.8379510	127.883	49	16.680	111.203	5/8/2006
T0608500157_A-2	37.3147452	-121.8363503	126.358	28	12.880	113.478	5/8/2006
T0608500157_A-3	37.3148226	-121.8366410	125.041	18	11.500	113.541	5/8/2006
T0608500157_A-4	37.3147602	-121.8367501	125.540	12	11.530	114.010	3/15/2004
T0608500157_A-5	37.3146437	-121.8368921	125.824	24	13.190	112.634	5/8/2006
T0608500157_A-6	37.3145719	-121.8367968	126.224	23	13.350	112.874	5/8/2006
T0608500157_A-7	37.3147874	-121.8367592	126.513	25	13.000	113.513	5/8/2006
T0608500157_A-8	37.3147201	-121.8368672	127.266	22	13.390	113.876	5/8/2006
T0608500157_A-9	37.3148843	-121.8369413	125.835	37	13.270	112.565	5/8/2006
T0608500157_AR-2	37.3147808	-121.8367277	125.444	28	12.160	113.284	5/8/2006
T0608500334_MW-1	37.3151404	-121.8374542	125.093	30	12.680	112.413	5/8/2006

T0608500334_MW-10	37.3153471	-121.8371229	124.885	20	12.700	112.185	5/8/2006
T0608500334_MW-11	37.3152253	-121.8380212	124.370	21	13.080	111.290	5/8/2006
T0608500334_MW-12	37.3152019	-121.8380499	124.329	42	12.830	111.499	5/8/2006
T0608500334_MW-13	37.3155877	-121.8371810	124.314	23	12.650	111.664	5/8/2006
T0608500334_MW-14	37.3155877	-121.8371810	124.314	41	12.700	111.614	5/8/2006
T0608500334_MW-2	37.3155877	-121.8371810	124.314	33	12.980	111.334	5/8/2006
T0608500334_MW-3	37.3149094	-121.8372751	125.561	24	13.700	111.861	5/8/2006
T0608500334_MW-4	37.3153027	-121.8376440	126.417	23	12.760	113.657	5/8/2006
T0608500334_MW-5	37.3155877	-121.8371810	124.314	23	11.630	112.684	5/8/2006
T0608500334_MW-6	37.3155877	-121.8371810	124.314	22	12.460	111.854	5/8/2006
T0608500334_MW-7	37.3151951	-121.8369286	126.372	24	13.110	113.262	5/8/2006
T0608500334_MW-8	37.3150822	-121.8370131	125.743	23	13.400	112.343	5/8/2006
T0608500334_MW-9	37.3153733	-121.8373865	126.094	23	12.020	114.074	5/8/2006
T0608501493_MW-1	37.3150094	-121.8358461	126.854	35	13.150	113.704	5/8/2006
T0608501493_MW-10	37.3149381	-121.8355243	127.984	34	13.460	114.524	5/8/2006
T0608501493_MW-11	37.3147653	-121.8357923	126.496	32	12.590	113.906	5/8/2006
T0608501493_MW-13	37.3154515	-121.8360727	126.920	34	13.770	113.150	5/8/2006
T0608501493_MW-2	37.3149455	-121.8357388	127.244	35	15.060	112.184	3/19/2002
T0608501493_MW-3	37.3151004	-121.8356522	127.577	33	14.010	113.567	5/8/2006
T0608501493_MW-4	37.3150576	-121.8354888	128.348	34	14.180	114.168	5/8/2006
T0608501493_MW-5	37.3148362	-121.8358464	126.656	33	12.680	113.976	5/8/2006
T0608501493_MW-6	37.3149862	-121.8360902	125.652	27	11.480	114.172	5/8/2006
T0608501493_MW-7	37.3152232	-121.8360622	125.476	32	11.820	113.656	5/8/2006
T0608501493_MW-8	37.3153110	-121.8357503	126.690	32	13.620	113.070	5/8/2006
T0608501493_MW-9	37.3151805	-121.8354189	127.465	35	13.390	114.075	5/8/2006
T0608501771_MW-10	37.3160328	-121.8368658	123.188	49	12.470	110.718	2/13/2007
T0608501771_MW-11	37.3159109	-121.8370650	123.462	49	11.150	112.312	5/26/2006
T0608501771_MW-12	37.3161615	-121.8369993	123.619	20	11.340	112.279	5/26/2006
T0608501771_MW-13	37.3159266	-121.8370798	123.172	20	11.180	111.992	5/26/2006
T0608501771_MW-4	37.3155480	-121.8366032	124.942	22	13.340	111.602	5/26/2006
T0608501771_MW-5	37.3155151	-121.8368270	124.757	35	12.560	112.197	5/26/2006
T0608501771_MW-6	37.3155668	-121.8366612	124.802	47	12.270	112.532	5/26/2006
T0608501771_MW-7	37.3156257	-121.8367027	124.996	19	13.520	111.476	5/26/2006
T0608501771_MW-8	37.3157280	-121.8367039	125.780	47	11.620	114.160	5/26/2006
T0608501771_MW-9	37.3158215	-121.8367882	123.833	19	10.900	112.933	5/26/2006
T0608543715_EX-1	37.3150975	-122.0318308	247.019	40	39.280	207.739	4/28/2008
T0608500255_C-10	37.3205781	-121.9714022	137.264	40	25.080	112.184	5/4/2006
T0608500255_C-6	37.3205933	-121.9717632	138.378	46	25.780	112.598	5/4/2006
T0608500255_C-7	37.3204638	-121.9718824	138.685	46	25.800	112.885	5/4/2006
T0608500255_C-9	37.3207009	-121.9716230	137.671	40	25.500	112.171	5/4/2006
T0608500255_KPCMW-5	37.3202282	-121.9714051	136.853	43	30.550	106.303	2/10/2012
T0608500628_S-DP1-3	37.3215557	-121.9061012	108.564	23	23.000	85.564	1/1/2003
T0608500628_S-DP2-3	37.3215557	-121.9061012	108.564	3	3.000	105.564	1/1/2003
T0608500628_S-DP3-8	37.3215557	-121.9061012	108.564	23	23.000	85.564	1/1/2003

T0608500628_W-DP-1	37.3215557	-121.9061012	108.564	3	3.000	105.564	1/1/2003
T0608500628_W-DP-2	37.3215557	-121.9061012	108.564	3	3.000	105.564	1/1/2003
T0608500628_W-DP-3	37.3215557	-121.9061012	108.564	23	23.000	85.564	1/1/2003
T0608500628_W-DP-5	37.3215557	-121.9061012	108.564	23	23.000	85.564	1/1/2003
T0608500628_W-MW-1	37.3215557	-121.9061012	108.564	23	23.000	85.564	12/2/2003
T0608500628_W-MW-2	37.3215557	-121.9061012	108.564	23	23.000	85.564	12/8/2003
T0608500628_W-MW-3	37.3215557	-121.9061012	108.564	23	23.000	85.564	12/10/2003
T0608518361_MW-1	37.3193623	-121.8812155	101.967	25	5.860	96.107	3/29/2006
T0608518361_MW-2	37.3192633	-121.8813206	102.362	24	6.210	96.152	3/29/2006
T0608518361_MW-3	37.3192534	-121.8811829	102.928	19	6.760	96.168	3/3/2010
T0608518361_MW-4	37.3192355	-121.8810352	102.328	20	6.290	96.038	3/29/2006
T0608518361_MW-5	37.3194325	-121.8810585	102.377	20	5.960	96.417	3/29/2006
T0608518361_MW-6	37.3195969	-121.8814718	102.102	40	5.950	96.152	3/3/2010
T0608518361_MW-7	37.3186455	-121.8812089	103.263	25	7.750	95.513	3/3/2010
T0608518361_MW-8	37.3192085	-121.8813446	102.496	30	6.510	95.986	3/3/2010
T0608595380_MW-1	37.3207445	-121.8778170	105.496	25	12.130	93.366	3/2/2007
T0608595380_MW-2	37.3207471	-121.8779084	105.313	25	11.540	93.773	3/2/2007
T0608595380_MW-3	37.3208674	-121.8779175	106.126	25	13.250	92.876	3/2/2007
T0608500351_C-1	37.3208583	-121.8274811	126.321	21	10.780	115.541	2/26/2003
T0608500351_C-2	37.3210662	-121.8274144	126.344	25	10.680	115.664	5/17/2004
T0608500351_C-3	37.3208373	-121.8277437	125.787	24	10.540	115.247	2/26/2003
T0608500351_C-4	37.3208506	-121.8271373	126.884	25	11.350	115.534	2/26/2003
T0608500351_C-5	37.3209218	-121.8279907	127.340	27	12.310	115.030	2/26/2003
T0608500351_C-6	37.3211082	-121.8277251	127.347	26	11.980	115.367	2/26/2003
T0608500351_C-7	37.3206259	-121.8280604	126.256	28	10.640	115.616	2/26/2003
T0608500351_C-8	37.3205316	-121.8276975	127.838	29	10.590	117.248	2/26/2003
T0608502407_MW-1	37.3220207	-121.8260611	128.202	22	11.350	116.852	3/11/2009
T0608502407_MW-2	37.3220656	-121.8258518	128.021	21	12.380	115.641	3/11/2009
T0608502407_MW-3	37.3219217	-121.8258389	129.522	22	10.500	119.022	5/29/2008
T0608502407_MW-4	37.3218908	-121.8259763	128.903	22	11.170	117.733	3/7/2006
T0608502407_MW-5	37.3219579	-121.8261473	128.680	22	10.300	118.380	3/7/2006
T0608502407_MW-6	37.3220760	-121.8259798	127.943	22	11.200	116.743	2/24/2005
T0608502407_MW-7	37.3219731	-121.8257488	128.513	21	12.010	116.503	3/11/2009
T0608552981_MW-1A	37.3223848	-121.8254344	128.456	24	12.100	116.356	4/14/2005
T0608552981_MW-2A	37.3223848	-121.8254344	128.456	24	12.680	115.776	2/23/2005
T0608552981_MW-3	37.3223848	-121.8254344	128.456	24	12.960	115.496	4/14/2005
T0608552981_MW-4	37.3223848	-121.8254344	128.456	24	12.230	116.226	4/14/2005
T0608548766_MW-17	37.3217987	-122.0679005	385.701	40	19.320	366.381	4/9/2019
T0608548766_MW-18	37.3217987	-122.0679005	385.701	40	18.890	366.811	4/9/2019
T0608500255_C-11	37.3209732	-121.9712259	136.838	43	36.010	100.828	2/16/2011
T0608500255_C-11R	37.3209732	-121.9712260	136.838	49	31.690	105.148	3/11/2013
T0608501193_MW1	37.3240038	-121.9648485	124.957	40	33.720	91.237	5/21/2002
T0608501423_EX-1	37.3228085	-121.9655758	127.636	44	34.450	93.186	5/13/2020
T0608501423_MW-16	37.3228583	-121.9652915	127.380	36	28.430	98.950	5/3/2007

T0608501423_MW-18	37.3227973	-121.9655939	127.491	45	30.130	97.361	5/5/2012
T0608501423_MW-21A	37.3227958	-121.9656424	127.352	45	33.840	93.512	5/16/2019
T0608501423_MW-22	37.3228358	-121.9655698	127.287	44	34.280	93.007	5/13/2020
T0608501423_WELL 1	37.3227958	-121.9656424	127.352	27	26.850	100.502	5/29/2008
T0608500380_MW-1	37.3233890	-121.8999513	98.295	39	19.460	78.835	2/26/2004
T0608500380_MW-2	37.3236488	-121.8999915	97.604	35	23.170	74.434	5/1/2006
T0608500380_MW-3	37.3234953	-121.8997478	97.689	37	23.400	74.289	5/1/2006
T0608500380_MW-4	37.3232137	-121.8998439	98.340	36	24.110	74.230	5/1/2006
T0608500380_MW-5	37.3232754	-121.9001506	99.021	36	24.190	74.831	5/1/2006
T0608500380_MW-6	37.3233717	-121.8997662	97.530	39	23.030	74.500	5/1/2006
T0608568177_MW-1	37.3249235	-121.8954563	94.460	30	19.360	75.100	4/29/2004
T0608568177_MW-2	37.3249490	-121.8953072	93.502	30	18.430	75.072	4/29/2004
T0608568177_MW-3	37.3250246	-121.8954105	94.362	29	19.370	74.992	4/29/2004
T10000010223_MW-1	37.3273994	-121.8954095	91.413	23	17.380	74.033	4/10/2019
T10000010223_MW-3	37.3273791	-121.8951107	92.148	22	18.450	73.698	4/10/2019
T10000010223_MW-4	37.3270127	-121.8951118	91.681	23	17.520	74.161	4/10/2019
T0608501801_EX-1	37.3275537	-121.8837807	97.179	19	10.620	86.559	2/7/2008
T0608501801_EX-2	37.3274522	-121.8836615	96.959	18	9.750	87.209	5/10/2007
T0608501801_MW-1	37.3273261	-121.8836838	97.073	19	9.230	87.843	5/10/2005
T0608501801_MW-10	37.3275336	-121.8831704	97.843	19	11.260	86.583	5/21/2019
T0608501801_MW-14	37.3275174	-121.8836470	97.185	20	12.290	84.895	2/3/2020
T0608501801_MW-2	37.3274079	-121.8838525	96.641	19	3.310	93.331	2/8/2007
T0608501801_MW-5	37.3274591	-121.8833974	97.876	20	8.890	88.986	5/4/2006
T0608501801_MW-7	37.3274618	-121.8840929	96.849	20	10.370	86.479	5/4/2006
T0608501801_MW-8	37.3275636	-121.8841828	96.715	20	10.620	86.095	3/27/2019
T0608501801_MW-9	37.3272987	-121.8831108	97.953	20	10.850	87.103	5/21/2019
T0608501287_S-1	37.3267066	-121.8750893	96.978	20	12.490	84.488	2/27/2003
T0608501287_S-10	37.3270673	-121.8753768	95.956	26	11.990	83.966	2/22/2002
T0608501287_S-11	37.3265885	-121.8747295	96.728	26	12.120	84.608	2/27/2003
T0608501287_S-12	37.3272150	-121.8751824	96.199	26	12.090	84.109	2/27/2003
T0608501287_S-13	37.3267944	-121.8759193	96.901	28	12.130	84.771	2/27/2003
T0608501287_S-2	37.3268485	-121.8751998	96.813	23	12.360	84.453	2/27/2003
T0608501287_S-3	37.3268763	-121.8753099	96.560	19	12.010	84.550	2/27/2003
T0608501287_S-4	37.3267630	-121.8755398	97.103	20	12.380	84.723	2/27/2003
T0608501287_S-5	37.3266105	-121.8754689	98.403	18	13.410	84.993	2/27/2003
T0608501287_S-6	37.3265059	-121.8753827	98.725	24	13.880	84.845	2/27/2003
T0608501287_S-7	37.3266757	-121.8749266	96.991	26	12.150	84.841	2/27/2003
T0608501287_S-8	37.3268753	-121.8749474	96.554	30	12.180	84.374	2/27/2003
T0608501287_S-9	37.3270570	-121.8750299	96.414	27	11.990	84.424	2/27/2003
T0608501906_STMWD-20	37.3222782	-121.8721074	102.614	40	11.920	90.694	2/23/2006
T0608501906_STMWD-21	37.3222782	-121.8721074	102.614	40	11.440	91.174	2/23/2006
T0608501906_STMWD-22	37.3222782	-121.8721074	102.614	40	12.380	90.234	2/23/2006
T10000008197_MW1	37.3225379	-121.8770964	103.405	23	15.190	88.215	12/22/2016
T10000008197_MW2	37.3225379	-121.8770964	103.405	23	15.590	87.815	12/22/2016

T10000008197_MW3	37.3225379	-121.8770964	103.405	23	15.080	88.325	12/22/2016
T10000008197_MW4	37.3225379	-121.8770964	103.405	24	14.900	88.505	12/22/2016
T10000008197_MW5	37.3225379	-121.8770964	103.405	23	15.430	87.975	12/22/2016
T0608500771_B-10A	37.3281580	-121.8122459	134.126	18	8.480	125.646	1/27/2010
T0608500771_B-12A	37.3281370	-121.8124833	133.904	15	10.540	123.364	3/7/2006
T0608500771_B-19	37.3278059	-121.8126026	132.126	20	7.990	124.136	3/7/2006
T0608500771_B-20	37.3282853	-121.8123852	133.948	21	10.950	122.998	3/7/2006
T0608500771_B-21	37.3279296	-121.8120076	133.801	20	10.340	123.461	1/27/2010
T0608500771_B-22	37.3280303	-121.8120670	134.237	20	9.810	124.427	1/27/2010
T0608500771_B-23	37.3282351	-121.8117210	135.528	17	8.530	126.998	1/27/2010
T0608500771_B-4A	37.3283444	-121.8115680	136.141	17	9.400	126.741	3/25/2003
T0608500771_B-5A	37.3280564	-121.8116124	134.346	15	7.190	127.156	3/7/2006
T0608500771_B-8A	37.3279514	-121.8122680	132.856	17	7.390	125.466	3/7/2006
T0608500771_B-9A	37.3278039	-121.8123595	131.316	14	5.800	125.516	3/15/2005
T0608500771_MW-1	37.3280614	-121.8119025	134.959	20	9.970	124.989	1/27/2010
T0608575945_A-10	37.3242774	-121.8093212	144.065	24	12.450	131.615	3/16/2006
T0608575945_A-11	37.3243176	-121.8091742	144.749	23	13.450	131.299	3/16/2006
T0608575945_A-12	37.3243704	-121.8089115	144.320	19	13.400	130.920	3/16/2006
T0608575945_A-13	37.3244424	-121.8090056	145.119	20	14.200	130.919	3/16/2006
T0608575945_A-14	37.3243910	-121.8092366	144.548	20	13.400	131.148	3/16/2006
T0608575945_A-15	37.3243392	-121.8094463	143.993	20	13.100	130.893	3/16/2006
T0608575945_A-16	37.3240561	-121.8090870	145.145	20	13.150	131.995	3/16/2006
T0608575945_A-17A	37.3239031	-121.8090624	144.445	20	9.900	134.545	3/3/2005
T0608575945_A-17B	37.3239031	-121.8090624	144.445	49	9.530	134.915	3/3/2005
T0608575945_A-18A	37.3239031	-121.8090624	144.445	20	12.500	131.945	3/16/2006
T0608575945_A-18B	37.3239031	-121.8090624	144.445	49	12.300	132.145	3/16/2006
T0608575945_A-19A	37.3239031	-121.8090624	144.445	20	12.100	132.345	3/16/2006
T0608575945_A-19B	37.3246047	-121.8096779	142.393	49	11.350	131.043	3/16/2006
T0608575945_A-20A	37.3239031	-121.8090624	144.445	19	13.500	130.945	3/16/2006
T0608575945_A-20B	37.3239031	-121.8090624	144.445	49	13.050	131.395	3/16/2006
T0608575945_A-4	37.3241647	-121.8090770	145.394	26	13.550	131.844	3/16/2006
T0608575945_A-5	37.3241869	-121.8088827	145.385	24	13.700	131.685	3/16/2006
T0608575945_A-6	37.3240277	-121.8089020	144.709	24	12.400	132.309	3/16/2006
T0608575945_A-7	37.3239031	-121.8090624	144.445	24	11.800	132.645	3/16/2006
T0608575945_A-8	37.3240150	-121.8093263	145.145	24	12.350	132.795	3/16/2006
T0608575945_A-9	37.3241430	-121.8093749	144.749	24	12.650	132.099	3/16/2006
T0608575945_OB-1	37.3240929	-121.8089113	144.979	15	12.600	132.379	3/16/2006
T0608500371_MW-2	37.3248106	-121.7973522	159.975	25	9.960	150.015	2/16/2002
T0608500371_MW-3	37.3244426	-121.7974422	161.771	32	10.080	151.691	2/7/2006
T0608500371_MW-4	37.3249106	-121.7978267	158.602	27	9.490	149.112	2/7/2006
T0608500371_MW-5	37.3251409	-121.7975392	158.688	26	9.680	149.008	2/7/2006
T0608500371_MW-6	37.3253542	-121.7986878	155.339	26	9.450	145.889	2/16/2002
T0608500371_MW-7	37.3247925	-121.7980938	159.482	26	11.260	148.222	2/16/2002
T0608572628_MW-7	37.3311885	-121.9812262	127.254	45	30.540	96.714	12/30/2009

SL608592510_MW-1	37.3283124	-121.9665038	115.736	30	15.750	99.986	3/28/2006
SL608592510_MW-1D	37.3282981	-121.9664958	115.740	46	15.590	100.150	3/28/2006
SL608592510_MW-2	37.3283081	-121.9663398	116.079	25	16.660	99.419	3/28/2006
SL608592510_MW-2D	37.3282994	-121.9663259	116.066	42	16.180	99.886	3/28/2006
SL608592510_MW-3	37.3284822	-121.9661546	115.636	23	16.200	99.436	3/28/2006
SL608592510_MW-3D	37.3284848	-121.9661386	115.649	32	16.310	99.339	3/28/2006
SL608592510_MW-5D	37.3285961	-121.9659481	115.111	32	15.870	99.241	3/28/2006
SL608592510_MW-6	37.3283570	-121.9662981	116.231	22	16.910	99.321	3/29/2006
SL608592510_MW-6D	37.3283570	-121.9662981	116.231	39	17.000	99.231	3/29/2006
SL608592510_MW-8	37.3283768	-121.9662942	116.188	23	16.630	99.558	3/29/2006
SL608592510_MW-8D	37.3283809	-121.9662908	116.187	39	16.610	99.577	3/29/2006
SL608592510_MW-9D	37.3287728	-121.9655401	114.793	30	15.690	99.103	3/28/2006
T0608595356_MW-1	37.3301126	-121.9497353	113.529	39	27.060	86.469	5/1/2006
T0608595356_MW-2	37.3303329	-121.9499428	113.684	40	27.080	86.604	5/1/2006
T0608595356_MW-3	37.3304227	-121.9497298	114.394	40	27.740	86.654	5/1/2006
T0608501312_MW-10	37.3317292	-121.9341479	108.622	41	34.950	73.672	1/5/2004
T0608501312_MW-11	37.3318262	-121.9340323	108.778	43	31.460	77.318	1/3/2006
T0608501312_MW-8	37.3323001	-121.9339901	104.870	42	31.100	73.770	1/5/2004
T0608501312_SV-1	37.3319746	-121.9341637	108.064	36	29.420	78.644	1/8/2007
T0608501312_SV-2	37.3320854	-121.9340516	107.396	40	29.240	78.156	1/8/2007
T0608500629_STMW-1	37.3305100	-121.9196413	99.661	35	17.740	81.921	1/23/2018
T0608500629_STMW-10	37.3307823	-121.9196250	99.412	30	17.230	82.182	1/23/2018
T0608500629_STMW-11	37.3306627	-121.9196665	98.951	31	19.180	79.771	1/23/2018
T0608500629_STMW-12	37.3307334	-121.9195607	99.348	30	17.550	81.798	1/23/2018
T0608500629_STMW-13	37.3308500	-121.9196016	98.832	30	17.330	81.502	1/23/2018
T0608500629_STMW-3A	37.3306453	-121.9198792	99.061	35	17.840	81.221	1/23/2018
T0608500629_STMW-4	37.3306983	-121.9197938	98.921	30	19.800	79.121	3/15/2012
T0608500629_STMW-5	37.3305552	-121.9195768	100.039	30	18.150	81.889	1/23/2018
T0608500629_STMW-6	37.3304731	-121.9195589	99.772	30	18.850	80.922	1/23/2018
T0608500629_STMW-7	37.3306186	-121.9197092	99.482	30	18.100	81.382	1/23/2018
T0608500629_STMW-8	37.3306662	-121.9197206	99.386	25	0.000	99.386	12/26/2008
T0608500629_STMW-9	37.3307288	-121.9197483	98.971	30	17.680	81.291	1/23/2018
T10000008386_MW-5	37.3300900	-121.9113596	99.739	45	14.330	85.409	4/3/2019
T10000008386_MW-6	37.3304916	-121.9118095	99.635	25	15.610	84.025	4/3/2019
T10000008386_MW-7	37.3304471	-121.9110043	100.051	25	15.840	84.211	4/3/2019
T0608501640_MW-10	37.3330352	-121.8941637	84.299	27	13.910	70.389	2/28/2017
T0608501640_MW-12	37.3330955	-121.8940840	83.283	27	12.710	70.573	2/28/2017
T0608501640_MW-13	37.3329605	-121.8939965	83.204	27	13.010	70.194	2/28/2017
T10000010223_MW-2	37.3275043	-121.8952053	91.182	22	17.360	73.822	4/10/2019
T0608501344_MW-12B	37.3304187	-121.8818084	95.153	34	13.830	81.323	2/21/2008
T0608501344_MW-13A	37.3304187	-121.8818084	95.153	20	13.450	81.703	3/18/2008
T0608501344_MW-13B	37.3304187	-121.8818084	95.153	34	13.360	81.793	2/21/2008
T0608501801_EX-3	37.3277100	-121.8839509	96.464	18	9.340	87.124	2/7/2008
T0608501801_MW-15	37.3276797	-121.8835890	97.764	19	11.780	85.984	5/21/2019

T0608501801_MW-16	37.3277361	-121.8838434	96.950	20	12.690	84.260	2/3/2020
T0608501801_MW-3	37.3277645	-121.8838411	97.112	20	8.590	88.522	2/22/2005
T0608501801_MW-4	37.3276286	-121.8835766	97.759	20	10.190	87.569	5/4/2006
T0608501801_MW-6	37.3276520	-121.8840095	95.960	20	10.170	85.790	5/10/2005
T0608501689_MW-1	37.3331588	-121.8757104	91.764	22	0.000	91.764	12/2/2009
T0608501689_MW-2	37.3332161	-121.8757938	92.170	10	0.000	92.170	12/2/2009
T0608501689_MW-3	37.3330897	-121.8757382	92.050	18	11.860	80.190	12/31/2010
T0608501689_MW-4	37.3330179	-121.8757738	91.584	18	11.280	80.304	12/31/2010
T0608501689_MW-5	37.3331285	-121.8755774	91.740	15	11.460	80.280	12/31/2010
T0608501689_MW-6	37.3331857	-121.8756187	91.313	19	11.520	79.793	5/22/2012
T0608501689_MW-7	37.3332496	-121.8756839	91.401	24	11.850	79.551	12/31/2010
T0608501689_STMW-10	37.3331588	-121.8757104	91.764	23	12.690	79.074	12/30/2010
T0608501689_STMW-11	37.3331588	-121.8757104	91.764	23	15.150	76.614	12/30/2010
T0608501689_STMW-12	37.3331588	-121.8757104	91.764	14	0.000	91.764	12/2/2009
T0608501689_STMW-13	37.3331588	-121.8757104	91.764	20	0.000	91.764	12/2/2009
T0608501689_STMW-14	37.3331588	-121.8757104	91.764	21	0.000	91.764	12/2/2009
T0608501689_STMW-15	37.3331588	-121.8757104	91.764	23	11.540	80.224	12/30/2010
T0608501689_STMW-16	37.3331588	-121.8757104	91.764	24	12.160	79.604	12/30/2010
T0608501689_STMW-17	37.3331588	-121.8757104	91.764	23	12.040	79.724	12/31/2010
T0608501689_STMW-8	37.3331588	-121.8757104	91.764	23	12.390	79.374	12/30/2010
T0608501689_STMW-9	37.3331588	-121.8757104	91.764	23	11.350	80.414	12/30/2010
T0608513416_MW-2	37.3300530	-121.8571416	103.247	25	2.800	100.447	3/2/2009
T0608513416_MW-3	37.3298475	-121.8569555	104.655	22	4.570	100.085	3/2/2009
T0608513416_MW-5	37.3294426	-121.8568956	103.702	26	7.560	96.142	3/2/2009
T0608513416_MW-6	37.3296639	-121.8568978	104.489	27	7.560	96.929	3/2/2009
T0608513416_RW-1	37.3299232	-121.8569202	104.254	25	3.100	101.154	3/2/2009
T0608500333_MW-10	37.3322699	-121.8540019	102.287	31	9.020	93.267	5/5/2004
T0608500333_MW-11	37.3321386	-121.8541703	104.335	29	9.130	95.205	2/4/2004
T0608500333_MW-13	37.3324011	-121.8541470	103.515	26	9.330	94.185	5/15/2003
T0608500333_MW-2	37.3322994	-121.8538889	103.420	32	8.960	94.460	5/15/2003
T0608500333_MW-3	37.3324058	-121.8535551	103.227	28	8.710	94.517	5/15/2003
T0608500333_MW-6	37.3324186	-121.8537813	102.917	27	8.520	94.397	5/15/2003
T0608500333_MW-9	37.3323906	-121.8539868	103.018	31	8.400	94.618	5/15/2003
T0608513416_MW-10	37.3300802	-121.8566969	104.256	37	15.300	88.956	3/6/2014
T0608513416_MW-1A	37.3300802	-121.8566969	104.256	25	3.500	100.756	3/2/2009
T0608513416_MW-2A	37.3300802	-121.8566969	104.256	40	14.780	89.476	3/6/2014
T0608513416_MW-7	37.3300802	-121.8566969	104.256	39	15.770	88.486	3/6/2014
T0608513416_MW-8	37.3300802	-121.8566969	104.256	39	15.630	88.626	3/6/2014
T0608513416_MW-9	37.3300802	-121.8566969	104.256	24	14.340	89.916	3/6/2014
T0608501288_S-10	37.3375879	-121.9789434	108.769	30	14.520	94.249	2/4/2002
T0608501288_S-11	37.3374387	-121.9789113	108.663	34	15.380	93.283	2/4/2002
T0608501288_S-12	37.3374070	-121.9787340	108.897	34	14.560	94.337	2/4/2002
T0608501288_S-13	37.3374778	-121.9786151	108.703	35	15.210	93.493	2/4/2002
T0608501288_S-14	37.3376523	-121.9789930	108.866	45	14.500	94.366	2/4/2002

T0608501288_S-15	37.3375212	-121.9791430	108.107	45	14.970	93.137	2/4/2002
T0608501288_S-16	37.3374036	-121.9784151	107.395	38	13.140	94.255	2/4/2002
T0608501288_S-17	37.3370554	-121.9787603	107.867	40	13.000	94.867	2/4/2002
T0608502406_EW-1	37.3336327	-121.9147901	94.675	35	18.410	76.265	3/3/2007
T0608502406_EW-2	37.3335942	-121.9147441	94.859	34	13.590	81.269	3/14/2006
T0608502406_MW-10	37.3337127	-121.9149560	94.660	30	14.150	80.510	12/20/2006
T0608502406_MW-11	37.3338372	-121.9146146	94.261	35	16.470	77.791	3/14/2006
T0608502406_MW-12	37.3340152	-121.9148303	93.566	35	16.250	77.316	3/14/2006
T0608502406_MW-13	37.3337964	-121.9145796	94.493	30	14.350	80.143	3/14/2006
T0608502406_MW-14	37.3336527	-121.9144129	94.964	29	14.200	80.764	3/14/2006
T0608502406_MW-15	37.3335059	-121.9144129	95.277	30	13.540	81.737	3/2/2005
T0608502406_MW-16	37.3333802	-121.9148630	95.109	27	13.230	81.879	3/14/2006
T0608502406_MW-17	37.3336137	-121.9152654	95.337	27	15.000	80.337	3/14/2006
T0608502406_MW-18	37.3335527	-121.9146988	95.034	30	14.230	80.804	3/14/2006
T0608502406_MW-19	37.3336570	-121.9148183	94.553	42	17.260	77.293	3/14/2006
T0608502406_MW-20	37.3338017	-121.9149910	94.150	27	14.600	79.550	12/20/2006
T0608502406_MW-8	37.3335061	-121.9148627	95.536	34	13.330	82.206	3/14/2006
T0608502406_MW-9	37.3336979	-121.9148602	94.288	30	14.870	79.418	12/20/2006
T0608502406_SV-1	37.3335102	-121.9148563	95.532	15	14.820	80.712	3/11/2002
T0608502406_SV-2	37.3336201	-121.9147730	94.741	15	14.600	80.141	3/11/2002
SL18381801_CP-22	37.3380636	-121.9088290	80.844	40	10.120	70.724	3/26/2012
SL18381801_CP-27	37.3385790	-121.9070541	78.693	41	9.010	69.683	3/26/2012
SL18381801_CP-6	37.3380636	-121.9088290	80.844	32	17.070	63.774	5/10/2010
T0608501640_MW-11	37.3332409	-121.8940443	83.812	27	14.280	69.532	3/11/2019
T0608500345_EW-1	37.3380725	-121.8879898	80.655	36	11.920	68.735	3/6/2006
T0608500345_EW-2	37.3380239	-121.8880766	80.830	33	12.480	68.350	3/6/2006
T0608500345_EW-3	37.3379732	-121.8881896	80.449	32	11.470	68.979	3/6/2006
T0608500345_EW-4	37.3379126	-121.8883059	80.559	32	11.860	68.699	3/6/2009
T0608500345_MW-1	37.3377253	-121.8878616	80.852	20	11.650	69.202	3/6/2006
T0608500345_MW-10	37.3379433	-121.8882775	80.440	31	13.700	66.740	3/6/2009
T0608500345_MW-11	37.3378622	-121.8882304	81.000	29	11.840	69.160	3/6/2006
T0608500345_MW-12	37.3384650	-121.8888147	82.045	35	21.730	60.315	3/6/2009
T0608500345_MW-13	37.3381498	-121.8882295	80.785	34	13.040	67.745	3/6/2006
T0608500345_MW-14	37.3381080	-121.8883412	81.111	34	13.400	67.711	3/6/2006
T0608500345_MW-15	37.3382445	-121.8886202	81.732	34	13.780	67.952	3/6/2006
T0608500345_MW-16	37.3384750	-121.8881792	80.001	33	12.310	67.691	3/6/2006
T0608500345_MW-2	37.3378662	-121.8877776	79.760	20	11.420	68.340	3/6/2006
T0608500345_MW-3	37.3379897	-121.8878662	80.487	18	13.560	66.927	3/6/2006
T0608500345_MW-4	37.3380601	-121.8879582	80.401	20	12.250	68.151	3/6/2009
T0608500345_MW-5	37.3380038	-121.8880461	80.996	17	12.610	68.386	3/6/2006
T0608500345_MW-7	37.3380356	-121.8880087	80.681	34	12.170	68.511	3/6/2006
T0608500345_MW-9	37.3377572	-121.8877254	81.061	39	11.480	69.581	3/6/2006
T0608500345_PZ-1	37.3382162	-121.8881326	80.573	31	14.220	66.353	3/6/2009
T0608500345_PZ-2	37.3382087	-121.8881412	80.536	20	13.950	66.586	3/6/2006

T0608501495_MW-10	37.3341649	-121.8520832	104.282	21	8.360	95.922	5/18/2010
T0608501495_MW-11	37.3340857	-121.8520496	105.073	21	9.170	95.903	5/18/2010
T0608501495_MW-12	37.3343417	-121.8519496	104.529	20	9.790	94.739	12/9/2011
T0608501495_MW-13	37.3343442	-121.8517825	104.189	20	7.950	96.239	5/18/2010
T0608501495_MW-14	37.3342895	-121.8522662	104.939	17	8.750	96.189	5/18/2010
T0608501495_MW-15	37.3346968	-121.8521637	104.174	17	7.600	96.574	5/18/2010
T0608501495_MW-16	37.3347146	-121.8518316	103.521	17	7.140	96.381	5/18/2010
T0608501495_MW-17	37.3343540	-121.8511766	106.371	17	9.490	96.881	5/18/2010
T0608501495_MW-18	37.3343877	-121.8528391	104.371	16	9.240	95.131	1/17/2011
T0608501495_MW-2	37.3343383	-121.8518147	104.041	28	6.930	97.111	4/14/2003
T0608501495_MW-3	37.3341732	-121.8518189	105.248	28	7.840	97.408	4/14/2003
T0608501495_MW-4	37.3343853	-121.8517993	103.936	24	5.360	98.576	4/14/2003
T0608501495_MW-5	37.3342221	-121.8517514	105.217	26	7.210	98.007	4/14/2003
T0608501495_MW-6	37.3340863	-121.8519518	105.378	26	8.340	97.038	4/14/2003
T0608501495_MW-7	37.3340720	-121.8516661	106.042	28	9.110	96.932	1/13/2003
T0608501495_MW-8	37.3339493	-121.8518455	106.140	27	8.760	97.380	4/14/2003
T0608501495_MW-9	37.3345629	-121.8516615	103.883	30	6.710	97.173	4/14/2003
T0608501441_MW-24	37.3382735	-121.9930831	130.781	43	24.450	106.331	2/20/2007
T0608500174_V-1	37.3377951	-121.9767474	104.280	35	11.480	92.800	3/2/2004
T0608500174_V-2	37.3377951	-121.9767474	104.280	38	11.080	93.200	3/2/2004
T0608500174_V-3	37.3377951	-121.9767474	104.280	33	11.100	93.180	3/2/2004
T0608500174_V-4	37.3377951	-121.9767474	104.280	38	11.530	92.750	3/2/2004
T0608501288_S-18	37.3377470	-121.9786313	108.380	37	14.480	93.900	2/4/2002
T0608500556_C-1	37.3384075	-121.9760714	104.358	46	11.020	93.338	5/11/2005
T0608500556_MW-17	37.3385817	-121.9754819	103.631	38	9.530	94.101	5/24/2006
T0608500556_MW-23	37.3383333	-121.9760333	104.998	23	9.850	95.148	5/24/2006
T0608500556_MW-29	37.3383633	-121.9759798	104.611	36	12.580	92.031	1/30/2013
T0608500556_MW-30	37.3384207	-121.9759667	104.248	35	12.180	92.068	1/30/2013
T0608500556_MW-31	37.3384677	-121.9759215	104.119	33	12.470	91.649	1/30/2013
T0608500556_MW-32	37.3385201	-121.9757489	103.798	37	12.260	91.538	1/30/2013
T0608500556_MW-33	37.3385151	-121.9756718	103.203	38	11.660	91.543	1/30/2013
T0608500556_MW-7	37.3381900	-121.9759419	105.796	48	13.970	91.826	1/22/2002
T0608500556_MW-8	37.3384906	-121.9758111	103.685	39	9.540	94.145	5/24/2006
T0608500556_MW-9	37.3382356	-121.9756711	103.925	36	8.740	95.185	5/24/2006
T0608501130_VE-1	37.3384878	-121.9378117	86.668	49	7.060	79.608	3/30/2006
T0608501130_VE-2	37.3383686	-121.9379422	88.272	46	8.120	80.152	3/30/2006
T0608501130_VE-3	37.3383758	-121.9378378	88.700	43	9.650	79.050	3/30/2006
T0608550099_MW-1	37.3434524	-121.9279474	73.828	25	10.540	63.288	3/2/2004
T0608550099_MW-2	37.3435729	-121.9279645	73.836	25	10.770	63.066	3/4/2005
T0608550099_MW-3	37.3436618	-121.9278232	73.525	26	10.930	62.595	3/2/2004
T0608550099_MW-3A	37.3434524	-121.9279474	73.828	19	10.930	62.898	3/8/2007
T0608550099_MW-3B	37.3436487	-121.9278517	73.914	24	10.940	62.974	3/8/2007
T0608550099_MW-4	37.3436307	-121.9277296	72.848	26	8.210	64.638	12/22/2005
T0608550099_MW-5	37.3434524	-121.9279474	73.828	25	7.280	66.548	3/30/2005

T0608550099_MW-6	37.3434524	-121.9279474	73.828	28	8.800	65.028	3/4/2005
T0608516089_MW-1	37.3436094	-121.9186233	76.643	30	16.550	60.093	12/6/2005
T0608516089_MW-2	37.3433968	-121.9188328	76.284	30	16.310	59.974	12/6/2005
T0608516089_MW-3	37.3437544	-121.9188272	74.933	30	15.190	59.743	12/6/2005
SL18381801_CP-17R	37.3401487	-121.9086810	79.693	39	12.200	67.493	3/26/2012
SL18381801_CP-24	37.3392640	-121.9084450	78.596	39	11.260	67.336	12/27/2017
SL18381801_CP-25	37.3387450	-121.9081361	78.838	42	9.550	69.288	3/26/2012
SL18381801_CP-29	37.3389725	-121.9072631	79.852	22	10.480	69.372	12/3/2012
T0608500392_MW-1	37.3429518	-121.9107813	71.655	47	5.010	66.645	4/17/2006
T0608500392_MW-2	37.3427573	-121.9108248	71.331	48	3.680	67.651	4/17/2006
T0608500392_MW-3	37.3429512	-121.9109730	71.696	42	4.480	67.216	4/17/2006
T0608500392_MW-4	37.3428704	-121.9112122	71.721	43	4.270	67.451	4/17/2006
T0608500392_MW-5	37.3428043	-121.9111483	71.970	39	4.390	67.580	4/17/2006
T0608500392_MW-6	37.3426664	-121.9109402	71.601	35	4.320	67.281	4/17/2006
T0608500392_MW-7	37.3431452	-121.9109601	71.806	27	0.000	71.806	1/22/2002
T0608500392_MW-8	37.3429911	-121.9110524	71.554	20	8.530	63.024	3/4/2013
T0608500392_MW-9	37.3430433	-121.9108975	71.810	20	9.640	62.170	2/28/2012
T0608501528_U-1	37.3420985	-121.9103817	71.973	43	4.960	67.013	5/23/2006
T0608501528_U-11	37.3423649	-121.9104580	70.512	44	3.630	66.882	5/23/2006
T0608501528_U-11A	37.3423854	-121.9103236	70.247	23	5.200	65.047	5/30/2019
T0608501528_U-12	37.3423854	-121.9103236	70.247	44	3.100	67.147	5/23/2006
T0608501528_U-12A	37.3423854	-121.9103236	70.247	23	4.780	65.467	5/30/2019
T0608501528_U-13	37.3422905	-121.9100737	70.932	44	4.660	66.272	5/23/2006
T0608501528_U-14	37.3421678	-121.9106931	72.379	44	3.940	68.439	5/23/2006
T0608501528_U-15	37.3424799	-121.9099442	70.265	46	3.770	66.495	5/23/2006
T0608501528_U-15A	37.3423854	-121.9103236	70.247	22	5.110	65.137	5/30/2019
T0608501528_U-16	37.3426252	-121.9100679	69.888	46	3.590	66.298	5/23/2006
T0608501528_U-16A	37.3423854	-121.9103236	70.247	23	4.810	65.437	5/30/2019
T0608501528_U-17	37.3424483	-121.9102487	69.768	25	3.590	66.178	5/23/2006
T0608501528_U-17B	37.3423854	-121.9103236	70.247	48	4.370	65.877	5/30/2019
T0608501528_U-2	37.3423106	-121.9104819	70.816	49	3.550	67.266	5/23/2006
T0608501528_U-3	37.3424834	-121.9104174	70.001	48	2.970	67.031	5/23/2006
T0608501528_U-3A	37.3423854	-121.9103236	70.247	23	4.880	65.367	5/30/2019
T0608501528_U-4A	37.3423854	-121.9103236	70.247	23	4.380	65.867	5/30/2019
T0608501528_U-5	37.3424404	-121.9102069	69.787	46	3.910	65.877	5/23/2006
T0608501528_U-5A	37.3423854	-121.9103236	70.247	23	4.700	65.547	5/30/2019
T0608501528_U-6	37.3423434	-121.9101338	70.477	47	3.840	66.637	5/23/2006
T0608501528_U-6A	37.3423854	-121.9103236	70.247	23	4.770	65.477	5/30/2019
T0608501528_U-7	37.3422638	-121.9105562	71.301	48	3.690	67.611	5/23/2006
T0608501528_U-8	37.3426339	-121.9104479	70.043	46	3.350	66.693	5/23/2006
T0608501528_U-9	37.3427077	-121.9103380	69.720	45	3.050	66.670	5/23/2006
T0608501528_UR-1	37.3424268	-121.9103687	70.133	40	4.210	65.923	5/23/2006
T0608501528_UR-1A	37.3423854	-121.9103236	70.247	23	5.050	65.197	5/30/2019
T0608501528_UR-2	37.3423300	-121.9105398	70.690	44	3.320	67.370	5/23/2006

T10000002982_MW-1	37.3423696	-121.8785392	79.619	15	9.060	70.559	5/25/2012
T10000002982_MW-2	37.3421195	-121.8785138	80.328	15	9.380	70.948	5/25/2012
T10000002982_MW-3	37.3425042	-121.8781435	79.300	15	8.800	70.500	5/25/2012
T10000002983_MW-1	37.3423696	-121.8785392	79.619	15	9.060	70.559	5/25/2012
T10000002983_MW-2	37.3421195	-121.8785138	80.328	15	9.380	70.948	5/25/2012
T10000002983_MW-3	37.3425042	-121.8781435	79.300	15	8.800	70.500	5/25/2012
T0608582655_MW-1	37.3437753	-121.8777750	79.412	20	11.340	68.072	2/24/2009
T0608582655_MW-2	37.3439636	-121.8778330	78.959	20	10.610	68.349	2/24/2009
T0608582655_MW-3	37.3438462	-121.8779090	78.565	20	9.980	68.585	2/24/2009
T10000001904_MW-1	37.3432335	-121.8628373	95.148	29	9.430	85.718	3/29/2011
T10000001904_MW-2	37.3429783	-121.8632716	94.422	22	9.710	84.712	3/29/2011
T10000001904_MW-3	37.3435640	-121.8630683	93.855	23	9.400	84.455	3/29/2011
T10000001904_MW-4	37.3432335	-121.8628373	95.148	27	8.950	86.198	3/29/2011
T0608501630_EX-1	37.3399137	-121.8427406	107.161	38	10.150	97.011	5/17/2005
T0608501630_EX-2	37.3398395	-121.8427608	107.673	38	10.150	97.523	5/17/2005
T0608501630_EX-3	37.3397624	-121.8427454	107.698	38	10.330	97.368	5/22/2006
T0608501630_EX-4	37.3397538	-121.8426176	107.662	38	10.580	97.082	5/22/2006
T0608501511_U-10	37.3462616	-121.9372606	74.206	41	5.150	69.056	3/6/2019
T0608501511_U-11	37.3461611	-121.9374773	74.467	40	5.820	68.647	3/6/2019
T0608501511_U-12	37.3463156	-121.9375749	74.044	41	6.960	67.084	3/5/2019
T0608501511_U-13	37.3463021	-121.9374153	74.466	40	6.970	67.496	3/5/2019
T0608501511_U-14	37.3463731	-121.9374308	74.040	41	6.700	67.340	3/7/2019
T0608501511_U-15	37.3463926	-121.9376190	74.311	41	8.120	66.191	3/5/2019
T0608501511_U-16	37.3468198	-121.9376246	73.881	28	12.910	60.971	5/2/2006
T0608501511_U-17	37.3464454	-121.9378536	74.261	40	6.630	67.631	3/6/2019
T0608501511_U-18	37.3464218	-121.9375418	74.646	37	8.810	65.836	3/5/2019
T0608501511_U-5	37.3459928	-121.9373808	74.510	38	4.860	69.650	5/2/2006
T0608501511_U-6	37.3464433	-121.9370341	73.868	40	6.570	67.298	5/2/2006
T0608501511_U-7	37.3460985	-121.9370811	74.390	39	4.330	70.060	5/2/2006
T0608501511_U-8	37.3465680	-121.9375419	74.524	40	10.990	63.534	5/2/2006
T0608501511_U-9	37.3461790	-121.9376813	74.163	40	5.960	68.203	5/2/2006
T0608501511_UV-1	37.3463992	-121.9375394	74.501	30	7.240	67.261	3/7/2019
T0608501511_UV-2	37.3463465	-121.9375769	73.927	16	7.140	66.787	3/7/2019
T0608501511_UV-3	37.3464259	-121.9375770	74.825	17	7.140	67.685	3/7/2019
T0608501511_UV-4	37.3463886	-121.9374736	73.970	8	0.000	73.970	1/2/2002
T0608501511_UV-5	37.3463282	-121.9374182	74.278	17	5.820	68.458	3/27/2018
T0608501511_UV-6	37.3462869	-121.9374544	74.428	13	7.480	66.948	3/7/2019
T0608500217_MW-2	37.3451244	-121.9187106	72.498	30	22.120	50.378	3/17/2015
T0608500217_MW-3	37.3451120	-121.9191862	73.407	29	21.000	52.407	3/17/2015
T0608500217_MW-4	37.3453082	-121.9189170	72.409	29	21.240	51.169	3/17/2015
T0608500217_MW-5	37.3445200	-121.9178807	72.412	25	22.510	49.902	3/17/2015
T0608500217_MW-7	37.3445286	-121.9181202	73.852	25	22.860	50.992	3/17/2015
T0608500442_MW-24	37.3452987	-121.9161041	70.928	20	12.170	58.758	3/21/2011
T0608500710_EW-11	37.3481802	-121.8925025	69.184	28	0.000	69.184	2/16/2016

T0608500710_EW-6	37.3481793	-121.8929456	69.357	28	0.000	69.357	2/16/2016
T0608500710_MW-10	37.3479895	-121.8934739	68.451	19	0.000	68.451	2/16/2016
T0608500710_MW-12	37.3474022	-121.8924110	69.963	19	0.000	69.963	2/10/2015
T0608500710_MW-15	37.3496224	-121.8928392	64.295	19	0.000	64.295	12/1/2015
T0608500710_MW-16	37.3493655	-121.8933816	64.358	23	0.000	64.358	2/16/2016
T0608500710_MW-17	37.3489825	-121.8925117	67.081	24	5.300	61.781	2/22/2017
T0608500710_MW-18	37.3486234	-121.8925176	66.641	24	5.910	60.731	2/22/2017
T0608500710_MW-19	37.3486792	-121.8929018	67.227	22	6.650	60.577	2/22/2017
T0608500710_MW-21	37.3486982	-121.8933057	66.397	30	0.000	66.397	2/16/2016
T0608500710_MW-22	37.3484329	-121.8923335	67.757	22	5.210	62.547	2/22/2017
T0608500710_MW-28	37.3486057	-121.8925036	66.678	29	5.850	60.828	2/22/2017
T0608500710_MW-29	37.3486498	-121.8925338	66.573	20	5.840	60.733	2/22/2017
T0608500710_MW-31	37.3488876	-121.8927109	66.146	30	5.740	60.406	2/22/2017
T0608500710_MW-32	37.3484016	-121.8923505	67.201	30	6.040	61.161	2/22/2017
T0608500710_MW-33	37.3488780	-121.8929775	66.130	30	6.020	60.110	2/22/2017
T0608500710_MW-4	37.3482245	-121.8925168	68.544	20	7.160	61.384	2/22/2017
T0608500710_MW-5	37.3478703	-121.8927400	69.947	20	0.000	69.947	2/16/2016
T0608501187_MW-4	37.3484700	-121.8952684	67.154	15	9.510	57.644	1/28/2019
T0608501187_MW-42	37.3485955	-121.8958050	67.552	14	11.170	56.382	1/28/2019
T0608501187_MW-43	37.3484678	-121.8960552	67.905	15	11.250	56.655	1/28/2019
T0608501187_MW-44	37.3482621	-121.8964663	67.935	16	10.520	57.415	1/28/2019
T0608501187_MW-47T	37.3479906	-121.8953678	68.800	12	11.290	57.510	1/28/2019
T0608501187_MW-5	37.3486254	-121.8954818	66.640	12	10.240	56.400	1/28/2019
T0608501187_MW-6	37.3483976	-121.8957005	66.921	15	9.910	57.011	1/28/2019
T0608501187_MW-7	37.3482457	-121.8956079	68.131	12	10.050	58.081	1/28/2019
T0608501187_MW-9	37.3481358	-121.8954902	68.612	15	10.960	57.652	1/28/2019
T0608501187_RW-10	37.3481025	-121.8958402	68.422	16	10.550	57.872	1/28/2019
T0608501187_RW-11	37.3481082	-121.8957612	69.038	16	11.400	57.638	1/28/2019
T0608501187_RW-13	37.3481511	-121.8957954	68.515	17	11.660	56.855	1/28/2019
T0608501187_RW-16	37.3482935	-121.8955087	68.008	18	10.230	57.778	1/28/2019
T0608501187_RW-18	37.3481978	-121.8955189	68.449	17	10.340	58.109	1/28/2019
T0608501187_RW-19	37.3482082	-121.8954304	68.118	11	10.500	57.618	1/28/2019
T0608501187_RW-19B	37.3479906	-121.8953678	68.800	9	5.810	62.990	1/28/2019
T0608501187_RW-23	37.3480952	-121.8953467	68.427	14	10.170	58.257	1/28/2019
T0608501187_RW-24	37.3479906	-121.8953678	68.800	20	11.000	57.800	1/28/2019
T0608501304_S-13	37.3499322	-121.8978819	60.275	28	5.050	55.225	2/21/2019
T0608500710_EW-1	37.3481590	-121.8921723	67.724	19	5.550	62.174	2/22/2017
T0608500710_MW-25	37.3484813	-121.8920666	68.462	20	7.120	61.342	2/22/2017
T0608500710_MW-26	37.3482904	-121.8922675	67.454	30	6.130	61.324	2/22/2017
T0608500710_MW-27	37.3481930	-121.8921936	67.579	20	6.090	61.489	2/22/2017
T0608500710_MW-30	37.3484880	-121.8920501	68.422	30	7.300	61.122	2/22/2017
T0608502019_MW-1	37.3450533	-121.8845417	72.556	22	7.700	64.856	3/16/2005
T0608502019_MW-2	37.3451369	-121.8849617	74.257	22	9.750	64.507	3/16/2005
T0608502019_MW-3	37.3452819	-121.8848253	74.179	22	9.310	64.869	3/16/2005

T0608502019_MW-4	37.3454030	-121.8850830	73.080	22	9.020	64.060	5/5/2006
T0608540008_MW-1	37.3452162	-121.8718295	93.420	30	21.090	72.330	4/22/2008
T0608540008_MW-2	37.3451018	-121.8722840	95.423	35	25.390	70.033	3/28/2008
T0608540008_MW-3	37.3455141	-121.8723668	93.452	35	22.220	71.232	3/28/2008
T0608540008_MW-4	37.3456610	-121.8719052	93.099	30	20.500	72.599	4/22/2008
T0608567776_MW1	37.3469009	-121.8675157	90.985	27	15.350	75.635	5/10/2010
T0608567776_MW2	37.3469920	-121.8674228	91.588	27	14.990	76.598	5/10/2010
T0608567776_MW3	37.3469879	-121.8672522	91.797	27	15.750	76.047	5/10/2010
T10000006973_MW1	37.3471604	-121.8681846	91.609	25	15.440	76.169	4/11/2016
T10000006973_MW2	37.3471524	-121.8684002	91.460	25	15.190	76.270	4/11/2016
T10000006973_MW3	37.3473360	-121.8682167	91.194	25	14.940	76.254	4/11/2016
T0608500368_#11	37.3505775	-121.8263855	116.270	14	3.020	113.250	1/11/2005
T0608500368_#13	37.3505775	-121.8263855	116.270	16	3.180	113.090	1/11/2005
T0608500368_#15	37.3505775	-121.8263855	116.270	16	3.050	113.220	1/11/2005
T0608500368_#16A	37.3505775	-121.8263855	116.270	15	4.860	111.410	1/11/2005
T0608500368_#4	37.3505775	-121.8263855	116.270	16	2.480	113.790	1/11/2005
T0608500368_#6	37.3505775	-121.8263855	116.270	15	3.820	112.450	1/11/2005
T0608500368_#9	37.3505775	-121.8263855	116.270	15	3.080	113.190	1/11/2005
T0608500368_EW-5	37.3505775	-121.8263855	116.270	17	4.300	111.970	1/14/2008
T0608500368_EW-6	37.3505775	-121.8263855	116.270	17	4.260	112.010	1/14/2008
T0608500368_HLA-3	37.3506359	-121.8271739	115.423	15	4.030	111.393	4/11/2006
T0608500368_WCC-13	37.3505775	-121.8263855	116.270	16	1.460	114.810	4/21/2010
T0608500368_WCC-15	37.3505775	-121.8263855	116.270	16	3.630	112.640	1/14/2008
T0608500368_WCC-2	37.3505775	-121.8263855	116.270	19	2.940	113.330	1/11/2005
T0608500368_WCC-3	37.3507329	-121.8268247	115.954	20	4.320	111.634	4/11/2006
T0608500368_WCC-9	37.3505775	-121.8263855	116.270	15	3.900	112.370	4/21/2010
T0608500591_MW-2	37.3507094	-121.8275544	115.427	24	3.950	111.477	1/11/2005
T0608500591_MW-6	37.3506818	-121.8275298	114.924	22	3.660	111.264	1/11/2005
T0608500379_MW-1	37.3520485	-121.9986546	100.154	34	20.530	79.624	3/29/2004
T0608500379_MW-C	37.3518143	-121.9986276	100.998	49	21.360	79.638	3/29/2004
T0608501525_MW-10	37.3528795	-121.9925511	92.589	45	14.130	78.459	1/31/2003
T0608501525_MW-11	37.3525306	-121.9922622	93.795	49	12.560	81.235	4/17/2006
T0608501525_MW-9	37.3528109	-121.9923957	93.374	45	14.160	79.214	4/17/2006
T0608501525_U-10	37.3530728	-121.9920645	92.855	44	12.630	80.225	4/17/2006
T0608501525_U-11	37.3531179	-121.9925281	92.030	46	14.360	77.670	4/17/2003
T0608501525_U-12	37.3538749	-121.9923837	88.772	42	12.540	76.232	4/17/2003
T0608501525_U-14	37.3528109	-121.9923957	93.374	28	14.370	79.004	4/17/2006
T0608501525_U-15	37.3528109	-121.9923957	93.374	29	14.180	79.194	4/17/2006
T0608501525_U-16	37.3528109	-121.9923957	93.374	27	12.390	80.984	4/17/2006
T0608500370_C-1	37.3521341	-121.9771206	82.298	38	10.400	71.898	5/26/2006
T0608500370_C-10	37.3521539	-121.9769871	82.404	31	11.310	71.094	2/21/2005
T0608500370_C-11	37.3518610	-121.9769661	81.775	28	9.450	72.325	5/26/2006
T0608500370_C-12	37.3521395	-121.9774061	83.048	25	11.290	71.758	2/21/2005
T0608500370_C-13	37.3521395	-121.9774061	83.048	25	12.300	70.748	2/21/2005

T0608500370_C-2	37.3518227	-121.9771392	80.483	44	7.540	72.943	5/26/2006
T0608500370_C-3	37.3521395	-121.9774061	83.048	43	8.600	74.448	5/26/2006
T0608500370_C-4	37.3519976	-121.9774150	82.361	46	9.320	73.041	5/26/2006
T0608500370_C-5	37.3516781	-121.9772115	79.490	45	4.640	74.850	2/21/2005
T0608500370_C-6	37.3519061	-121.9776057	80.924	42	5.670	75.254	2/21/2005
T0608500370_C-7	37.3523573	-121.9771614	82.526	40	11.200	71.326	2/21/2005
T0608500370_C-9	37.3521358	-121.9772552	82.176	29	10.020	72.156	2/21/2005
T0608500370_C-8	37.3523610	-121.9767194	82.262	41	11.730	70.532	2/21/2005
T0608501270_S-14	37.3527161	-121.9593690	76.702	44	14.750	61.952	2/12/2002
T0608501270_S-15	37.3530800	-121.9593944	75.041	44	14.370	60.671	2/12/2002
T0608501270_S-20	37.3527751	-121.9596077	76.872	42	14.950	61.922	2/12/2002
T0608501270_S-21	37.3525008	-121.9585903	77.130	45	14.850	62.280	2/12/2002
T0608501270_S-24	37.3529388	-121.9583702	79.161	34	18.080	61.081	2/12/2002
T0608501270_S-25	37.3530785	-121.9589570	75.397	11	0.930	74.467	2/12/2002
T0608500820_VE-1	37.3518418	-121.9539787	76.252	17	9.510	66.742	5/12/2005
T0608500820_VE-2	37.3518886	-121.9539280	75.490	17	9.480	66.010	5/12/2005
T0608500820_VE-3	37.3519301	-121.9540032	76.132	17	9.720	66.412	5/12/2005
T0608510936_MW-1	37.3520798	-121.9407335	71.431	25	11.920	59.511	4/21/2005
T0608510936_MW-2	37.3521174	-121.9406515	71.949	25	12.480	59.469	4/21/2005
T0608510936_MW-3	37.3520273	-121.9406690	72.143	25	12.300	59.843	2/3/2006
T0608510936_MW-4	37.3519806	-121.9405757	73.128	25	13.440	59.688	4/21/2005
T0608501304_S-10	37.3503997	-121.8974122	60.676	30	5.700	54.976	2/21/2019
T0608501304_S-11	37.3502611	-121.8977640	60.901	23	6.090	54.811	2/21/2019
T0608501304_S-15	37.3508803	-121.8971483	60.106	25	6.070	54.036	2/21/2019
T0608501304_S-16	37.3507200	-121.8967882	61.258	24	7.000	54.258	2/21/2019
T0608501304_S-18	37.3513212	-121.8974810	59.795	24	6.200	53.595	3/3/2017
T0608501304_S-23	37.3503748	-121.8971253	60.681	28	5.000	55.681	3/3/2017
T0608501304_S-3	37.3500664	-121.8973100	61.886	20	5.710	56.176	2/21/2019
T0608501304_S-9	37.3504647	-121.8972741	60.733	30	5.630	55.103	2/21/2019
T0608501304_SP-1	37.3502080	-121.8971829	61.572	14	4.770	56.802	3/3/2017
T0608501304_SP-2	37.3503142	-121.8972687	61.007	16	4.360	56.647	2/21/2019
T0608501304_SR-1	37.3502193	-121.8974060	60.665	30	4.630	56.035	2/21/2019
T0608515327_MW-1	37.3519686	-121.8695091	91.036	25	15.290	75.746	4/7/2004
T0608515327_MW-2	37.3518543	-121.8695613	90.973	25	15.470	75.503	4/7/2004
T0608515327_MW-3	37.3519889	-121.8693404	91.404	25	15.410	75.994	4/7/2004
T0608515327_MW-4	37.3518838	-121.8693135	92.135	25	16.250	75.885	4/7/2004
T0608500667_MW-16A	37.3555765	-121.8641845	88.633	15	6.440	82.193	3/29/2011
T0608500667_MW-16B	37.3555610	-121.8642086	88.854	23	6.320	82.534	3/29/2011
T0608500667_MW-16C	37.3555756	-121.8642184	88.138	30	6.520	81.618	3/29/2011
T0608500667_MW-17B	37.3555302	-121.8640316	87.501	23	6.020	81.481	3/29/2011
T0608500667_MW-19	37.3555666	-121.8641019	87.615	22	5.630	81.985	3/29/2011
T0608500667_MW-9A	37.3555666	-121.8641019	87.615	15	5.800	81.815	3/29/2011
T0608500667_MW-9B	37.3555443	-121.8641092	87.198	23	5.520	81.678	3/29/2011
T0608500368_EW-1	37.3508475	-121.8266438	115.643	14	5.820	109.823	4/12/2005

T0608500368_EW-4R	37.3509097	-121.8264755	116.620	15	4.290	112.330	4/19/2012
T0608500368_HLA-1	37.3513396	-121.8260699	117.782	15	4.310	113.472	1/11/2005
T0608500368_HLA-2	37.3511523	-121.8267613	115.538	15	3.220	112.318	4/11/2006
T0608500368_P-2	37.3507977	-121.8266056	116.694	14	3.970	112.724	1/14/2008
T0608500368_WCC-1	37.3508750	-121.8261143	118.359	20	3.780	114.579	1/11/2005
T0608500368_WCC-5	37.3508618	-121.8265544	116.409	19	3.150	113.259	1/11/2005
T0608500591_EA-4	37.3511627	-121.8274526	115.105	14	3.680	111.425	1/11/2005
T0608500591_MW-1	37.3509208	-121.8277644	116.528	25	4.790	111.738	4/12/2005
T0608500591_MW-10	37.3509737	-121.8284579	110.530	24	0.040	110.490	4/11/2006
T0608500591_MW-11	37.3511024	-121.8272319	115.326	11	3.390	111.936	1/11/2005
T0608500591_MW-12	37.3509632	-121.8282336	110.862	17	0.350	110.512	1/11/2005
T0608500591_MW-13	37.3511236	-121.8282613	110.985	18	0.450	110.535	1/11/2005
T0608500591_MW-5	37.3508652	-121.8272777	115.293	24	3.270	112.023	4/11/2006
T0608500591_MW-7	37.3511159	-121.8277967	116.073	25	4.910	111.163	1/11/2005
T0608500591_MW-8	37.3516202	-121.8275581	115.891	21	4.340	111.551	1/11/2005
T0608500591_MW-9	37.3513486	-121.8284623	111.496	24	0.860	110.636	1/11/2005
T0608500591_WELL #1	37.3511627	-121.8274526	115.105	22	4.100	111.005	4/11/2006
T0608500591_WELL #3	37.3511627	-121.8274526	115.105	24	4.820	110.285	1/11/2005
T0608501467_MW-1	37.3521438	-121.8245534	122.746	18	7.050	115.696	4/4/2011
T0608501467_MW-10B	37.3519527	-121.8245585	122.450	40	6.910	115.540	3/8/2006
T0608501467_MW-13	37.3520308	-121.8249388	121.323	18	6.500	114.823	4/4/2011
T0608501467_MW-15	37.3518414	-121.8257723	118.844	20	5.450	113.394	4/4/2011
T0608501467_MW-16	37.3525814	-121.8246921	121.870	20	7.000	114.870	4/4/2011
T0608501467_MW-2	37.3520641	-121.8246088	122.663	17	6.620	116.043	3/8/2006
T0608501467_MW-3	37.3522692	-121.8245805	122.903	19	7.120	115.783	4/4/2011
T0608501467_MW-4	37.3520516	-121.8243342	123.168	15	7.610	115.558	4/4/2011
T0608501467_MW-5	37.3522858	-121.8243359	122.572	13	6.960	115.612	3/8/2006
T0608501467_MW-6	37.3524579	-121.8248918	121.808	18	7.110	114.698	4/4/2011
T0608501467_MW-7	37.3523245	-121.8250883	121.092	18	6.940	114.152	5/1/2013
T0608501467_MW-8	37.3531250	-121.8253355	119.089	20	4.930	114.159	4/4/2011
T0608501467_MW-9B	37.3521987	-121.8246630	122.887	40	7.800	115.087	4/4/2011
T0608501467_RW-1	37.3521702	-121.8245736	122.764	12	7.250	115.514	3/8/2006
T0608501467_RW-2	37.3521383	-121.8247172	122.668	19	6.880	115.788	4/4/2011
T0608501467_RW-3	37.3520724	-121.8246532	122.435	19	7.060	115.375	3/8/2006
T0608501467_RW-4	37.3519841	-121.8245811	122.380	19	6.890	115.490	3/8/2006
T0608501996_MW-1	37.3516256	-121.8263792	118.491	17	5.000	113.491	4/11/2006
T0608501996_MW-2	37.3515825	-121.8269417	118.839	19	6.000	112.839	4/11/2006
T0608501996_MW-3	37.3512894	-121.8267243	116.819	16	4.410	112.409	4/11/2006
T0608501996_MW-4	37.3514645	-121.8269359	119.187	23	8.050	111.137	4/19/2012
T0608501996_MW-5	37.3515321	-121.8266541	118.604	22	6.850	111.754	4/19/2012
T0608501996_MW-8	37.3515825	-121.8269417	118.839	21	6.100	112.739	4/19/2012
T0608501492_E-1	37.3564234	-121.8195230	135.537	30	11.660	123.877	5/7/2010
T0608501492_EX-1	37.3564823	-121.8191620	137.542	27	10.650	126.892	4/26/2006
T0608501492_EX-2	37.3564209	-121.8191649	137.158	28	10.210	126.948	4/26/2006

T0608501492_MW-10	37.3564896	-121.8195832	135.602	28	0.620	134.982	12/9/2010
T0608501492_MW-11	37.3562076	-121.8188972	137.169	26	10.880	126.289	4/26/2006
T0608501492_MW-15	37.3564581	-121.8207902	129.431	26	6.450	122.981	4/26/2006
T0608501492_MW-16	37.3557601	-121.8195534	133.833	27	9.290	124.543	4/26/2006
T0608501492_MW-3	37.3564954	-121.8191490	137.647	36	11.160	126.487	4/26/2006
T0608501492_MW-4	37.3564815	-121.8192366	137.011	29	10.960	126.051	4/14/2005
T0608501492_MW-6	37.3563817	-121.8191494	137.519	29	10.480	127.039	4/26/2006
T0608501492_MW-9	37.3562840	-121.8194054	135.418	33	9.840	125.578	4/26/2006
T0608500166_A-1	37.3561457	-121.9592652	68.950	42	10.980	57.970	5/9/2003
T0608500166_A-2	37.3561577	-121.9591558	70.032	49	12.130	57.902	5/9/2003
T0608500166_A-5	37.3560641	-121.9591986	69.103	40	11.000	58.103	5/9/2003
T0608500166_A-6	37.3562339	-121.9591883	66.719	38	8.340	58.379	5/9/2003
T0608500166_SP-1	37.3561497	-121.9592515	69.060	32	11.410	57.650	5/9/2003
T0608500166_SP-2	37.3561231	-121.9591394	70.155	32	11.740	58.415	5/9/2003
T0608500166_SP-3	37.3560743	-121.9592839	68.331	29	10.300	58.031	5/9/2003
T0608500166_V-1	37.3561497	-121.9592515	69.060	20	11.400	57.660	5/9/2003
T0608500166_V-2	37.3561231	-121.9591394	70.155	21	11.800	58.355	5/9/2003
T0608500356_EA-3	37.3556105	-121.9593071	69.983	45	9.950	60.033	2/26/2004
T0608500356_EA-4	37.3555261	-121.9591815	70.683	41	10.270	60.413	2/26/2004
T0608500356_GT-1	37.3556118	-121.9592490	69.360	25	9.960	59.400	2/26/2004
T0608500356_MW-1	37.3555757	-121.9589226	70.967	41	11.080	59.887	2/26/2004
T0608500356_MW-3	37.3556671	-121.9589783	71.194	45	10.130	61.064	2/26/2004
SL20266884_MW-15	37.3607804	-121.9199913	52.617	25	8.100	44.517	5/8/2019
SL20266884_MW-16	37.3607804	-121.9199913	52.617	26	9.430	43.187	5/8/2019
SL20266884_MW-17	37.3607804	-121.9199913	52.617	27	9.120	43.497	5/8/2019
SL20266884_MW-18	37.3607804	-121.9199913	52.617	26	9.230	43.387	5/8/2019
SL20266884_MW-19	37.3607804	-121.9199913	52.617	23	8.720	43.897	5/9/2018
SL20266884_MW-21	37.3607804	-121.9199913	52.617	49	8.630	43.987	5/8/2019
SL20266884_MW-4	37.3607804	-121.9199913	52.617	34	8.550	44.067	5/11/2012
SL20266884_MW-7	37.3607445	-121.9197606	52.434	32	8.580	43.854	5/11/2012
T0608501162_2	37.3586812	-121.9168619	56.221	34	15.580	40.641	2/16/2010
T0608501162_3	37.3586120	-121.9168144	56.018	17	14.900	41.118	2/16/2010
T0608501162_4	37.3585121	-121.9168281	56.324	26	14.590	41.734	2/16/2010
T0608501162_C-1	37.3586254	-121.9169073	56.467	27	14.410	42.057	2/16/2010
T0608501162_C-10	37.3589819	-121.9166961	56.075	41	17.310	38.765	5/14/2012
T0608501162_C-11	37.3592203	-121.9168722	54.949	41	15.510	39.439	5/3/2010
T0608501162_C-12	37.3590287	-121.9171849	55.384	40	14.160	41.224	2/16/2010
T0608501162_C-13	37.3588518	-121.9174576	55.589	39	13.470	42.119	2/16/2010
T0608501162_C-14	37.3587025	-121.9176504	55.586	40	12.720	42.866	5/10/2006
T0608501162_C-15	37.3585258	-121.9174617	55.725	39	12.450	43.275	5/10/2006
T0608501162_C-17	37.3589150	-121.9165098	55.493	40	12.380	43.113	5/10/2006
T0608501162_C-18	37.3589150	-121.9165098	55.493	37	13.250	42.243	5/10/2006
T0608501162_C-19	37.3589150	-121.9165098	55.493	40	14.330	41.163	5/3/2010
T0608501162_C-2	37.3587224	-121.9167818	55.898	29	14.990	40.908	5/3/2010

T0608501162_C-20	37.3585757	-121.9169835	56.721	38	14.520	42.201	5/3/2010
T0608501162_C-21	37.3586820	-121.9171307	56.758	38	14.000	42.758	5/3/2010
T0608501162_C-22	37.3589150	-121.9165098	55.493	34	14.770	40.723	5/3/2010
T0608501162_C-23	37.3595012	-121.9170320	56.177	32	15.120	41.057	3/29/2013
T0608501162_C-25	37.3591618	-121.9164670	58.325	35	19.970	38.355	5/10/2006
T0608501162_C-27	37.3585014	-121.9161583	56.442	40	16.530	39.912	5/10/2006
T0608501162_C-28	37.3587046	-121.9178531	56.005	41	13.100	42.905	5/10/2006
T0608501162_C-29	37.3588441	-121.9177326	55.536	41	12.640	42.896	5/3/2010
T0608501162_C-3	37.3585407	-121.9165479	55.304	21	14.520	40.784	5/3/2010
T0608501162_C-30	37.3589760	-121.9175316	55.492	38	13.250	42.242	5/3/2010
T0608501162_C-31	37.3591939	-121.9172287	55.521	40	13.680	41.841	2/16/2010
T0608501162_C-33	37.3589150	-121.9165098	55.493	35	13.920	41.573	5/10/2006
T0608501162_C-34	37.3589150	-121.9165098	55.493	30	16.540	38.953	5/13/2013
T0608501162_C-35	37.3589150	-121.9165098	55.493	34	15.370	40.123	3/26/2013
T0608501162_C-36	37.3589150	-121.9165098	55.493	30	16.200	39.293	3/26/2013
T0608501162_C-37	37.3589150	-121.9165098	55.493	30	16.250	39.243	3/26/2013
T0608501162_C-7	37.3586913	-121.9168751	56.382	29	15.050	41.332	2/16/2010
T0608501162_C-8	37.3589150	-121.9165098	55.493	35	13.480	42.013	5/13/2013
T0608501162_C-9	37.3587432	-121.9164908	56.343	33	17.350	38.993	5/10/2006
T0608501162_MW-1	37.3586770	-121.9172625	57.032	27	13.700	43.332	5/3/2010
T0608501162_MW-10	37.3587848	-121.9172295	56.359	30	13.920	42.439	2/16/2010
T0608501162_MW-2	37.3586008	-121.9171900	57.444	29	13.440	44.004	5/3/2010
T0608501162_MW-3	37.3586433	-121.9171116	56.949	29	13.940	43.009	2/16/2010
T0608501162_MW-5	37.3587787	-121.9169176	56.458	25	14.550	41.908	2/16/2010
T0608501162_MW-6	37.3588218	-121.9169848	56.628	29	14.400	42.228	2/16/2010
T0608501162_MW-7	37.3588418	-121.9170627	56.258	30	14.450	41.808	2/16/2010
T0608501162_MW-8	37.3588495	-121.9171473	56.188	30	14.030	42.158	2/16/2010
T0608500330_C-1	37.3563990	-121.9052712	57.739	39	10.900	46.839	1/15/2002
T0608500330_C-10	37.3564750	-121.9055710	56.605	30	9.570	47.035	1/15/2002
T0608500330_C-11	37.3563142	-121.9057052	58.242	30	12.310	45.932	1/15/2002
T0608500330_C-12	37.3563150	-121.9049208	58.450	29	11.330	47.120	1/15/2002
T0608500330_C-13	37.3563142	-121.9057052	58.242	28	11.490	46.752	1/15/2002
T0608500330_C-15	37.3559025	-121.9051368	57.710	23	10.890	46.820	1/15/2002
T0608500330_C-2	37.3563841	-121.9052866	57.640	40	11.430	46.210	1/15/2002
T0608500330_C-3	37.3565049	-121.9051334	58.263	30	11.510	46.753	1/15/2002
T0608500330_C-5	37.3567732	-121.9054539	57.234	29	11.750	45.484	1/15/2002
T0608500330_C-6	37.3562692	-121.9058912	58.575	29	11.920	46.655	1/15/2002
T0608500330_C-7	37.3561962	-121.9051653	58.648	29	11.890	46.758	1/15/2002
T0608500330_C-8	37.3564678	-121.9053681	58.842	31	0.000	58.842	1/15/2002
T0608500330_C-9	37.3567017	-121.9051354	58.879	30	13.670	45.209	1/15/2002
T0608500100_GX-38	37.3611356	-121.8970742	57.813	23	6.850	50.963	1/9/2002
T0608500100_MW-1	37.3612131	-121.8970483	57.608	24	6.980	50.628	1/9/2002
T0608500100_MW-2	37.3610878	-121.8973192	57.428	24	6.950	50.478	1/9/2002
T0608500100_MW-3	37.3610581	-121.8968419	57.921	24	7.110	50.811	1/9/2002

T0608500744_MW-1	37.3561614	-121.8917560	65.239	20	6.670	58.569	4/6/2006
T0608500744_MW-2	37.3561488	-121.8919025	65.637	22	6.070	59.567	4/6/2006
T0608500744_MW-3	37.3562942	-121.8918508	65.104	20	5.920	59.184	4/6/2006
T0608501966_B-1	37.3589280	-121.8911803	70.185	25	0.000	70.185	12/12/2013
T0608501966_B-2	37.3588731	-121.8911500	70.224	23	13.100	57.124	3/13/2008
T0608501966_STMW-1	37.3588805	-121.8909797	70.535	28	13.170	57.365	3/14/2013
T0608501966_STMW-10	37.3589510	-121.8913812	69.071	25	13.120	55.951	3/13/2008
T0608501966_STMW-12	37.3594805	-121.8917550	67.103	25	13.650	53.453	3/2/2011
T0608501966_STMW-13	37.3591669	-121.8915664	69.431	25	13.060	56.371	3/13/2008
T0608501966_STMW-14	37.3590892	-121.8916475	69.260	25	12.850	56.410	3/3/2011
T0608501966_STMW-15	37.3593407	-121.8911462	70.405	25	14.000	56.405	3/13/2008
T0608501966_STMW-16	37.3592642	-121.8905994	71.844	25	18.140	53.704	5/31/2016
T0608501966_STMW-17	37.3596053	-121.8911830	69.526	25	15.120	54.406	5/31/2016
T0608501966_STMW-18	37.3596291	-121.8913195	67.782	25	13.970	53.812	5/31/2016
T0608501966_STMW-2	37.3589342	-121.8908685	70.814	28	13.300	57.514	3/14/2008
T0608501966_STMW-3	37.3590870	-121.8909702	70.204	27	11.600	58.604	3/14/2008
T0608501966_STMW-4	37.3591299	-121.8910267	70.086	27	11.640	58.446	3/14/2008
T0608501966_STMW-5	37.3590568	-121.8911066	70.159	27	11.840	58.319	3/14/2008
T0608501966_STMW-6	37.3590370	-121.8912513	69.331	27	12.020	57.311	3/14/2008
T0608501966_STMW-7	37.3588619	-121.8912948	68.935	25	11.940	56.995	3/30/2009
T0608501966_STMW-8	37.3589179	-121.8910171	70.597	25	13.500	57.097	3/13/2008
T0608501966_STMW-9	37.3587514	-121.8912188	69.276	25	11.960	57.316	3/13/2008
T0608500349_MW-10	37.3561686	-121.8632716	89.221	23	7.850	81.371	1/11/2002
T0608500349_MW-13A	37.3563712	-121.8629829	88.815	11	5.810	83.005	4/19/2002
T0608500349_MW-13B	37.3563548	-121.8630017	89.000	48	4.860	84.140	1/11/2002
T0608500349_MW-14	37.3565557	-121.8635621	87.142	20	5.450	81.692	1/11/2002
T0608500349_MW-15	37.3563889	-121.8638381	87.387	20	5.510	81.877	1/11/2002
T0608500349_MW-16	37.3563824	-121.8628508	88.576	25	6.250	82.326	1/11/2002
T0608500349_MW-17	37.3563798	-121.8632432	88.463	25	0.000	88.463	1/11/2002
T0608500349_MW-18	37.3563595	-121.8634280	87.463	22	5.800	81.663	1/11/2002
T0608500349_MW-19	37.3561851	-121.8638971	87.107	21	5.680	81.427	1/11/2002
T0608500349_MW-4	37.3561764	-121.8629979	88.697	10	6.260	82.437	1/11/2002
T0608500349_MW-5	37.3563420	-121.8630149	89.178	24	7.950	81.228	1/11/2002
T0608500349_MW-6	37.3565380	-121.8627563	88.598	23	7.400	81.198	4/19/2002
T0608501663_EW-2	37.3576136	-121.8619567	87.818	25	6.310	81.508	5/23/2006
T0608500593_COEX-1	37.3572928	-121.8473031	99.111	24	10.150	88.961	2/22/2017
T0608500593_MW-1	37.3571069	-121.8474322	99.490	27	12.750	86.740	1/25/2007
T0608500593_MW-2	37.3571428	-121.8475786	98.514	25	8.610	89.904	2/22/2017
T0608500593_MW-3	37.3570483	-121.8477447	98.799	24	9.510	89.289	2/22/2017
T0608500593_MW-4	37.3573381	-121.8472678	97.994	25	8.950	89.044	2/22/2017
T0608500593_MW-5	37.3568883	-121.8472981	98.243	24	8.440	89.803	2/22/2017
T0608500593_MW-6	37.3571194	-121.8468261	98.359	25	12.860	85.499	12/18/2003
T0608500593_MW-7	37.3577531	-121.8472564	97.513	24	12.630	84.883	12/18/2003
T0608500593_MW-8	37.3575439	-121.8477147	98.712	24	9.460	89.252	2/22/2017

T0608500593_MW-9	37.3582619	-121.8472056	98.456	25	9.710	88.746	4/18/2006
T0608560113_MW-1	37.3573741	-121.8450277	100.765	29	14.020	86.745	4/1/2005
T0608560113_MW-10	37.3573764	-121.8449160	99.598	34	15.870	83.728	4/13/2009
T0608560113_MW-2	37.3572805	-121.8452458	100.902	29	13.500	87.402	4/1/2005
T0608560113_MW-3	37.3576051	-121.8450901	99.625	29	13.240	86.385	4/4/2006
T0608560113_MW-4	37.3575470	-121.8452609	99.528	29	13.050	86.478	4/4/2006
T0608560113_MW-5	37.3574864	-121.8451925	100.975	34	13.570	87.405	4/4/2006
T0608560113_MW-6	37.3571982	-121.8452632	100.618	30	13.860	86.758	4/4/2006
T0608560113_MW-7	37.3574865	-121.8452457	101.001	30	13.040	87.961	4/4/2006
T0608560113_MW-8	37.3573764	-121.8449160	99.598	30	14.260	85.338	4/3/2007
T0608560113_MW-9	37.3573764	-121.8449160	99.598	34	16.400	83.198	4/13/2009
T0608501281_S-10	37.3602178	-121.8389464	111.379	38	22.690	88.689	4/19/2006
T0608501281_S-2	37.3602178	-121.8389464	111.379	45	24.130	87.249	4/19/2006
T0608501281_S-4	37.3604751	-121.8389110	110.247	45	22.710	87.537	4/19/2006
T0608501281_S-5	37.3600133	-121.8389589	112.077	41	24.650	87.427	4/19/2006
T0608501281_S-6	37.3602321	-121.8387657	111.226	45	24.040	87.186	4/19/2006
T0608501281_S-8	37.3601603	-121.8387215	111.854	45	27.380	84.474	1/23/2003
T0608501281_S-9	37.3603158	-121.8391926	110.127	33	22.810	87.317	4/19/2006
T0608501509_EW-1	37.3588512	-121.8418218	103.273	35	21.700	81.573	4/24/2006
T0608501509_EW-2	37.3589450	-121.8420201	102.868	35	19.480	83.388	4/24/2006
T0608501509_EW-3	37.3590470	-121.8418555	103.832	35	22.190	81.642	5/31/2011
T0608501509_EW-7	37.3590023	-121.8428184	102.353	35	19.750	82.603	4/24/2006
T0608501509_MW-1	37.3587581	-121.8418790	102.508	34	20.320	82.188	4/24/2006
T0608501509_MW-2	37.3589302	-121.8415979	104.196	34	22.850	81.346	4/24/2006
T0608501509_MW-3	37.3589802	-121.8420097	103.044	35	20.300	82.744	4/24/2006
T0608501509_MW-4	37.3586747	-121.8420117	102.440	35	19.740	82.700	4/24/2006
T0608501509_MW-5	37.3590023	-121.8428184	102.353	35	18.250	84.103	4/24/2006
T0608501509_MW-6	37.3590023	-121.8428184	102.353	34	24.160	78.193	4/24/2006
T0608501509_MW-7	37.3590023	-121.8428184	102.353	35	20.470	81.883	5/10/2010
T0608501135_GX-137	37.3594836	-121.8226342	131.475	33	9.190	122.285	3/17/2004
T0608501135_GX-137A	37.3593622	-121.8225625	131.966	31	9.260	122.706	3/17/2004
T0608501135_GX-137B	37.3594117	-121.8228128	130.955	31	8.340	122.615	3/17/2004
T0608501135_GX-137G	37.3593219	-121.8229925	131.233	25	8.900	122.333	3/17/2004
T0608501492_MW-1	37.3565568	-121.8191143	137.684	38	11.550	126.134	4/26/2006
T0608501492_MW-12	37.3565100	-121.8184575	139.429	27	12.080	127.349	4/26/2006
T0608501492_MW-13	37.3570426	-121.8191317	138.510	27	11.990	126.520	4/26/2006
T0608501492_MW-14	37.3569734	-121.8201127	134.453	24	9.580	124.873	4/26/2006
T0608501492_MW-2	37.3565148	-121.8190409	137.903	35	11.220	126.683	4/26/2006
T0608501492_MW-5	37.3566383	-121.8193712	136.452	34	10.000	126.452	4/26/2006
T0608501492_MW-7	37.3566270	-121.8188921	138.657	30	11.490	127.167	4/26/2006
T0608501492_MW-8	37.3566825	-121.8194889	135.659	25	9.960	125.699	4/26/2006
T0608501874_MW-9	37.3606604	-121.9600174	58.283	20	7.830	50.453	4/13/2014
T0608501874_STMW-12	37.3614089	-121.9592983	57.682	20	10.000	47.682	5/13/2015
T0608501874_STMW-13	37.3619609	-121.9592808	56.381	20	9.230	47.151	5/13/2015

T0608501559_LW-1	37.3652044	-121.9502950	48.027	22	9.790	38.237	4/22/2003
T0608501559_LW-2	37.3651264	-121.9504728	46.890	18	7.800	39.090	4/22/2003
T0608501559_LW-3	37.3653972	-121.9504881	48.621	18	9.500	39.121	4/22/2003
T0608593159_MW-1	37.3646061	-121.9551553	49.775	20	4.740	45.035	2/18/2005
T0608593159_MW-2	37.3646010	-121.9549980	49.140	19	4.290	44.850	2/18/2005
T0608593159_MW-3	37.3648620	-121.9549947	48.798	20	3.660	45.138	2/18/2005
T0608593159_MW-4	37.3650040	-121.9549352	47.866	20	5.680	42.186	2/20/2007
T0608593159_MW-5	37.3650030	-121.9547516	47.926	20	5.080	42.846	2/18/2005
T0608593159_MW-6	37.3647420	-121.9548438	49.372	20	5.360	44.012	3/14/2006
SL1824R1157_MW-10-S	37.3621212	-121.9442026	53.295	25	4.910	48.385	4/25/2005
SL1824R1157_MW-13-S	37.3618939	-121.9443399	52.377	25	4.800	47.577	4/25/2005
SL1824R1157_MW-16-S	37.3617285	-121.9445075	51.544	25	5.400	46.144	4/25/2005
SL1824R1157_MW-19-S	37.3616849	-121.9444051	51.763	25	5.260	46.503	4/25/2005
SL1824R1157_MW-2	37.3614678	-121.9446060	51.077	35	6.060	45.017	4/25/2005
SL1824R1157_MW-20-S	37.3627551	-121.9443544	54.042	25	4.390	49.652	4/25/2005
SL1824R1157_MW-3	37.3627255	-121.9431949	48.079	35	2.670	45.409	4/25/2005
SL1824R1157_MW-4	37.3632595	-121.9432182	46.139	37	1.850	44.289	4/25/2005
SL1824R1157_MW-5	37.3627194	-121.9445226	53.367	25	4.750	48.617	4/25/2005
SL1824R1157_MW-8-S	37.3614678	-121.9446060	51.077	25	4.350	46.727	4/25/2005
SL1824R1157_MW-9-S	37.3621039	-121.9445095	52.641	25	4.780	47.861	4/25/2005
T0608500772_MW-6	37.3641304	-121.9430969	44.290	20	5.270	39.020	3/30/2007
T0608500772_MW-7	37.3643283	-121.9431926	44.227	15	7.700	36.527	4/9/2015
T0608500541_EW-1	37.3660187	-121.9412101	40.803	25	6.860	33.943	2/16/2005
T0608500541_EW-2	37.3660187	-121.9412101	40.803	35	4.750	36.053	3/12/2008
T0608500541_EW-3	37.3660187	-121.9412101	40.803	25	6.730	34.073	2/16/2005
T0608500541_EW-4	37.3660187	-121.9412101	40.803	25	6.710	34.093	2/16/2005
T0608500541_MW-1	37.3662909	-121.9409110	40.105	15	6.840	33.265	12/13/2006
T0608500541_MW-2	37.3661670	-121.9412080	40.690	15	6.930	33.760	2/16/2005
T0608500541_MW-3	37.3660427	-121.9409333	41.799	14	7.350	34.449	12/22/2003
T0608500541_MW-4	37.3660187	-121.9412101	40.803	15	6.950	33.853	12/13/2006
T0608500541_MW-5	37.3660187	-121.9412101	40.803	15	4.670	36.133	12/13/2006
T0608500541_MW-6	37.3660187	-121.9412101	40.803	15	9.780	31.023	2/16/2005
T0608500541_MW-7	37.3660187	-121.9412101	40.803	15	11.740	29.063	12/17/2002
T0608500541_MW-8	37.3660187	-121.9412101	40.803	17	11.270	29.533	2/16/2005
T0608500541_MW-9	37.3660187	-121.9412101	40.803	17	9.870	30.933	2/16/2005
SL20266884_MW-5	37.3611268	-121.9197362	52.221	30	9.210	43.011	5/12/2006
SL20266884_MW-6	37.3612157	-121.9196541	51.473	29	7.910	43.563	5/12/2006
T0608500101_EW-1	37.3654757	-121.9040015	51.193	19	6.980	44.213	2/10/2020
T0608500101_EW-2	37.3655345	-121.9039929	51.237	19	7.010	44.227	2/10/2020
T0608500101_EW-3	37.3655322	-121.9040941	51.399	19	6.930	44.469	2/10/2020
T0608500101_MW2	37.3654893	-121.9037449	50.679	19	3.480	47.199	12/13/2012
T0608500101_MW3	37.3654602	-121.9039988	51.195	16	4.440	46.755	12/13/2012
T0608500101_MW4	37.3655562	-121.9039924	51.267	20	0.000	51.267	12/13/2012
T0608500101_MW5	37.3655322	-121.9040823	51.382	21	4.570	46.812	12/13/2012

T0608500101_MW6	37.3656712	-121.9037842	50.653	22	3.710	46.943	12/13/2012
T0608500100_MW-4R	37.3613300	-121.8972983	58.452	21	9.260	49.192	1/9/2002
T0608562782_DMW-1	37.3617366	-121.8970162	57.797	17	8.490	49.307	4/11/2018
T0608562782_DMW-2	37.3617366	-121.8976800	57.247	17	8.740	48.507	4/18/2016
T0608562782_MW-1	37.3619300	-121.8973219	56.753	20	8.700	48.053	4/18/2016
SL374291196_106A	37.3656861	-121.8857220	74.092	30	13.250	60.842	2/7/2013
SL374291196_21	37.3656114	-121.8860380	73.554	36	12.060	61.494	5/22/2012
SL374291196_22	37.3658135	-121.8862179	74.413	37	13.320	61.093	5/22/2012
SL374291196_24	37.3653404	-121.8859764	72.605	35	11.220	61.385	5/22/2012
SL374291196_25	37.3655091	-121.8862727	71.455	35	10.440	61.015	5/22/2012
SL374291196_70A	37.3653932	-121.8855937	80.050	28	18.630	61.420	5/22/2012
SL374291196_87A	37.3650963	-121.8855813	73.089	24	11.060	62.029	5/22/2012
SL374291196_88A	37.3652366	-121.8857523	72.930	24	11.020	61.910	5/22/2012
SL374291196_89A	37.3654278	-121.8858056	73.907	19	10.790	63.117	5/22/2012
SL374291196_MW-6	37.3657899	-121.8864769	72.480	21	11.720	60.760	2/22/2017
SL374291196_1	37.3638206	-121.8837771	82.468	26	6.070	76.398	5/25/2006
SL374291196_10	37.3639125	-121.8844731	79.772	25	14.040	65.732	5/25/2006
SL374291196_11	37.3635994	-121.8845958	80.310	25	16.550	63.760	5/22/2012
SL374291196_12	37.3635300	-121.8852372	78.734	25	11.360	67.374	2/23/2012
SL374291196_13	37.3635660	-121.8842342	80.896	40	15.070	65.826	2/22/2017
SL374291196_14	37.3632208	-121.8838502	80.630	42	14.940	65.690	5/25/2006
SL374291196_15	37.3632099	-121.8833008	81.930	40	16.110	65.820	2/13/2006
SL374291196_16	37.3635627	-121.8834810	81.738	41	16.180	65.558	2/23/2017
SL374291196_18	37.3643828	-121.8848126	78.745	40	13.640	65.105	5/22/2012
SL374291196_19	37.3644795	-121.8847104	78.270	38	10.540	67.730	5/25/2006
SL374291196_20	37.3645813	-121.8845773	77.718	39	9.020	68.698	5/25/2006
SL374291196_26	37.3645738	-121.8840848	77.287	34	17.050	60.237	5/3/2011
SL374291196_29	37.3635855	-121.8831844	80.831	37	14.580	66.251	5/25/2006
SL374291196_30	37.3630401	-121.8837762	80.562	40	14.680	65.882	5/25/2006
SL374291196_31	37.3629464	-121.8841542	80.022	35	16.780	63.242	5/9/2017
SL374291196_32	37.3629546	-121.8845503	79.365	36	15.400	63.965	2/7/2013
SL374291196_33	37.3632102	-121.8848862	79.612	37	14.110	65.502	2/23/2012
SL374291196_38A	37.3648114	-121.8849572	78.281	20	14.860	63.421	5/25/2006
SL374291196_75A	37.3650851	-121.8853124	81.602	31	19.070	62.532	5/22/2012
SL374291196_84A	37.3647442	-121.8851577	79.468	26	16.740	62.728	2/23/2012
SL374291196_85A	37.3648536	-121.8852873	74.970	22	12.380	62.590	5/22/2012
SL374291196_86A	37.3649820	-121.8854450	73.681	23	11.090	62.591	5/22/2012
SL374291196_9	37.3643938	-121.8843922	81.024	18	10.520	70.504	5/25/2006
SL374291196_97A	37.3652781	-121.8854526	80.329	31	18.370	61.959	5/22/2012
SL374291196_A-1	37.3631724	-121.8852104	78.738	25	15.250	63.488	5/22/2012
SL374291196_A-2	37.3631724	-121.8852104	78.738	26	10.610	68.128	2/23/2012
SL374291196_A-3	37.3631724	-121.8852104	78.738	24	10.260	68.478	5/25/2006
SL374291196_C-35	37.3631724	-121.8852104	78.738	36	10.250	68.488	2/23/2012
SL374291196_C-36	37.3631724	-121.8852104	78.738	40	20.600	58.138	2/23/2012

SL374291196_C-37	37.3631724	-121.8852104	78.738	40	20.180	58.558	2/23/2012
SL374291196_C-38	37.3631724	-121.8852104	78.738	35	12.070	66.668	2/23/2012
SL374291196_C-39	37.3631724	-121.8852104	78.738	35	7.230	71.508	5/13/2019
SL374291196_C-40	37.3631724	-121.8852104	78.738	34	12.350	66.388	5/22/2012
SL374291196_E-17	37.3631724	-121.8852104	78.738	38	13.460	65.278	2/22/2017
SL374291196_E-2	37.3631724	-121.8852104	78.738	49	7.410	71.328	5/25/2006
SL374291196_E-3	37.3631724	-121.8852104	78.738	46	7.510	71.228	5/25/2006
SL374291196_E-6	37.3631724	-121.8852104	78.738	43	14.320	64.418	2/22/2017
SL374291196_E-7	37.3631724	-121.8852104	78.738	45	14.930	63.808	2/23/2017
SL374291196_E-8	37.3631724	-121.8852104	78.738	32	10.220	68.518	5/25/2006
SL374291196_E-9	37.3631724	-121.8852104	78.738	40	14.420	64.318	5/25/2006
SL374291196_MW-1	37.3643634	-121.8829495	84.158	22	12.180	71.978	2/23/2017
SL374291196_MW-2	37.3651273	-121.8836429	81.349	23	15.020	66.329	5/25/2006
SL374291196_MW-3	37.3648419	-121.8840379	81.078	21	12.520	68.558	5/25/2006
SL374291196_MW-4	37.3645186	-121.8843867	82.134	21	12.890	69.244	5/25/2006
SL374291196_MW-5	37.3643586	-121.8845227	80.024	21	9.890	70.134	5/25/2006
T0608501600_MW-3	37.3650701	-121.8495633	109.147	43	18.200	90.947	5/16/2006
T0608501600_MW-4	37.3652488	-121.8497369	108.945	48	23.480	85.465	2/5/2002
T0608501600_MW-5	37.3652398	-121.8494439	109.515	49	19.140	90.375	5/16/2006
T0608501600_TSG-MW-10	37.3651091	-121.8497690	108.584	35	18.390	90.194	5/16/2006
T0608501600_TSG-MW-11A	37.3652090	-121.8497647	108.728	30	18.240	90.488	5/16/2006
T0608501600_TSG-MW-12A	37.3653416	-121.8493949	109.966	36	19.790	90.176	5/16/2006
T0608501600_TSG-MW-13A	37.3649732	-121.8495941	108.767	36	18.720	90.047	5/16/2006
T0608501600_TSG-MW-19A	37.3651603	-121.8495870	109.281	30	19.070	90.211	5/16/2006
T0608501600_TSG-MW-23	37.3651775	-121.8495541	109.340	37	19.480	89.860	5/16/2006
T0608501600_TSG-MW-24	37.3653586	-121.8490617	110.469	36	20.500	89.969	5/16/2006
T0608501600_TSG-MW-25	37.3651323	-121.8490717	110.118	36	20.410	89.708	5/16/2006
T0608501600_TSG-MW-26A	37.3652812	-121.8493357	110.052	31	19.990	90.062	5/16/2006
T0608501600_TSG-MW-27A	37.3651896	-121.8492454	110.281	33	20.320	89.961	5/16/2006
T0608501600_TSG-MW-8A	37.3652000	-121.8493467	109.954	33	20.250	89.704	5/16/2006
T0608501600_TSG-MW-9	37.3650323	-121.8496539	108.647	34	15.400	93.247	2/19/2009
T0608553115_MW-19	37.3635941	-121.8284016	145.088	35	28.420	116.668	5/19/2015
T0608553115_MW-1A	37.3637803	-121.8279874	144.879	34	22.530	122.349	3/7/2006
T0608553115_MW-2A	37.3637124	-121.8281152	144.064	35	22.540	121.524	2/6/2008
T0608553115_MW-3A	37.3636865	-121.8280140	144.678	34	22.960	121.718	3/7/2006
T0608553115_MW-4A	37.3635767	-121.8280536	143.984	34	22.910	121.074	3/7/2006
T0608553115_MW-5A	37.3633236	-121.8281314	143.599	35	23.000	120.599	5/30/2011
T0608553115_MW-6A	37.3633944	-121.8279203	143.721	35	22.500	121.221	5/30/2011
T0608553115_MW-7A	37.3635789	-121.8283630	144.476	35	23.730	120.746	5/30/2011
T0608553115_MW-8A	37.3634901	-121.8282890	144.015	35	23.200	120.815	5/30/2011
T0608591395_EX-1	37.3662807	-121.8268595	153.272	34	24.920	128.352	3/10/2008
T0608591395_MW-1	37.3661015	-121.8269678	152.340	33	24.470	127.870	3/10/2008
T0608591395_MW-2	37.3662994	-121.8269033	153.286	35	25.010	128.276	3/10/2008

T0608591395_MW-3	37.3664116	-121.8267903	153.554	34	25.020	128.534	3/10/2008
T0608591395_MW-4	37.3660329	-121.8266716	151.794	34	23.610	128.184	3/10/2008
T0608591395_MW-5	37.3663291	-121.8268276	153.505	34	26.100	127.405	3/9/2009
T0608591395_MW-6	37.3662066	-121.8268771	152.506	34	25.420	127.086	3/9/2009
T0608591395_MW-7	37.3662502	-121.8269159	152.784	35	25.710	127.074	3/9/2009
T0608500938_MW-2	37.3675750	-122.0226824	104.179	30	27.990	76.189	4/18/2006
T0608500938_MW-2A	37.3675819	-122.0226782	104.241	45	27.100	77.141	1/15/2020
T0608500228_PMW-3R	37.3704492	-122.0142382	82.577	33	17.230	65.347	4/4/2018
T0608501404_WW-1	37.3693225	-121.9556614	44.074	24	6.530	37.544	4/17/2006
T0608501404_WW-2	37.3693156	-121.9558072	44.090	23	6.500	37.590	4/17/2006
T0608501404_WW-3	37.3695172	-121.9556528	43.141	21	6.340	36.801	4/17/2006
T10000012412_RW-1	37.3702008	-121.9470975	40.876	10	6.150	34.726	2/20/2019
T10000012412_RW-2	37.3709124	-121.9461586	42.007	10	9.670	32.337	2/20/2019
T10000012412_RW-3	37.3715261	-121.9475151	40.285	10	7.440	32.845	2/20/2019
T0608500355_MW-3	37.3701539	-121.9164144	40.597	18	4.890	35.707	3/20/2004
T0608500355_MW-4	37.3702605	-121.9163923	40.656	18	5.430	35.226	3/20/2004
T0608500355_MW-6	37.3704234	-121.9165106	41.047	18	6.620	34.427	3/20/2004
T0608500355_MW-7	37.3705299	-121.9165693	40.057	17	6.020	34.037	3/20/2004
T0608500355_MW-8	37.3703946	-121.9168053	41.266	19	7.230	34.036	3/20/2004
T0608500355_MW-9	37.3705009	-121.9163337	40.766	19	6.770	33.996	12/13/2003
T0608501600_TSG-MW-15A	37.3700000	-121.8500000	124.306	38	19.460	104.846	5/17/2006
T0608501600_TSG-MW-16A	37.3700000	-121.8500000	124.306	38	18.620	105.686	5/17/2006
T0608501600_TSG-MW-17A	37.3700000	-121.8500000	124.306	35	18.540	105.766	5/17/2006
SLT2O3744_FTW-1	37.3758505	-122.0115374	65.705	23	10.960	54.745	4/26/2012
SL721241222_IW-1B	37.3769996	-121.9732007	37.059	48	5.800	31.259	5/2/2013
T0608500304_1	37.3738043	-121.9180488	38.531	24	5.980	32.551	3/25/2010
T0608500304_E-1	37.3738043	-121.9180488	38.531	22	7.280	31.251	2/24/2017
T0608500304_MW-1	37.3741388	-121.9182818	39.881	19	7.460	32.421	2/24/2017
T0608500304_MW-1R	37.3741143	-121.9183369	39.745	20	7.300	32.445	3/27/2006
T0608500304_MW-2	37.3745067	-121.9187667	39.133	19	7.660	31.473	3/25/2005
T0608500304_MW-3	37.3749534	-121.9182547	39.674	19	7.640	32.034	3/27/2006
T0608500304_MW-4	37.3743001	-121.9179875	40.496	22	8.280	32.216	3/25/2005
T0608500304_MW-5	37.3737126	-121.9174731	37.944	25	4.550	33.394	3/27/2006
T0608500304_MW-5R	37.3736880	-121.9174813	37.944	19	5.200	32.744	3/10/2009
T0608500304_MW-6	37.3742392	-121.9188687	39.348	25	6.710	32.638	3/25/2005
T0608500304_MW-6R	37.3742480	-121.9188602	39.239	20	7.640	31.599	3/27/2006
T0608500304_MW-7	37.3746204	-121.9191169	39.021	25	7.190	31.831	3/25/2005
T0608500304_MW-8B	37.3741707	-121.9182921	40.090	39	7.350	32.740	3/27/2006
T0608500304_MW-9	37.3738043	-121.9180488	38.531	19	7.370	31.161	2/24/2017
T0608500304_MW-A	37.3743132	-121.9174993	38.806	13	6.650	32.156	3/27/2006
T0608500304_MW-B	37.3739894	-121.9181461	39.691	20	6.500	33.191	3/10/2009
T0608500304_MW-C	37.3739659	-121.9185468	38.641	19	6.920	31.721	3/27/2006
T10000005550_MW-1	37.3776052	-121.9025832	56.723	30	18.430	38.293	3/17/2015
T10000005550_MW-2	37.3773649	-121.9003391	57.641	32	21.400	36.241	3/17/2015

T10000005550_MW-3	37.3768448	-121.9015469	57.128	30	18.890	38.238	3/17/2015
T0608501379_MW-1	37.3741664	-121.8941450	65.493	43	21.450	44.043	1/27/2002
T0608501379_MW-2	37.3741175	-121.8943317	65.112	37	22.300	42.812	1/27/2002
T0608501379_MW-3	37.3743142	-121.8943633	65.024	45	22.630	42.394	1/27/2002
T0608501379_MW-4	37.3742281	-121.8944378	65.695	46	22.610	43.085	1/27/2002
T0608500353_E-1	37.3744404	-121.8730656	93.008	39	9.450	83.558	4/26/2004
T0608500353_MW-10	37.3745779	-121.8731952	93.056	29	12.360	80.696	4/26/2004
T0608500353_MW-11	37.3745032	-121.8727383	93.651	32	10.680	82.971	4/26/2004
T0608500353_MW-12	37.3742480	-121.8731517	92.211	25	9.740	82.471	4/26/2004
T0608500353_MW-13	37.3742480	-121.8731517	92.211	24	12.440	79.771	4/26/2004
T0608500353_MW-3	37.3742480	-121.8731517	92.211	40	9.350	82.861	4/26/2004
T0608500353_MW-4	37.3742344	-121.8729318	92.901	41	10.510	82.391	1/27/2004
T0608500353_MW-5	37.3744683	-121.8730975	93.300	40	10.520	82.780	4/26/2004
T0608500353_MW-8	37.3746379	-121.8729283	93.026	35	10.010	83.016	4/26/2004
T0608501547_MW-4	37.3813669	-122.0400716	94.150	38	29.640	64.510	3/21/2007
T0608501547_MW-5	37.3814093	-122.0399618	93.982	39	29.260	64.722	3/21/2007
T0608501547_MW-7	37.3812905	-122.0398328	93.987	38	29.240	64.747	3/21/2007
T0608501547_MW-8	37.3813045	-122.0399217	93.807	38	28.240	65.567	5/16/2006
T0608501547_MW-9A	37.3813666	-122.0398337	93.803	42	29.080	64.723	3/21/2007
T0608501547_V-1	37.3812873	-122.0398867	93.963	46	28.310	65.653	5/16/2006
T0608501547_V-2	37.3812719	-122.0398934	94.006	46	29.040	64.966	3/21/2007
T0608501547_V-3	37.3812653	-122.0398725	94.046	45	28.140	65.906	3/21/2007
T0608501547_V-4	37.3812810	-122.0398640	93.995	45	29.100	64.895	3/21/2007
T0608500373_C-2	37.3814561	-122.0180140	61.155	26	13.820	47.335	3/30/2004
T0608500373_C-4	37.3812659	-122.0182796	61.102	35	13.950	47.152	3/8/2003
T0608500373_C-5	37.3814561	-122.0180140	61.155	36	15.040	46.115	3/28/2002
T0608500373_C-8	37.3819612	-122.0184099	59.191	31	14.790	44.401	3/8/2003
T0608500373_C-9	37.3812540	-122.0186502	61.973	30	19.300	42.673	3/8/2003
SL721241222_MW-35A	37.3795797	-121.9726946	35.534	20	8.610	26.924	5/2/2013
T0608500977_EW1	37.3781292	-121.9102917	42.667	25	7.200	35.467	3/31/2006
T0608500977_MW3	37.3781493	-121.9101414	43.550	20	6.780	36.770	3/31/2006
T0608500977_MW4	37.3782040	-121.9104610	41.273	30	5.200	36.073	3/31/2006
T0608500977_MW5	37.3780879	-121.9105478	41.156	20	5.660	35.496	3/31/2006
T0608500977_MW6	37.3780934	-121.9103562	41.417	20	6.030	35.387	3/31/2006
SL720051206_53-S	37.3875341	-122.0075739	37.961	20	8.210	29.751	5/10/2018
SL720051206_54-S	37.3875341	-122.0075739	37.961	19	7.630	30.331	5/10/2018
SL720051206_56-D	37.3876565	-122.0081616	38.839	39	10.600	28.239	5/10/2018
SL720051206_56-S	37.3876566	-122.0081511	38.805	22	9.430	29.375	5/10/2018
SL720051206_57-D	37.3868571	-122.0078324	38.998	32	7.710	31.288	5/10/2018
SL720051206_57-S	37.3868581	-122.0078423	38.940	17	7.940	31.000	5/10/2018
T0608577145_MW-1	37.3872546	-121.9967027	32.390	15	7.320	25.070	3/2/2010
T0608577145_MW-2	37.3870405	-121.9966365	31.612	15	6.730	24.882	3/2/2010
T0608577145_MW-3	37.3871712	-121.9968269	32.033	15	6.890	25.143	3/2/2010
T0608577145_MW-4	37.3872546	-121.9967027	32.390	26	9.780	22.610	3/9/2009

T0608577145_P-1	37.3872546	-121.9967027	32.390	29	8.530	23.860	3/2/2010
SL20257875_IF1-10	37.3867802	-121.9650616	23.197	20	3.450	19.747	2/24/2005
SL20257875_IF1-11	37.3878413	-121.9664460	25.198	20	7.240	17.958	2/24/2005
SL20257875_IF1-12	37.3867420	-121.9654056	24.873	20	7.710	17.163	2/24/2005
SL20257875_IF1-14	37.3866173	-121.9651939	23.501	22	3.700	19.801	2/24/2005
SL20257875_IF1-16	37.3871621	-121.9654397	27.092	20	7.900	19.192	2/24/2005
SL20257875_IF1-2	37.3866173	-121.9651939	23.501	21	4.350	19.151	2/24/2005
SL20257875_IF1-3	37.3862488	-121.9655215	26.055	18	8.430	17.625	2/24/2005
SL20257875_IF1-5	37.3857109	-121.9637422	27.511	22	6.860	20.651	2/24/2005
SL20257875_IF1-9	37.3864417	-121.9654227	24.527	16	6.820	17.707	2/24/2005
SL20257875_R-2	37.3865563	-121.9651810	22.643	12	9.130	13.513	2/24/2005
SL20257875_R-3	37.3867543	-121.9650177	23.337	18	3.700	19.637	2/24/2005
SL20257875_R-4	37.3865846	-121.9653759	24.131	23	5.790	18.341	2/24/2005
SL20257875_SC-11-2	37.3843019	-121.9639077	25.937	20	4.650	21.287	2/24/2005
SL20257875_SC-11-7	37.3855513	-121.9648894	26.345	20	7.340	19.005	2/24/2005
SL20257875_SC-11-8	37.3855407	-121.9648820	26.393	20	7.320	19.073	2/24/2005
SL20257875_SC-11-3	37.3850143	-121.9627766	27.265	20	5.870	21.395	2/24/2005
T0608501131_EW-1R	37.3833708	-121.9503269	27.223	16	9.970	17.253	1/11/2002
T0608501131_LF-2	37.3836892	-121.9505836	28.155	18	10.100	18.055	1/11/2002
T0608501131_MW-10	37.3834089	-121.9502208	26.173	21	9.840	16.333	1/11/2002
T0608501131_MW-7	37.3835489	-121.9508158	27.168	21	9.760	17.408	1/11/2002
T0608502376_MW-8	37.3875684	-121.9534510	24.106	18	7.800	16.306	12/15/2015
T0608502376_MW-9	37.3875684	-121.9534510	24.106	18	7.060	17.046	12/15/2015
T0608585984_MW1	37.3870544	-121.9390513	23.121	14	7.450	15.671	1/17/2013
T0608585984_MW2	37.3870958	-121.9389502	21.873	14	6.370	15.503	1/17/2013
T0608585984_MW3	37.3872024	-121.9390555	21.936	14	7.290	14.646	1/17/2013
T0608585984_MW4	37.3871874	-121.9391174	22.582	14	7.800	14.782	3/30/2010
T0608585984_MW5	37.3873202	-121.9391239	21.725	15	7.650	14.075	1/17/2013
T0608585984_MW6	37.3870424	-121.9388721	21.930	15	7.000	14.930	1/17/2013
T0608585984_MW7	37.3870424	-121.9398721	20.851	15	6.300	14.551	1/17/2013
T0608585984_MW8	37.3874049	-121.9392002	21.564	15	6.780	14.784	1/17/2013
T0608585984_MW9	37.3875058	-121.9399217	21.673	17	8.890	12.783	1/17/2013
SL18309729_01MW-11	37.3903160	-122.0320282	55.084	26	11.960	43.124	1/12/2006
SL18309729_01MW-12	37.3896294	-122.0327225	57.517	30	9.960	47.557	4/15/2010
SL18309729_01MW-13	37.3912087	-122.0320587	52.450	35	8.430	44.020	1/12/2006
SL18309729_01MW-14	37.3911209	-122.0316391	52.517	28	8.030	44.487	1/12/2006
SL18309729_01MW-15	37.3915024	-122.0317001	51.837	25	7.810	44.027	1/12/2006
SL18309729_01MW-16	37.3896294	-122.0327225	57.517	30	8.210	49.307	4/24/2012
SL18309729_01MW-8	37.3902779	-122.0326462	54.217	28	9.780	44.437	4/20/2020
SL18309729_01MW-9	37.3902168	-122.0324783	53.825	28	9.430	44.395	4/20/2020
SL18309729_05EW-1U	37.3902397	-122.0325089	54.119	28	8.480	45.639	4/15/2010
SL18309729_05EW-2U	37.3901100	-122.0321274	53.688	26	10.610	43.078	5/17/2006
SL18309729_05EW-3U	37.3903694	-122.0329285	54.513	28	9.980	44.533	1/12/2006
SL18309729_05MW-11U	37.3914642	-122.0326309	52.356	25	8.880	43.476	1/12/2006

SL18309729_05MW-1L	37.3903122	-122.0327301	54.425	49	8.370	46.055	4/20/2020
SL18309729_05MW-2U	37.3890839	-122.0328293	58.340	26	11.350	46.990	4/20/2020
SL18309729_05MW-3L	37.3896294	-122.0327225	57.517	46	10.580	46.937	4/20/2020
SL18309729_05MW-4U	37.3889771	-122.0333176	58.715	24	11.050	47.665	4/20/2020
SL18309729_05MW-5U	37.3899040	-122.0333328	57.104	25	10.930	46.174	4/20/2020
SL18309729_05MW-7U	37.3900185	-122.0326462	57.126	29	12.100	45.026	4/20/2020
SL18309729_05MW-9U	37.3913918	-122.0323181	52.372	26	9.170	43.202	1/12/2006
SL18309729_05PZ-1U	37.3896294	-122.0327225	57.517	26	10.900	46.617	4/20/2020
SL18309729_05PZ-2U	37.3896294	-122.0327225	57.517	26	11.430	46.087	4/20/2020
SL18309729_05TPZ-3U2	37.3896294	-122.0327225	57.517	28	12.500	45.017	1/18/2018
SL18309729_05TPZ-4U1	37.3898239	-122.0326538	57.069	21	12.090	44.979	4/20/2020
SL18309729_05TPZ-4U2	37.3898392	-122.0326462	56.985	28	11.950	45.035	4/20/2020
SL18309729_19MW-1	37.3896294	-122.0327225	57.517	32	11.780	45.737	4/24/2012
T0608501529_MW-1	37.3895467	-122.0312103	55.265	32	11.410	43.855	4/20/2006
T0608501529_MW-10	37.3898540	-122.0302299	52.328	25	10.050	42.278	4/20/2006
T0608501529_MW-11	37.3899075	-122.0306746	52.778	24	10.140	42.638	4/20/2006
T0608501529_MW-11SEQ	37.3903182	-122.0320335	55.142	23	13.140	42.002	1/30/2009
T0608501529_MW-14SEQ	37.3911263	-122.0316462	52.533	28	8.240	44.293	2/28/2011
T0608501529_MW-16SEQ	37.3913801	-122.0311158	48.364	29	8.220	40.144	2/28/2011
T0608501529_MW-2	37.3896213	-122.0309152	54.014	28	10.450	43.564	4/20/2006
T0608501529_MW-3	37.3894994	-122.0310344	55.387	33	11.180	44.207	4/20/2006
T0608501529_MW-4	37.3897748	-122.0312607	53.895	32	10.320	43.575	4/20/2006
T0608501529_MW-5	37.3897017	-122.0310414	53.608	32	9.970	43.638	4/20/2006
T0608501529_MW-6	37.3895190	-122.0308719	54.248	32	10.530	43.718	4/20/2006
T0608501529_MW-7	37.3893597	-122.0310134	55.626	32	11.890	43.736	4/20/2006
T0608501529_MW-9	37.3900604	-122.0313934	52.670	31	9.620	43.050	4/20/2006
T0608501529_RW-1	37.3897098	-122.0311104	53.811	30	10.390	43.421	1/28/2008
T0608501601_MW-14	37.3900000	-122.0300000	50.771	30	9.010	41.761	1/22/2002
T0608501601_E-1	37.3886921	-122.0263038	52.232	27	8.830	43.402	2/29/2008
T0608501601_MW-10	37.3884413	-122.0263337	51.306	30	8.890	42.416	4/28/2003
T0608501601_MW-11	37.3884505	-122.0258211	50.640	24	8.620	42.020	2/28/2008
T0608501601_MW-12	37.3887731	-122.0257163	49.660	29	8.690	40.970	2/28/2008
T0608501601_MW-13	37.3888558	-122.0260205	50.111	28	8.700	41.411	2/28/2008
T0608501601_MW-15	37.3889767	-122.0256962	49.262	29	8.190	41.072	2/28/2008
T0608501601_MW-16	37.3893575	-122.0267640	48.900	25	6.240	42.660	2/28/2008
T0608501601_MW-17	37.3895077	-122.0262350	47.088	24	6.390	40.698	2/28/2008
T0608501601_MW-18R	37.3897869	-122.0261397	46.350	28	6.220	40.130	3/1/2006
T0608501601_MW-19	37.3894521	-122.0254836	47.592	25	7.000	40.592	2/28/2008
T0608501601_MW-3	37.3887642	-122.0262510	51.798	27	8.840	42.958	2/28/2008
T0608501601_MW-4	37.3887947	-122.0264014	51.967	28	8.800	43.167	2/28/2008
T0608501601_MW-5	37.3886522	-122.0264540	51.651	27	7.600	44.051	2/29/2008
T0608501601_MW-6	37.3885410	-122.0263223	51.936	27	8.020	43.916	2/28/2008
T0608501601_MW-9	37.3885800	-122.0267250	50.751	25	6.680	44.071	2/28/2008
T0608501601_TSG-MW-22A	37.3892333	-122.0261748	48.208	35	6.490	41.718	2/29/2008

T0608501601_TSG-MW-24A	37.3894182	-122.0262897	47.457	32	5.860	41.597	2/28/2008
T0608501601_TSG-MW-26A	37.3892097	-122.0255623	48.344	33	7.400	40.944	2/28/2008
T0608501601_TSG-MW-28A	37.3895406	-122.0253366	47.475	35	8.070	39.405	5/9/2002
T0608501601_TSG-MW-30A	37.3888698	-122.0265323	52.177	34	0.000	52.177	1/22/2002
T0608501601_TSG-MW-32A	37.3887369	-122.0262949	52.226	39	9.880	42.346	2/28/2008
T0608501601_TSG-RW-14	37.3890739	-122.0261550	48.814	32	7.230	41.584	2/29/2008
T0608501601_TSG-RW-20	37.3889256	-122.0261086	49.933	32	8.010	41.923	2/29/2008
T0608501601_TSG-RW-21	37.3891866	-122.0258693	48.646	31	7.160	41.486	2/29/2008
SL720051206_55-S	37.3882007	-122.0071877	35.842	19	7.650	28.192	5/10/2018
T10000000225_MW-1	37.3889486	-122.0048073	33.874	15	7.270	26.604	3/2/2010
T10000000225_MW-2	37.3890617	-122.0048061	33.904	19	7.180	26.724	3/2/2010
T10000000225_MW-3	37.3889581	-122.0045485	33.947	20	7.560	26.387	3/2/2010
T10000000225_MW-4	37.3891599	-122.0046413	34.010	20	8.230	25.780	3/18/2011
SL20257875_IF1-15	37.3885797	-121.9641005	24.337	22	6.230	18.107	5/31/2005
SL20257875_IF1-4	37.3886651	-121.9654623	23.523	18	6.920	16.603	2/24/2005
T0608550728_DPE-1	37.3935079	-121.9075161	44.379	15	8.850	35.529	3/21/2006
T0608550728_MW-1A	37.3935374	-121.9075614	44.403	14	9.690	34.713	1/25/2017
T0608550728_MW-1B	37.3935494	-121.9075714	44.314	43	8.620	35.694	3/21/2006
T0608550728_MW-2A	37.3934841	-121.9074254	44.626	13	9.550	35.076	3/21/2006
T0608550728_MW-3A	37.3936149	-121.9074582	44.688	15	10.150	34.538	1/25/2017
T0608550728_MW-4A	37.3936283	-121.9079482	43.364	15	9.020	34.344	3/21/2006
T0608550728_SVE-1	37.3933997	-121.9076395	43.749	14	8.530	35.219	3/21/2006
SL18297718_B-1	37.3942210	-122.1490933	197.357	42	19.350	178.007	12/15/2008
SL18297718_B-10	37.3942210	-122.1490933	197.357	34	23.200	174.157	12/12/2014
SL18297718_B-11	37.3940070	-122.1509793	189.836	36	23.250	166.586	12/12/2014
SL18297718_B-13	37.3943044	-122.1513245	175.772	23	11.760	164.012	4/4/2018
SL18297718_B-14	37.3940819	-122.1513226	174.437	32	9.900	164.537	12/12/2014
SL18297718_B-16	37.3945155	-122.1517413	174.180	30	15.030	159.150	4/4/2018
SL18297718_B-17	37.3948420	-122.1520235	175.415	34	19.390	156.025	12/12/2014
SL18297718_B-2	37.3954595	-122.1501434	195.447	25	15.000	180.447	12/15/2008
SL18297718_B-21	37.3953288	-122.1525552	164.407	36	9.450	154.957	12/3/2012
SL18297718_B-25	37.3960723	-122.1520454	166.926	24	21.110	145.816	12/15/2008
SL18297718_	37.3947563	-122.1512157	194.580	49	31.010	163.570	5/19/2009
SL18297718_B-4	37.3941838	-122.1510037	190.936	34	25.770	165.166	12/14/2005
SL18297718_B-5	37.3941263	-122.1508137	193.547	35	26.940	166.607	12/1/2005
SL18297718_B-7	37.3941348	-122.1506272	195.876	35	24.870	171.006	5/19/2009
SL18297718_B-8	37.3935483	-122.1506992	195.213	32	28.390	166.823	12/1/2005
SL18297718_B-9	37.3938619	-122.1508361	191.602	32	25.550	166.052	5/19/2009
SL18297718_EW-1	37.3940331	-122.1509381	190.562	35	24.550	166.012	12/19/2006
SL18297718_EW-3	37.3947199	-122.1517502	178.551	30	22.460	156.091	12/1/2005
SL18209589_EM-1	37.3957131	-122.0486661	57.829	32	11.110	46.719	4/3/2006
SL18209589_EM-3	37.3957159	-122.0490093	57.638	32	10.800	46.838	4/3/2006
SL18209589_EM-4	37.3958048	-122.0485283	57.770	27	11.290	46.480	4/3/2006

SL18209589_W1	37.3941961	-122.0495077	64.582	39	13.950	50.632	4/3/2006
SL18209589_W12	37.3964036	-122.0488781	54.842	25	9.770	45.072	4/3/2006
SL18209589_W13	37.3968069	-122.0494901	54.184	34	8.850	45.334	4/3/2006
SL18209589_W14	37.3956968	-122.0501120	62.534	32	15.680	46.854	4/3/2006
SL18209589_W15	37.3956702	-122.0496298	63.960	33	15.580	48.380	4/3/2006
SL18209589_W17	37.3948609	-122.0484004	62.671	27	13.550	49.121	4/3/2006
SL18209589_W18	37.3944167	-122.0487449	64.302	33	15.190	49.112	4/3/2006
SL18209589_W19	37.3943440	-122.0496812	65.896	33	15.280	50.616	4/3/2006
SL18209589_W24	37.3943275	-122.0498280	65.510	34	15.500	50.010	4/3/2006
SL18209589_W25	37.3943586	-122.0490363	63.812	34	14.600	49.212	4/3/2006
SL18209589_W26	37.3949896	-122.0491055	64.848	34	16.810	48.038	4/3/2006
SL18209589_W27	37.3953578	-122.0491980	64.071	32	13.380	50.691	4/3/2006
SL18209589_W28	37.3957102	-122.0492316	61.194	33	13.350	47.844	4/3/2006
SL18209589_W29	37.3943364	-122.0489240	62.846	34	13.980	48.866	4/3/2006
SL18209589_W2A	37.3938453	-122.0506472	64.854	43	10.950	53.904	4/3/2006
SL18209589_W30	37.3943872	-122.0491663	64.334	33	14.670	49.664	4/3/2006
SL18209589_W31	37.3959364	-122.0491551	57.184	38	10.090	47.094	4/3/2006
SL18209589_W33	37.3955508	-122.0484463	58.006	40	9.840	48.166	4/3/2006
SL18209589_W36	37.3963631	-122.0488978	55.716	35	9.660	46.056	4/3/2006
SL18209589_W40	37.3974164	-122.0483885	54.934	34	11.310	43.624	4/30/2013
SL18209589_W46	37.3949877	-122.0492438	65.925	42	17.470	48.455	4/25/2007
SL18209589_W47	37.3960495	-122.0485466	56.090	28	9.460	46.630	4/3/2006
SL18209589_W5A	37.3938165	-122.0496423	64.121	36	11.600	52.521	4/3/2006
SL18209589_W6	37.3955565	-122.0490913	61.386	33	13.450	47.936	4/3/2006
SL18209589_W7	37.3952338	-122.0486042	61.506	43	13.870	47.636	4/3/2006
SL18209589_W8A	37.3950128	-122.0505188	64.675	36	14.290	50.385	4/3/2006
SL18209589_W11	37.3959362	-122.0482646	55.570	29	9.370	46.200	4/25/2007
SL18209589_W37	37.3957023	-122.0473820	55.878	31	9.300	46.578	4/3/2006
SL18209589_W39	37.3971654	-122.0476674	52.107	28	7.610	44.497	4/3/2006
SL18209589_W41	37.3980581	-122.0474271	50.178	28	8.250	41.928	4/3/2006
SL18209589_W45	37.3951284	-122.0482258	59.612	34	1.420	58.192	4/21/2011
T0608501392_MW-2	37.3941903	-122.0286032	42.643	16	10.500	32.143	2/11/2008
T0608501392_MW-3R	37.3945495	-122.0288679	39.888	19	8.860	31.028	2/9/2010
T0608501392_MW-4	37.3938267	-122.0287648	40.957	16	6.810	34.147	2/9/2010
T0608501392_MW-5	37.3945495	-122.0288679	39.888	19	6.870	33.018	5/1/2006
T0608501392_MW-6	37.3944094	-122.0287246	40.155	20	6.640	33.515	2/9/2010
T0608501392_MW-7	37.3943412	-122.0284097	39.697	20	6.790	32.907	2/9/2010
T0608501392_MW-8	37.3943006	-122.0282065	39.703	20	6.680	33.023	2/9/2010
T0608501131_MW-4	37.3999433	-121.9503111	11.484	24	10.750	0.734	1/11/2002
T0608502279_MW-1	37.3967209	-121.8727746	108.696	43	30.780	77.916	4/28/2004
T0608502279_MW-3	37.3964926	-121.8726525	108.303	43	25.800	82.503	4/28/2004
T0608500150_MW-10	37.3989528	-122.1143937	83.114	49	33.270	49.844	3/1/2006
T0608500150_MW-11	37.3992800	-122.1138002	81.115	47	31.610	49.505	3/1/2006
T0608500150_MW-9	37.3991595	-122.1144058	82.351	48	32.670	49.681	3/1/2006

T0608501243_MW-22R	37.4034970	-122.0974241	51.241	19	9.560	41.681	1/10/2013
T0608501243_MW-24R	37.4035806	-122.0977784	49.836	20	9.670	40.166	1/10/2013
SL18209589_W42	37.3989916	-122.0473072	49.714	29	8.700	41.014	4/3/2006
L10006514573_G-15	37.4043115	-121.9723872	19.604	25	6.750	12.854	2/7/2017
T0608591787_AEC-1	37.4052637	-121.9314644	22.212	30	11.660	10.552	12/19/2008
T0608591787_AEC-10B	37.4051843	-121.9320278	21.843	46	11.050	10.793	12/19/2002
T0608591787_AEC-12A	37.4049654	-121.9324555	20.873	19	12.560	8.313	12/19/2008
T0608591787_AEC-2	37.4053125	-121.9317761	22.114	31	11.610	10.504	12/19/2008
T0608591787_AEC-3	37.4054200	-121.9316427	23.329	26	10.310	13.019	12/19/2008
T0608591787_AEC-6A	37.4051950	-121.9320092	21.897	20	10.750	11.147	12/19/2002
T0608591787_AEC-7A	37.4052190	-121.9324614	21.091	19	11.640	9.451	1/18/2007
T0608591787_AEC-8A	37.4048817	-121.9321527	20.858	18	11.380	9.478	1/18/2007
T0608591787_AEC-9A	37.4047918	-121.9327411	19.502	20	10.950	8.552	1/18/2007
T0608500923_MW-2	37.4050150	-121.9035480	39.415	28	11.220	28.195	5/16/2003
T0608500923_MW-4	37.4050083	-121.9035293	39.623	25	10.650	28.973	2/19/2010
T0608500923_MW-5	37.4050286	-121.9032568	39.150	22	8.960	30.190	2/19/2010
T0608500923_MW-6	37.4048020	-121.9034785	39.213	22	8.910	30.303	2/26/2013
T0608500923_MW-7	37.4045877	-121.9036619	38.600	22	9.500	29.100	2/19/2010
T0608500923_MW-8	37.4046363	-121.9031786	37.711	22	8.400	29.311	2/19/2010
T0608501282_MW-1	37.4052985	-122.1104058	49.226	30	8.750	40.476	1/14/2002
T0608501282_MW-3	37.4054736	-122.1103391	49.419	25	10.740	38.679	1/14/2002
T0608501282_MW-4	37.4055568	-122.1105478	49.228	25	10.660	38.568	1/14/2002
T0608501282_MW-5	37.4054891	-122.1107882	50.165	30	10.510	39.655	1/14/2002
T0608501282_MW-6	37.4052817	-122.1105153	48.782	31	8.960	39.822	1/14/2002
T0608501282_MW-7	37.4055914	-122.1095028	33.426	31	11.270	22.156	1/14/2002
T0608501282_MW-8	37.4060034	-122.1098873	39.417	29	11.940	27.477	1/14/2002
T0608501282_MW-9	37.4059588	-122.1105148	48.762	31	10.930	37.832	1/14/2002
T0608501243_MW-32	37.4038510	-122.0978523	48.660	20	8.760	39.900	1/10/2013
T0608501243_MW-13R	37.4038009	-122.0976618	50.875	19	10.750	40.125	1/10/2013
T0608501243_MW-25R	37.4036905	-122.0976364	50.695	20	10.240	40.455	1/10/2013
T0608501243_MW-33	37.4040046	-122.0976149	48.280	20	8.800	39.480	1/10/2013
T0608500185_BC-1	37.4058111	-122.0786058	43.913	23	9.450	34.463	2/4/2003
T0608500185_BC-2	37.4059812	-122.0783106	42.245	30	8.080	34.165	2/4/2003
T0608500185_BC-3	37.4057006	-122.0784134	43.026	30	8.200	34.826	2/4/2003
T0608500185_BC-4	37.4061744	-122.0786442	42.236	30	8.700	33.536	2/4/2003
T0608500185_BC-5	37.4059438	-122.0786925	43.590	30	9.150	34.440	2/4/2003
T0608500185_E-1	37.4061827	-122.0786565	42.207	32	8.400	33.807	2/4/2003
T0608501749_MW-11	37.4067446	-122.0786131	40.663	22	6.510	34.153	2/4/2004
T0608501749_MW-12	37.4070208	-122.0786696	41.066	31	8.000	33.066	2/4/2004
T0608501749_MW-13	37.4072304	-122.0783795	38.319	22	5.440	32.879	2/4/2004
T0608501749_MW-14	37.4072833	-122.0784330	38.155	30	5.350	32.805	2/4/2004
T0608501749_MW-15	37.4077719	-122.0782886	37.794	25	5.710	32.084	2/4/2004
T0608501749_MW-16	37.4084186	-122.0787879	35.876	19	5.490	30.386	2/4/2004
T0608501749_MW-17	37.4084000	-122.0785621	35.697	20	5.500	30.197	2/4/2004

T0608501749_MW-18I	37.4085765	-122.0785158	36.140	42	6.560	29.580	2/4/2004
T0608501749_MW-18S	37.4085802	-122.0785314	37.255	20	6.160	31.095	2/4/2004
T0608501749_MW-2	37.4067151	-122.0784817	40.858	22	6.990	33.868	2/4/2004
T0608501749_MW-3	37.4067388	-122.0782773	39.920	22	6.760	33.160	2/4/2004
T0608501749_MW-4	37.4068510	-122.0783232	40.647	23	7.580	33.067	2/4/2004
T0608501749_MW-5	37.4070436	-122.0784940	40.155	24	7.160	32.995	2/4/2004
T0608501749_MW-6	37.4070509	-122.0782891	39.127	31	6.170	32.957	2/4/2004
T0608598655_MW-22A	37.4083691	-122.0778056	35.140	22	4.920	30.220	2/27/2008
T0608598655_MW-22B	37.4083704	-122.0774742	36.323	25	6.050	30.273	2/27/2008
T0608598655_MW-22D	37.4079878	-122.0777461	37.474	18	5.290	32.184	2/27/2008
T0608598655_MW-22E	37.4089743	-122.0778286	35.464	19	5.990	29.474	2/27/2008
T0608598655_MW-22F	37.4088453	-122.0774627	37.159	19	6.500	30.659	2/27/2008
T0608598655_MW-22G	37.4086677	-122.0778588	35.209	24	5.810	29.399	2/27/2008
T0608598655_MW-22H	37.4093889	-122.0777798	35.872	23	6.250	29.622	2/27/2008
T0608598655_MW-22L	37.4081729	-122.0775078	36.206	18	4.970	31.236	2/27/2008
T0608598655_MW-22M	37.4080981	-122.0778941	35.830	21	4.010	31.820	2/27/2009
T0608598655_MW-22N	37.4081198	-122.0777464	35.714	22	4.720	30.994	2/27/2008
T0608598655_MW-22O	37.4079849	-122.0779126	36.657	21	4.650	32.007	2/27/2008
T0608598655_MW-22P	37.4080029	-122.0774993	37.846	17	5.210	32.636	2/27/2008
T10000004491_VCY-10-A2	37.4064624	-122.0676165	41.145	45	8.730	32.415	1/3/2014
T10000004491_VCY-1-A1	37.4074628	-122.0684902	42.420	15	10.360	32.060	1/3/2014
T10000004491_VCY-1-A2	37.4074804	-122.0684792	42.496	42	10.500	31.996	1/3/2014
T10000004491_VCY-2-A1R	37.4066393	-122.0677674	41.564	23	10.100	31.464	1/3/2014
T10000004491_VCY-2-A2R	37.4066554	-122.0677506	41.702	43	9.450	32.252	1/3/2014
T10000004491_VCY-3-A1	37.4050314	-122.0679960	44.986	24	11.050	33.936	1/3/2014
T10000004491_VCY-3-A2	37.4050497	-122.0680306	43.930	42	10.800	33.130	1/3/2014
T10000004491_VCY-4-A1	37.4056235	-122.0686606	45.911	20	10.750	35.161	1/3/2014
T10000004491_VCY-4-A2	37.4056071	-122.0686693	45.769	44	10.460	35.309	1/3/2014
T10000004491_VCY-5-A1	37.4058784	-122.0679387	45.609	23	10.930	34.679	1/3/2014
T10000004491_VCY-6-A1	37.4064401	-122.0684218	45.273	25	13.020	32.253	1/3/2014
T10000004491_VCY-7-A1	37.4063846	-122.0687364	43.516	25	11.950	31.566	1/3/2014
T10000004491_VCY-8-A2	37.4059185	-122.0675479	42.359	44	9.650	32.709	1/3/2014
T10000004491_VCY-9-A2	37.4062074	-122.0675123	41.302	44	9.000	32.302	1/3/2014
T10000001779_MCH-1UA	37.4090986	-122.0683518	34.999	24	11.410	23.589	9/19/2019
T10000001779_MCH-2LA	37.4090996	-122.0683708	35.337	42	11.290	24.047	9/19/2019
T10000001779_MCH-3UA	37.4093597	-122.0664650	31.722	23	7.230	24.492	9/19/2019
T10000001779_MCH-4LA	37.4095740	-122.0655743	30.462	44	5.580	24.882	9/19/2019
T10000001779_W89-1	37.4063338	-122.0567630	36.644	30	11.340	25.304	9/19/2019
T10000001779_W89-2	37.4071718	-122.0576609	34.825	30	9.480	25.345	9/19/2019
T10000001779_W89-5	37.4095538	-122.0595258	29.218	25	7.210	22.008	9/19/2019
T10000001779_ERM-1	37.4061236	-122.0506081	32.953	29	10.740	22.213	9/19/2019
T10000001779_ERM-2	37.4063611	-122.0505166	31.475	19	6.110	25.365	9/19/2019
T10000001779_ERM-3	37.4061421	-122.0504570	32.533	21	6.670	25.863	9/19/2019
T10000001779_W14-1	37.4061826	-122.0506578	33.149	48	6.680	26.469	9/19/2019

T10000001779_W14-10	37.4059951	-122.0503541	32.775	20	6.700	26.075	9/19/2019
T10000001779_W14-11	37.4063148	-122.0506913	32.082	20	6.700	25.382	9/19/2019
T10000001779_W14-12	37.4062147	-122.0507822	32.830	20	6.950	25.880	9/19/2019
T10000001779_W14-13	37.4065687	-122.0508067	31.709	20	6.550	25.159	9/19/2019
T10000001779_W14-2	37.4061657	-122.0506867	33.349	25	7.800	25.549	9/19/2019
T10000001779_W14-3	37.4058344	-122.0506961	33.900	30	7.070	26.830	9/19/2019
T10000001779_W14-4	37.4063145	-122.0505745	32.394	20	7.320	25.074	9/19/2019
T10000001779_W58-1	37.4056048	-122.0514168	33.783	18	6.780	27.003	9/19/2019
T10000001779_W60-1	37.4064957	-122.0523857	33.743	30	9.900	23.843	9/19/2019
T10000001779_W60-2	37.4063392	-122.0523790	33.838	36	9.360	24.478	9/19/2019
T10000001779_WSI-1	37.4052126	-122.0524072	35.542	34	7.450	28.092	9/19/2019
T10000001779_WSI-2	37.4057135	-122.0517118	33.824	23	8.210	25.614	9/19/2019
T10000001779_WSI-3	37.4069277	-122.0527425	32.939	26	9.870	23.069	9/19/2019
T10000001779_WT14-1	37.4088985	-122.0507759	28.082	18	6.090	21.992	9/19/2019
T10000001779_WT41A-1	37.4098589	-122.0535507	26.521	12	7.280	19.241	9/19/2019
T10000001779_WU4-1	37.4055029	-122.0545867	38.019	29	14.690	23.329	9/19/2019
T10000001779_WU4-3	37.4092945	-122.0555086	28.231	31	8.290	19.941	9/19/2019
T10000001779_WWR-3	37.4097156	-122.0527557	24.338	20	4.720	19.618	9/19/2019
T0608500338_EA-2	37.4060068	-121.9959792	8.637	20	7.190	1.447	5/17/2003
T0608500338_EA-3	37.4061656	-121.9962163	10.118	19	7.410	2.708	5/2/2002
T0608500338_EA-4	37.4060069	-121.9964125	11.020	20	9.740	1.280	5/17/2003
T0608500338_MW-A	37.4061011	-121.9962540	9.495	13	8.000	1.495	2/11/2002
L10006514573_G-13	37.4103874	-121.9747425	11.809	25	6.810	4.999	2/25/2005
L10006514573_G-14	37.4067455	-121.9744939	21.227	25	16.300	4.927	2/7/2017
L10006514573_G-2R	37.4102565	-121.9666667	11.543	32	9.700	1.843	3/5/2008
T0608500169_EW-9	37.4073517	-121.8881951	53.774	27	5.730	48.044	1/6/2006
T0608500169_MW-1	37.4073121	-121.8877580	54.715	27	6.200	48.515	2/3/2004
T0608500169_MW-2	37.4074214	-121.8876649	55.129	30	6.790	48.339	1/18/2005
T0608500169_MW-3	37.4075343	-121.8880825	54.767	30	6.880	47.887	1/7/2008
T0608500169_MW-4	37.4073454	-121.8881404	54.515	25	6.440	48.075	1/7/2008
T0608500169_MW-5	37.4072612	-121.8875716	53.897	30	4.860	49.037	1/7/2008
T0608500169_MW-6	37.4071861	-121.8878647	54.940	21	5.960	48.980	1/7/2008
T0608500169_MW-8	37.4074736	-121.8882867	54.522	30	5.950	48.572	1/6/2006
T0608500169_VE-1	37.4073796	-121.8876573	54.787	12	6.060	48.727	4/19/2006
T0608500169_VE-2	37.4073678	-121.8877709	55.584	11	7.140	48.444	1/18/2005
T0608500169_VE-3	37.4073188	-121.8879144	55.201	14	7.030	48.171	1/18/2005
T0608500169_VE-4	37.4073580	-121.8881013	54.602	12	6.480	48.122	1/7/2008
T0608500169_VE-6	37.4074429	-121.8880144	55.156	9	6.860	48.296	1/6/2006
T0608500169_VE-7	37.4074576	-121.8881976	54.207	9	6.300	47.907	1/7/2008
T0608500169_VE-8	37.4074161	-121.8882123	54.234	11	6.370	47.864	1/18/2005
T0608500170_BC-1A	37.4147559	-122.0929559	18.464	17	4.970	13.494	2/21/2003
T0608500170_BC-2	37.4149426	-122.0930088	18.792	19	5.800	12.992	2/21/2003
T0608500170_BC-3	37.4148913	-122.0932608	19.805	19	7.070	12.735	2/21/2003
T0608500170_BC-4	37.4146211	-122.0931028	19.134	17	2.200	16.934	2/21/2003

T0608500170_BC-5	37.4146689	-122.0928117	18.646	14	5.050	13.596	3/22/2006
T0608500170_E-1	37.4146847	-122.0929963	18.989	17	4.730	14.259	2/21/2003
T0608500170_E-2	37.4149456	-122.0929693	18.167	22	5.380	12.787	2/21/2003
T0608500170_E-6	37.4147567	-122.0930667	19.369	14	5.440	13.929	2/21/2003
T0608500170_E-7	37.4149138	-122.0930380	18.978	25	6.140	12.838	2/21/2003
T0608500170_P-13	37.4149338	-122.0930922	19.378	25	6.390	12.988	12/3/2014
T0608500170_P-6	37.4149325	-122.0931513	19.419	25	6.460	12.959	2/21/2003
T0608500170_P-7	37.4149577	-122.0930438	18.951	23	5.230	13.721	3/22/2006
T0608500170_S-1	37.4149368	-122.0932439	19.495	12	5.830	13.665	12/3/2014
T0608500170_SP-1	37.4149302	-122.0930430	18.914	17	5.970	12.944	12/4/2012
T0608500170_SP-2	37.4148935	-122.0933030	19.760	18	6.980	12.780	12/3/2014
T0608500170_V-1	37.4149302	-122.0930430	18.914	9	6.020	12.894	2/21/2003
T0608500170_V-2	37.4148935	-122.0933030	19.760	10	7.150	12.610	12/3/2014
T0608501146_MW-1	37.4138431	-122.0747457	22.323	20	8.150	14.173	3/20/2008
T0608501146_MW-2	37.4138756	-122.0744902	22.946	20	7.140	15.806	3/20/2008
T0608501146_MW-3	37.4135080	-122.0744571	23.800	20	6.430	17.370	3/20/2008
T0608501146_MW-4	37.4141266	-122.0743146	23.002	20	7.050	15.952	3/20/2008
T0608501146_MW-5	37.4142326	-122.0743121	23.347	20	7.930	15.417	3/20/2008
T0608501146_MW-6	37.4143475	-122.0744916	21.925	20	9.980	11.945	3/20/2008
T0608501146_MW-7	37.4143447	-122.0746704	21.753	20	10.480	11.273	3/20/2008
T0608501146_MW-8	37.4143625	-122.0748246	22.715	20	10.270	12.445	3/20/2008
T10000001779_15B18A2	37.4151501	-122.0644179	19.283	41	6.940	12.343	9/19/2019
T10000001779_MCH-10LA	37.4132420	-122.0652783	23.429	45	6.860	16.569	9/19/2019
T10000001779_MCH-11UA*	37.4135237	-122.0664006	20.630	23	4.310	16.320	9/19/2019
T10000001779_MCH-5UA	37.4119028	-122.0644171	25.137	24	5.370	19.767	9/19/2019
T10000001779_MCH-7UA	37.4123960	-122.0676439	25.995	20	9.290	16.705	9/19/2019
T10000001779_MCH-8LA	37.4123808	-122.0676059	25.622	45	9.300	16.322	9/19/2019
T10000001779_MCH-9UA*	37.4138285	-122.0682587	22.857	26	9.790	13.067	9/19/2019
T10000001779_14C15A	37.4145062	-122.0558548	16.511	27	6.200	10.311	9/19/2019
T10000001779_14D12A	37.4150865	-122.0572479	16.416	25	8.180	8.236	9/19/2019
T10000001779_14E14A	37.4132744	-122.0596654	22.307	22	8.960	13.347	9/19/2019
T10000001779_15A02A	37.4142127	-122.0620233	19.971	22	7.180	12.791	9/19/2019
T10000001779_15H05A	37.4129478	-122.0610946	22.263	32	6.280	15.983	9/19/2019
T10000001779_EA1-3	37.4134455	-122.0560910	20.408	27	5.700	14.708	9/19/2019
T10000001779_EA1-6	37.4140998	-122.0570861	18.138	21	3.530	14.608	9/19/2019
T10000001779_PZA1-3A	37.4134409	-122.0560801	20.427	27	8.050	12.377	9/19/2019
T10000001779_PZA1-3B	37.4133773	-122.0560105	20.461	28	7.800	12.661	9/19/2019
T10000001779_PZA1-3C	37.4133384	-122.0559179	20.344	27	7.620	12.724	9/19/2019
T10000001779_PZA1-3D	37.4134317	-122.0560149	20.389	27	7.690	12.699	9/19/2019
T10000001779_PZA1-6A	37.4140531	-122.0570148	18.498	21	6.650	11.848	9/19/2019
T10000001779_PZA1-6B	37.4141183	-122.0570005	17.941	21	6.520	11.421	9/19/2019
T10000001779_PZA1-6C	37.4141692	-122.0571048	18.056	21	6.750	11.306	9/19/2019
T10000001779_W29-1	37.4152436	-122.0557566	17.314	18	9.770	7.544	9/19/2019
T10000001779_W29-3	37.4136667	-122.0561920	19.432	20	8.060	11.372	9/19/2019

T10000001779_W29-4	37.4127735	-122.0560219	21.290	19	7.900	13.390	9/19/2019
T10000001779_W56-1	37.4132103	-122.0572604	21.009	26	8.730	12.279	9/19/2019
T10000001779_W56-2	37.4131284	-122.0576306	20.389	25	7.240	13.149	9/19/2019
T10000001779_W89-10	37.4136800	-122.0613888	19.433	26	5.850	13.583	9/19/2019
T10000001779_W89-6	37.4103288	-122.0624241	28.105	26	6.530	21.575	9/19/2019
T10000001779_W89-7	37.4111989	-122.0626799	27.276	25	6.330	20.946	9/19/2019
T10000001779_W89-8	37.4115055	-122.0590017	25.550	27	9.060	16.490	9/19/2019
T10000001779_W89-9	37.4125974	-122.0593482	25.423	24	11.130	14.293	9/19/2019
T10000001779_W9-1	37.4135054	-122.0566048	21.007	30	8.880	12.127	9/19/2019
T10000001779_W9-10	37.4151774	-122.0564026	15.644	24	7.400	8.244	9/19/2019
T10000001779_W9-13*	37.4128572	-122.0573667	22.004	43	7.120	14.884	9/19/2019
T10000001779_W9-16	37.4101826	-122.0566876	26.275	29	7.260	19.015	9/19/2019
T10000001779_W9-19	37.4107098	-122.0564954	26.139	30	8.080	18.059	9/19/2019
T10000001779_W9-2	37.4129080	-122.0570647	21.656	31	8.010	13.646	9/19/2019
T10000001779_W9-22	37.4137605	-122.0559529	18.737	47	7.510	11.227	9/19/2019
T10000001779_W9-25	37.4139801	-122.0574142	18.964	40	7.320	11.644	9/19/2019
T10000001779_W9-33	37.4121574	-122.0560814	22.488	49	6.770	15.718	9/19/2019
T10000001779_W9-34	37.4122745	-122.0571927	22.072	42	7.530	14.542	9/19/2019
T10000001779_W9-36	37.4114054	-122.0558247	23.954	43	8.240	15.714	9/19/2019
T10000001779_W9-44	37.4113417	-122.0564845	23.550	25	6.820	16.730	9/19/2019
T10000001779_W9-47	37.4135207	-122.0572531	21.253	24	9.170	12.083	9/19/2019
T10000001779_W9-7	37.4128798	-122.0573239	22.099	33	7.830	14.269	9/19/2019
T10000001779_W9-8	37.4113772	-122.0565024	23.645	40	8.120	15.525	9/19/2019
T10000001779_W9-9	37.4132296	-122.0572539	20.932	45	7.780	13.152	9/19/2019
T10000001779_W9SC-11	37.4134864	-122.0572300	21.211	22	8.790	12.421	9/19/2019
T10000001779_W9SC-12	37.4134963	-122.0572354	21.260	38	8.390	12.870	9/19/2019
T10000001779_W9SC-13	37.4134254	-122.0571960	21.204	22	8.740	12.464	9/19/2019
T10000001779_W9SC-7	37.4136136	-122.0558431	19.250	20	8.500	10.750	9/19/2019
T10000001779_W9SC-8	37.4136079	-122.0558568	19.286	34	8.300	10.986	9/19/2019
T10000001779_WU4-12	37.4112043	-122.0578983	24.614	40	7.500	17.114	9/19/2019
T10000001779_WU4-13	37.4125577	-122.0590340	25.785	45	11.360	14.425	9/19/2019
T10000001779_WU4-15	37.4151578	-122.0564332	15.585	44	7.970	7.615	9/19/2019
T10000001779_WU4-16	37.4150317	-122.0588894	17.072	28	6.300	10.772	9/19/2019
T10000001779_WU4-17	37.4140373	-122.0574498	18.602	22	7.230	11.372	9/19/2019
T10000001779_28OW-01	37.4112226	-122.0537008	20.631	17	4.440	16.191	9/19/2019
T10000001779_28OW-09*	37.4108850	-122.0536940	21.135	17	7.300	13.835	9/19/2019
T10000001779_28OW-19	37.4107208	-122.0545087	22.054	40	4.900	17.154	9/19/2019
T10000001779_28OW-23	37.4104932	-122.0545791	24.404	40	6.550	17.854	9/19/2019
T10000001779_EA1-1	37.4112648	-122.0546234	21.537	25	2.540	18.997	9/19/2019
T10000001779_EA1-2	37.4112217	-122.0531039	21.021	26	1.320	19.701	9/19/2019
T10000001779_EA1-5	37.4148081	-122.0544217	18.973	27	7.700	11.273	9/19/2019
T10000001779_PIC-1	37.4120645	-122.0547984	20.928	18	6.670	14.258	9/19/2019
T10000001779_PIC-11	37.4117217	-122.0547568	20.604	18	5.230	15.374	9/19/2019
T10000001779_PIC-14	37.4116586	-122.0551653	21.887	18	6.690	15.197	9/19/2019

T10000001779_PIC-15	37.4116406	-122.0552786	21.955	18	6.490	15.465	9/19/2019
T10000001779_PIC-16	37.4119889	-122.0551137	20.760	34	6.890	13.870	9/19/2019
T10000001779_PIC-18	37.4119917	-122.0549037	20.276	34	6.150	14.126	9/19/2019
T10000001779_PIC-19	37.4117847	-122.0549785	21.109	34	6.920	14.189	9/19/2019
T10000001779_PIC-2	37.4119835	-122.0549000	20.138	18	6.660	13.478	9/19/2019
T10000001779_PIC-20	37.4120007	-122.0550185	20.438	26	6.900	13.538	9/19/2019
T10000001779_PIC-24	37.4118841	-122.0549427	20.581	18	5.770	14.811	9/19/2019
T10000001779_PIC-25	37.4118864	-122.0549738	20.774	18	5.850	14.924	9/19/2019
T10000001779_PIC-26	37.4118907	-122.0550668	21.090	18	6.110	14.980	9/19/2019
T10000001779_PIC-27	37.4118930	-122.0550944	21.130	18	6.280	14.850	9/19/2019
T10000001779_PIC-28	37.4118701	-122.0549597	20.755	18	5.810	14.945	9/19/2019
T10000001779_PIC-29	37.4118724	-122.0549907	20.921	18	6.940	13.981	9/19/2019
T10000001779_PIC-30	37.4118767	-122.0550838	21.181	18	6.240	14.941	9/19/2019
T10000001779_PIC-32	37.4119271	-122.0550091	20.758	20	7.020	13.738	9/19/2019
T10000001779_PIC-6	37.4118118	-122.0548000	20.452	18	5.800	14.652	9/19/2019
T10000001779_PZA1-1A	37.4112510	-122.0545833	21.406	25	5.240	16.166	9/19/2019
T10000001779_PZA1-1B	37.4112385	-122.0546238	21.602	26	5.930	15.672	9/19/2019
T10000001779_PZA1-1C	37.4112070	-122.0545316	21.235	25	5.320	15.915	9/19/2019
T10000001779_PZA1-1D	37.4111456	-122.0544730	21.175	26	4.820	16.355	9/19/2019
T10000001779_PZA1-1E	37.4113001	-122.0546106	21.291	26	5.240	16.051	9/19/2019
T10000001779_PZA1-2A	37.4111920	-122.0531022	20.996	24	3.920	17.076	9/19/2019
T10000001779_PZA1-2B	37.4111878	-122.0531355	20.920	26	3.910	17.010	9/19/2019
T10000001779_PZA1-2C	37.4111742	-122.0532395	20.942	26	3.810	17.132	9/19/2019
T10000001779_PZA1-2D	37.4112357	-122.0530747	20.849	25	3.930	16.919	9/19/2019
T10000001779_PZA1-5A*	37.4147915	-122.0543146	18.710	26	6.090	12.620	9/19/2019
T10000001779_PZA1-5B	37.4148962	-122.0542863	18.833	28	10.790	8.043	9/19/2019
T10000001779_PZA1-5C	37.4149147	-122.0539826	18.067	28	9.390	8.677	9/19/2019
T10000001779_PZA1-5D	37.4149719	-122.0544770	18.671	27	10.660	8.011	9/19/2019
T10000001779_PZNX-2*	37.4107442	-122.0533858	22.560	17	10.080	12.480	9/19/2019
T10000001779_UST85-MW02	37.4112045	-122.0546477	21.970	15	5.410	16.560	9/19/2019
T10000001779_UST85-MW03	37.4112498	-122.0546123	21.510	16	5.410	16.100	9/19/2019
T10000001779_W29-2	37.4138420	-122.0556034	19.304	18	8.900	10.404	9/19/2019
T10000001779_W29-5	37.4145934	-122.0552816	18.179	20	9.620	8.559	9/19/2019
T10000001779_W29-7	37.4152359	-122.0557185	17.339	43	8.890	8.449	9/19/2019
T10000001779_W29-8	37.4138669	-122.0555936	19.340	47	8.210	11.130	9/19/2019
T10000001779_W9-17	37.4107351	-122.0547914	23.007	38	5.940	17.067	9/19/2019
T10000001779_W9-18	37.4111205	-122.0543173	21.739	24	5.770	15.969	9/19/2019
T10000001779_W9-20	37.4120890	-122.0550262	20.419	45	5.930	14.489	9/19/2019
T10000001779_W9-21	37.4119163	-122.0541686	19.542	46	4.360	15.182	9/19/2019
T10000001779_W9-23	37.4129783	-122.0552789	19.392	18	4.230	15.162	9/19/2019
T10000001779_W9-24	37.4154224	-122.0551163	16.854	20	9.080	7.774	9/19/2019
T10000001779_W9-26	37.4146714	-122.0554072	17.067	17	8.620	8.447	9/19/2019
T10000001779_W9-27	37.4143254	-122.0551968	19.001	48	9.500	9.501	9/19/2019
T10000001779_W9-28	37.4130374	-122.0549702	19.747	48	7.130	12.617	9/19/2019

T10000001779_W9-29	37.4111661	-122.0535676	20.421	17	3.870	16.551	9/19/2019
T10000001779_W9-30	37.4105410	-122.0534788	23.757	18	5.690	18.067	9/19/2019
T10000001779_W9-31	37.4134084	-122.0553671	19.874	26	8.410	11.464	9/19/2019
T10000001779_W9-35	37.4120753	-122.0550190	20.454	24	6.180	14.274	9/19/2019
T10000001779_W9-37	37.4104121	-122.0549155	24.271	20	6.570	17.701	9/19/2019
T10000001779_W9-42	37.4111797	-122.0535816	20.472	38	4.040	16.432	9/19/2019
T10000001779_W9-43	37.4145639	-122.0548126	19.402	31	11.030	8.372	9/19/2019
T10000001779_W9-45	37.4118999	-122.0541648	19.603	24	4.760	14.843	9/19/2019
T10000001779_W9SC-1	37.4133702	-122.0551390	19.791	14	8.440	11.351	9/19/2019
T10000001779_W9SC-14	37.4108256	-122.0543938	21.719	20	5.110	16.609	9/19/2019
T10000001779_W9SC-15	37.4108392	-122.0544010	21.887	33	5.180	16.707	9/19/2019
T10000001779_W9SC-16	37.4106950	-122.0542947	22.315	22	5.150	17.165	9/19/2019
T10000001779_W9SC-17	37.4106064	-122.0545580	23.797	24	6.510	17.287	9/19/2019
T10000001779_W9SC-18	37.4133519	-122.0550732	19.546	14	8.220	11.326	9/19/2019
T10000001779_W9SC-2	37.4133784	-122.0551461	19.786	28	8.570	11.216	9/19/2019
T10000001779_W9SC-21	37.4100179	-122.0546727	25.257	23	6.690	18.567	9/19/2019
T10000001779_W9SC-3	37.4133758	-122.0551357	19.752	34	8.510	11.242	9/19/2019
T10000001779_W9SC-4	37.4133277	-122.0550314	19.435	14	8.080	11.355	9/19/2019
T10000001779_W9SC-5	37.4133359	-122.0550350	19.427	28	8.240	11.187	9/19/2019
T10000001779_WIC-1	37.4118759	-122.0550398	21.071	24	6.180	14.891	9/19/2019
T10000001779_WIC-10	37.4119260	-122.0550181	20.771	17	7.040	13.731	9/19/2019
T10000001779_WIC-11	37.4119234	-122.0550211	20.768	22	6.950	13.818	9/19/2019
T10000001779_WIC-12	37.4119235	-122.0550229	20.768	26	7.030	13.738	9/19/2019
T10000001779_WIC-2	37.4118721	-122.0550182	20.994	36	6.790	14.204	9/19/2019
T10000001779_WIC-3	37.4119710	-122.0550134	20.583	24	7.650	12.933	9/19/2019
T10000001779_WIC-4	37.4119681	-122.0550007	20.536	34	6.540	13.996	9/19/2019
T10000001779_WIC-5	37.4118902	-122.0550257	20.937	12	5.790	15.147	9/19/2019
T10000001779_WIC-6	37.4118902	-122.0550240	20.937	16	5.930	15.007	9/19/2019
T10000001779_WIC-7	37.4118920	-122.0550245	20.928	22	5.930	14.998	9/19/2019
T10000001779_WIC-8	37.4118920	-122.0550288	20.928	26	5.910	15.018	9/19/2019
T10000001779_WIC-9	37.4119261	-122.0550195	20.771	12	7.110	13.661	9/19/2019
T10000001779_WNX-1	37.4107640	-122.0536487	22.025	16	5.320	16.705	9/19/2019
T10000001779_WNX-2	37.4108868	-122.0535067	22.152	16	5.410	16.742	9/19/2019
T10000001779_WNX-3*	37.4107905	-122.0533049	22.182	18	6.460	15.722	9/19/2019
T10000001779_WNX-4	37.4107423	-122.0534245	22.499	16	5.310	17.189	9/19/2019
T10000001779_WU4-10	37.4126223	-122.0531261	19.856	30	5.960	13.896	9/19/2019
T10000001779_WU4-21	37.4151172	-122.0536911	18.416	19	10.830	7.586	9/19/2019
T10000001779_WU4-24	37.4136761	-122.0529896	19.490	18	8.510	10.980	9/19/2019
T10000001779_WU4-25	37.4126612	-122.0524692	20.055	18	6.250	13.805	9/19/2019
T10000001779_WU4-8	37.4148091	-122.0543459	18.877	16	10.700	8.177	9/19/2019
T10000001779_WU4-9	37.4148117	-122.0543598	18.886	47	10.320	8.566	9/19/2019
T10000001779_WWR-1	37.4112249	-122.0530729	20.887	22	4.180	16.707	9/19/2019
T10000001779_WWR-2	37.4104449	-122.0526504	23.030	20	3.800	19.230	9/19/2019
L10006514573_G-06	37.4145469	-121.9716963	8.075	24	5.900	2.175	2/21/2005

L10006514573_G-07	37.4152370	-121.9727590	5.789	20	3.330	2.459	2/21/2005
L10006514573_G-08	37.4156824	-121.9738003	8.207	25	3.440	4.767	2/6/2006
L10006514573_G-10	37.4111130	-121.9723396	10.968	24	7.940	3.028	2/25/2005
L10006514573_G-11	37.4131370	-121.9714082	9.450	25	4.820	4.630	2/24/2005
L10006514573_G-12	37.4114174	-121.9712903	11.312	24	7.050	4.262	2/25/2005
L10006514573_G-18	37.4112616	-121.9718112	11.167	25	7.150	4.017	2/25/2005
L10006514573_G-19	37.4109307	-121.9729466	11.539	25	7.940	3.599	2/25/2005
L10006514573_G-17	37.4132206	-121.9707456	7.389	25	5.590	1.799	2/24/2005
L10006514573_G-3R	37.4137447	-121.9651549	12.421	27	12.800	-0.379	2/7/2017
SL18213593_B-40	37.4166637	-121.8900054	49.733	46	8.320	41.413	1/6/2004
T0608501518_MW-14	37.4160460	-121.8769721	95.764	45	31.050	64.714	3/13/2007
T0608501518_MW-16	37.4155258	-121.8755656	103.558	42	35.370	68.188	3/13/2007
T0608501518_MW-17	37.4155210	-121.8754605	104.412	45	35.350	69.062	3/13/2007
T0608501518_MW-18	37.4154889	-121.8752152	105.197	45	35.500	69.697	3/13/2007
T0608501518_MW-19	37.4157435	-121.8753347	104.471	45	35.370	69.101	3/13/2007
T0608501518_VE-3	37.4155341	-121.8754757	103.989	43	36.450	67.539	1/3/2020
T0608501518_VE-4	37.4154990	-121.8751893	105.643	43	37.300	68.343	1/3/2020
T0608501518_VE-5	37.4155940	-121.8753859	103.953	43	36.450	67.503	1/3/2020
T0608501880_EX-1	37.4164558	-121.8749085	104.176	45	34.380	69.796	3/5/2007
T0608501880_EX-2	37.4163856	-121.8748937	104.839	45	35.090	69.749	12/6/2006
T0608501880_EX-3	37.4163439	-121.8746959	106.227	45	36.350	69.877	12/1/2005
T0608501880_EX-4	37.4165094	-121.8747659	105.064	44	35.020	70.044	12/6/2006
T0608501880_EX-5	37.4164063	-121.8750054	104.042	45	34.840	69.202	12/6/2006
T0608501880_MW-10	37.4165432	-121.8753196	101.953	43	34.160	67.793	12/6/2006
T0608501880_MW-11	37.4163077	-121.8752507	103.206	43	35.220	67.986	12/6/2006
T0608501880_MW-6	37.4164063	-121.8750054	104.042	44	34.990	69.052	12/6/2006
T0608501880_MW-7	37.4166381	-121.8750144	103.112	44	33.870	69.242	12/6/2006
T0608501880_MW-8	37.4165792	-121.8749905	103.578	44	33.350	70.228	3/5/2007
T0608501880_MW-9	37.4164230	-121.8752841	102.620	44	35.140	67.480	12/6/2006
SL0608551347_MW-4	37.4205004	-122.0989389	11.386	27	0.820	10.566	4/5/2018
T0608500183_A-2	37.4160730	-122.1038234	17.740	8	7.320	10.420	1/28/2003
T0608500183_A-3	37.4164129	-122.1040654	17.191	15	6.640	10.551	1/28/2003
T0608500183_A-4	37.4164911	-122.1039312	17.025	22	6.920	10.105	1/28/2003
T0608500183_A-5	37.4165406	-122.1040163	17.043	24	6.800	10.243	1/28/2003
T0608500183_A-6	37.4163863	-122.1040141	17.192	17	7.100	10.092	1/28/2003
T0608500183_A-7	37.4163387	-122.1041190	17.558	17	7.610	9.948	1/28/2003
T0608500183_A-8	37.4163800	-122.1041013	17.375	18	7.330	10.045	1/28/2003
T0608500183_A-9	37.4162263	-122.1036982	16.816	16	6.500	10.316	1/28/2003
T0608500183_E-1	37.4163853	-122.1039514	17.185	20	6.600	10.585	1/28/2003
T0608500183_E-2	37.4162869	-122.1037767	16.761	20	6.380	10.381	1/28/2003
T0608500183_MW-9	37.4164061	-122.1034108	16.957	20	7.430	9.527	1/28/2003
T0608500170_MW-WA1	37.4151356	-122.0930274	18.397	17	6.050	12.347	3/22/2006
T0608500170_MW-WA2	37.4151318	-122.0932797	18.237	16	5.980	12.257	2/21/2003
T0608500170_P-10	37.4156496	-122.0938182	17.636	20	5.630	12.006	3/22/2006

T0608500170_P-11	37.4156253	-122.0938191	17.722	20	6.080	11.642	3/22/2006
T0608500170_P-8	37.4151719	-122.0937368	19.906	20	6.840	13.066	12/3/2014
T0608500170_P-9	37.4155099	-122.0937864	18.723	8	7.000	11.723	3/22/2006
SL18310730_MW1	37.4204813	-122.0858026	14.142	24	7.650	6.492	1/7/2013
SL18310730_MW2	37.4205443	-122.0854810	13.666	21	7.860	5.806	12/6/2010
SL18310730_PA4	37.4206464	-122.0864058	13.860	19	6.390	7.470	1/7/2013
SL18310730_PA5	37.4193252	-122.0859584	13.477	20	4.960	8.517	12/6/2010
SL18310730_PA6	37.4193244	-122.0859284	13.261	42	4.190	9.071	1/7/2013
T10000001779_15A06A	37.4157638	-122.0634887	18.048	20	6.640	11.408	9/19/2019
T10000001779_15A08A	37.4165162	-122.0641688	17.463	24	6.630	10.833	9/19/2019
T10000001779_15B17A2	37.4156050	-122.0648678	17.727	41	5.740	11.987	9/19/2019
T10000003442_SMW-1	37.4202960	-122.0579950	10.425	15	7.210	3.215	4/23/2013
T10000003442_SMW-2	37.4203970	-122.0585560	10.670	15	7.540	3.130	4/23/2013
T10000003442_SMW-3	37.4199710	-122.0587090	10.645	15	6.710	3.935	4/23/2013
T10000001779_11N21A1	37.4190639	-122.0560118	9.356	21	7.430	1.926	9/19/2019
T10000001779_11N22A1	37.4185631	-122.0571103	10.817	25	7.940	2.877	9/19/2019
T10000001779_14D02A	37.4169978	-122.0564612	13.331	25	7.230	6.101	9/19/2019
T10000001779_14D09A	37.4157740	-122.0588464	16.402	16	7.120	9.282	9/19/2019
T10000001779_14D13A	37.4159421	-122.0592149	16.035	17	7.310	8.725	9/19/2019
T10000001779_14D24A	37.4159648	-122.0575107	15.576	16	12.070	3.506	9/19/2019
T10000001779_14D25A2	37.4174311	-122.0575482	11.209	36	6.170	5.039	9/19/2019
T10000001779_14D26A1	37.4174092	-122.0575374	11.209	28	13.840	-2.631	9/19/2019
T10000001779_15A01A	37.4166701	-122.0627759	15.955	22	10.620	5.335	9/19/2019
T10000001779_15A04A	37.4158070	-122.0616608	17.448	19	8.150	9.298	9/19/2019
T10000001779_EA1-4	37.4156530	-122.0557479	16.221	20	6.210	10.011	9/19/2019
T10000001779_PZA1-4B	37.4156229	-122.0559568	15.450	25	8.590	6.860	9/19/2019
T10000001779_PZA1-4C	37.4156141	-122.0561426	15.944	25	8.740	7.204	9/19/2019
T10000001779_UST115-MW01	37.4189652	-122.0572811	11.279	16	5.180	6.099	9/19/2019
T10000001779_UST115-MW02	37.4189348	-122.0572955	11.333	16	5.430	5.903	9/19/2019
T10000001779_W8-1	37.4202652	-122.0579895	10.227	30	8.320	1.907	9/19/2019
T10000001779_W8-11	37.4198857	-122.0580790	10.368	38	7.890	2.478	9/19/2019
T10000001779_W8-2	37.4205680	-122.0579824	10.473	48	7.550	2.923	9/19/2019
T10000001779_W8-4	37.4198533	-122.0580723	10.346	22	7.840	2.506	9/19/2019
T10000001779_W8-6	37.4206345	-122.0581140	10.458	37	9.190	1.268	9/19/2019
T10000001779_WNB-14	37.4159935	-122.0583046	15.490	29	6.630	8.860	9/19/2019
T10000001779_WU4-18	37.4176708	-122.0560448	11.266	24	6.980	4.286	9/19/2019
T10000001779_WU4-19	37.4169001	-122.0574028	14.414	42	8.390	6.024	9/19/2019
T10000001779_14C06A	37.4157815	-122.0553821	15.899	20	8.870	7.029	9/19/2019
T10000001779_14C33A	37.4156397	-122.0544769	16.360	17	9.650	6.710	9/19/2019
T10000001779_PZA1-4D*	37.4157202	-122.0556884	15.624	25	12.300	3.324	9/19/2019
T10000001779_PZA2-4E	37.4156489	-122.0556582	16.880	43	12.290	4.590	9/19/2019
T10000001779_UST29-MW01	37.4159531	-122.0534738	15.193	16	12.490	2.703	9/19/2019
T10000001779_UST29-MW02	37.4160809	-122.0535222	14.469	16	11.920	2.549	9/19/2019
T10000001779_W12-20	37.4192816	-122.0542944	10.702	19	8.480	2.222	9/19/2019

T10000001779_W12-6	37.4185443	-122.0548025	9.070	30	7.180	1.890	9/19/2019
T10000001779_WU4-14	37.4156842	-122.0556762	16.022	22	8.990	7.032	9/19/2019
T10000001778_W19-1	37.4184267	-122.0422320	12.177	35	8.310	3.867	2/1/2003
T10000001778_W19-4	37.4189314	-122.0429589	10.610	36	7.140	3.470	2/1/2003
T10000001778_W4-12	37.4209806	-122.0442661	6.841	36	4.720	2.121	2/1/2003
T10000001778_W4-14	37.4198703	-122.0428386	9.514	16	5.690	3.824	2/1/2003
T10000001778_W4-17	37.4209922	-122.0442736	6.865	15	4.790	2.075	2/1/2003
T10000001778_W7-10	37.4183356	-122.0421540	12.557	18	9.060	3.497	2/1/2003
T10000001778_W5-23	37.4206086	-122.0395486	8.131	14	5.330	2.801	2/1/2003
T10000001778_W5-3	37.4187288	-122.0374882	10.852	30	6.230	4.622	2/1/2003
T10000001778_W5-34	37.4199691	-122.0389155	8.810	20	5.350	3.460	2/1/2003
T10000001778_WU5-14	37.4205413	-122.0410231	6.525	40	4.200	2.325	2/1/2003
L10006514573_G-05	37.4167363	-121.9705506	5.502	25	4.030	1.472	2/24/2005
L10006514573_G-21	37.4174240	-121.9691727	5.543	20	3.560	1.983	2/24/2005
L10006514573_G-4R	37.4169647	-121.9681438	9.569	21	11.750	-2.181	2/7/2017
SL0608551347_DPE-1	37.4210163	-122.0983223	10.674	17	0.300	10.374	4/5/2018
SL0608551347_DPE-2	37.4210861	-122.0983031	10.462	17	7.660	2.802	3/31/2007
SL0608551347_MW-1	37.4213124	-122.0989272	10.686	30	0.320	10.366	4/5/2018
SL0608551347_MW-2	37.4214590	-122.0981896	10.718	30	0.140	10.578	4/5/2018
SL0608551347_MW-3	37.4210460	-122.0983019	10.659	30	0.560	10.099	4/5/2018
SL0608551347_MW-5	37.4214501	-122.0981918	10.628	17	0.210	10.418	4/5/2018
SL0608551347_MW-6	37.4212533	-122.0989440	10.845	17	0.430	10.415	4/5/2018
SL0608551347_MW-7	37.4210958	-122.0982980	10.410	18	0.160	10.250	4/5/2018
SL1823B659_IW-2B	37.4213142	-122.1033645	10.508	47	4.840	5.668	12/20/2010
SL1823B659_MW-01A	37.4218330	-122.1033230	10.736	15	5.900	4.836	12/4/2014
SL1823B659_MW-01B1	37.4218330	-122.1033230	10.736	30	5.730	5.006	12/4/2014
SL1823B659_MW-01B3	37.4218330	-122.1033230	10.736	42	5.750	4.986	12/4/2014
SL1823B659_MW-10A	37.4221117	-122.1034501	10.569	22	6.220	4.349	12/4/2014
SL1823B659_MW-10B1	37.4221040	-122.1034643	10.576	33	6.240	4.336	12/4/2014
SL1823B659_MW-10B3	37.4221033	-122.1034475	10.600	44	6.000	4.600	12/4/2014
SL1823B659_MW-11A1	37.4218384	-122.1034174	10.794	19	5.970	4.824	12/4/2014
SL1823B659_MW-11B1	37.4218384	-122.1034174	10.794	42	6.300	4.494	12/4/2014
SL1823B659_MW-12A1	37.4218318	-122.1033028	10.741	27	5.700	5.041	12/4/2014
SL1823B659_MW-12A2	37.4218318	-122.1033028	10.741	32	7.070	3.671	2/16/2016
SL1823B659_MW-13A1	37.4218248	-122.1031817	10.727	13	5.850	4.877	12/4/2014
SL1823B659_MW-13A2	37.4218248	-122.1031817	10.727	27	5.530	5.197	12/4/2014
SL1823B659_MW-13B1	37.4218248	-122.1031817	10.727	42	5.810	4.917	12/4/2014
SL1823B659_MW-15B3-1	37.4214177	-122.1033322	10.978	7	5.650	5.328	2/16/2016
SL1823B659_MW-16B2	37.4214270	-122.1032320	11.101	10	2.550	8.551	2/16/2016
SL1823B659_MW-7RA	37.4221208	-122.1028898	9.848	23	6.280	3.568	2/24/2011
SL1823B659_MW-7RB1	37.4221184	-122.1028730	9.943	32	6.190	3.753	2/24/2011
SL1823B659_MW-7RB2	37.4221157	-122.1028569	9.897	42	6.190	3.707	2/24/2011
SL1823B659_MW-9A	37.4223773	-122.1034086	10.447	22	5.950	4.497	12/4/2014
SL1823B659_MW-9B1	37.4223670	-122.1034114	10.539	34	6.150	4.389	12/4/2014

SL1823B659_MW-9B3	37.4223874	-122.1034055	10.482	46	5.770	4.712	12/4/2014
SL1823B659_RW-2A	37.4218031	-122.1034492	11.096	27	6.350	4.746	12/20/2010
SL18288709_F12	37.4236113	-122.1025741	22.701	16	5.820	16.881	2/13/2007
SL18288709_F13	37.4247489	-122.1028697	6.802	20	5.290	1.512	2/8/2009
SL18288709_F14	37.4236048	-122.1031521	13.688	23	5.400	8.288	2/13/2007
SL18288709_F4	37.4246355	-122.1021938	7.162	25	1.650	5.512	4/15/2005
SL18288709_F8	37.4231044	-122.1033971	8.207	25	5.120	3.087	2/8/2009
T0608500186_A-1	37.4213266	-122.1013123	10.997	18	7.360	3.637	2/12/2007
T0608500186_A-2	37.4216407	-122.1010927	9.676	16	6.000	3.676	2/12/2007
T0608500186_A-3	37.4217179	-122.1014018	9.113	19	5.710	3.403	2/12/2007
T0608500186_A-4	37.4219349	-122.1012537	8.697	20	5.930	2.767	2/6/2009
T0608500186_A-5	37.4219236	-122.1010104	9.100	20	6.220	2.880	2/12/2007
T0608500186_A-6	37.4217148	-122.1007696	9.267	20	5.580	3.687	5/26/2004
T0608500186_E-1	37.4215957	-122.1011251	9.959	16	6.220	3.739	2/14/2008
T0608500186_E-2	37.4216905	-122.1011595	9.495	22	6.030	3.465	2/14/2008
T0608500186_E-3	37.4215901	-122.1014340	9.528	20	5.820	3.708	2/12/2007
SL18224622_MW-10	37.4206499	-122.0948478	11.424	15	5.000	6.424	3/24/2005
SL18224622_MW-11	37.4206499	-122.0948478	11.424	13	5.310	6.114	3/24/2005
SL18224622_MW-12	37.4210173	-122.0969330	9.126	17	5.710	3.416	3/24/2005
SL18224622_MW-13	37.4214321	-122.0969108	8.786	15	5.280	3.506	3/24/2005
SL18224622_MW-6	37.4206804	-122.0965147	10.384	14	5.710	4.674	3/24/2005
SL18224622_MW-7	37.4206499	-122.0948478	11.424	32	5.960	5.464	3/24/2005
SL18224622_MW-BN	37.4207241	-122.0947700	10.962	24	5.950	5.012	4/18/2006
SL18224622_MW-BS	37.4206499	-122.0948478	11.424	10	6.510	4.914	4/18/2006
SL18310730_IZGWE1	37.4207901	-122.0864018	13.196	42	6.560	6.636	1/7/2013
SL18310730_OEXI1	37.4212364	-122.0861030	16.071	41	10.120	5.951	12/6/2010
SL18310730_OEXI2	37.4217722	-122.0860235	19.224	48	15.080	4.144	1/7/2013
SL18310730_PA10	37.4215744	-122.0860154	17.607	27	12.920	4.687	1/7/2013
SL18310730_PA11	37.4215962	-122.0860185	17.689	41	12.830	4.859	1/7/2013
SL18310730_PA12	37.4229618	-122.0851566	11.259	26	10.910	0.349	1/7/2013
SL18310730_PA13	37.4229814	-122.0851465	11.159	42	10.620	0.539	1/7/2013
SL18310730_PA14	37.4219274	-122.0860211	20.985	30	18.230	2.755	1/7/2013
SL18310730_PA7A	37.4207528	-122.0863716	12.989	41	6.250	6.739	1/7/2013
SL18310730_PA8	37.4212792	-122.0863925	17.618	27	11.420	6.198	1/7/2013
SL18310730_PA9	37.4212791	-122.0863766	17.336	42	11.730	5.606	1/7/2013
T10000001779_10J04A	37.4247944	-122.0631988	4.903	15	2.950	1.953	9/19/2019
T10000001779_10J05A	37.4221955	-122.0605441	6.864	17	4.180	2.684	9/19/2019
T10000001779_11E02A	37.4263008	-122.0577437	5.072	18	4.900	0.172	9/19/2019
T10000001779_11M02A	37.4240000	-122.0595210	4.246	14	2.440	1.806	9/19/2019
T10000001779_11M07A	37.4215561	-122.0580406	7.373	11	5.720	1.653	9/19/2019
T10000001779_11M14A1	37.4211957	-122.0568140	8.033	25	6.670	1.363	9/19/2019
T10000001779_11M16A1	37.4211482	-122.0560519	8.327	29	6.820	1.507	9/19/2019
T10000001779_11M17A	37.4218641	-122.0577854	7.271	12	5.970	1.301	9/19/2019
T10000001779_11M18A1	37.4217058	-122.0577029	7.540	26	8.590	-1.050	9/19/2019

T10000001779_W8-8	37.4225675	-122.0581823	5.764	26	4.620	1.144	9/19/2019
T10000001779_WNB-12	37.4241048	-122.0580422	6.128	42	5.800	0.328	9/19/2019
T10000001779_WNB-26	37.4253926	-122.0605593	3.471	8	0.830	2.641	9/19/2019
T10000001779_WNB-7	37.4241075	-122.0580492	6.146	20	5.510	0.636	9/19/2019
T10000001779_WSI-4	37.4214811	-122.0584903	7.458	30	5.190	2.268	9/19/2019
T10000001778_W2-13	37.4256690	-122.0494005	0.836	16	3.140	-2.304	2/1/2003
T10000001778_WNB-17	37.4252604	-122.0509128	0.835	23	1.580	-0.745	2/1/2003
T10000001778_WNB-18	37.4230979	-122.0529790	3.972	23	1.000	2.972	2/1/2003
T10000001779_WNB-13	37.4238756	-122.0550307	4.808	38	4.590	0.218	9/19/2019
T10000001779_WNB-8	37.4220865	-122.0552277	7.565	22	6.710	0.855	9/19/2019
T10000001778_W2-12	37.4248037	-122.0471847	2.012	16	5.010	-2.998	2/1/2003
T10000001778_W2-16	37.4261644	-122.0482201	2.198	18	5.690	-3.492	2/1/2003
T10000001778_W2-3	37.4250603	-122.0457108	2.407	20	3.700	-1.293	2/1/2003
T10000001778_W26-1	37.4232743	-122.0460257	5.684	14	6.750	-1.066	5/1/2003
T10000001778_W3-1	37.4224530	-122.0424710	5.795	20	5.220	0.575	2/1/2003
T10000001778_W3-19	37.4230383	-122.0439514	4.667	32	5.130	-0.463	2/1/2003
T10000001778_W3-20	37.4232621	-122.0425535	4.903	22	4.950	-0.047	2/1/2003
T10000001778_W3-21	37.4228380	-122.0418630	4.727	34	4.640	0.087	2/1/2003
T10000001778_W3-24	37.4245319	-122.0429860	1.822	35	3.670	-1.848	2/1/2003
T10000001778_W3-6	37.4245952	-122.0429635	2.734	18	3.050	-0.316	2/1/2003
T10000001778_W4-15	37.4214292	-122.0424235	6.093	15	5.510	0.583	2/1/2003
T10000001778_WFH-01	37.4220821	-122.0477470	5.904	10	5.790	0.114	2/1/2003
T10000001778_WFH-02	37.4220332	-122.0479113	5.903	10	5.770	0.133	2/1/2003
T10000001778_WFH-03	37.4218807	-122.0478083	5.565	10	5.260	0.305	2/1/2003
T10000001778_WFH-04	37.4213996	-122.0474264	6.828	10	5.770	1.058	2/1/2003
T10000001778_WFH-05	37.4213359	-122.0476730	6.881	10	5.680	1.201	2/1/2003
T10000001778_WFH-06	37.4212768	-122.0475508	6.626	10	2.500	4.126	2/1/2003
T10000001778_WSW-1	37.4261639	-122.0463565	0.473	10	0.910	-0.437	2/1/2003
T10000001778_WSW-2	37.4246085	-122.0448822	0.599	10	1.280	-0.681	2/1/2003
T10000001778_WSW-3	37.4247856	-122.0454025	3.291	28	2.870	0.421	2/1/2003
T10000001778_WU5-2	37.4219762	-122.0434776	4.810	35	7.900	-3.090	2/1/2003
T10000001778_WU5-20	37.4219706	-122.0439046	5.848	34	5.190	0.658	2/1/2003
T10000001778_WU5-25	37.4225496	-122.0439545	5.793	34	5.150	0.643	2/1/2003
T10000001778_WU5-3	37.4241376	-122.0447588	3.917	11	6.700	-2.783	2/1/2003
T10000001778_WU5-4	37.4241568	-122.0447661	3.922	33	6.710	-2.788	2/1/2003
T10000001778_WU5-5	37.4220926	-122.0440311	6.394	16	8.190	-1.796	2/1/2003
T10000001778_WU5-6	37.4244163	-122.0429977	2.301	34	5.430	-3.129	2/1/2003
T10000001778_WU5-7	37.4245151	-122.0429998	1.404	23	4.270	-2.866	2/1/2003
T10000001778_WU5-8	37.4257595	-122.0448750	1.607	34	1.990	-0.383	2/1/2003
T10000001778_WU5-9	37.4267518	-122.0452366	0.089	20	1.760	-1.671	5/1/2003
T10000001778_W3-11	37.4239867	-122.0401474	2.211	19	3.500	-1.289	2/1/2003
T10000001778_W3-3	37.4261401	-122.0411421	2.174	18	3.080	-0.906	2/1/2003
T10000001778_W3-8	37.4246380	-122.0415720	2.843	18	3.280	-0.437	2/1/2003
T10000001778_W4-2	37.4214540	-122.0416100	7.168	20	5.710	1.458	2/1/2003

T10000001778_WGC2-1	37.4252216	-122.0377059	1.054	19	1.670	-0.616	5/1/2003
T10000001778_WGC2-4	37.4265992	-122.0366180	2.709	20	1.730	0.979	2/1/2003
T10000001778_WGC2-5	37.4267121	-122.0380310	2.719	22	2.420	0.299	2/1/2003
T10000001778_WGC2-6	37.4257761	-122.0351499	3.279	24	1.300	1.979	2/1/2003
T0608500260_MW-14	37.4274784	-121.9137605	15.872	19	1.480	14.392	4/12/2006
T0608500260_MW-15	37.4281893	-121.9138616	15.025	20	1.930	13.095	4/12/2006
T0608500260_RW-10	37.4276162	-121.9138984	15.999	25	1.850	14.149	4/12/2006
T0608500260_RW-5	37.4267835	-121.9132779	18.584	25	3.500	15.084	4/12/2006
T0608500260_RW-6	37.4270067	-121.9136514	18.432	24	3.350	15.082	4/12/2006
T0608500260_RW-7	37.4271389	-121.9135910	17.685	25	3.440	14.245	4/12/2006
T0608500260_RW-8	37.4273066	-121.9135872	16.112	25	1.690	14.422	4/12/2006
T0608500260_RW-9	37.4273831	-121.9136800	16.035	24	1.430	14.605	4/12/2006
T0608501504_MW-10	37.4280593	-121.9097974	19.782	22	7.120	12.662	1/28/2008
T0608501504_MW-11	37.4277653	-121.9100741	18.581	22	5.510	13.071	5/14/2007
T0608501504_MW-12	37.4277016	-121.9095987	18.170	22	7.110	11.060	1/28/2008
T0608501504_MW-13	37.4276993	-121.9096010	18.269	23	6.540	11.729	1/28/2008
T0608501504_MW-14	37.4280621	-121.9095441	20.096	23	8.030	12.066	1/11/2006
T0608501504_MW-15	37.4283614	-121.9096438	17.717	20	6.330	11.387	1/28/2008
T0608501504_MW-16	37.4283876	-121.9094724	17.693	20	6.360	11.333	1/11/2006
T0608501504_MW-17	37.4282858	-121.9092817	17.353	20	6.280	11.073	1/11/2006
T0608501504_MW-8	37.4277984	-121.9098391	18.751	21	7.610	11.141	1/27/2005
T0608501504_MW-9	37.4279677	-121.9094972	20.750	23	7.810	12.940	1/28/2008
T0608589973_MW-1	37.4280581	-121.9141935	16.334	19	5.610	10.724	2/2/2004
T0608589973_MW-2	37.4278254	-121.9139914	16.179	18	4.720	11.459	4/7/2004
T0608589973_MW-3	37.4279943	-121.9144722	17.587	19	6.530	11.057	4/7/2004
T0608589973_MW-4	37.4277057	-121.9144704	17.827	19	6.630	11.197	4/7/2004
T0608525893_CW-1	37.4281811	-121.9041629	19.877	19	3.690	16.187	3/23/2006
T0608525893_CW-2	37.4285353	-121.9043505	19.926	21	4.090	15.836	3/23/2006
T0608525893_CW-3	37.4282529	-121.9043584	18.906	23	3.120	15.786	3/23/2006
T0608525893_CW-4	37.4283249	-121.9045156	18.890	25	3.280	15.610	3/23/2006
T0608501277_MW-6	37.4259003	-122.1475939	41.796	20	18.850	22.946	3/17/2006
T0608502062_MW-1	37.4273027	-122.1436541	33.781	30	16.850	16.931	2/22/2006
T0608502062_MW-2	37.4275712	-122.1436718	34.000	30	16.860	17.140	2/22/2006
T0608502062_MW-3	37.4274093	-122.1430957	33.568	30	16.910	16.658	2/22/2006
T0608502062_MW-4	37.4274459	-122.1434763	33.767	21	7.920	25.847	2/22/2006
T0608502062_MW-5	37.4277248	-122.1431952	33.286	30	18.510	14.776	5/16/2013
T0608500175_MW-1	37.4313616	-122.1257514	15.705	18	8.640	7.065	12/23/2002
T0608500175_MW-12	37.4314033	-122.1251948	15.496	22	7.080	8.416	12/27/2005
T0608500175_MW-13	37.4314018	-122.1252690	15.647	22	9.050	6.597	12/23/2002
T0608500175_MW-14	37.4313538	-122.1257440	15.772	21	5.950	9.822	3/19/2008
T0608500175_MW-2	37.4313307	-122.1256415	16.383	24	7.890	8.493	3/2/2009
T0608500175_MW-20	37.4312332	-122.1254629	16.481	20	8.190	8.291	12/23/2002
T0608500175_MW-6	37.4312086	-122.1258183	16.559	20	6.710	9.849	12/27/2005
SL18288709_F11	37.4263197	-122.1028042	5.207	16	4.430	0.777	4/15/2005

SL18288709_F20	37.4280943	-122.1028293	5.506	25	2.130	3.376	4/15/2005
T10000001779_10B01A	37.4293626	-122.0662670	8.434	20	9.260	-0.826	9/19/2019
T10000001779_10H02A	37.4274624	-122.0635475	3.216	18	3.560	-0.344	9/19/2019
T10000001779_WNB-1	37.4270487	-122.0601668	8.172	25	7.680	0.492	9/19/2019
T10000001779_WNB-10	37.4270463	-122.0601392	8.627	44	7.460	1.167	9/19/2019
T10000001779_WNB-11	37.4268383	-122.0573932	4.574	45	7.900	-3.326	9/19/2019
T0608501315_MW-1	37.4336000	-121.8913435	34.076	26	8.850	25.226	12/17/2002
T0608501315_MW-10A	37.4337513	-121.8919553	31.521	20	9.050	22.471	12/17/2002
T0608501315_MW-10B	37.4337510	-121.8919556	31.521	40	8.900	22.621	12/17/2002
T0608501315_MW-11	37.4340626	-121.8926520	30.338	38	7.300	23.038	12/17/2002
T0608501315_MW-2	37.4334838	-121.8914061	34.597	27	8.790	25.807	12/17/2002
T0608501315_MW-3	37.4335392	-121.8910854	35.438	27	9.290	26.148	12/17/2002
T0608501315_MW-4	37.4337288	-121.8913700	33.964	20	9.200	24.764	12/17/2002
T0608501315_MW-5	37.4336538	-121.8915902	32.868	20	8.380	24.488	3/29/2002
T0608501315_MW-6	37.4335741	-121.8914242	33.936	20	9.000	24.936	12/17/2002
T0608501315_MW-7	37.4336496	-121.8916085	32.590	39	8.560	24.030	3/29/2002
T0608501315_MW-8	37.4335666	-121.8914578	33.769	40	9.200	24.569	12/17/2002
T0608501315_MW-9A	37.4338723	-121.8920488	32.465	20	10.810	21.655	12/8/2003
T0608501315_MW-9B	37.4338723	-121.8920485	32.465	40	9.830	22.635	12/8/2003
T0608502363_MW-1	37.4329556	-122.1282759	15.784	20	5.780	10.004	4/5/2006
T0608502363_MW-10	37.4332251	-122.1275978	14.030	26	6.140	7.890	4/1/2010
T0608502363_MW-2	37.4330453	-122.1282297	15.454	20	6.200	9.254	4/5/2006
T0608502363_MW-3	37.4330310	-122.1283079	15.259	20	5.480	9.779	4/5/2006
T0608502363_MW-4	37.4331086	-122.1280625	15.317	25	5.870	9.447	4/5/2006
T0608502363_MW-5	37.4331836	-122.1280911	14.643	25	5.310	9.333	4/5/2006
T0608502363_MW-6	37.4329090	-122.1281491	15.868	25	7.400	8.468	4/1/2010
T0608502363_MW-7	37.4330636	-122.1281057	15.489	26	6.960	8.529	4/1/2010
T0608502363_MW-8	37.4331332	-122.1279590	15.133	26	6.810	8.323	4/1/2010
T0608502363_MW-9	37.4328558	-122.1279521	14.916	26	6.430	8.486	4/1/2010
T0608500175_E-1	37.4314193	-122.1255427	16.053	21	1.010	15.043	3/4/2003
T0608500175_E-2	37.4317027	-122.1252445	15.678	23	5.920	9.758	2/27/2007
T0608500175_MW-11	37.4316837	-122.1250043	14.736	22	6.580	8.156	2/27/2007
T0608500175_MW-15	37.4314299	-122.1263499	18.089	19	8.470	9.619	12/27/2005
T0608500175_MW-18	37.4316678	-122.1256198	16.971	19	7.960	9.011	3/2/2009
T0608500175_MW-19	37.4318799	-122.1245983	14.097	18	5.980	8.117	12/23/2002
T0608500175_MW-21	37.4316052	-122.1254337	16.265	42	8.440	7.825	3/2/2009
T0608500175_MW-22	37.4315078	-122.1253529	15.596	44	8.960	6.636	12/27/2005
T0608500175_MW-3	37.4314271	-122.1255295	16.060	25	8.920	7.140	12/27/2005
T0608500175_MW-4	37.4314446	-122.1256159	15.674	25	8.510	7.164	12/27/2005
T0608500175_MW-5	37.4314888	-122.1256610	15.292	19	8.100	7.192	12/23/2002
T0608500175_MW-7	37.4314321	-122.1257892	17.150	22	8.300	8.850	3/2/2009
T0608500175_MW-8	37.4315170	-122.1257129	16.929	22	8.100	8.829	3/2/2009
T0608500175_MW-9	37.4317015	-122.1254761	16.138	25	7.620	8.518	3/2/2009
T0608500175_SP-1A	37.4314460	-122.1256238	15.628	12	9.080	6.548	3/2/2009

T0608500175_SP-1B	37.4314460	-122.1256238	15.628	20	8.990	6.638	12/27/2005
T0608500175_SP-2	37.4314349	-122.1252659	15.613	21	8.730	6.883	12/23/2002
T0608500175_V-2	37.4314533	-122.1252710	15.575	12	8.720	6.855	12/23/2002
SL1821Y617_MW-17	37.4335923	-122.0989954	6.567	29	7.730	-1.163	12/4/2012
T0608501249_MW-2	37.4360324	-121.8847224	53.861	31	12.060	41.801	3/1/2011
T0608501249_S-1	37.4358993	-121.8840321	58.382	31	14.800	43.582	3/1/2011
T0608501249_S-10	37.4364595	-121.8846537	55.869	28	15.540	40.329	3/18/2003
T0608501249_S-11	37.4356507	-121.8846643	54.871	26	14.370	40.501	3/18/2003
T0608501249_S-13	37.4363481	-121.8851332	52.741	23	13.100	39.641	3/1/2011
T0608501249_S-14	37.4360979	-121.8848603	52.585	24	11.990	40.595	12/7/2011
T0608501249_S-2	37.4359306	-121.8842283	56.988	30	13.800	43.188	3/1/2011
T0608501249_S-3	37.4358090	-121.8842077	57.095	29	14.110	42.985	3/1/2011
T0608501249_S-4	37.4360939	-121.8841188	58.496	28	14.890	43.606	3/3/2009
T0608501249_S-4R	37.4361053	-121.8841296	58.274	25	15.480	42.794	12/7/2011
T0608501249_S-5	37.4358518	-121.8839020	58.145	30	16.560	41.585	3/18/2003
T0608501249_S-6	37.4356510	-121.8840338	58.071	30	16.350	41.721	3/18/2003
T0608501249_S-7	37.4358007	-121.8844526	56.197	30	0.000	56.197	3/3/2009
T0608501249_S-7R	37.4358289	-121.8845728	57.271	25	15.690	41.581	12/7/2011
T0608501249_S-8	37.4360249	-121.8845233	56.076	27	0.000	56.076	3/3/2009
T0608501249_S-8R	37.4361837	-121.8847207	53.642	25	12.900	40.742	3/6/2012
T0608501249_S-9	37.4362137	-121.8843889	55.936	28	0.000	55.936	3/3/2009
T0608501249_SR-1	37.4360854	-121.8841661	58.141	36	16.270	41.871	3/18/2002
T0608501249_SR-3	37.4359142	-121.8842337	57.029	36	15.780	41.249	3/18/2002
T0608501249_SR-6	37.4361281	-121.8840039	59.216	36	14.800	44.416	3/1/2011
T0608501513_EW-1	37.4352639	-121.8853826	52.869	25	12.470	40.399	5/31/2006
T0608501513_EW-2	37.4352639	-121.8853826	52.869	25	12.210	40.659	5/31/2006
T0608501513_EW-3	37.4352639	-121.8853826	52.869	25	13.110	39.759	5/31/2006
T0608501513_MW-1	37.4349938	-121.8845485	55.840	25	13.120	42.720	3/8/2005
T0608501513_MW-10	37.4352639	-121.8853826	52.869	20	11.600	41.269	3/1/2011
T0608501513_MW-11	37.4352639	-121.8853826	52.869	20	12.740	40.129	3/1/2011
T0608501513_MW-12	37.4352639	-121.8853826	52.869	20	13.450	39.419	3/1/2011
T0608501513_MW-13	37.4349176	-121.8856697	49.236	18	9.670	39.566	3/1/2011
T0608501513_MW-2	37.4351646	-121.8843139	56.581	26	13.550	43.031	5/31/2006
T0608501513_MW-3	37.4353147	-121.8846878	54.590	26	12.230	42.360	5/31/2006
T0608501513_MW-4	37.4355423	-121.8851969	53.581	25	12.600	40.981	3/3/2009
T0608501513_MW-5	37.4352639	-121.8853826	52.869	25	12.930	39.939	5/31/2006
T0608501513_MW-6	37.4353752	-121.8844415	55.992	25	13.250	42.742	5/31/2006
T0608501513_MW-7	37.4352639	-121.8853826	52.869	20	12.540	40.329	3/8/2005
T0608501513_MW-8	37.4352639	-121.8853826	52.869	19	10.780	42.089	3/8/2005
T0608501513_MW-9	37.4352639	-121.8853826	52.869	20	12.240	40.629	3/8/2005
T0608501568_MW-10	37.4397622	-122.1620770	64.640	29	15.810	48.830	5/31/2003
T0608591760_MW-7	37.4456078	-121.8930654	26.463	11	5.100	21.363	3/4/2005
T0608591760_MW-8	37.4454747	-121.8928242	26.580	22	9.200	17.380	3/3/2006
T10000004214_MW-1	37.4480224	-122.1259751	10.586	15	6.810	3.776	5/6/2013

T10000004214_MW-2	37.4480152	-122.1255666	11.322	14	7.740	3.582	5/6/2013
T10000004214_MW-3	37.4478227	-122.1255856	10.590	14	6.980	3.610	5/6/2013
T0608591760_MW-1	37.4465726	-121.8929557	25.773	18	2.700	23.073	3/4/2005
T0608591760_MW-2	37.4464297	-121.8929102	25.736	19	3.000	22.736	3/4/2005
T0608591760_MW-3	37.4465189	-121.8926004	26.763	19	2.900	23.863	3/4/2005
T0608591760_MW-4	37.4465527	-121.8931253	25.789	22	3.280	22.509	3/4/2005
T0608591760_MW-5	37.4460337	-121.8929903	26.619	19	4.700	21.919	3/4/2005
T0608591760_MW-6	37.4456682	-121.8931835	26.234	23	5.420	20.814	12/20/2005
T0608501499_MW-10	37.4542551	-121.9106053	29.299	12	6.610	22.689	2/17/2005
T0608501499_MW-11	37.4542740	-121.9104954	29.463	12	7.340	22.123	2/17/2005
T0608501499_MW-12	37.4542869	-121.9104293	29.798	12	7.800	21.998	2/17/2005
T0608501499_MW-13	37.4545658	-121.9106054	29.533	25	7.230	22.303	2/17/2005
T0608501499_MW-15	37.4542328	-121.9109130	28.377	27	6.730	21.647	2/17/2005
T0608501499_MW-16	37.4539220	-121.9108501	27.699	27	7.480	20.219	2/17/2005
T0608501499_MW-17	37.4542829	-121.9106846	28.912	23	7.400	21.512	2/17/2005
T0608501499_MW-6	37.4542613	-121.9105969	29.552	30	6.790	22.762	2/17/2005
T0608501499_MW-7	37.4543422	-121.9106138	28.948	28	6.990	21.958	2/17/2005
T0608501499_MW-8	37.4543748	-121.9106349	29.028	12	7.190	21.838	2/17/2005
T0608501499_MW-9	37.4543073	-121.9106152	28.760	12	6.760	22.000	2/17/2005
T0608501499_TW-1	37.4541733	-121.9106359	28.149	12	8.020	20.129	2/17/2005
T0608501499_TW-2	37.4539824	-121.9105982	27.912	12	7.370	20.542	2/17/2005
T0608501499_TW-3	37.4537724	-121.9105537	27.745	11	7.660	20.085	2/17/2005
T10000001827_MW-1	37.4523028	-121.9100877	24.055	24	7.200	16.855	3/1/2011
T10000001827_MW-2	37.4522087	-121.9100155	24.930	24	7.530	17.400	3/1/2011
T10000001827_MW-3	37.4521398	-121.9101364	24.017	24	6.660	17.357	3/1/2011
T10000001827_MW-4	37.4522203	-121.9098754	25.330	24	7.590	17.740	3/1/2011
T0608599114_MW-1	37.4549669	-122.1150463	3.715	13	2.660	1.055	4/23/2012
T0608599114_MW-11	37.4551174	-122.1152863	3.295	14	1.840	1.455	4/23/2012
T0608599114_MW-12	37.4552265	-122.1152697	3.184	34	2.050	1.134	4/23/2012
T0608599114_MW-2	37.4553642	-122.1152869	3.019	12	2.340	0.679	4/23/2012
T0608599114_MW-3	37.4551105	-122.1155307	3.313	13	2.420	0.893	4/23/2012
T0608599114_MW-4	37.4558466	-122.1152595	1.536	14	1.550	-0.014	4/23/2012
T0608599114_MW-5	37.4543458	-122.1146517	3.163	14	7.000	-3.837	4/23/2012
T0608599114_MW-8	37.4549459	-122.1159960	3.702	13	0.000	3.702	4/23/2012
SLT2O104110_MW-1	37.4569596	-121.9105872	36.041	22	9.610	26.431	5/2/2006
SLT2O104110_MW-2	37.4571998	-121.9105345	37.200	22	10.410	26.790	5/2/2006
SLT2O104110_MW-3	37.4573411	-121.9101152	37.217	20	9.320	27.897	5/2/2006

Note – If the minimum depth to water occurred on more than one day, the Date reflects that last occurrence between the period of 2000 to 2020.

APPENDIX C

Interpolation Method Comparison and Validation

APPENDIX C – INTERPOLATION METHOD COMPARISON AND VALIDATION

Appendix C compares the existing highest groundwater condition map created using four different interpolation methods: spline, kriging, inverse distance weighting (IDW), and multi-quadratic radial basis (MQRB). Each of these interpolation methods uses a different mathematical function and a limited number of measured data points to predict raster cell values in GIS, and these methods are often used to predict unknown values across a given geographic area where measured data is not available. Interpolation inherently introduces uncertainty into maps, such as those of existing highest groundwater conditions (Chapter 4) and future groundwater conditions assuming sea-level rise (Appendix D). Appendix C also presents a validation of the spline-based map of existing highest groundwater conditions using an independent data set of groundwater levels from the historically wet winter of 2022-2023.

C.1 Comparison of Interpolation Methods

Tables C-1 and C-2 summarize and compare the area and percentage of emergent and shallow groundwater relative to the outcome measure–lower threshold based on each of the four different interpolation methods. Table C-1 shows results when the salt ponds are excluded from the area and percentage calculations, and Table C-2 shows results when the salt ponds are included. Emergent groundwater refers to locations where the interpolated highest groundwater level is above ground surface. Shallow groundwater is defined as locations where the interpolated depth to water is 0 to 3 feet below ground surface (bgs). The total area of the outcome measure–lower threshold is 81 square miles, which is used to calculate the percentage of outcome measure–lower threshold that is interpolated as emergent groundwater and shallow groundwater in both Table C-1 and Table C-2. The results in Tables C-1 and C-2 are summarized from each map of existing highest groundwater conditions using interpolation methods by spline (Figures C-1), kriging (Figures C-2), IDW (Figures C-3), and MQRB (Figures C-4).

Appendix C illustrates that the four interpolation methods produce groundwater condition maps with substantially different locations and area (in square miles) of emergent and shallow groundwater. Valley Water uses the spline interpolation because this method exactly honors the input data points, which tends to create reasonably smooth groundwater elevation contour maps that represent actual groundwater conditions in an aquifer (Figures C-1). In contrast, the kriging, IDW, and MQRB interpolation methods tend to produce maps with irregular and discontinuous contour boundaries that are less representative of actual groundwater conditions in an aquifer (Figures C-2 to C-4). For example, these three methods produce maps with very large areas of emergent groundwater (Figures C-2 to C-4) that are not consistent with observed data.

The kriging, IDW, and MQRB interpolation methods also tend to overestimate the area of groundwater emergence compared to the spline method. In Tables C-1 and C-2, emergent groundwater based on spline interpolation is 1.7 and 2.9 square miles (2.1 and 3.6% of the outcome measure–lower threshold), while MQRB interpolation is about 2.5 to 3 times greater at 5.3 and 7.6 square miles (6.5 and 9.4% of the outcome measure–lower threshold). Using the spline method to create the maps is important to minimize overestimates of emergent groundwater. As described in Chapter 4, recent groundwater elevation data from the historically wet winter of 2023 were used to help verify the existing highest groundwater condition maps, and the 2023 data indicate that even the spline-based maps tend to overestimate the actual groundwater emergence conditions.

Tables C-1 and C-2 indicate less variability in the estimated shallow groundwater area compared to the emergent groundwater among the four interpolation methods because the difference in the interpolation methods is buffered by the range in depth to water up to 3 feet bgs. There is more apparent variability in emergent groundwater because the interpolated groundwater contours are compared to the actual ground surface, making differences among the four interpolated groundwater emergent areas more prominent.

Table C-1. Comparison of shallow and emergent groundwater area estimated by interpolation method, excluding the salt ponds

Interpolation Method	Emergent Groundwater		Shallow Groundwater (0 to 3 feet below ground surface)	
	Area (square miles)	Percentage of OM–LT (%)	Area (square miles)	Percentage of OM–LT (%)
Spline	1.7	2.1%	12	15%
Kriging	4.2	5.2%	12	15%
IDW	5.1	6.3%	13	16%
MQRB	5.3	6.5%	13	16%

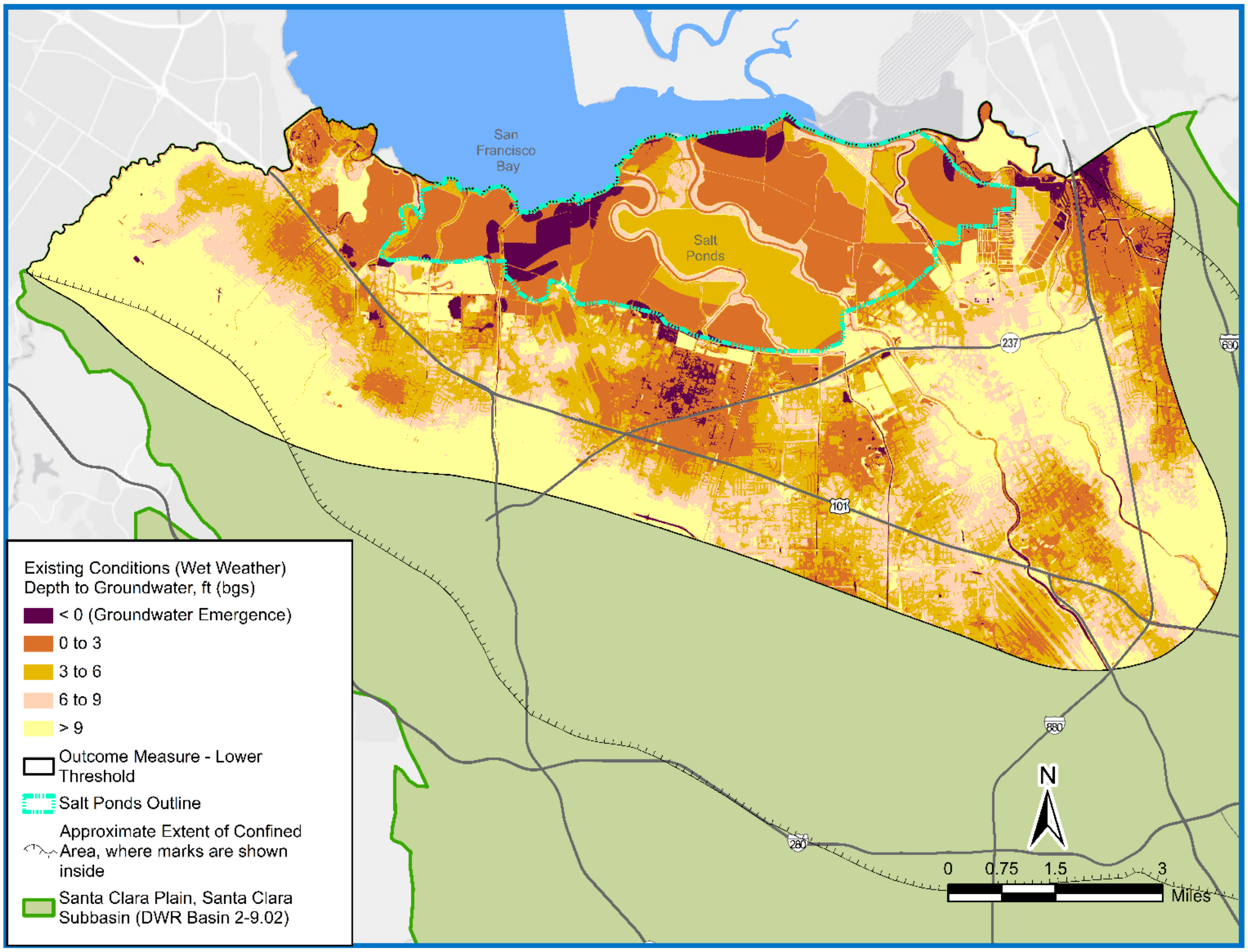
Note: OM–LT = seawater intrusion outcome measure–lower threshold (81 square miles and includes 14 square miles of salt ponds).

Table C-2. Comparison of shallow and emergence groundwater area estimated by interpolation method, including the salt ponds

Interpolation Method	Emergent Groundwater		Shallow Groundwater (0 to 3 feet below ground surface)	
	Area (square miles)	Percentage of OM–LT (%)	Area (square miles)	Percentage of OM–LT (%)
Spline	2.9	3.6	20	25%
Kriging	6.5	8.0	19	23%
IDW	7.6	9.4	19	23%
MQRB	7.6	9.4	19	23%

Note: OM–LT = seawater intrusion outcome measure–lower threshold (81 square miles and includes 14 square miles of salt ponds).

Figure C-1. Existing highest groundwater conditions within the seawater intrusion outcome measure–lower threshold from 2000 to 2020 created using spline interpolation method



Note: ft (bgs), feet below ground surface. This map is a temporal composite of the highest recorded groundwater levels at individual wells between 2000 and 2020 and thus is a theoretical highest case scenario for shallow groundwater. Under real-world conditions, it is unlikely that all wells would simultaneously have the highest recorded water levels. This map tends to overestimate the presence of shallow and emergent groundwater.

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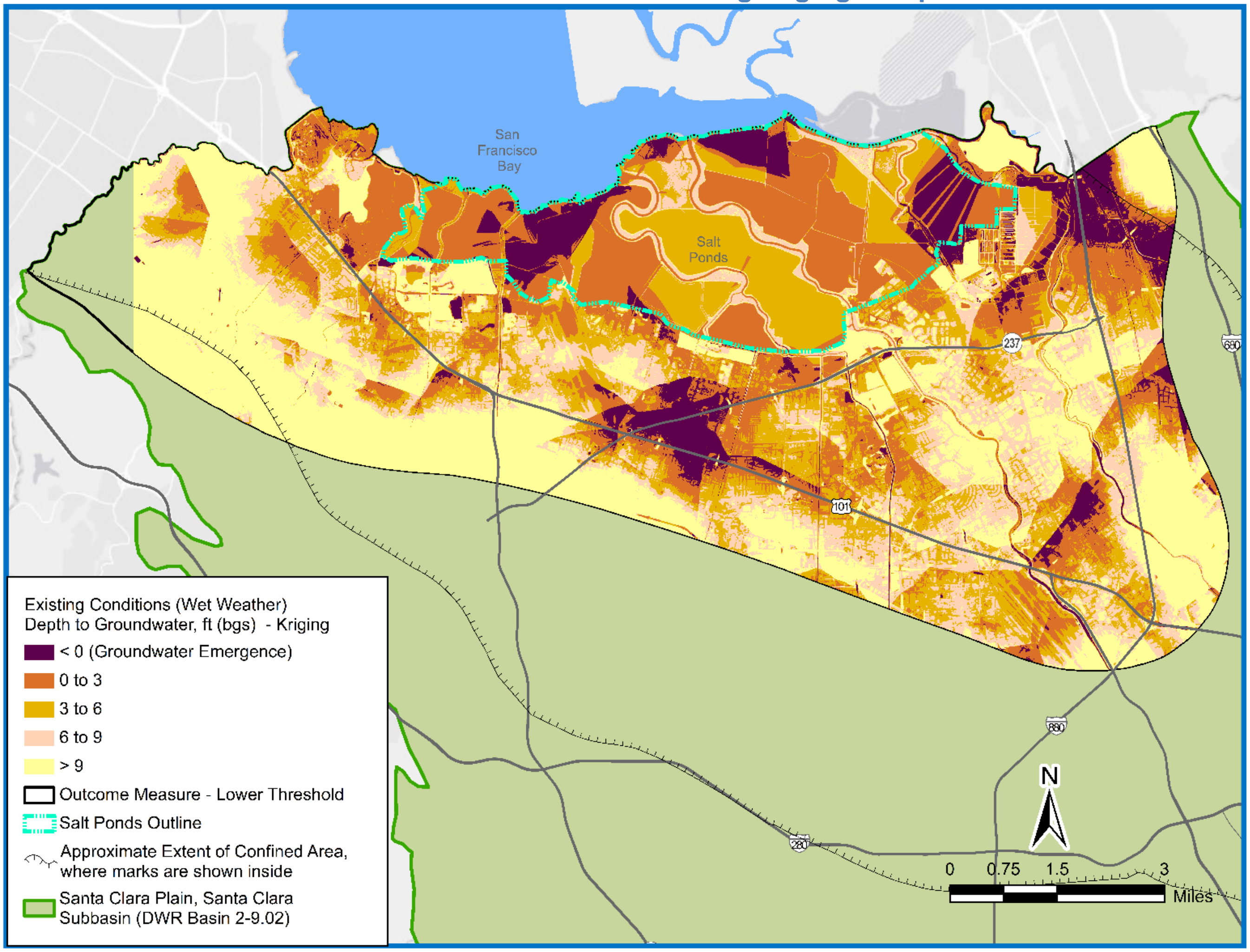
Figure C-2. Existing highest groundwater conditions within the seawater intrusion outcome measure–lower threshold from 2000 to 2020 created using kriging interpolation method



Note: ft (bgs), feet below ground surface. This map is a temporal composite of the highest recorded groundwater levels at individual wells between 2000 and 2020 and thus is a theoretical highest case scenario for shallow groundwater. Under real-world conditions, it is unlikely that all wells would simultaneously have the highest recorded water levels. This map tends to overestimate the presence of shallow and emergent groundwater.

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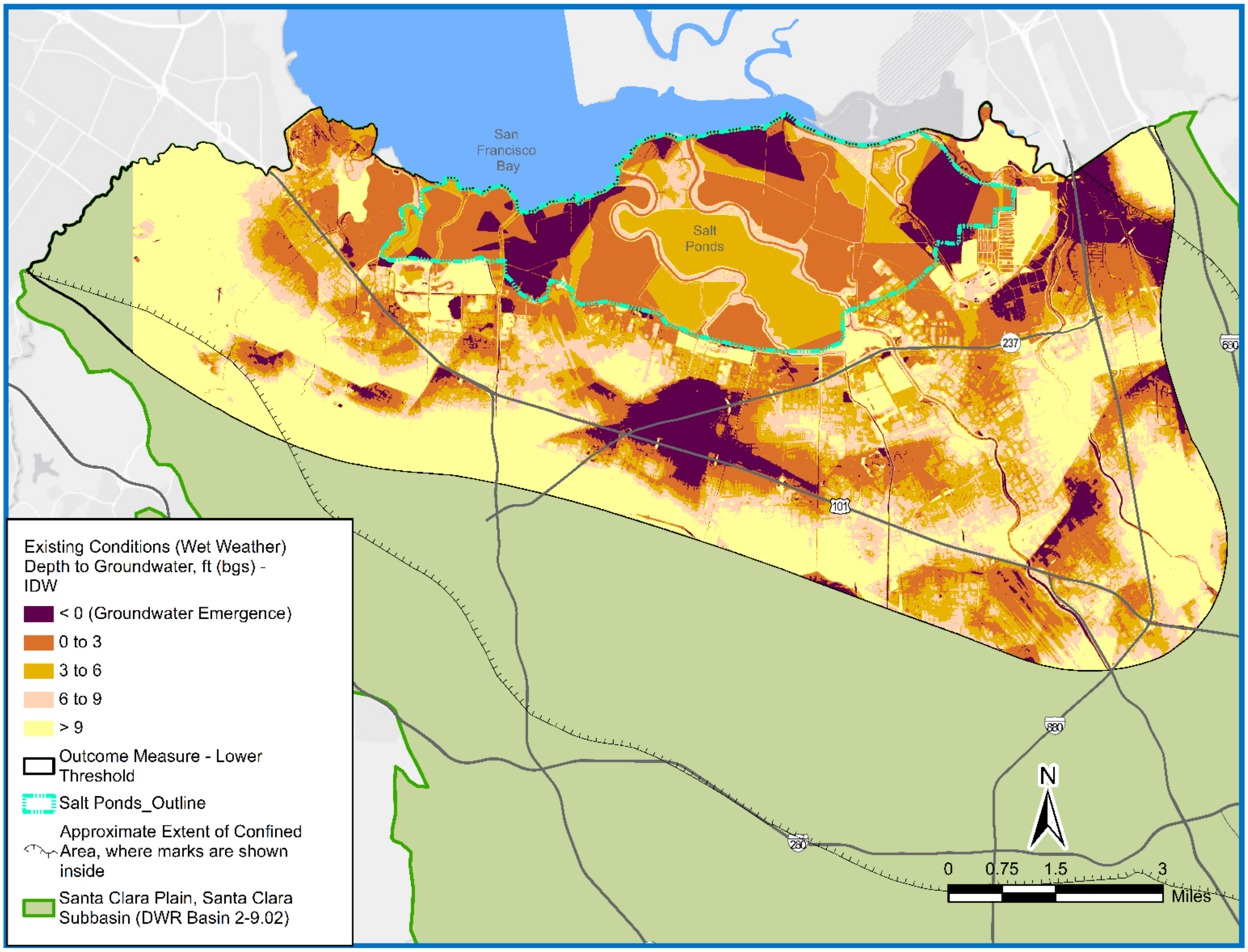
Figure C-3. Existing highest groundwater conditions within the seawater intrusion outcome measure–lower threshold from 2000 to 2020 created using inverse distance weighting (IDW) interpolation method



Note: ft (bgs), feet below ground surface. This map is a temporal composite of the highest recorded groundwater levels at individual wells between 2000 and 2020 and thus is a theoretical highest case scenario for shallow groundwater. Under real-world conditions, it is unlikely that all wells would simultaneously have the highest recorded water levels. This map tends to overestimate the presence of shallow and emergent groundwater.

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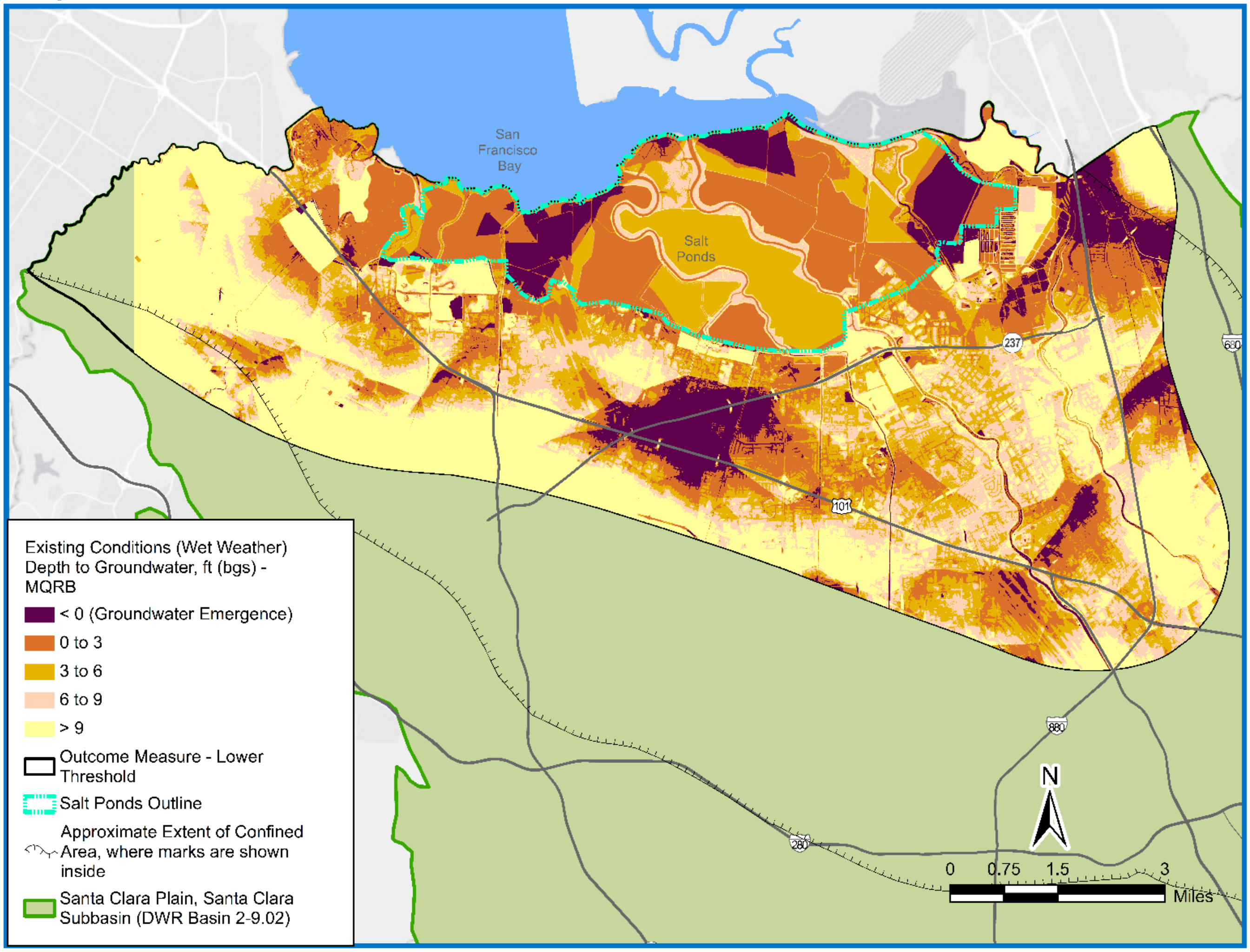
Figure C-4. Existing highest groundwater conditions within the seawater intrusion outcome measure–lower threshold from 2000 to 2020 created using multi-quadratic radial basis (MQRB) interpolation method



Note: ft (bgs), feet below ground surface. This map is a temporal composite of the highest recorded groundwater levels at individual wells between 2000 and 2020 and thus is a theoretical highest case scenario for shallow groundwater. Under real-world conditions, it is unlikely that all wells would simultaneously have the highest recorded water levels. This map tends to overestimate the presence of shallow and emergent groundwater.

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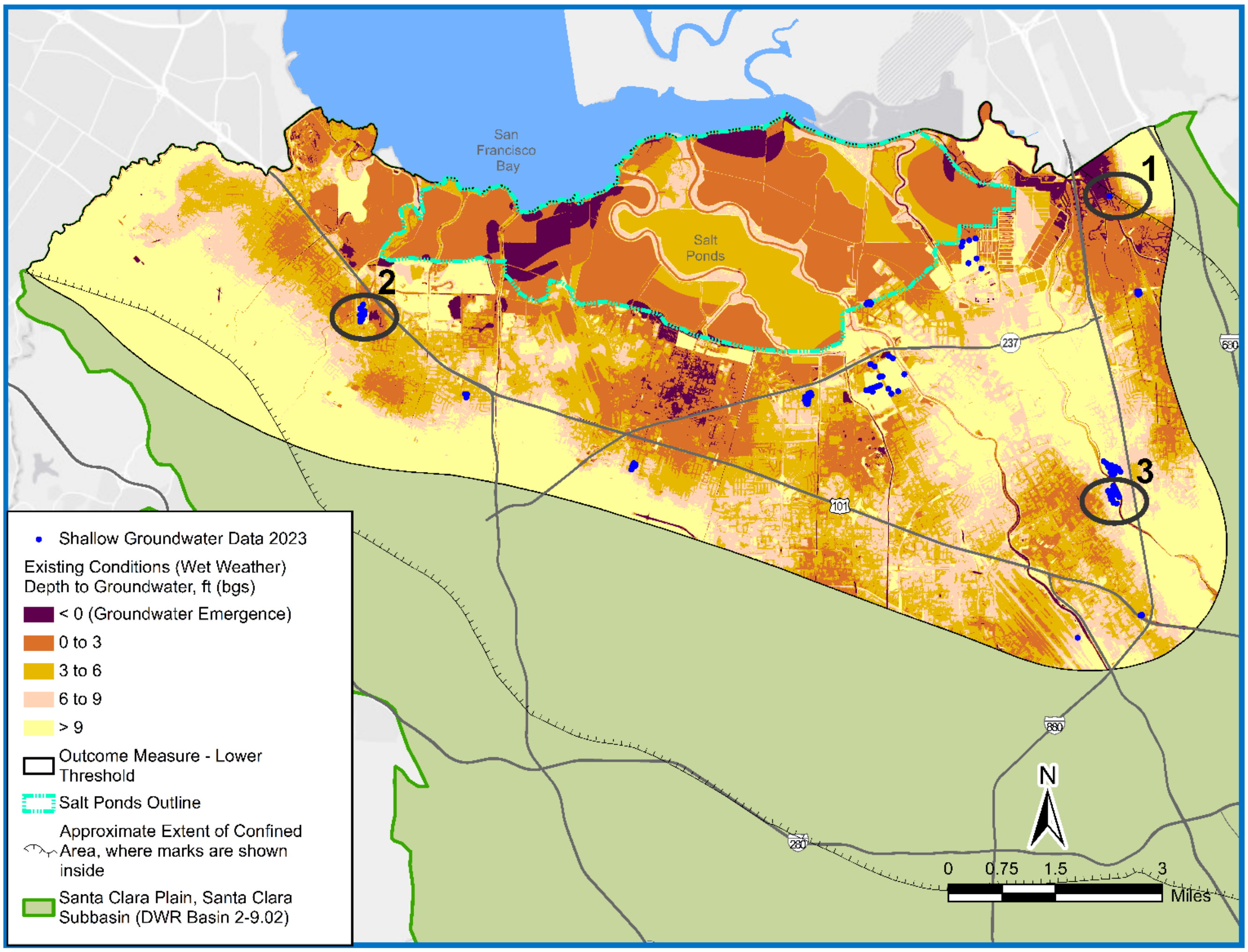
C.2 Validation of Existing Highest Groundwater Condition Maps

To help verify the spline-based map of existing highest groundwater conditions, an independent data set of depth to water measurements from 317 GeoTracker wells during the historically wet winter of 2022-2023 is shown on Figure C-5 and Table C-1. These depth to water measurements include all available data in GeoTracker and were compiled and filtered following the methods outlined in Chapter 4 and Appendix B. Therefore, this validation data set represents the highest groundwater levels within the shallow groundwater aquifer between January and May 2023, a period that was a historically wet winter for Santa Clara County and much of California.

Figure C-5. Location of validation wells with minimum depth to water measured between January and May 2023 and the existing highest groundwater conditions within the seawater intrusion outcome measure–lower threshold from 2000 to 2020

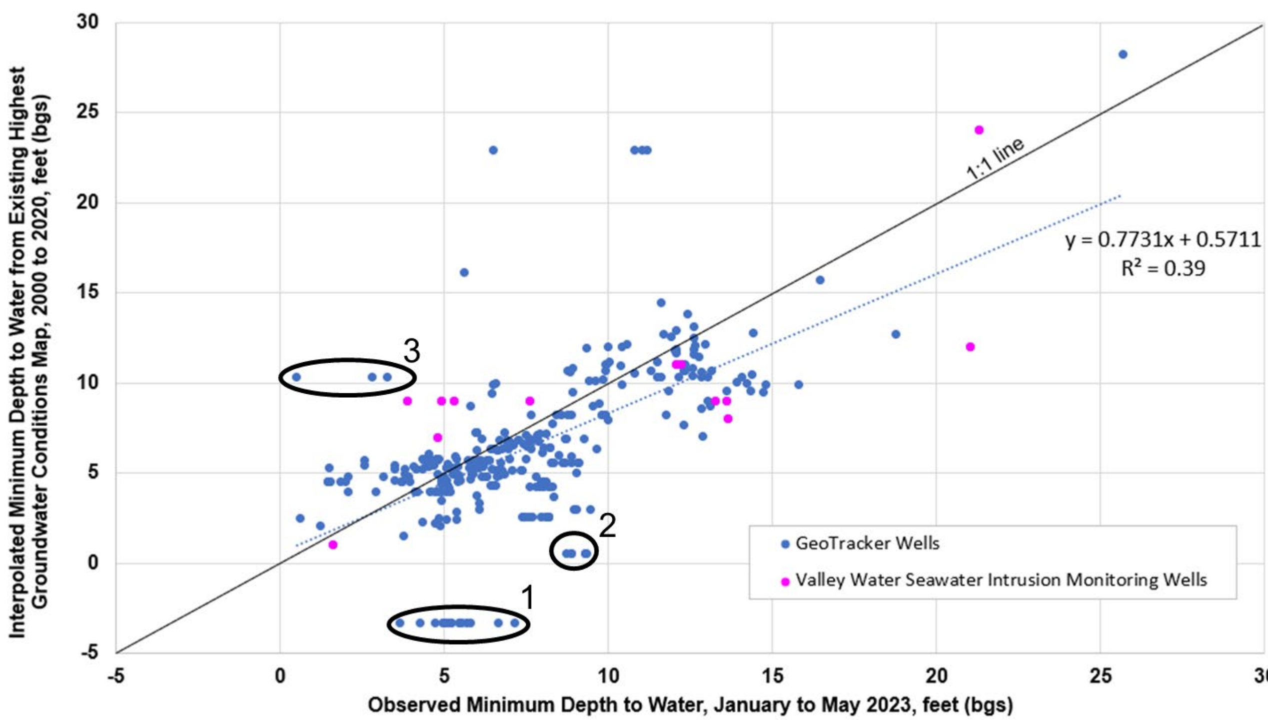


Notes: Wells in circles 1, 2, and 3 correspond to the data points in circles 1, 2, and 3 in Figure C-6. This figure is modified from Figure C-1.

In Figure C-6, the observed minimum 2023 depth to water measurements from the 317 wells (validation data set) are compared to the interpolated minimum 2000-2020 depth to water measurement from the existing highest groundwater conditions map. As an additional validation dataset, the observed minimum depth to water measurements between January and May 2023 from Valley Water' seawater intrusion monitoring wells (Figure 3-4 and Table 3-1) are also shown on Figure C-6. Data points above the 1:1 line indicate the interpolated depth to water values are greater (e.g., groundwater is deeper) than the observed values, while data points below the 1:1 line indicate the interpolated values are less than the observed values (Figure C-6). Data points above the 1:1 line represent locations where the interpolated map tends to underpredict the presence of shallow groundwater. Conversely, data points below the 1:1 line represent locations where the interpolated map tends to overestimate the presence of shallow groundwater and groundwater emergence.

The linear regression has a relatively low coefficient of determination (R^2 = 0.39), indicating a relatively weak fit between the observed and interpolated minimum depth to water values (Figure C-6). Additionally, the regression line falls below the 1:1 line because most of the data points fall below this line, illustrating the extent to which the map tends to overestimate shallow groundwater and groundwater emergence. A total of 70% (230 of 330) of the 2023 validation data fall below the 1:1 line, indicating the magnitude that the map tends to overestimate shallow groundwater and groundwater emergence (Figure C-6). About half of the seawater intrusion wells are above the 1:1 line and about half are below the line (Figure C-6). While a few of the seawater intrusion monitoring wells are close to the 1:1 line and indicate the interpolated map is a good estimate of observed depth to water, the map underestimates shallow groundwater by as much as 5 feet and overestimates shallow groundwater by as much as 9 feet at other seawater intrusion monitoring wells (Figure C-6).

Figure C-6. Observed minimum depth to water (January to May 2023) versus interpolated minimum depth to water measured extracted from the existing highest groundwater conditions map (2000 to 2020)



Notes: the dotted line is the linear regression. Data points in circles 1, 2, and 3 correspond to the well locations in related circles in Figure C-5. Data points below the 1:1 line represent locations where the interpolated map overestimates shallow groundwater and groundwater emergence. Five of the seawater intrusion monitoring wells are not shown because either no water level data was available between January and May, 2023 (06S01W12G005, 06S01W14L005, and 06S02W06J003), the well (07S01E09L008) is outside the interpolated area shown on Figure C-5, or the well screen is deeper than 50 feet below ground surface (bgs) (06S02W05F003).

Additional examples of this overestimation and underestimation are illustrated by the circles in Figures C-5 and C-6. Circles 1 and 2 are locations where the interpolated map overestimates shallow groundwater and groundwater emergence, while circle 3 is where the interpolated map underestimates shallow groundwater. These three sets of locations are highlighted here because they represent some of the most notable cases of over- and under-estimates based on the 2023 validation data. In circle 1, there are 16 well locations where the map indicates about 3 feet of groundwater emergence, while the observed (actual) depth to water measurements in 2023 range from about 4 to 7 feet bgs. This indicates the map overestimates groundwater emergence by about 7 to 10 feet at those locations. In circle 2, there are 6 well locations where the map indicates shallow groundwater with about 0.5 feet minimum depth to water, while the observed depth to water in 2023 is about 9 feet bgs, an overestimate of almost 10 feet at those locations. In circle 3, there are 3 well locations where the map indicates about 10.3 feet minimum depth to water, while the observed measurements in 2023 range from about 0.5 to 4 feet bgs. In this case, the map underestimates shallow groundwater conditions by almost 11 to 14 feet at those locations.

This validation provides important insight into the proper interpretation and appropriate use of the map of existing highest groundwater conditions (Figures 4-1, 4-2, and C-5):

- The map represents estimated (interpolated) highest groundwater conditions, and in some locations, the actual highest groundwater may be shallower (closer to land surface) than shown on the map. However, in most locations, the actual highest groundwater is deeper (further away from land surface) than shown in the map. Importantly, the map also tends to overestimate locations of groundwater emergence.
- This study presents maps created using the spline interpolation method (Figures 4-2, C-1, and C-5) because the other interpolation methods (kriging, IDW, and MQRB) tend to produce even greater overestimates of shallow groundwater and groundwater emergence, and in many cases, very unrealistic spatial extents of groundwater emergence (Figure C-2 to C-4).
- The maps of existing highest groundwater conditions (Figures 4-1 and 4-2) are used to project how future sea-level rise will impact shallow groundwater and groundwater emergence. Because the maps of existing highest groundwater conditions tend to overestimate the presence of shallow groundwater and groundwater emergence, the maps of future groundwater conditions assuming sea-level rise are also likely to overestimate future conditions of shallow groundwater and groundwater emergence. A validation of the maps of future groundwater conditions is discussed further in Appendix D.

Table C-1. GeoTracker wells with 2023 minimum depth to water measurements

GeoTracker Global ID_Field Point Name	Latitude	Longitude	Ground Surface Elevation (feet NAVD88)	Well Depth (feet below ground surface)	2023 Minimum Depth to Water (feet below ground surface)	Date
SL0002020074_MW-33	37.3899467	-121.9106236	43.743	NA	0.50	4/26/2023
T10000012628_MW-5	37.4311111	-121.9060441	16.594	NA	0.60	3/15/2023
L10002780473_G-3	37.4411334	-121.9491623	4.522	NA	1.21	1/31/2023
SL18228626_P24A	37.4081220	-121.9896767	7.829	NA	1.45	1/9/2023
SL18228626_21A	37.4081337	-121.9896709	7.832	NA	1.46	1/9/2023
SL18228626_20A	37.4081341	-121.9896434	7.964	NA	1.48	1/9/2023
SL18228626_22A	37.4081344	-121.9896988	7.940	NA	1.48	1/9/2023
SL18228626_27A	37.4081305	-121.9896363	7.930	NA	1.50	1/9/2023
SL18228626_P23A	37.4081223	-121.9896314	7.881	NA	1.52	1/9/2023
SL18228626_19A	37.4081334	-121.9896125	8.496	NA	1.82	1/9/2023
SL18228626_26A	37.4081304	-121.9896194	8.103	NA	1.98	1/9/2023
SL18288709_PB3-2R	37.4260771	-122.1032561	5.089	NA	2.05	2/20/2023

SL18288709_LDPC-1-1	37.4239220	-122.1039939	6.333	NA	2.08	2/20/2023
SL18288709_PB3-3	37.4252502	-122.1039419	5.551	NA	2.55	2/20/2023
SL18288709_PB2-7	37.4249748	-122.1034556	5.974	NA	2.58	2/20/2023
SL0002020074_MW-9	37.3899467	-121.9106236	43.743	NA	2.81	4/26/2023
SL18288709_LDPC-1-2	37.4239220	-122.1039939	6.333	NA	2.93	2/20/2023
SL18228626_P16A	37.4081360	-121.9903629	6.333	NA	3.15	1/9/2023
SL0002020074_MW-10	37.3899467	-121.9106236	43.743	NA	3.25	4/26/2023
SL18228626_P17A	37.4087946	-121.9903420	6.705	NA	3.48	1/9/2023
SL18228626_P33A	37.4077641	-121.9895986	7.795	NA	3.48	1/9/2023
SL18228626_P32A	37.4077961	-121.9895980	7.802	NA	3.50	1/9/2023
SLT2O107113_EW1	37.4505849	-121.9135583	13.824	NA	3.64	3/20/2023
SL18228626_P44A	37.4081653	-121.9896729	6.609	NA	3.70	1/9/2023
SL18228626_P42A	37.4081913	-121.9896312	6.655	NA	3.72	1/9/2023
L10002780473_G-2	37.4398530	-121.9510761	4.570	NA	3.75	1/31/2023
SL18228626_3A	37.4081304	-121.9902428	7.362	NA	3.78	1/9/2023
SL18228626_9A	37.4077077	-121.9896000	7.717	NA	3.78	1/9/2023
L10002780473_G-5	37.4407679	-121.9507832	7.249	NA	3.93	1/31/2023
SL18228626_P43A	37.4081648	-121.9895987	6.906	NA	3.95	1/9/2023
SL18228626_2A	37.4074671	-121.9899721	7.827	NA	4.05	1/9/2023
SL18288709_CMT1D-1	37.4239319	-122.1040119	6.258	NA	4.09	2/20/2023
SL18228626_P34A	37.4077365	-121.9895981	7.679	NA	4.15	1/9/2023
SL18288709_CMT1D-2	37.4239319	-122.1040119	6.258	NA	4.17	2/20/2023
SLT2O107113_OBN2	37.4505849	-121.9135583	13.824	NA	4.27	3/20/2023
SL18228626_P40A	37.4077657	-121.9896832	7.692	NA	4.32	1/9/2023
SL18228626_25A	37.4080928	-121.9896405	7.625	NA	4.32	1/9/2023
T10000012628_MW6	37.4312379	-121.9061887	15.780	NA	4.33	3/15/2023
SL18228626_P39A	37.4075399	-121.9896765	7.975	NA	4.38	1/9/2023
SL18228626_6B	37.4080707	-121.9896412	7.678	NA	4.44	1/9/2023
SL18228626_P31A	37.4078742	-121.9895961	7.844	NA	4.48	1/9/2023
SL18228626_P30A	37.4079287	-121.9895961	7.806	NA	4.50	1/9/2023
SL18228626_P35A	37.4076514	-121.9895976	7.936	NA	4.52	1/9/2023
SL18228626_1A	37.4080119	-121.9897095	7.802	NA	4.52	1/9/2023
SL18288709_CMT1U-1	37.4239131	-122.1039819	6.648	NA	4.55	2/20/2023
SL18228626_E7A	37.4079284	-121.9896772	7.625	NA	4.68	1/9/2023
SL18228626_10A	37.4085158	-121.9895499	7.116	NA	4.68	1/9/2023
SL18228626_P45A	37.4081078	-121.9896961	7.837	NA	4.68	1/9/2023
SL18228626_P36A	37.4076047	-121.9895974	8.120	NA	4.68	1/9/2023
SL18288709_CMT1U-2	37.4239131	-122.1039819	6.648	NA	4.71	2/20/2023
SLT2O107113_OBS	37.4505849	-121.9135583	13.824	NA	4.73	3/20/2023
T10000012628_MW7	37.4310661	-121.9061467	15.884	NA	4.74	3/15/2023
SL18288709_PB1-2	37.4230257	-122.1038296	8.218	NA	4.76	2/20/2023
T10000011881_MW-2C	37.4079960	-122.0765663	36.682	NA	4.80	3/15/2023
SL18228626_P37A	37.4075396	-121.9895965	8.333	NA	4.80	1/9/2023
SL18288709_CMT1D-3	37.4239319	-122.1040119	6.258	NA	4.81	2/20/2023
SL18228626_P41A	37.4081054	-121.9896091	8.030	NA	4.82	1/9/2023
T10000012628_MW-3	37.4310598	-121.9060585	16.431	NA	4.83	3/15/2023
T10000012628_MW-4	37.4311480	-121.9060803	16.443	NA	4.88	3/15/2023
SL18288709_LDPC-1-4	37.4239220	-122.1039939	6.333	NA	4.90	2/20/2023
L10002780473_G-12	37.4415094	-121.9475453	7.554	NA	4.91	1/31/2023

SL18288709_CMT3U-1	37.4239867	-122.1039644	6.986	NA	4.91	2/20/2023
T10000012628_MW10	37.4313098	-121.9057569	16.997	NA	4.92	3/15/2023
SLT2O107113_PM7	37.4505849	-121.9135583	13.824	NA	4.97	3/20/2023
SL18228626_12A	37.4091564	-121.9887363	6.988	NA	4.98	1/9/2023
SLT2O107113_PM19	37.4505849	-121.9135583	13.824	NA	5.00	3/20/2023
T10000012628_MW-1	37.4311654	-121.9060213	16.593	NA	5.05	3/15/2023
SL18288709_LDPC-1-7	37.4239220	-122.1039939	6.333	NA	5.05	2/20/2023
SL18288709_CMT3U-2	37.4239867	-122.1039644	6.986	NA	5.05	2/20/2023
SL18288709_LDPC-3-3	37.4239955	-122.1039630	7.034	NA	5.06	2/20/2023
SLT2O107113_PM1	37.4505849	-121.9135583	13.824	NA	5.07	3/20/2023
SL18288709_LDPC-3-1	37.4239955	-122.1039630	7.034	NA	5.07	2/20/2023
SL18262683_LF-10A	37.3945111	-122.0331892	42.815	NA	5.10	3/15/2023
SL18228626_11A	37.4094740	-121.9895345	6.882	NA	5.10	1/9/2023
SL18288709_LDPC-3-4	37.4239955	-122.1039630	7.034	NA	5.11	2/20/2023
T10000012628_MW9	37.4311420	-121.9057005	18.081	NA	5.16	3/15/2023
SLT2O107113_PM18	37.4505849	-121.9135583	13.824	NA	5.18	3/20/2023
SL18288709_CMT1U-3	37.4239131	-122.1039819	6.648	NA	5.18	2/20/2023
SLT2O107113_PM8	37.4505849	-121.9135583	13.824	NA	5.20	3/20/2023
SL18288709_CMT3D-2	37.4240064	-122.1039633	7.123	NA	5.21	2/20/2023
SLT2O107113_PM2	37.4505849	-121.9135583	13.824	NA	5.24	3/20/2023
SL18288709_CMT3D-1	37.4240064	-122.1039633	7.123	NA	5.24	2/20/2023
SL18288709_F25-2	37.4225910	-122.1038456	8.408	NA	5.27	2/20/2023
SL18288709_F25-3	37.4225950	-122.1038205	8.514	NA	5.32	2/20/2023
SL18228626_P38A	37.4074302	-121.9895964	8.660	NA	5.35	1/9/2023
T0608500101_MW6	37.3656712	-121.9037842	50.653	22	5.36	3/20/2023
SL18288709_PB2-1	37.4230255	-122.1038021	8.129	NA	5.37	2/20/2023
T10000012628_MW-2	37.4310665	-121.9059927	16.598	NA	5.39	3/15/2023
SL18288709_F25-1	37.4225923	-122.1038574	8.345	NA	5.42	2/20/2023
SL18288709_F25-4	37.4225968	-122.1038343	8.493	NA	5.43	2/20/2023
SL18228626_13A	37.4096593	-121.9889364	6.483	NA	5.46	1/9/2023
SLT2O107113_PM4	37.4505849	-121.9135583	13.824	NA	5.47	3/20/2023
SL18262683_LF-65B1	37.3945543	-122.0331832	42.794	NA	5.47	3/15/2023
SLT2O107113_PM20	37.4505849	-121.9135583	13.824	NA	5.48	3/20/2023
SL18288709_CMT3U-3	37.4239867	-122.1039644	6.986	NA	5.50	2/20/2023
SLT2O107113_PM9	37.4505849	-121.9135583	13.824	NA	5.52	3/20/2023
L10002780473_PZ-1	37.4374444	-121.9472139	7.926	NA	5.59	1/31/2023
SLT2O107113_PM21	37.4505849	-121.9135583	13.824	NA	5.68	3/20/2023
T0608500101_MW4	37.3655562	-121.9039924	51.267	20	5.74	3/20/2023
SL18288709_LDPC-3-5	37.4239955	-122.1039630	7.034	NA	5.76	2/20/2023
T0608552020_MW-5	37.4280558	-121.9738415	7.020	NA	5.78	4/10/2023
SLT2O107113_PM5	37.4505849	-121.9135583	13.824	NA	5.79	3/20/2023
T0608500101_MW2	37.3654893	-121.9037449	50.679	19	5.79	3/20/2023
SL18288709_LDPC-3-7	37.4239955	-122.1039630	7.034	NA	5.79	2/20/2023
T10000011881_MW-2B	37.4080453	-122.0765503	36.435	NA	5.82	3/15/2023
SL18288709_F8	37.4231044	-122.1033971	8.207	NA	5.86	2/20/2023
T0608500101_EW-5	37.3655349	-121.9040044	51.254	18	5.87	3/20/2023
T0608500101_EW-6	37.3655248	-121.9040868	51.376	18	5.88	3/20/2023
SL18288709_CMT3D-3	37.4240064	-122.1039633	7.123	NA	5.94	2/20/2023
T0608500101_EW-1	37.3654757	-121.9040015	51.193	29	5.97	3/20/2023

L10006514573_G-21	37.4174240	-121.9691727	5.543	NA	5.98	5/23/2023
T0608500101_EW-4	37.3654703	-121.9040101	51.197	18	5.98	3/20/2023
T0608500101_MW3	37.3654602	-121.9039988	51.195	16	5.98	3/20/2023
T0608500101_EW-2	37.3655345	-121.9039929	51.237	29	5.99	3/20/2023
SL18262683_LF-72B1	37.3939156	-122.0339334	46.199	NA	6.00	3/15/2023
T10000012628_MW8	37.4308466	-121.9061130	16.650	NA	6.05	3/15/2023
SL18288709_F13	37.4247489	-122.1028697	6.802	NA	6.05	2/20/2023
T10000012628_MW11	37.4306577	-121.9059272	17.174	NA	6.06	3/15/2023
T0608500101_MW5	37.3655322	-121.9040823	51.382	21	6.11	3/20/2023
T0608500101_EW-3	37.3655322	-121.9040941	51.399	30	6.14	3/20/2023
L10002780473_G-14	37.4408003	-121.9507957	5.013	NA	6.15	1/31/2023
SL18262683_LF-58B1	37.3942747	-122.0333049	44.576	NA	6.15	3/15/2023
SL18262683_PT-5S	37.3941369	-122.0337986	46.246	NA	6.15	3/15/2023
SL18262683_LF-63B1	37.3946336	-122.0334306	43.737	NA	6.17	3/15/2023
T10000011881_MW-4B	37.4082316	-122.0764089	35.849	NA	6.27	3/15/2023
T10000011881_MW-4C	37.4082318	-122.0763951	35.981	NA	6.30	3/15/2023
SL18262683_MW-3A	37.3945931	-122.0334896	43.619	NA	6.30	3/15/2023
SL18262683_MW-3B1	37.3945897	-122.0334730	43.619	NA	6.38	3/15/2023
T10000011881_MW-3B	37.4082457	-122.0769115	35.751	NA	6.41	3/15/2023
SL18262683_LF-71B1	37.3944611	-122.0338197	45.728	NA	6.41	3/15/2023
T0608552020_MW-8A	37.4281028	-121.9741813	8.022	NA	6.45	4/10/2023
SL18262683_LF-7A	37.3946894	-122.0335715	44.179	NA	6.47	3/15/2023
SL18262683_PT-4S	37.3941110	-122.0338350	46.183	NA	6.47	3/15/2023
T10000011881_MW-3C	37.4082455	-122.0769007	35.697	NA	6.48	3/15/2023
L10006514573_H-07	37.4100720	-121.9731942	27.728	NA	6.48	5/23/2023
T0608552020_MW-7A	37.4278723	-121.9750808	8.175	NA	6.49	4/10/2023
SL18262683_PT-3S	37.3940834	-122.0338684	46.121	NA	6.54	3/15/2023
SL18288709_CMT9U-1	37.4239872	-122.1037789	8.612	NA	6.56	2/20/2023
L10006514573_G-13	37.4103874	-121.9747425	11.809	NA	6.56	5/23/2023
T10000011881_MW-3A	37.4082456	-122.0769230	35.782	NA	6.57	3/15/2023
T10000011881_MW-4A	37.4082312	-122.0764199	35.896	NA	6.60	3/15/2023
SL18262683_LF-54B1	37.3939117	-122.0339886	46.519	NA	6.61	3/15/2023
SL18288709_CMT9U-2	37.4239872	-122.1037789	8.612	NA	6.63	2/20/2023
SLT2O107113_PM6	37.4505849	-121.9135583	13.824	NA	6.64	3/20/2023
SL18262683_LF-60B1	37.3945698	-122.0337895	45.242	NA	6.65	3/15/2023
SL18262683_PT-6S	37.3940402	-122.0339716	46.780	NA	6.67	3/15/2023
T10000011881_MW-1B	37.4075903	-122.0765570	37.107	NA	6.69	3/15/2023
T10000011881_MW-1A	37.4075906	-122.0765692	37.116	NA	6.70	3/15/2023
SL18288709_LDPC-9-1	37.4239963	-122.1037771	8.716	NA	6.70	2/20/2023
SL18288709_LDPC-9-4	37.4239963	-122.1037771	8.716	NA	6.71	2/20/2023
SL18262683_M-7A	37.3942621	-122.0332851	44.402	NA	6.73	3/15/2023
SL18288709_LDPC-9-3	37.4239963	-122.1037771	8.716	NA	6.74	2/20/2023
SL18262683_PT-2A	37.3941046	-122.0338676	46.075	NA	6.76	3/15/2023
T10000011881_MW-2A	37.4080459	-122.0765350	36.291	NA	6.82	3/15/2023
SL18262683_SD-3	37.3940015	-122.0340347	46.860	NA	6.84	3/15/2023
SL18262683_SD-2	37.3940471	-122.0340219	46.963	NA	6.90	3/15/2023
SL18262683_PT-1S	37.3940238	-122.0339386	46.477	NA	6.93	3/15/2023
SL18288709_CMT9D-1	37.4240069	-122.1037792	8.829	NA	6.96	2/20/2023
SL18262683_IP-6	37.3940470	-122.0339195	46.408	NA	6.97	3/15/2023

SL18288709_CMT9D-2	37.4240069	-122.1037792	8.829	NA	6.97	2/20/2023
SL18262683_LF-68B1	37.3943510	-122.0338190	46.261	NA	6.98	3/15/2023
SL18262683_LF-62B1	37.3948048	-122.0336709	44.172	NA	7.00	3/15/2023
SL18262683_IP-9	37.3941193	-122.0338379	46.111	NA	7.04	3/15/2023
SL18288709_CMT9U-3	37.4239872	-122.1037789	8.612	NA	7.06	2/20/2023
SL18262683_PT-1A	37.3940284	-122.0339333	46.496	NA	7.09	3/15/2023
SL18262683_LF-44B1	37.3941771	-122.0339050	46.505	NA	7.09	3/15/2023
SLT2O107113_PM22	37.4505849	-121.9135583	13.824	NA	7.14	3/20/2023
SL18262683_PT-6A	37.3940298	-122.0339813	46.720	NA	7.25	3/15/2023
SL18262683_SD-1	37.3940909	-122.0340055	46.997	NA	7.26	3/15/2023
SL18288709_LDPC-9-5	37.4239963	-122.1037771	8.716	NA	7.35	2/20/2023
SL18288709_PMW29U	37.4239878	-122.1031983	9.492	NA	7.39	2/20/2023
SL18288709_LDPC-9-7	37.4239963	-122.1037771	8.716	NA	7.39	2/20/2023
SL18262683_IP-1	37.3941944	-122.0339129	46.543	NA	7.43	3/15/2023
SL18288709_CMT29U-1	37.4239911	-122.1031986	9.598	NA	7.44	2/20/2023
L10006514573_G-07	37.4152370	-121.9727590	5.789	NA	7.48	5/23/2023
SL18262683_IP-5	37.3941955	-122.0338688	46.352	NA	7.50	3/15/2023
SL18288709_CMT9D-3	37.4240069	-122.1037792	8.829	NA	7.54	2/20/2023
SL18288709_CMT29U-2	37.4239911	-122.1031986	9.598	NA	7.57	2/20/2023
SL18288709_CMT22U-1	37.4239897	-122.1033767	9.614	NA	7.59	2/20/2023
SL18262683_PT-3A	37.3941909	-122.0337892	46.218	NA	7.60	3/15/2023
SL18262683_MW-1B1	37.3942863	-122.0337955	46.462	NA	7.61	3/15/2023
SL18262683_LF-8A	37.3945229	-122.0333952	45.148	NA	7.63	3/15/2023
SL20266884_MW-20	37.3607804	-121.9199913	52.617	24	7.64	5/18/2023
SL18288709_CMT29U-3	37.4239911	-122.1031986	9.598	NA	7.69	2/20/2023
SL18262683_LF-6A	37.3942177	-122.0338195	46.245	NA	7.70	3/15/2023
SL18288709_CMT22U-2	37.4239897	-122.1033767	9.614	NA	7.78	2/20/2023
T10000012628_MW12	37.4308772	-121.9055241	19.331	NA	7.80	3/15/2023
SL18262683_IP-2	37.3942338	-122.0338737	46.602	NA	7.83	3/15/2023
SL18262683_MW-1A	37.3942861	-122.0338268	46.529	NA	7.88	3/15/2023
SL18288709_LDPC-22-3	37.4239982	-122.1033754	9.703	NA	7.92	2/20/2023
SL18262683_MW-2B1	37.3945279	-122.0335004	45.787	NA	7.92	3/15/2023
SL18288709_LDPC-29-4	37.4240000	-122.1031969	9.665	NA	7.95	2/20/2023
SL18288709_CMT29D-3	37.4240150	-122.1031978	9.725	NA	7.97	2/20/2023
SL18288709_CMT29D-2	37.4240150	-122.1031978	9.725	NA	7.98	2/20/2023
L10006514573_G-17	37.4132206	-121.9707456	7.389	NA	7.98	5/23/2023
SL18288709_CMT22U-3	37.4239897	-122.1033767	9.614	NA	8.02	2/20/2023
SL18288709_CMT22D-1	37.4240089	-122.1033775	9.845	NA	8.02	2/20/2023
SL18288709_PMW29D	37.4240106	-122.1031978	9.691	NA	8.04	2/20/2023
SL18288709_CMT29D-1	37.4240150	-122.1031978	9.725	NA	8.09	2/20/2023
SL18262683_MW-2A	37.3945288	-122.0335175	45.987	NA	8.10	3/15/2023
SL18288709_LDPC-29-6	37.4240000	-122.1031969	9.665	NA	8.11	2/20/2023
SL18288709_LDPC-29-7	37.4240000	-122.1031969	9.665	NA	8.11	2/20/2023
SL18288709_LDPC-29-3	37.4240000	-122.1031969	9.665	NA	8.18	2/20/2023
SL18288709_LDPC-22-1	37.4239982	-122.1033754	9.703	NA	8.18	2/20/2023
SL18288709_LDPC-29-2	37.4240000	-122.1031969	9.665	NA	8.19	2/20/2023
SL18288709_LDPC-29-1	37.4240000	-122.1031969	9.665	NA	8.20	2/20/2023
SL18288709_CMT22D-2	37.4240089	-122.1033775	9.845	NA	8.21	2/20/2023
SL18288709_LDPC-22-6	37.4239982	-122.1033754	9.703	NA	8.23	2/20/2023

SL18288709_CMT22D-3	37.4240089	-122.1033775	9.845	NA	8.23	2/20/2023
SL18288709_CMT16U-2	37.4239886	-122.1035597	10.265	NA	8.27	2/20/2023
SL18262683_LF-13A	37.3935101	-122.0342385	49.537	NA	8.30	3/15/2023
SL18288709_LDPC-22-4	37.4239982	-122.1033754	9.703	NA	8.31	2/20/2023
SL18288709_CMT16U-1	37.4239886	-122.1035597	10.265	NA	8.32	2/20/2023
L10006514573_G-08	37.4156824	-121.9738003	8.207	NA	8.35	5/23/2023
SL20266884_MW-21	37.3607804	-121.9199913	52.617	49	8.40	5/18/2023
L10006514573_G-11	37.4131370	-121.9714082	9.450	NA	8.49	5/23/2023
SL20266884_MW-23	37.3607804	-121.9199913	52.617	49	8.57	5/18/2023
SL18288709_LDPC-16-1	37.4239980	-122.1035580	10.384	NA	8.62	2/20/2023
SL18288709_LDPC-16-3	37.4239980	-122.1035580	10.384	NA	8.64	2/20/2023
SL18288709_LDPC-16-4	37.4239980	-122.1035580	10.384	NA	8.67	2/20/2023
SL18288709_CMT16D-1	37.4240081	-122.1035600	10.465	NA	8.68	2/20/2023
SL18288709_CMT39U-1	37.4239933	-122.1029222	10.899	NA	8.71	2/20/2023
SL18288709_CMT16D-2	37.4240081	-122.1035600	10.465	NA	8.71	2/20/2023
SL20266884_MW-19	37.3607804	-121.9199913	52.617	23	8.74	5/18/2023
SL374261193_MW-4	37.3942353	-121.9112359	41.100	NA	8.75	4/12/2023
SL374261193_MW-14	37.3948975	-121.9106577	42.181	NA	8.85	4/12/2023
SL18288709_CMT16U-3	37.4239886	-122.1035597	10.265	NA	8.86	2/20/2023
SL18288709_CMT39U-2	37.4239933	-122.1029222	10.899	NA	8.87	2/20/2023
SL18288709_CMT39U-3	37.4239933	-122.1029222	10.899	NA	8.88	2/20/2023
L10006514573_MW-4B	37.4106930	-121.9737220	11.427	NA	8.88	5/23/2023
SL20266884_MW-17	37.3607804	-121.9199913	52.617	27	8.89	5/18/2023
SL374261193_MW-7	37.3946380	-121.9097552	42.152	NA	8.91	4/12/2023
SL374261193_MW-15	37.3952742	-121.9110384	42.203	NA	8.93	4/12/2023
SL18288709_CMT39D-3	37.4240153	-122.1029228	10.716	NA	8.95	2/20/2023
SL18288709_CMT39D-1	37.4240153	-122.1029228	10.716	NA	9.01	2/20/2023
L10006514573_G-01	37.4107481	-121.9691476	8.775	NA	9.04	5/23/2023
SL18288709_LDPC-16-5	37.4239980	-122.1035580	10.384	NA	9.07	2/20/2023
SL18288709_LDPC-16-6	37.4239980	-122.1035580	10.384	NA	9.10	2/20/2023
SL18288709_CMT16D-3	37.4240081	-122.1035600	10.465	NA	9.27	2/20/2023
SL18288709_LDPC-39-3	37.4240029	-122.1029197	11.066	NA	9.29	2/20/2023
SL18288709_LDPC-39-1	37.4240029	-122.1029197	11.066	NA	9.31	2/20/2023
SL18288709_LDPC-39-6	37.4240029	-122.1029197	11.066	NA	9.32	2/20/2023
SL374261193_MW-6	37.3948289	-121.9110689	42.584	NA	9.32	4/12/2023
SL374261193_MW-24	37.3954704	-121.9113664	41.225	NA	9.43	4/12/2023
SL18288709_CMT39D-2	37.4240153	-122.1029228	10.716	NA	9.44	2/20/2023
L10006514573_MW-5B	37.4108900	-121.9730570	11.383	NA	9.54	5/23/2023
SL374261193_MW-9	37.3952790	-121.9103258	41.656	NA	9.61	4/12/2023
L10006514573_G-16R	37.4097441	-121.9683801	8.857	NA	9.63	5/23/2023
L10006514573_G-12	37.4114174	-121.9712903	11.312	NA	9.73	5/23/2023
SL20266884_MW-16	37.3607804	-121.9199913	52.617	25	9.78	5/18/2023
SL374261193_MW-13	37.3937813	-121.9117660	41.582	NA	9.84	4/12/2023
SL374261193_P-1	37.3953536	-121.9112471	41.989	NA	9.90	4/12/2023
SL20266884_MW-18	37.3607804	-121.9199913	52.617	26	9.92	5/18/2023
SL374261193_MW-17	37.3953130	-121.9117569	41.544	NA	9.93	4/12/2023
SL374261193_MW-10	37.3949722	-121.9108700	42.459	NA	9.94	4/12/2023
L10006514573_G-10	37.4111130	-121.9723396	10.968	NA	10.00	5/23/2023
SL374261193_MW-11	37.3951104	-121.9113784	42.544	NA	10.00	4/12/2023

SL374261193_MW-23	37.3955550	-121.9109410	42.190	NA	10.01	4/12/2023
SL374261193_MW-8	37.3950646	-121.9109943	42.610	NA	10.39	4/12/2023
SL0002020074_MW-24	37.3898400	-121.9115453	43.482	NA	10.42	2/3/2023
SL374261193_MW-25	37.3950429	-121.9119610	42.485	NA	10.43	4/12/2023
SL374261193_MW-19	37.3954658	-121.9120990	41.868	NA	10.56	4/12/2023
SL0002020074_MW-21	37.3881500	-121.9105544	44.310	NA	10.80	2/3/2023
L10006514573_H-05	37.4100720	-121.9731942	27.728	NA	10.81	5/23/2023
L10006514573_C-1	37.4100720	-121.9731942	27.728	NA	11.03	5/23/2023
L10006514573_H-06	37.4100720	-121.9731942	27.728	NA	11.19	5/23/2023
SL374261193_MW-20	37.3953536	-121.9112471	41.989	NA	11.30	4/12/2023
SL0002020074_MW-14	37.3882681	-121.9113386	44.295	NA	11.48	4/26/2023
SL0002020074_MW-13	37.3895442	-121.9121167	42.537	NA	11.49	4/26/2023
L10006514573_G-2R	37.4102565	-121.9666667	11.543	NA	11.61	5/23/2023
SL0002020074_MW-11	37.3899467	-121.9106236	43.743	NA	11.62	2/3/2023
SL374261193_MW-1	37.3944270	-121.9122023	42.321	NA	11.68	4/12/2023
SL20266884_MW-15	37.3607804	-121.9199913	52.617	25	11.74	5/18/2023
L10002780473_G-7	37.4354709	-121.9459606	12.122	NA	11.85	1/31/2023
SL374261193_MW-18	37.3952624	-121.9123022	42.234	NA	11.91	4/12/2023
SL0002020074_MW-17	37.3906642	-121.9128394	41.945	NA	12.01	4/26/2023
SL374261193_MW-21	37.3957028	-121.9119121	42.259	NA	12.05	4/12/2023
SL0002020074_MW-16	37.3901906	-121.9124500	42.531	NA	12.05	4/26/2023
SL374261193_MW-22	37.3955925	-121.9123941	41.396	NA	12.07	4/12/2023
SL374261193_MW-27	37.3959258	-121.9121671	41.169	NA	12.08	4/12/2023
SL0002020074_MW-18	37.3899467	-121.9106236	43.743	NA	12.15	4/26/2023
SL0002020074_MW-22	37.3907125	-121.9111744	43.523	NA	12.21	4/26/2023
SL0002020074_MW-12	37.3904669	-121.9109406	43.766	NA	12.28	4/26/2023
L10006514573_G-19	37.4109307	-121.9729466	11.539	NA	12.29	5/23/2023
SL0002020074_MW-27	37.3907392	-121.9111911	43.558	NA	12.32	4/26/2023
SL0002020074_MW-2	37.3901344	-121.9107333	43.945	NA	12.34	2/3/2023
SL374261193_MW-30	37.3966818	-121.9140321	41.099	NA	12.42	4/12/2023
SL0002020074_MW-8	37.3900578	-121.9103233	44.203	NA	12.56	2/3/2023
SL0002020074_MW-20	37.3895233	-121.9100417	44.687	NA	12.58	2/3/2023
T0608552020_MW-6B	37.4281114	-121.9748465	8.584	NA	12.59	4/10/2023
SL0002020074_MW-5	37.3902900	-121.9104697	44.714	NA	12.61	4/26/2023
SL0002020074_MW-23	37.3902536	-121.9115178	44.664	NA	12.61	4/26/2023
SL374261193_MW-26	37.3955001	-121.9128283	41.499	NA	12.62	4/12/2023
SL374261193_MW-29	37.3962653	-121.9133472	40.929	NA	12.63	4/12/2023
SL0002020074_MW-26	37.3909144	-121.9108967	45.046	NA	12.76	2/3/2023
L10006514573_G-4R	37.4169647	-121.9681438	9.569	NA	12.82	5/23/2023
SL0002020074_MW-3	37.3899467	-121.9106236	43.743	NA	12.82	2/3/2023
SL0002020074_MW-25	37.3889950	-121.9120581	43.997	NA	12.84	2/3/2023
L10006514573_G-18	37.4112616	-121.9718112	11.167	NA	12.86	5/23/2023
SL374261193_MW-28	37.3958995	-121.9128163	40.581	NA	12.94	4/12/2023
T0608552020_MW-2	37.4277685	-121.9741076	6.847	NA	13.01	4/10/2023
SL0002020074_MW-7	37.3899467	-121.9106236	43.743	NA	13.02	2/3/2023
T0608552020_MW-1	37.4280558	-121.9738415	7.020	NA	13.11	4/10/2023
SL0002020074_MW-30	37.3895400	-121.9121819	43.923	NA	13.15	2/3/2023
SL0002020074_MW-15	37.3887594	-121.9116119	42.374	NA	13.62	4/26/2023
SL0002020074_MW-29	37.3897647	-121.9122236	42.114	NA	13.90	4/26/2023

SL0002020074_MW-32	37.3899467	-121.9106236	43.743	NA	14.08	2/3/2023
SL0002020074_MW-31	37.3891269	-121.9117489	42.762	NA	14.22	4/26/2023
T0608552020_MW-3	37.4279032	-121.9743309	7.958	NA	14.35	4/10/2023
SL0002020074_MW-28	37.3906911	-121.9120039	42.755	NA	14.38	4/26/2023
SL0002020074_MW-19	37.3917367	-121.9115042	45.131	NA	14.40	1/18/2023
T0608552020_MW-8B	37.4281106	-121.9741896	8.079	NA	14.70	4/10/2023
T0608552020_MW-4	37.4283165	-121.9743092	8.062	NA	14.79	4/10/2023
T0608552020_MW-7B	37.4278787	-121.9750895	8.252	NA	15.80	4/10/2023
L10006514573_G-3R	37.4137447	-121.9651549	12.421	NA	16.45	5/23/2023
L10006514573_MW-12A	37.4104260	-121.9738490	20.919	NA	18.75	5/23/2023
L10002780473_G-6R	37.4364806	-121.9492278	28.042	NA	25.66	1/31/2023

Note: NA, not available in GeoTracker.

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APPENDIX D
Future Groundwater Conditions

APPENDIX D – FUTURE GROUNDWATER CONDITIONS

Appendix D describes the methods used to evaluate and map estimated groundwater rise and emergence in response to future sea-level rise, based on OPC (2024) recommended sea-level rise projections in the San Francisco Bay (Bay). Chapter 2 provides additional explanation of OPC (2024) recommendations. Appendix D also presents a validation of the future groundwater condition maps using an independent data set of field observations during the January 11 and February 9, 2024, king tides.

D.1 Estimated Groundwater Rise and Emergence to Future Sea-Level Rise

The future groundwater condition maps were created using sea-level rise increments of 0.5, 1.0, 3.0, 5.0, and 6.5 feet because these values span the projected range of sea-level rise across the Intermediate, Intermediate-High, and High scenarios in the Bay from 2030 to 2100 and beyond (Table D-1). As explained in Chapter 2, sea-level rise scenarios for the San Francisco tide gauge are used for this analysis because these scenarios are generally similar but somewhat more conservative (higher) than the sea-level rise scenarios for the Alameda tide gauge. These two tide gauges are about equidistant to Santa Clara County. Based on this 0.5 to 6.5 feet range of sea-level rise, projected shallow and emergent groundwater areas are summarized by excluding the salt pond area (Table D-2) and including the salt pond area (Table D-3). Each map of future groundwater conditions assuming 0.5 to 6.5 feet of sea-level rise is shown in Figures D-1 to D-5.

Table D-1. Sea-level rise scenarios for San Francisco tide gauge, highlighting approximate 0.5 (blue), 1.0 (green), 3.0 (yellow), 5.0 (orange), and 6.5 (red) feet of future sea-level rise from 2020 to 2150

Year	Low	Int-Low	Intermediate	Int-High	High
2020	0.2	0.2	0.2	0.3	0.3
2030	0.3	0.4	0.4	0.4	0.4
2040	0.4	0.5	0.6	0.7	0.8
2050	0.5	0.6	0.8	1.0	1.3
2060	0.6	0.8	1.1	1.5	2.0
2070	0.7	1.0	1.4	2.2	2.9
2080	0.8	1.2	1.8	3.0	4.1
2090	0.9	1.4	2.4	3.8	5.3
2100	1.0	1.6	3.1	4.8	6.5
2110	1.0	1.8	3.8	5.6	7.8
2120	1.1	2.0	4.4	6.4	9.0
2130	1.2	2.2	4.9	7.0	9.9
2140	1.3	2.4	5.4	7.6	10.8
2150	1.3	2.6	6.0	8.1	11.7

Notes – the table presents the median value of sea-level rise, in feet, for each decade from 2020 to 2150, with a baseline of 2000. All median scenario values incorporate the local estimate of vertical land motion. These scenarios are taken from OPC (2024).

The rate of shallow groundwater rise is affected by many factors, including tidal range, salinity, topography, aquifer geology, soil characteristics, coastline change, shore slope, and surface permeability (Chesnaux, 2015; Hoover et al., 2017; Rotzoll & Fletcher, 2013). Consistent with prior Bay area studies, a linear (1:1) response between sea-level rise and shallow groundwater rise was assumed for all five future scenarios (Chapter 4). The existing highest groundwater condition maps, shown as depth to water below ground surface, were used to create the future groundwater conditions maps (Figures D-1 to D-5). As explained in Chapter 4 and Appendix C, the existing groundwater condition maps tend to overestimate the presence of shallow and emergent groundwater. Consequently, the maps of future groundwater conditions (Figures D-1 to D-5) also likely overestimate future conditions of shallow and emergent groundwater in response to sea-level rise.

Table D-2. Comparison of shallow and emergent groundwater area estimated assuming 0.5 to 6.5 feet of sea-level rise, excluding the salt ponds

Sea-Level Rise Scenario (feet)	Emergent Groundwater		Shallow Groundwater (0 to 3 feet below ground surface)	
	Area (square miles)	Percentage of OM–LT (%)	Area (square miles)	Percentage of OM–LT (%)
0.5	2.1	2.6%	14	17%
1.0	2.8	3.5%	16	20%
3.0	7.0	8.6%	23	28%
5.0	13	17%	26	32%
6.5	21	26%	24	30%

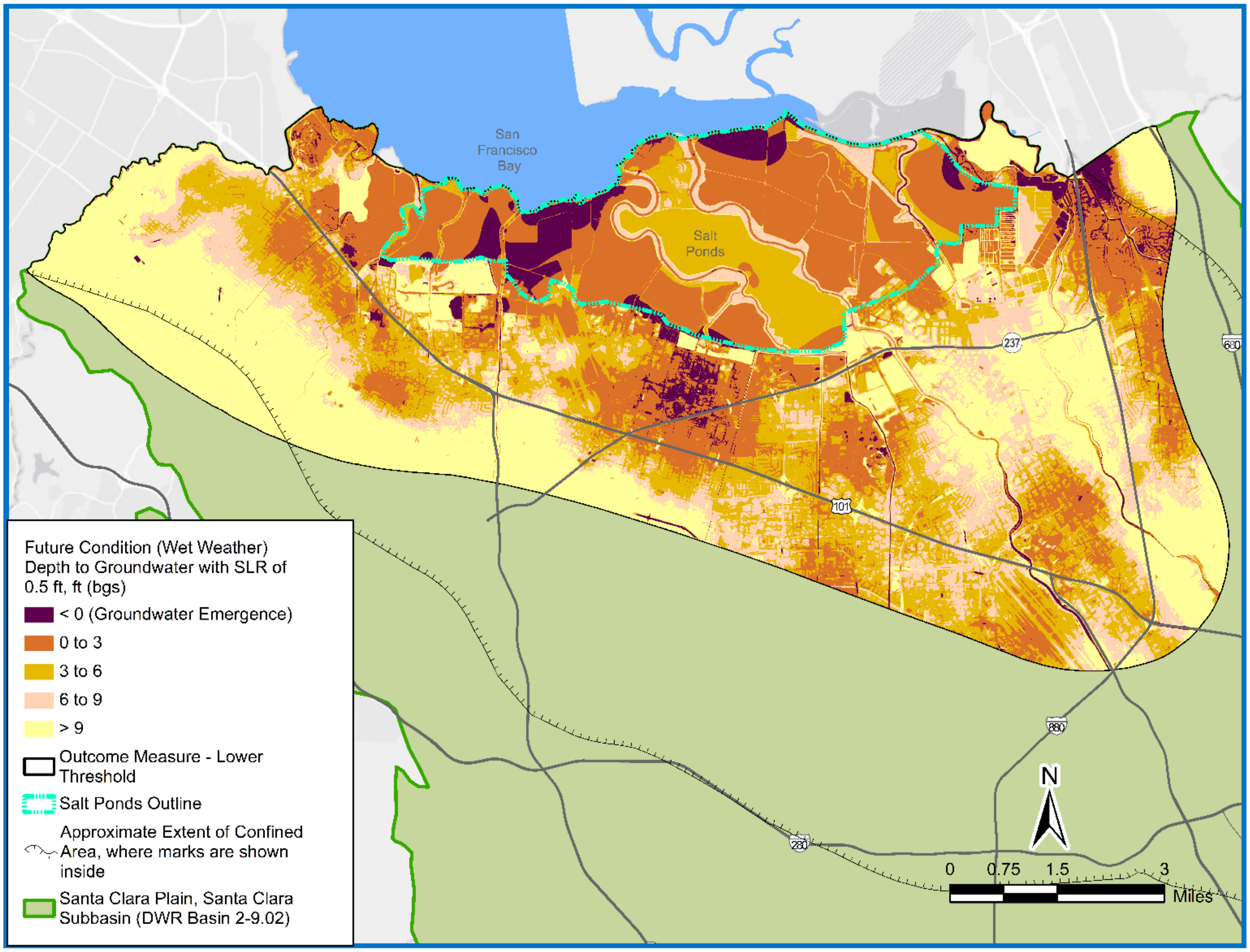
Note: OM–LT = seawater intrusion outcome measure – lower threshold (81 square miles and includes 14 square miles of salt ponds).

Table D-3. Comparison of shallow and emergent groundwater area estimated assuming 0.5 to 6.5 feet of sea-level rise, including the salt ponds

Sea-Level Rise Scenario (feet)	Emergent Groundwater		Shallow Groundwater (0 to 3 feet below ground surface)	
	Area (square miles)	Percentage of OM–LT (%)	Area (square miles)	Percentage of OM–LT (%)
0.5	3.8	4.7%	22	27%
1.0	5.1	6.3%	24	30%
3.0	12	15%	30	37%
5.0	22	28%	30	37%
6.5	34	41%	25	31%

Note: OM–LT = seawater intrusion outcome measure – lower threshold (81 square miles and includes 14 square miles of salt ponds).

Figure D-1. Future groundwater conditions assuming 0.5 feet of sea-level rise



Note: This map assumes a linear (1:1) response between 0.5 feet of sea-level rise and groundwater level rise. Because the map of existing highest groundwater condition tends to overestimate the presence of shallow and emergent groundwater, this map may also overestimate future shallow and emergent groundwater.

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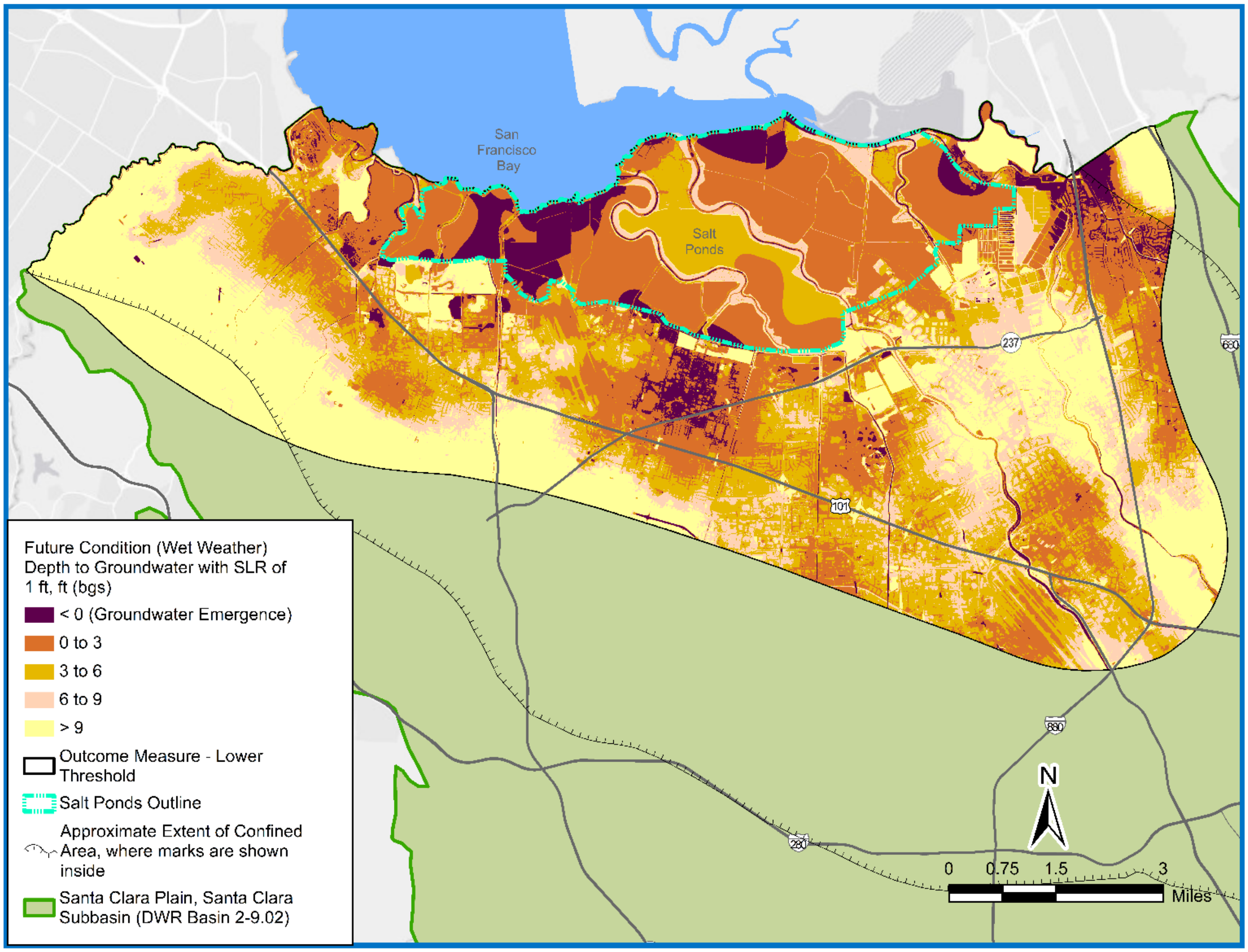
Figure D-2. Future groundwater conditions assuming 1.0 feet of sea-level rise



Note: This map assumes a linear (1:1) response between 1.0 feet of sea-level rise and groundwater level rise. Because the map of existing highest groundwater condition tends to overestimate the presence of shallow and emergent groundwater, this map may also overestimate future shallow and emergent groundwater.

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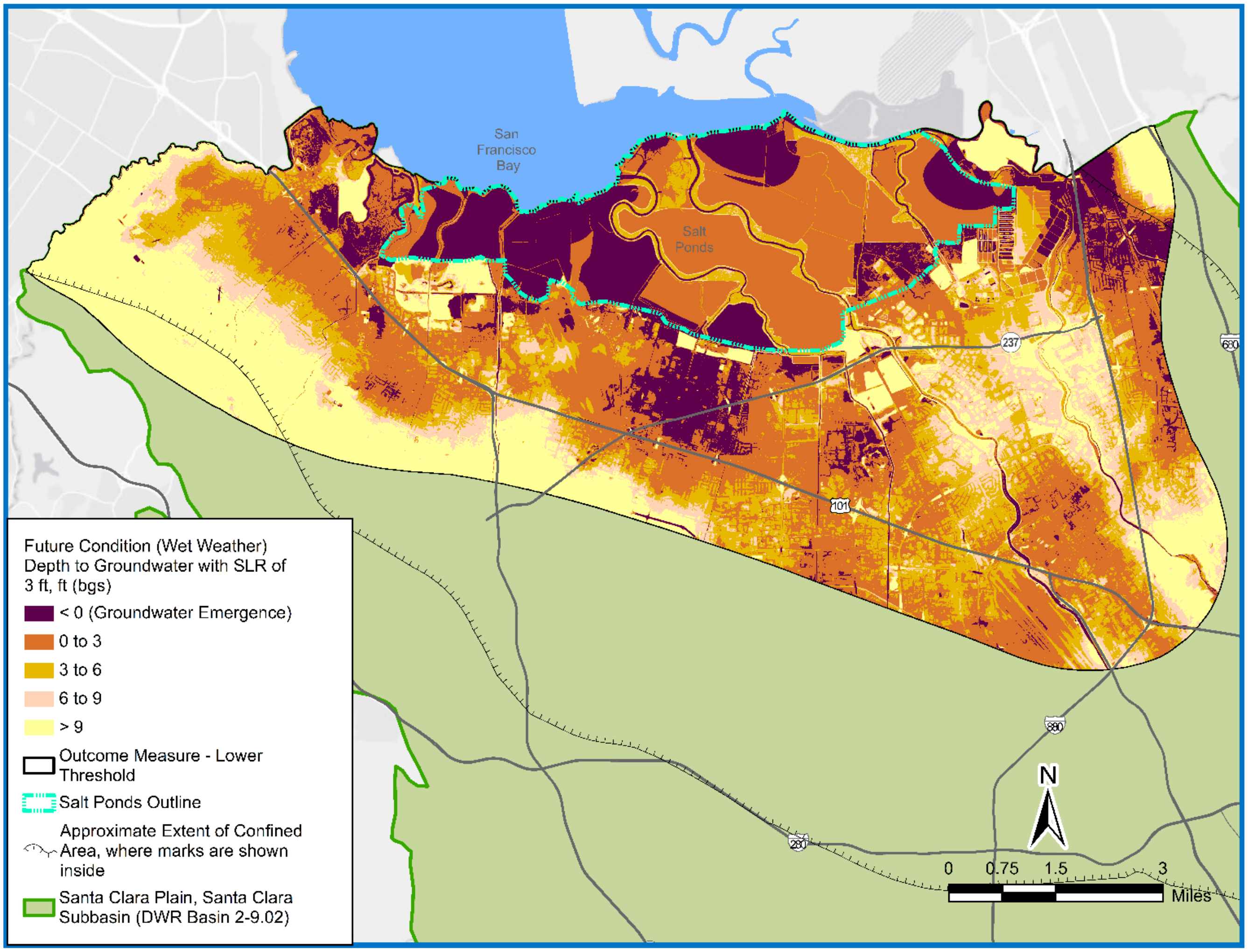
Figure D-3. Future groundwater conditions assuming 3.0 feet of sea-level rise



Note: This map assumes a linear (1:1) response between 3.0 feet of sea-level rise and groundwater level rise. Because the map of existing highest groundwater condition tends to overestimate the presence of shallow and emergent groundwater, this map may also overestimate future shallow and emergent groundwater.

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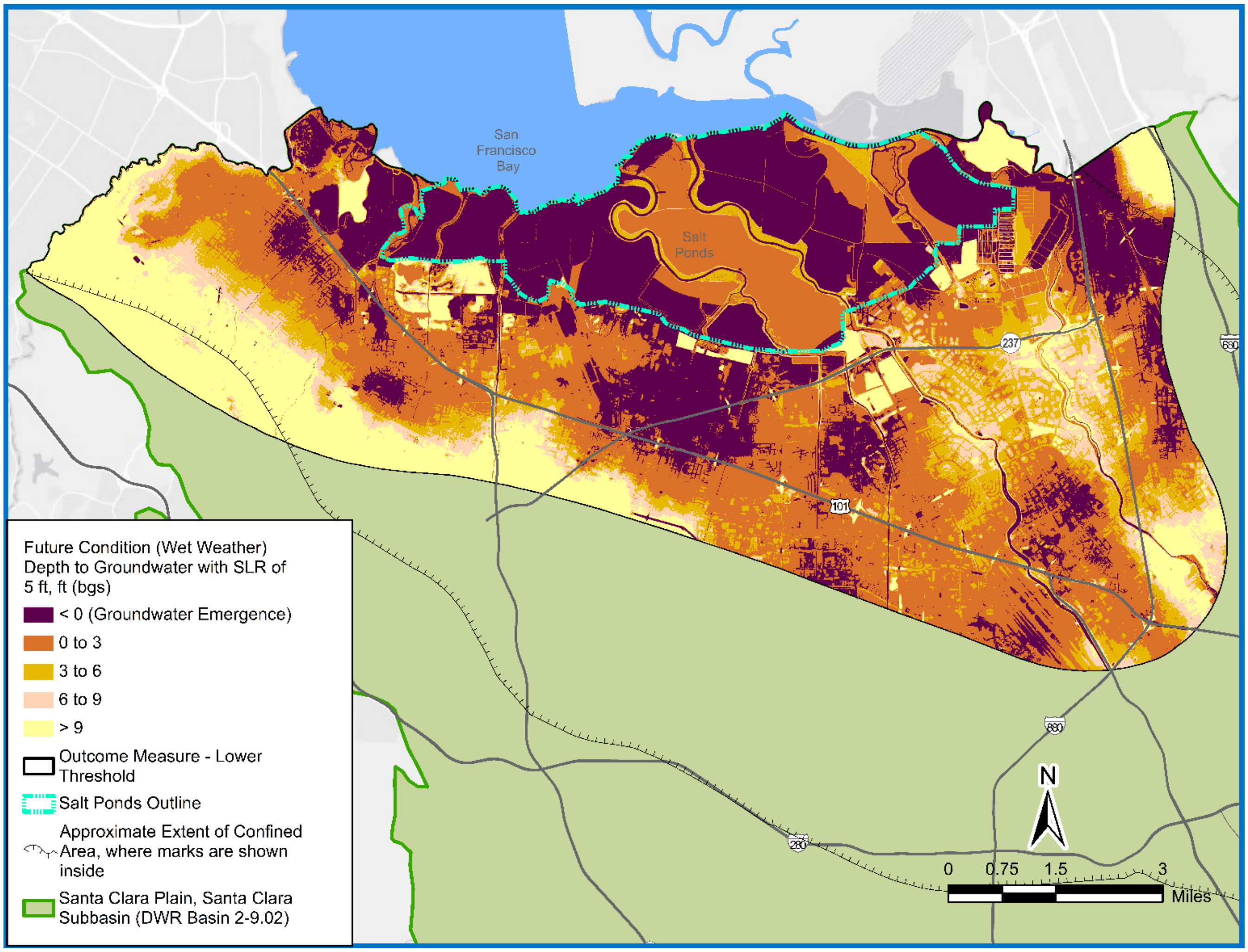
Figure D-4. Future groundwater conditions assuming 5.0 feet of sea-level rise



Note: This map assumes a linear (1:1) response between 5.0 feet of sea-level rise and groundwater level rise. Because the map of existing highest groundwater condition tends to overestimate the presence of shallow and emergent groundwater, this map may also overestimate future shallow and emergent groundwater.

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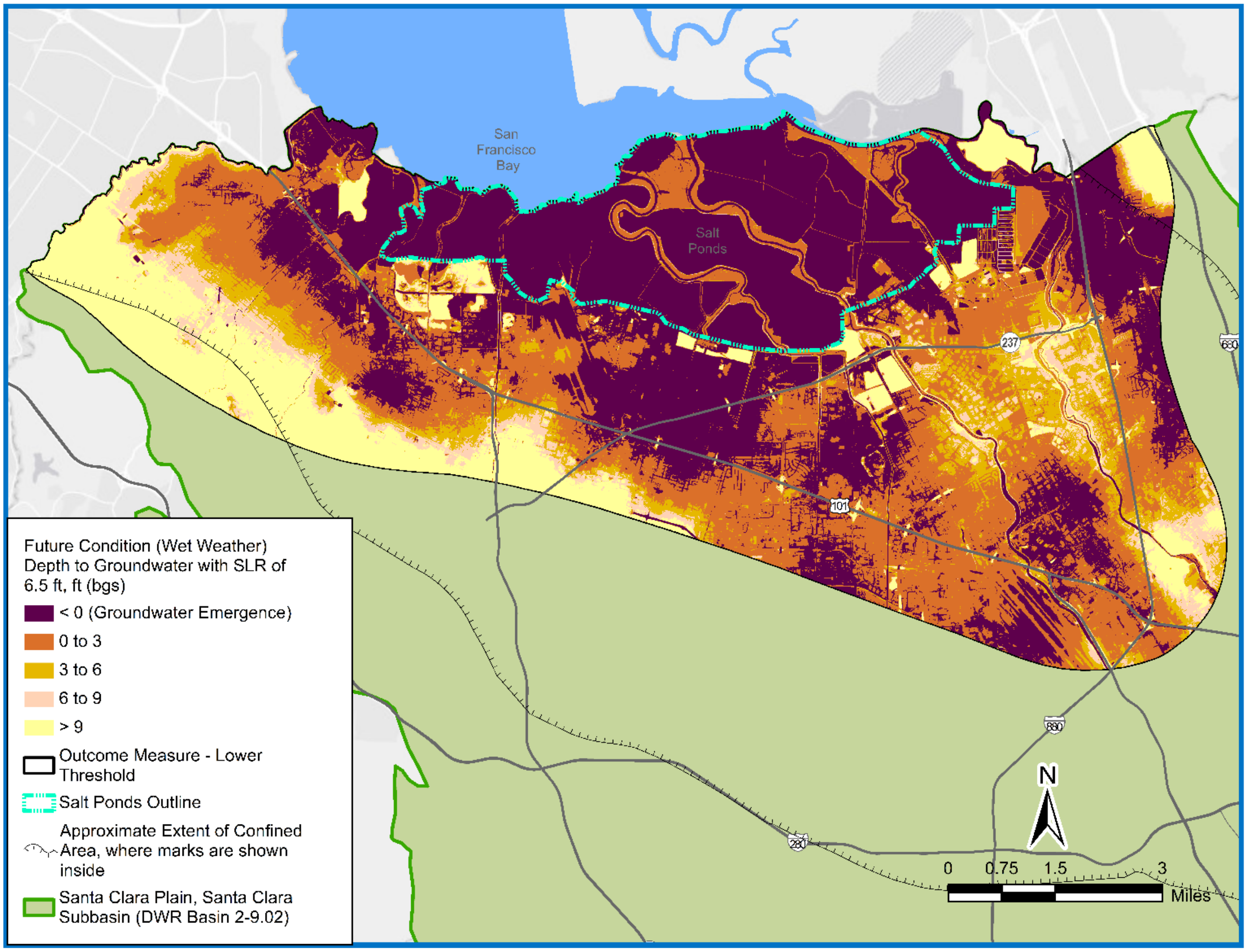
Figure D-5. Future groundwater conditions assuming 6.5 feet of sea-level rise



Note: This map assumes a linear (1:1) response between 6.5 feet of sea-level rise and groundwater level rise. Because the map of existing highest groundwater condition tends to overestimate the presence of shallow and emergent groundwater, this map may also overestimate future shallow and emergent groundwater.

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D2. Validation of Future Groundwater Condition Maps

An independent data set of field observations from the January 11 and February 9, 2024, king tides was used to help ground truth and validate the future groundwater condition maps (Figures D-1 to D-5). King tides are a natural phenomenon that are being used to help visualize future sea-level rise, including by the California Coastal Commission's California King Tide Project[1]. King tides in the Bay are typically one to two feet higher than the average high tide and therefore approximate projected future sea-level rise of one to two feet across the Intermediate to High scenarios by the middle to late twenty-first century (Table D-1).

Valley Water staff conducted field observations during the several days before, during, and after the January 11 and February 9, 2024, king tides. Each day, staff made field observations during the several hours preceding and following the highest high tide associated with the king tides. These observations included visual assessments and photographs to document if and where groundwater emerged at land surface. If emergent groundwater was present, conductivity measurements were taken of the emergent water, where site access was possible, and conductivity measurements were collected of any nearby and tidally influenced surface water bodies to provide context for the measurements.

The field observations were done in five general locations surrounding the western, southern, and eastern perimeter of the salt ponds in the Baylands (Figure 4-10). The five locations were selected because they include areas mapped as having estimated existing shallow groundwater (0-3 feet bgs) and groundwater emergence at land surface. These locations also include several areas with land surface elevation below sea level (Figure 4-6). As discussed in Chapter 3, these five locations also include areas near tidally influenced streams and Valley Water's seawater intrusion monitoring wells. All field observations and associated measurements were made either on Valley Water-owned land or public land. Figures D-6 to D-22 and Table D-4 show the location and results of field observations, and each location figure has a basemap of existing groundwater conditions (Figure 4-10) and a corresponding Google aerial image to help identify landmarks.

Within the five locations, a total of 42 areas mapped as having estimated groundwater emergence were observed by Valley Water staff during the king tides or evaluated using Google satellite images[2] to help visually identify the presence of direct connection to surface water because not all areas were accessible in the field (Table D-4). Based on the observation results, the 42 areas were each assigned to one of four categories: (1) confirmed groundwater emergence, (2) suspected groundwater emergence, (3) areas with direct connection to surface water or the Bay but that may also have unknown groundwater emergence, and (4) no observed groundwater emergence. In addition to the 42 areas, Valley Water staff observed two areas with apparent groundwater emergence that were not mapped accordingly. Of the 42 areas mapped as having estimated groundwater emergence, only 3 (7%) were confirmed groundwater emergence, 11 (26%) were suspected groundwater emergence, 19 (45%) had direct connection to surface water or the Bay but may have unknown groundwater emergence, and 9 (22%) had no observed groundwater emergence and are thus likely overestimates of mapped groundwater emergence (Table D-4). The confirmed and suspected groundwater emergence areas covered about 0.007 and 0.176 square miles (Table D-4), respectively, for a total of about 0.183 square miles[3]. The observation results from each of the five locations are detailed below.

[1] https://www.coastal.ca.gov/kingtides/

[2] The dates of the Google satellite images are unknown but likely to do not correspond with the same time period as the field observations in January and February 2024. Therefore, the satellite images were used primarily to help visually identify the presence of direct connection to surface water in areas that were not accessible in the field and based on the reasonable assumption that changes to the landscape have not change dramatically in between the time of the satellite images and the field observations.

[3] These three values are respectively equivalent to 4.48 acres, 113 acres, and 117 acres.

Table D-4. Valley Water staff field observations during January and February 2024 king tides of areas mapped (interpolated) as having groundwater emergence (based on Figure 4-9)

Area Name	Existing Highest Groundwater Condition Map (from Figure 4-9)	Field Observations of Groundwater Emergence During King Tides	Area of Field Confirmed or Suspected Groundwater Emergence (square miles)	Land Surface Elevation (feet above mean sea level)
Location 1				
south of Byxbee Park	groundwater emergence	confirmed	0.004	below sea level
Egret Pond		suspected	0.030	
Hawk Pond			0.007	
The Bowl			0.002	
Mayfield Slough		surface water connection	--	
Casey Forebay				
Charleston Slough				
slough				
Location 2				
NASA Ames	groundwater emergence	suspected	0.013	0 to 5
canal		suspected	0.003	below sea level
fitness trail		suspected	0.011	0 to 5
Stevens Creek		surface water connection	--	
Shoreline Amphitheatre		none observed	--	below sea level
dog park				0 to 5
PG&E A				5 to 10
PG&E B				
triangle-shaped area	0 to 3 feet DTW	suspected	0.044	
Location 3				
ponds	groundwater emergence	suspected	0.039	below sea level
Sunnyvale East Channel		surface water connection	--	0 to 5
Moffett Park		none observed	--	0 to 25
Location 4				
Twin Creeks	groundwater emergence	confirmed	0.002	below sea level
Baylands Park A		confirmed	0.001	
Baylands Park B		suspected	0.002	
canal		suspected	0.003	
Sunnyvale East Channel		surface water connection	--	
Calabazas Creek				
San Tomas Aquino Creek				
pond				
Baylands Park Area C				
stormwater detenton pond				
quarry	0 to 3 feet DTW	suspected	0.0001	0 to 5
Location 5				
area A	groundwater emergence	suspected	0.0069	5 to 10
area B			0.0143	
area C		surface water connection	--	0 to 5
area D				
Coyote Creek				below sea level
Lower Penitencia Creek				0 to 5
Berryessa Creek				
area F				5 to 10
Hall Memorial Pond				
Newby Island		none observed	--	10 to 25
area E				
area G				
area H				

Total area (square miles)	
confirmed:	0.007
suspected:	0.176
Total:	0.183

Note: DWT = depth to water

Location 1 – Area surrounding Byxbee Park and Egret Pond in Palo Alto

As shown in Figure D-6 and Table D-4, Location 1 has eight prominent areas labeled and identified by the map as having groundwater emergence. However, only one area was positively identified as having groundwater emergence during the king tide events, located just south of Byxbee Park and about 100 feet west of Mayfield Slough, designated as ‘groundwater emergence’ on Figure D-6. This area with groundwater emergence is below sea level (Figure 4-6), has no direct surface-water connection to the Bay, filled with groundwater during the king tide events (Figure D-7), and subsequently drained after the events (Figure D-6, see the satellite image).

Figure D-6. Location 1 field observations during the 2024 king tide events

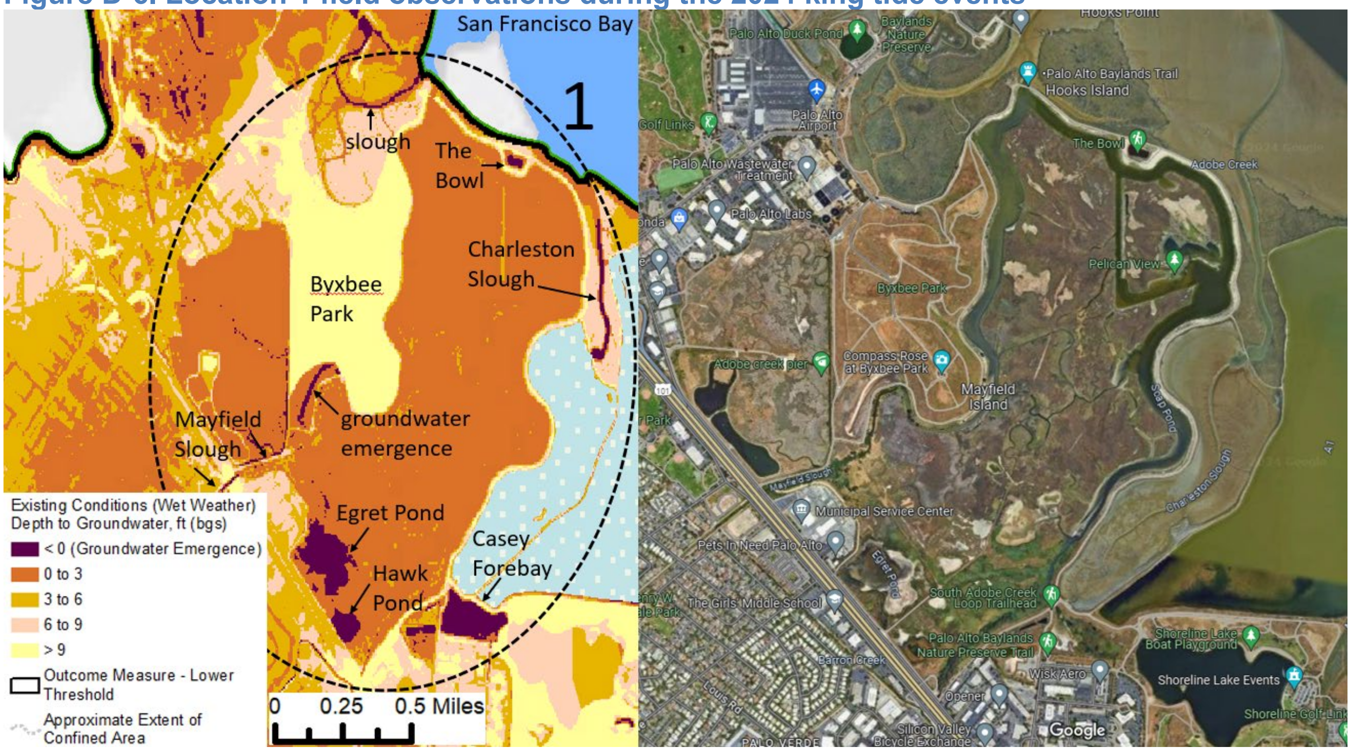


Figure D-7. Groundwater emergence area south of Byxbee Park during the 2024 king tide events

Note: Groundwater emergence from Location 1 (Figure 4-10) south of Byxbee Park about 100 feet west of Mayfield Slough (photo by Cheyne Hirota, Valley Water, taken on January 11, 2024 during the king tide).

Although some rainfall may have pooled in this depression prior to the king tides (Figure D-8), the specific conductance measurements were much higher than typical rainfall. Specific conductance measurements of the emergent groundwater were taken during several days throughout the king tide events, with concentrations ranging from about 9,000 to 58,000 µS/cm and an average of about 37,000 µS/cm. As context for these concentrations, specific conductance was also measured along Mayfield Slough, ranging from about 34,000 µS/cm on the Bay side of the tide gate, to 11,000 µS/cm on the inland side of the tide gate, to about 700 and 1,400 µS/cm in the slough near the groundwater emergence area. Monitoring wells screened in the shallow aquifer zone typically have specific conductance that range from about 500 to 1,500 µS/cm (Valley Water, 2022). Given that most concentrations of the emergent groundwater were higher than any measurement from the shallow groundwater or Mayfield Slough, it is likely that salts are actively being evapoconcentrated within this strip of land during the tidally driven cycles of groundwater emergence and subsequent evaporation. This is supported by the presence of a white, salt-encrusted surface of the dry land when groundwater emergence is not present in this area (Figures D-8 and D-9).

Figure D-8. Groundwater emergence area south of Byxbee Park prior to the 2024 king tide events

Note: Groundwater emergence from Location 1 (Figure 4-10) south of Byxbee Park about 100 feet west of Mayfield Slough (photo by Cheyne Hirota, Valley Water, taken on December 27, 2023 prior to the king tide).

The apparent present-day evapoconcentration of salts (Figure D-9) in the groundwater emergent area south of Byxbee Park may be the same processes during the geologic past that created surface salt deposits that are now buried in the subsurface and contributing to the elevated salinity in nearby seawater intrusion monitoring wells. This groundwater emergence area is only about 1,100 feet northwest from Valley Water monitoring wells (06S02W05F001 and 06S02W05F002) with suspected connate or evapoconcentration water (see Chapter 2 and Appendix A). The chloride concentrations in these two wells are much higher than ocean or Bay water, indicating some process other than present-day seawater intrusion.

Figure D-9. Evaporative salt deposits at the groundwater emergence area south of Byxbee Park

Note: Salt deposits at the groundwater emergence from Location 1 (Figure 4-10) south of Byxbee Park about 100 feet west of Mayfield Slough (photo by Scott Elkins, Valley Water, taken on October 30, 2024). The photo scale is about one square foot.

Based on another study of nearby geochemical and isotopic data in Palo Alto, Metzger (2002) concluded that the elevated chloride in the shallow aquifer is not associated with Bay water intrusion, but rather the result of groundwater flowing through chloride-rich deposits from the geologic past. In the Palo Alto Baylands, the evapoconcentration process is likely to occur in the salt marshes, creating hypersaline brine in shallow groundwater near the Bay (Hamlin, 1983; 1985). In much the same way as salt marshes that are flooded by tides, the evapoconcentration process within the localized areas of groundwater emergence, like the area south of Byxbee Park, also create chloride-rich deposits (Figures D-8 and D-9), both under present-day conditions and during the geologic past. The low topography and low elevation that characterize the present-day Baylands and enable tidally driven groundwater emergence were also characteristics of the Baylands over the recent geologic past. The sedimentary record of the Santa Clara Valley provides evidence that the San Francisco Bay shoreline has not migrated substantially during the past 1 to 1.5 million years, despite fluctuations in sea-level highstands because sedimentation rates have kept pace with tectonically driven subsidence rates of the Santa Clara Valley (Langenheim et al., 2015). For example, estuarine sediments are not found far from the current shore of the Bay (Langenheim et al., 2015). Given these similar geologic conditions and presence of elevated salinity in localized groundwater of the shallow aquifer, it is very likely that localized areas of groundwater emergence have occurred throughout the recent geologic past along the Baylands. Like today, groundwater emergence over the geologic past would have been similarly driven by the tides and the increases in sea level since at least the last glacial maximum about 20,000 years ago but likely much earlier (Langenheim et al., 2015; Wentworth et al., 2015, Wentworth and Tinsley, 2005). Therefore, the groundwater emergence phenomenon is not likely a new process caused solely by present-day tides or climate change induced sea-level rise, but rather a geologically persistent and endemic process[4] of the south Bay shoreline and associated shallow groundwater system.

Of the other seven areas shown on Figure D-6, Egret Pond, Hawk Pond, and The Bowl are areas of suspected groundwater emergence because they have ponded water and no obvious surface-water inflows or outflows. While Mayfield Slough, Casey Forebay, Charleston Slough, and the unnamed slough all have direct surface-water connections with the Bay, it is possible these four areas may also have some input from groundwater emergence but that remains unknown without more detailed field investigations that are beyond the scope of this study. The areas with direct surface-water connection to the Bay cannot be solely attributed to groundwater emergence and thus present an overestimate of the mapped groundwater emergence conditions. It is important to note that all seven areas have land surface elevation below sea level (Figure 4-6), which appears to be an important control on the presence of confirmed and suspected groundwater emergence within Location 1.

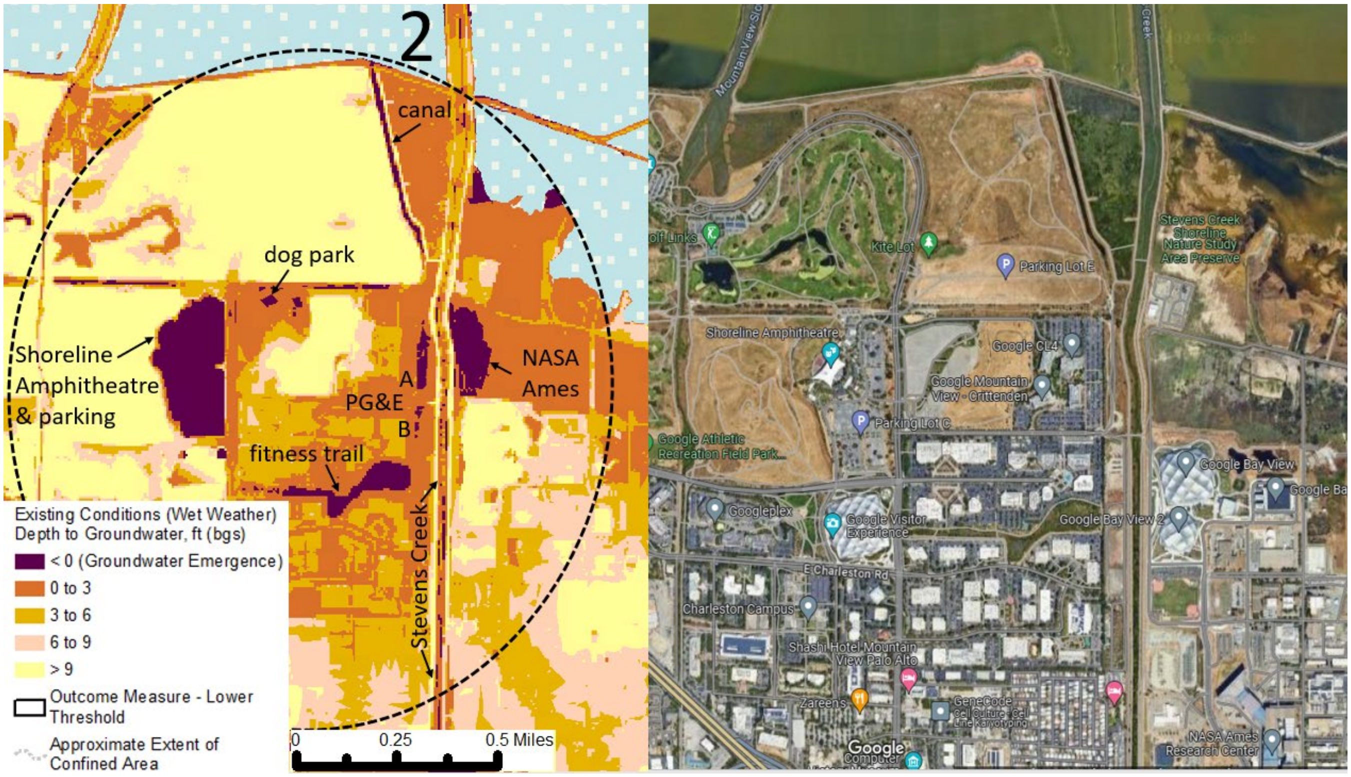
Location 2 – Area surrounding Shoreline Amphitheatre in the City of Mountain View.

As shown in Figure D-10 and Table D-4, Location 2 has eight prominent areas labeled and identified by the map as having groundwater emergence. It is important to note that the Location 2 area west of Stevens Creek is within a system operated by the City of Mountain View to prevent impacted groundwater from migrating laterally away from the Shoreline Regional Park Landfill (San Francisco Regional Water Quality Control Board, 2020). The system includes two extraction wells and a dewatering sump to “modify the local groundwater flow patterns by reducing groundwater levels in the area to depths as great as 60 feet below ground surface and inducing radial inward flow from as far away as approximately one mile” (San Francisco Regional Water Quality Control Board, 2020).

Perhaps because of this system, none of the areas in Location 2 were positively identified as having groundwater emergence during the king tide events. The largest of these areas is the Shoreline Amphitheatre and parking lots (Figure D-10). As shown in Figure 4-6, the Shoreline Amphitheatre land surface area is below sea level, which explains why the interpolated groundwater elevation appears as groundwater emergence. However, no groundwater emergence was observed at the Shoreline Amphitheatre area because the amphitheatre and parking lots are surrounded by a subsurface cut-off, slurry wall groundwater barrier (2.5 feet wide and extending to 55 feet bgs) and dewatering system (San Francisco Regional Water Quality Control Board, 2020). This cut-off wall is designed to reduce the migration of groundwater and landfill leachate into the area, and the dewatering system within the cut-off wall collects any seepage through the wall and discharges to Permanente Creek, under NPDES general permit of 80,000 gallons of groundwater per day (San Francisco Regional Water Quality Control Board, 2020). This cut-off wall and dewatering system explains why there is no groundwater emergence in this low-lying area. Similarly, small areas surrounding the nearby City of Mountain View dog park are mapped as groundwater emergence (Figure D-10), but Valley Water staff observed no standing water indicative of groundwater emergence during the king tide events.

[4] This interpretation is consistent with the geologic principle of uniformitarianism that geologic processes observed today have operated during Earth’s history and the present can be the key to the past.

Figure D-10. Location 2 field observations during the 2024 king tide events

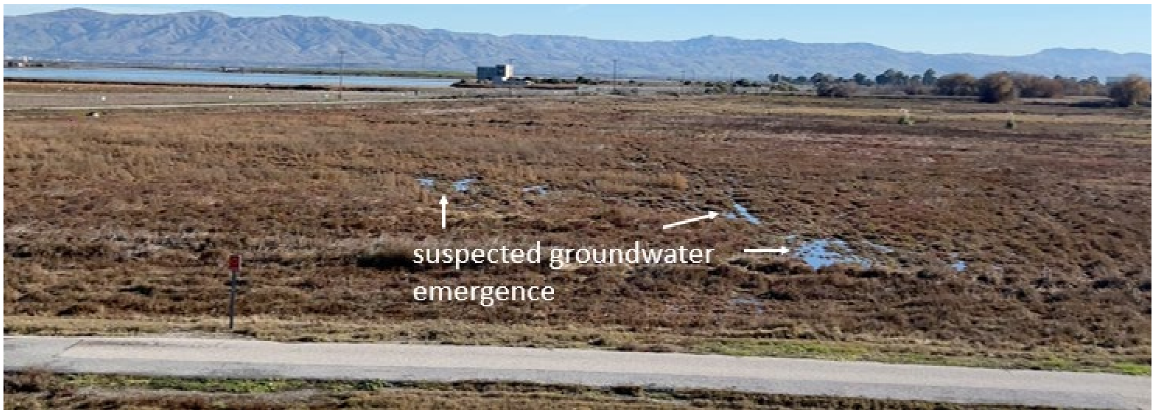


The areas labeled as PG&E A and B on Figure D-10 had standing water, but both areas appear to be puddles caused by the rainfall rather than groundwater emergence due to the lack of evaporative deposits at land surface, as shown in Figure D-11. The land surface elevation is 5 to 10 feet above sea level at PG&E A and B areas (Figure 4-6), which supports the lack of groundwater emergence. Several areas within Location 2 are suspected groundwater emergence but were not definitively confirmed during the king tide events. For example, Valley Water staff observed standing water in the area labeled NASA Ames that is likely groundwater emergence (Figure D-12) but could not rule out tidal surface water or rainfall puddles. The NASA Ames area has land surface elevation of 0 to 5 feet above sea level (Figure 4-6).

Figure D-11. Rainfall puddles at PG&E area B in Location 2 during the 2024 king tide events

Note: Photo by Victoria Garcia, Valley Water, taken on January 9, 2024.

Figure D-12. Suspected groundwater emergence at the NASA Ames site in Location 2 during the 2024 king tide events



Note: Photo by Victoria Garcia, Valley Water, taken on January 11, 2024.

Stevens Creek is identified as an area of groundwater emergence (Figure D-10). However, this creek has a direct connection with the Bay, and it is unknown if groundwater discharges into this creek, making it an area of groundwater emergence. Unlike Stevens Creek, the canal on the north side of Location 2 is below sea level (Figure 4-6) and mapped as groundwater emergence, including no clear surface connection to the Bay, based on aerial images (Figure D-10). Therefore, the water in this canal is suspected groundwater emergence, as shown in Figure D-13. Valley Water staff observed standing water in the triangle-shaped area east of the canal (Figure D-10), which is mapped as shallow groundwater (0 to 3 feet bls) and has a land surface elevation of 5 to 10 feet above sea level (Figure 4-6). The lack of apparent surface water inflows or outflows may indicate that the map in this area underestimates groundwater emergence.

Figure D-13. Suspected groundwater emergence at the canal area in Location 2 during the 2024 king tide events

Note: Photo of the southern end of the canal by Victoria Garcia, Valley Water, taken on January 9, 2024.

In Location 2, the area labeled fitness trail (Figure D-10) is suspected groundwater emergence because it appears to have had standing water and there is an outflow pipe on the east side into Steven Creeks (Figure D-14). While Valley Water staff observed this outflow (Figure D-14), staff were not at the fitness trail area and could not visually confirm if emergent groundwater was present here during the king tides. The fitness trail area land surface elevation is 0 to 5 feet above sea level (Figure 4-6). In Location 2, suspected groundwater emergence appears in areas (NASA Ames and fitness trail) with a land surface elevation 0 to 5 feet above sea level, which therefore appears to be an important control on groundwater emergence.

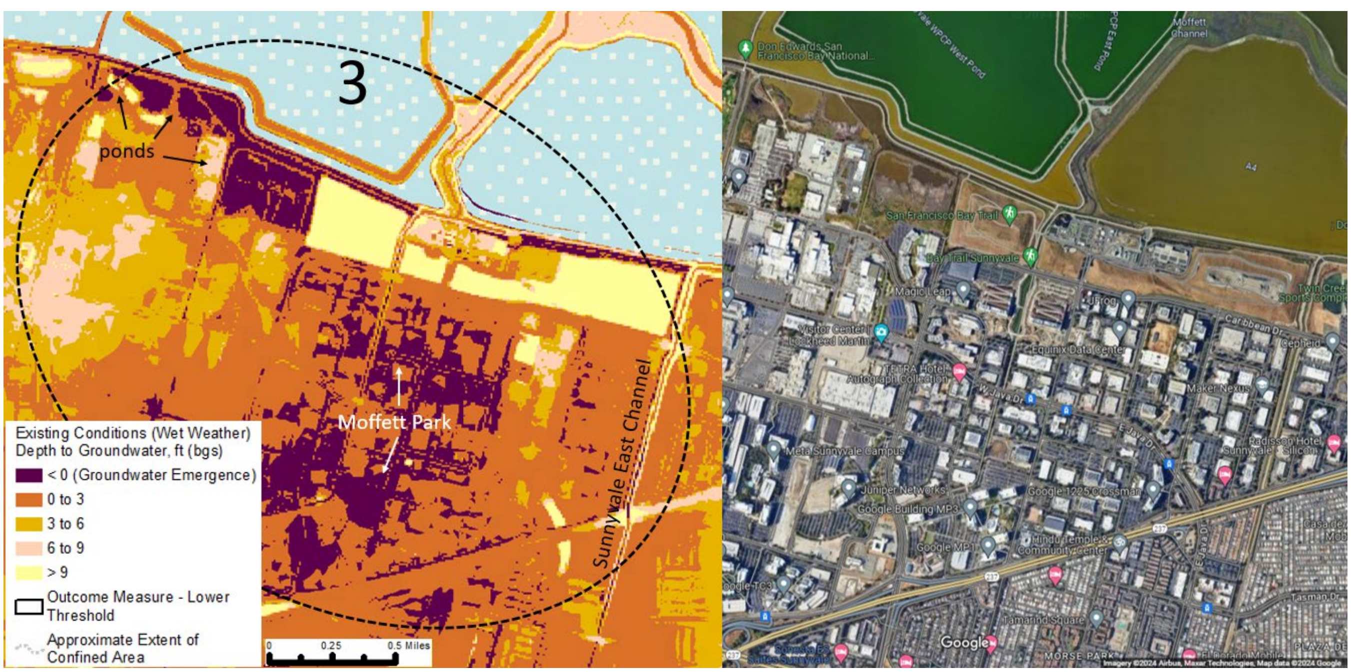
Figure D-14. Outflow from suspected groundwater emergence at the fitness trail area in Location 2 during the 2024 king tide events

Note: Photo by Victoria Garcia, Valley Water, taken on January 11, 2024.

Location 3 – Area surrounding the City of Sunnyvale Water Pollution Control Plant and neighborhoods south to Highway 237.

As shown in Figure D-15 and Table D-4, Location 3 has three prominent areas labeled and identified by the map as having groundwater emergence. Valley Water staff did not observe any groundwater emergence in the Moffett Park area south of Caribbean Drive and north of Highway 237, which is one of the largest mapped areas estimated for current and future groundwater emergence. The Moffett Park area has land surface elevations that range from 0 to 25 feet above sea level (Figure 4-6) and may explain why groundwater emergence was not observed in this area. Given the lack of observed groundwater emergence, the Moffett Park area may be one of the largest overestimated areas on the maps of estimated existing and future groundwater emergence in the south Bay (Figure 4-9).

Figure D-15. Location 3 field observations during the 2024 king tide events

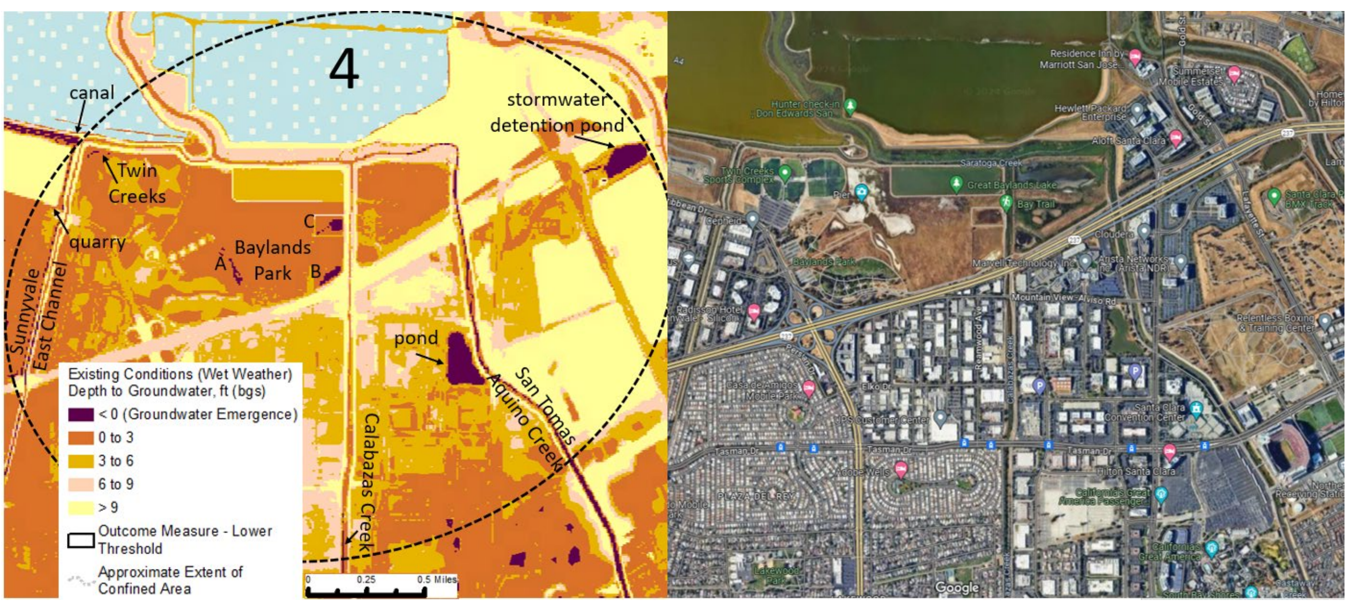


Sunnyvale East Channel is estimated to have groundwater emergence (Figure D-15), and similar to other creeks, sloughs, and channels, it is unknown how much groundwater emergence contributes to flow in this channel. Near the salt ponds in the northwestern area of Location 3, there are several ponds with standing water, as shown on Figure D-15. Although Valley Water staff did not visit these ponds during the king tides, these are suspected groundwater emergence areas because they lack surface water inflows and outflows. Similar to other areas with suspected groundwater emergence, the ponds' land surface area is below sea level (Figure 4-6).

Location 4 – Area surrounding the City of Sunnyvale Materials Recovery Transfer Station, Twin Creeks Sports Complex, and Baylands Park.

As shown in Figure D-16 and Table D-4, Location 4 has 10 prominent areas labeled and identified by the map as having groundwater emergence. However, only two areas were positively identified as having groundwater emergence during the king tide events and several others are suspected areas of groundwater emergence. As briefly discussed in Chapter 4 and illustrated in Figure 4-11, Valley Water staff confirmed groundwater emergence along a strip of land immediately adjacent to the levee on the south side of Sunnyvale East Channel and northwest of Twin Creeks Sports Complex (identified as Twin Creeks on Figure D-16). This area of groundwater emergence is below sea level (Figure 4-6). Photos in Figure D-17 are of the same area but taken from different perspectives to illustrate the spatial extent of groundwater emergence. During the king tide event, the pump station operated and removed the emergent groundwater into the Sunnyvale East Channel. The pump station is not owned or operated by Valley Water but appears to be located and designed to pump and remove emergent groundwater and stormwater from the south side of the levee.

Figure D-16. Location 4 field observations during the 2024 king tide events



Specific conductance measurements of the emergent groundwater were taken during several days throughout the king tide events, with concentrations ranging from about 14,000 to 64,000 µS/cm with an average of about 33,000 µS/cm. As context for these concentrations, specific conductance was also measured along Sunnyvale East Channel, ranging from about 6,700 to 19,000 µS/cm with an average of about 12,000 µS/cm. Given that most concentrations of the emergent groundwater were higher than any measurement from the Sunnyvale East Channel, it is possible that salts are being evapoconcentrated within this strip of land during cycles of groundwater emergence and evaporation. Another possible explanation is that the groundwater emergence has a relatively greater contribution from seawater intrusion compared to Sunnyvale East Channel, which is a mix of seawater from the Bay and freshwater inflows.

In addition to the Twin Creeks area, groundwater emergence was positively identified at Baylands Park area A (Figure D-16), which also has land surface elevations below sea level (Figure 4-6). The satellite imagery of area A in Figure D-16 shows dry pond depressions; however, these features were filled with groundwater emergence during the king tides events (Figure D-18). Specific conductance measurements of the emergent groundwater at area A were taken during several days throughout the king tide events, with concentrations ranging from about 77,000 to 81,000 μS/cm with an average of about 78,000 μS/cm. These were the highest specific conductance measurements during the field observations and are much higher than the nearby Sunnyvale East Channel and Bay water. Specific conductance of the Bay is typically less than about 49,000 μS/cm at the USGS Alviso Slough station and less than about 52,000 μS/cm at the Dumbarton Bridge station (Work et al., 2017). The elevated specific conductance at area A is likely caused by the evapoconcentration of salts during cycles of groundwater emergence and evaporation.

Figure D-17. Groundwater emergence northwest of Twin Creeks Sport Complex in Location 4 during the 2024 king tide events

Note: Photos of groundwater emergence taken from Location 4 (Figure 4-10) immediately adjacent to the levee on the south side of Sunnyvale East Channel, south of salt pond A4 near Twin Creeks Sports Complex (photos by Jason Gurdak, Valley Water, taken on January 10-12, 2024).

Of the other eight areas shown in Figure D-16, Baylands Park area B (Figure D-19) and the canal (Figure D-20) are both below sea level (Figure 4-6) and are areas of suspected groundwater emergence because there are no obvious surface-water inflows or outflows. The canal itself may have a direct surface-water connection to the Bay, but the adjacent area does not appear to be connected and is a suspected groundwater emergence area (Figure D-20). While Sunnyvale East Channel, Calabazas Creek, and San Tomas Aquino Creek all have direct surface-water connections with the Bay, they all have reaches below sea level (Figure 4-6) and may also have some input from groundwater emergence, but that remains unknown without more detailed field investigations. The pond, Baylands Park area C, and the stormwater detention pond all appear to have connections to surface-water or stormwater and are not likely areas of predominantly groundwater emergence. Although not mapped as an area of groundwater emergence, the bird preserve (Figure D-16) is another large surface water body in the Baylands Park area that is fed by surface water.

In addition to the 10 areas mapped as groundwater emergence in Location 4, Valley Water staff identified one area of suspected groundwater emergence that was not mapped as groundwater emergence, labeled as ‘quarry’ on Figure D-16 and Table D-4. As shown in Figure D-21, the quarry area is located between Caribbean Drive and the Stevens Creek Quarry (SCQ) Sunnyvale and immediately west of Sunnyvale East Channel at a land surface elevation of 0 to 5 feet above sea level (Figure 4-6). Given the heavy precipitation during the January 11 king tide, this area was first suspected as a puddle from the rain. However, the specific conductance was about 17,000 µS/cm, which is considerably higher than from rainfall alone. Therefore, this quarry area is suspected groundwater emergence.

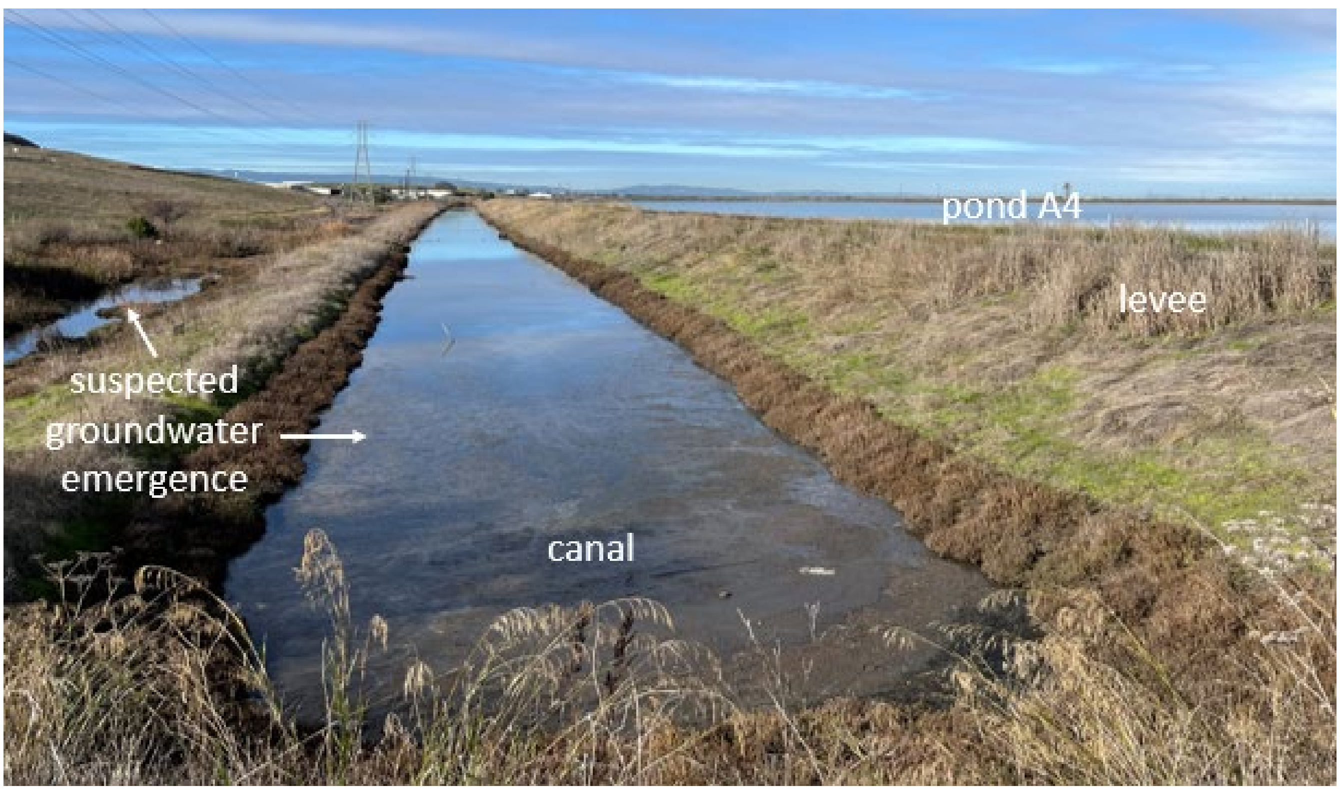
Figure D-18. Groundwater emergence at Baylands Park area A in Location 4 during the 2024 king tide events

Note: Photo by Jason Gurdak, Valley Water, taken on January 11, 2024.

Figure D-19. Suspected groundwater emergence at Baylands Park area B in Location 4 during the 2024 king tide events

Note: Photo by Jason Gurdak, Valley Water, taken on January 8, 2024.

Figure D-20. Suspected groundwater emergence at the canal on the north side of Location 4 during the 2024 king tide events



Note: Photo by Jason Gurdak, Valley Water, taken on January 8, 2024.

Figure D-21. Suspected groundwater emergence at the quarry area in Location 4 during the 2024 king tide events

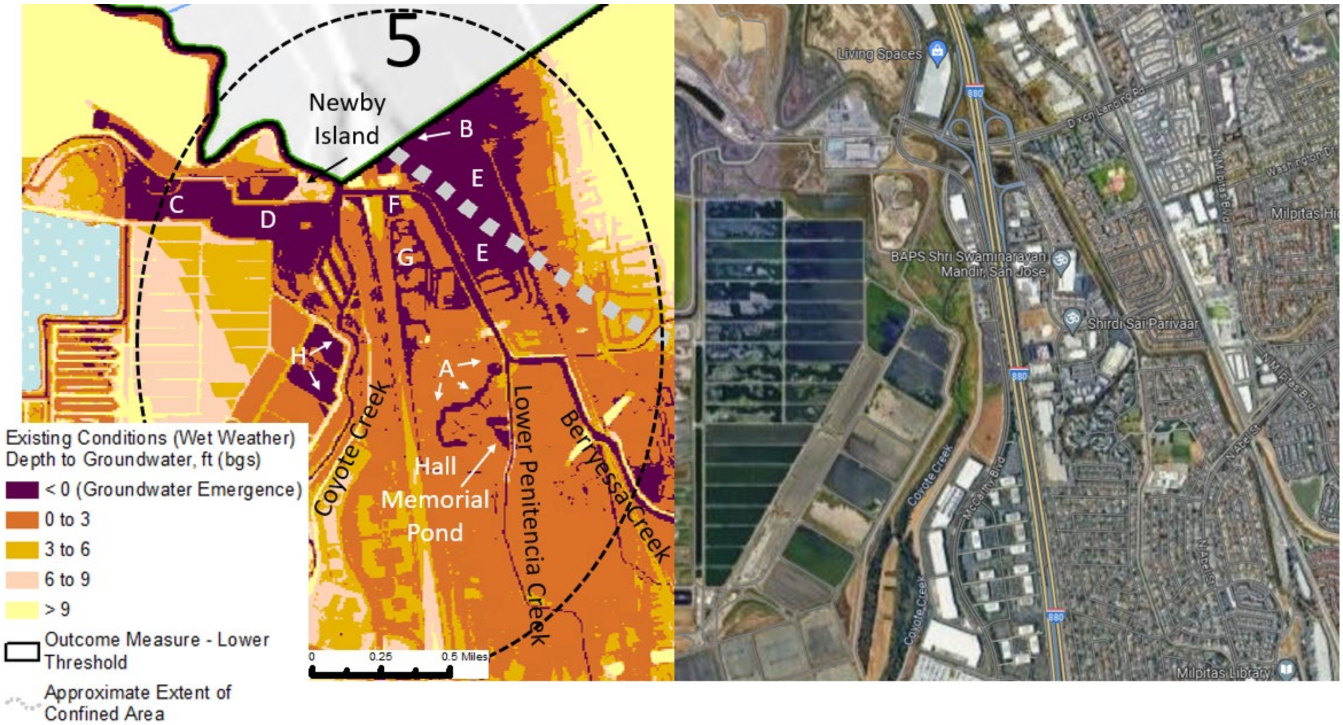
Note: Photo by Jason Gurdak, Valley Water, taken on January 12, 2024.

Location 5 – Area in the City of Milpitas, south of Newby Island Sanitary Landfill, near Highway 880.

As shown in Figure D-22 and Table D-4, Location 5 has 13 prominent areas labeled and identified by the map as having groundwater emergence. However, only two areas were identified as suspected groundwater emergence during the king tide events. The areas of suspected groundwater emergence range in elevation from 5 to 10 feet above sea level (Figure 4-6). Valley Water suspects groundwater emergence along area A, which has a pump station on the north end that appears designed to pump the emergent groundwater into the Lower Penitencia Creek. The specific conductance of area A ranged from about 650 to 800 μS/cm, which is much lower than Bay water and indicative of a relatively large percentage of freshwater groundwater. Area B is immediately west of the Dixon Landing North Business Park and appears to have localized but suspected groundwater emergence. The specific conductance of this area was about 2,000 μS/cm, which is much lower than Bay water and indicative of a relatively large percentage of freshwater groundwater, but possibly greater input of Bay water compared to area A.

Of the other 11 areas shown on Figure D-22, seven are areas with direct connection to surface water or the Bay but may also have unknown groundwater emergence. Areas C and D appear to have a combination of land that has direct connection to tidally influenced surface water and some suspected groundwater emergence. Area D appears to have greater area of suspected groundwater emergence than area C. Valley Water staff were not able to confirm the groundwater emergence in areas C or D during the king tide events. While Coyote Creek, Lower Penitencia Creek, and Berryessa Creek all have direct surface-water connections with the Bay, they may also have some input from groundwater emergence, but this remains unknown without more detailed field investigations that are beyond the scope of this study. Similarly, area F and Hall Memorial Pond have direct connection to the tidally influenced creeks, and while it appears largely influenced from surface water, groundwater emergence is possible but could not be confirmed by Valley Water staff.

Figure D-22. Location 4 field observations during the 2024 king tide events



As shown in Figure D-22, Newby Island and areas E, G, and H are identified by the map as having groundwater emergence. However, Newby Island is the location of the Newby Island Resource Recovery Park and Landfill and does not appear to have groundwater emergence. Similarly, area G and E, which includes neighborhoods near Dixon Landing Park, had no observed groundwater emergence during the king tide events. Area H are biosolid drying beds that are part of the San Jose/Santa Clara Water Pollution Control Plant, and it is unknown if any groundwater emergence occurs in these beds. These four areas all have land surface elevations from 10 to 25 feet above sea level (Figure 4-6). Therefore, Newby Island and areas E, G, and H in Figure D-22 are likely mapped overestimates of groundwater emergence.

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