3 Sustainable Management Criteria

This chapter of the GSP presents the sustainable management criteria that define whether groundwater conditions in the Subbasin are being managed sustainably to avoid undesirable results. These criteria are based on the sustainability goal for the Subbasin, which is discussed in Section 3.1. Both general and specific undesirable results for the Subbasin are discussed in Section 3.2. The minimum thresholds are discussed in Section 3.3, and the measurable objectives are discussed in Section 3.4. The monitoring network described in Section 3.5 is designed to be able to measure the groundwater conditions that form the basis of the sustainable management criteria. The monitoring network has been configured to assess developing conditions within the Subbasin and recommendations are made to fill the data gaps that have been identified. The sustainable management criteria defined in this GSP will be periodically re-evaluated and adjusted as needed to maintain groundwater conditions in the Subbasin that avoid undesirable results.

3.1 Sustainability Goal

The sustainability goal for the Subbasin is to ensure the long-term health and availability of groundwater resources for current and future stakeholders through ongoing, proactive stewardship. Long-term health and availability include:

- Maintaining sufficient groundwater in storage to allow for continued groundwater production that meets the operational demands and regulatory commitments of the City of Santa Monica as well as other groundwater producers and stakeholders.
- Ensuring groundwater conditions in the Subbasin support sufficient seaward flow of fresh water to prevent significant and unreasonable seawater intrusion in the Silverado aquifer.
- Continuing groundwater production at rates and in aquifers that do not impact the ability of groundwater dependent ecosystems to access groundwater.

The sustainability goal for the Subbasin was developed using historical data, including groundwater elevations, estimates of groundwater in storage, and groundwater quality, discussed in detail in Chapter 2 of this GSP. Over the past 30 years groundwater in storage has fluctuated, increasing between 1995 and 2010, when the City of Santa Monica's groundwater production was greatly reduced, and declining in recent years when production resumed (see Section 2.5.5.1 Quantification of Historical Water Budget). Overall, there has been a decline in groundwater in storage since 1985, with the bulk of that decline occurring between water years 2013 and 2015, in response to increased groundwater production and reduced groundwater recharge. The decrease in groundwater in storage is reflected in the measured groundwater elevations in the Charnock and Olympic Wellfields, which were lower in 2015 than they were in 1985 (see Section 2.4.1 Groundwater Elevation Data). However, the Subbasin did not experience land subsidence, reduction of interconnected surface and groundwater, or apparent seawater intrusion related to groundwater production during the period from 1985 to 2015, and available data indicates that it is not currently experiencing these undesirable results related to groundwater production.

The City of Santa Monica has worked with the Los Angeles RWQCB, State Water Resources Control Board Division of Drinking Water (DDW), and private parties responsible for groundwater contamination in the Subbasin to remediate groundwater that has been impacted by VOCs, MTBE, and other industrial contaminants. These contaminants have caused undesirable results related to groundwater quality in the Subbasin; However, the undesirable results were not caused by groundwater production. The City of Santa Monica is providing hydraulic control in the areas of contaminated groundwater adjacent to the Charnock and Olympic Wellfields (see Sections

2.1.2.3 Water Quality and 2.4.4 Groundwater Quality). This prevents impacted groundwater from migrating into areas with potable groundwater and removes the contaminated groundwater, thereby reducing contamination over time. Thus, groundwater production is critical to restoring beneficial use of the groundwater in parts of the Subbasin impacted by industrial contamination.

In 2017, the cities of Santa Monica, Los Angeles, Culver, and Beverly Hills, and the County of Los Angeles became the GSA for the Subbasin. The GSA has the ability, authority, and responsibility to continue to ensure long-term sustainable management of the groundwater resources within its jurisdiction. This authority includes monitoring and adjusting groundwater production from all wells, including but not limited to the City of Santa Monica's wells, in the Subbasin. The undesirable results, minimum thresholds, and measurable objectives discussed in this Chapter (see Sections 3.2 Undesirable Results through 3.4 Measurable Objectives) are intended to provide the metrics by which the GSA will decide if pumping adjustments or other projects or management actions are necessary. The GSA will continue to work with stakeholders to ensure sustainable management of the groundwater conditions within the Subbasin throughout the 50-year GSP planning and implementation horizon.

3.2 Undesirable results

Under SGMA, undesirable results occur when the effects caused by groundwater conditions occurring throughout the Subbasin cause significant and unreasonable impacts to any of six sustainability indicators. The definition of significant and unreasonable for each of the six indicators is determined by the GSA using the processes and criteria described in this GSP. The GSA is required to characterize undesirable results for each indicator, unless "undesirable results to one or more sustainability indicators are not present and are not likely to occur in the basin," (23 CCR 354.26 (d)). Each of the six sustainability indicators has the potential to occur within the Subbasin, but the Subbasin is not currently experiencing undesirable results for any of the six sustainability indicators as a result of groundwater production. General undesirable results in the Subbasin would be:

- Chronic Lowering of Groundwater Levels
- Significant and Unreasonable Reduction of Groundwater in Storage
- Significant and Unreasonable Seawater Intrusion Resulting from Groundwater Withdrawal
- Significant and Unreasonable Degradation of Water Quality Resulting from Groundwater Withdrawal
- Significant and Unreasonable Land Subsidence Resulting from Groundwater Withdrawal
- Significant and Unreasonable Reduction of Interconnected Surface Water and Groundwater Resulting from Groundwater Withdrawal

Sustainability indicators for which there are data gaps or too little data to fully evaluate the related undesirable results will be further defined by the development and implementation of additional monitoring capabilities through GSP implementation.

Undesirable results could occur within the Subbasin if groundwater production exceeds the sustainable yield. Projected groundwater production is anticipated to be approximately 9,000 AFY in the Subbasin. At this rate of production and incorporating additional assumptions about future mountain front and aerial recharge, groundwater in storage is projected to decline by approximately 2,200 AFY in the future (see Section 2.5.6.3 Projected Water Budget). This rate of decline is within the uncertainty of the model (see Section 2.6), groundwater elevations in the Subbasin are not projected to reach the minimum thresholds discussed in Section 3.3, and undesirable results are not anticipated to occur in the Subbasin related to groundwater elevation declines or change in storage. However, based on future projected conditions in the Subbasin, the future sustainable yield may roughly equal the planned future groundwater extractions of 9,000 AFY (the historical sustainable yield for the Subbasin ranges from 10,800 AFY to 19,700 AFY; see Section 2.6). Future extractions that exceed this volume may cause undesirable results.

A description of the undesirable results applicable to the sustainability indicators is provided in Sections 3.2.1 through 3.2.6. Each section describes the cause of groundwater conditions throughout the Subbasin that would lead to undesirable results and the potential effects of undesirable results on the beneficial uses and users of groundwater in the Subbasin.

The criteria used to define groundwater conditions at which undesirable results occur are described in Section 3.2.7. These criteria are based on a quantitative combination of minimum threshold exceedances for each sustainability indicator.

3.2.1 Chronic Lowering of Groundwater Levels

Potential Causes of Chronic Lowering of Groundwater Levels

Chronic lowering of groundwater levels is an undesirable result applicable to, but not currently occurring within, the Subbasin. The primary cause of groundwater conditions that would lead to chronic lowering of groundwater levels is groundwater production in excess of natural and artificial recharge over a period that contains both wet and dry water years.

Relationship Between Chronic Lowering of Groundwater Levels and Other Sustainability Indicators

Chronic lowering of groundwater levels is also associated with a reduction of groundwater in storage, potential seawater intrusion, and potential land subsidence in the Subbasin. Under projected operations, the volume of freshwater in storage is expected to decrease in the Subbasin between 2016 and 2076 (see Section 2.5.5.3 Quantification of Projected Water Budget). Some reductions in groundwater storage may be required for the operation of water quality management projects that mitigate historical groundwater quality degradation in the Subbasin, however seawater intrusion related to groundwater withdrawal is not desirable within the Subbasin. The City of Santa Monica and the GSA will monitor for potential seawater intrusion using chloride concentrations in the groundwater, rather than water levels (see Section 3.2.3 Seawater Intrusion).

There is no historical evidence of chronic lowering of groundwater levels causing significant and unreasonable degradation of groundwater quality in the Subbasin. However, chronic lowering of groundwater levels does have the potential to impact existing groundwater quality remediation programs in the Subbasin (see Section 3.2.4 Significant and Unreasonable Degradation of Water Quality).

Land subsidence may occur in the Subbasin if groundwater levels drop below historical low groundwater levels for a sufficient time to allow for the collapse of pore-structures and settling of clay rich sediments, which are prone to subsidence (see Section 3.2.5 Land Subsidence). However, there are no clay rich sediments within the Silverado aquifer, groundwater elevations are projected to stay within the Silverado aquifer, and DWR has classified the Subbasin as having a low risk for future land subsidence resulting from groundwater withdrawals (DWR 2014). The City of Santa Monica and the GSA will monitor for potential land subsidence using publicly available GPS and InSAR data for the Subbasin (see Section 3.2.5 Land Subsidence).

The only remaining areas of interconnected surface water and groundwater in this highly urbanized Subbasin occur adjacent to the coast, where the Ballona and Silverado aquifers are separated from the surface water system by the Bellflower aquitard (see Section 2.4.6 Interconnected Groundwater and Surface Water, and 2.4.7 Groundwater Dependent Ecosystems). Therefore, loss of interconnected surface water is not related to chronic lowering of groundwater levels from groundwater production in the Ballona and Silverado aquifers that, by necessity, occurs inland from the coast to prevent seawater intrusion.

Effects on Beneficial Uses and Users of Groundwater

Chronic lowering of groundwater levels has the potential to impact beneficial uses and users of groundwater, including groundwater production, and can impact groundwater quality treatment if wells must be taken offline as a result of decreasing groundwater levels. Undesirable results related to chronic lowering of groundwater levels will prevent the municipal and private well operators from meeting their water demand obligations using local groundwater sources. If wells go dry or if deepened wells draw water from formations with reduced water quality, the cost of groundwater would increase for all users. Additionally, loss of groundwater production from municipal wells in the Subbasin will result in a higher demand for imported water from outside the Subbasin, which will result in increased carbon emissions and broader environmental impacts. These impacts could result in higher water costs for all users in the Subbasin.

Criteria Used to Determine Undesirable Results Related to Chronic Declines in Groundwater Levels

Under projected operations, groundwater elevations in 2076 are expected to be similar to those in 2016 (Figure 3-1). However, the City of Santa Monica is preparing to replace existing, aging production wells in the Charnock wellfield with deeper wells. Production from these deeper wells may induce additional drawdown at the wellfield, not accounted for in the future simulations conducted for this GSP. Additional drawdown at the Charnock wellfield is not anticipated to impact groundwater remediation activities, and the City of Santa Monica actively monitors plume containment. Impacts from groundwater level declines will continue to be monitored and evaluated throughout the planning and implementation horizon for this GSP.

Chronic lowering of groundwater levels in the Subbasin could cause undesirable results if groundwater levels drop to elevations below which:

- Water quality degradation management projects' effectiveness is impaired,
- The volume of groundwater available is insufficient for municipal/industrial supplies,
- Significant and unreasonable seawater intrusion is induced, or
- Subsidence that substantially interferes with land use is induced.

Well construction information, production history, and previous investigations were used to assess the potential levels at which the Subbasin may experience a depletion of groundwater supply related to groundwater elevation. The data reviewed suggest that chronic lowering of groundwater levels indicating a depletion of groundwater supply may occur when pumping groundwater elevations in the San Pedro Formation fall below the approximate mid-point elevation of the combined Silverado and Sunnyside aquifers (City of Santa Monica 2013; City of Santa Monica 2018). At this elevation, which varies in the Subbasin but is approximately -300 ft MSL in the vicinity of the Charnock well field, groundwater modeling suggests that water levels would recover at a slower rate than if groundwater elevations were maintained at a higher elevation (City of Santa Monica 2013; City of Santa Monica 2018). A reduced rate of recovery has the potential to limit operational flexibility if longer-term drought conditions persist in the Subbasin and groundwater resources continue to be relied on as a source of drinking water.

Additionally, at the mid-point elevation of the combined Silverado and Sunnyside aquifers, three of the City of Santa Monica's current drinking water production wells would go dry (Charnock 13, 16, and 19). While the City of Santa Monica intends to conduct a review of the existing well infrastructure and replace older wells with deeper wells in the future, a loss of three wells in the Charnock Wellfield would reduce the City's current ability to produce groundwater by approximately 50%. This would constitute an undesirable result for the City, which is the sole producer of groundwater and a primary stakeholder in the Subbasin. The City of Santa Monica reviewed the minimum threshold criteria to determine the elevation at which undesirable results could occur.

Because the impacts to Subbasin stakeholders occur at production wells and the minimum thresholds are defined in representative monitoring wells, the criteria used to define undesirable results associated with chronic lowering of groundwater levels are static groundwater elevations that correspond to a pumping groundwater level at 50% of the combined thickness of the Silverado and Sunnyside aquifers, where present, in the Subbasin. These groundwater elevations are lower than historical low groundwater levels. Groundwater elevations that drop below historical low groundwater levels may be required in certain areas to maintain operational flexibility for groundwater quality management projects, to protect potable groundwater in the aquifers, and ensure ongoing beneficial use of groundwater for municipal and industrial supplies.

3.2.2 Significant and Unreasonable Reduction of Groundwater Storage

Potential Causes of Reduction of Groundwater in Storage

Significant and unreasonable reduction of groundwater in storage is an undesirable result applicable to, but not currently occurring within, the Subbasin. Reduction of groundwater in storage is directly related to chronic lowering of groundwater levels (see Section 3.2.1 Chronic Lowering of Groundwater Levels). The primary cause of a reduction of groundwater in storage is groundwater production in excess of natural and artificial recharge during a period containing both wet and dry water years. Additionally, in the Subbasin fresh groundwater in storage may be replaced by seawater over time. Seawater intrusion is discussed separately in Section 3.3.3 Significant and Unreasonable Seawater Intrusion.

Relationship Between Reduction of Groundwater in Storage and Other Sustainability Indicators

Reduction of groundwater in storage is directly related to chronic lowering of groundwater levels (see Section 3.2.1 Chronic Lowering of Groundwater Levels).

Effects on Beneficial Uses and Users of Groundwater

Significant and unreasonable reduction of groundwater in storage would impact beneficial uses and users of groundwater in the Subbasin by limiting the volume of groundwater available for municipal and industrial supplies and private golf courses, as well as potentially limiting the operational capacity and flexibility of water quality management projects. These impacts are directly related to the impacts from chronic lowering of groundwater levels (see Section 3.2.1 Chronic Lowering of Groundwater Levels) and could result in higher water costs for all users in the Subbasin.

Criteria Used to Determine Undesirable Results Related to Reduction of Groundwater in Storage

Significant and unreasonable reduction of groundwater in storage may occur in the vicinity of the City of Santa Monica's wellfields, if groundwater elevations decline to a level where recharge rates are too slow to replace groundwater removed from storage over a period of wet and dry years. Because the minimum thresholds for chronic lowering of groundwater levels were selected to prevent water levels from falling below the point at which recharge rates are anticipated to decline, and groundwater elevations are directly related to groundwater in storage, groundwater elevations in the Subbasin will be used to determine whether significant and unreasonable reduction of groundwater in storage occurs.

Well construction information, production history, and previous investigations indicate that significant and unreasonable reduction of groundwater storage would occur when pumping groundwater levels fall below 50% of the combined thickness of the Silverado and Sunnyside aquifers. At this elevation, groundwater recharge rates may decline and may no longer be sufficient to replace groundwater removed from storage over a cycle of wet and dry years (City of Santa Monica 2013; City of Santa Monica 2018). Additionally, if groundwater levels reach this elevation, the City of Santa Monica would lose approximately 50% of its current groundwater production capacity, which is a significant and unreasonable impact to Subbasin stakeholders. Therefore, the criterion used to define significant and unreasonable results associated with reduction of groundwater storage are static groundwater elevations that correspond to a pumping groundwater level at 50% of the combined thickness of the Silverado and Sunnyside aquifers. These static and pumping groundwater elevations are lower than historical low groundwater levels. However, reduction of groundwater storage beyond that previously experienced in the Subbasin may be required to maintain operational flexibility for groundwater quality management projects, protect potable aquifer, and ensure ongoing beneficial use of groundwater for municipal/industrial use.

3.2.3 Significant and Unreasonable Seawater Intrusion

Potential Causes of Significant and Unreasonable Seawater Intrusion

Significant and unreasonable seawater intrusion is an undesirable result that is applicable to, but not currently occurring, in the Santa Monica Subbasin. Seawater intrusion is related to chronic lowering of groundwater levels as groundwater elevations in the inland aquifers can induce a landward gradient that draws seawater into the Subbasin. The primary cause of seawater intrusion is groundwater production in excess of natural and artificial recharge during a period containing both wet and dry water years. Additionally, seawater intrusion may occur in the future, even if groundwater production rates are within the current understanding of the Subbasin water balance, as global sea level elevations rise.

Relationship Between Seawater Intrusion and Other Sustainability Indicators

Seawater intrusion has the potential to be induced by chronic lowering of groundwater levels if groundwater production occurs too close to the coast, or if groundwater production from inland wells results in a landward gradient at the coast. This impact was observed historically when groundwater production in the Ballona aquifer occurred close to the coast (see Section 2.4.3 Seawater Intrusion). As seawater intrusion occurs, it replaces fresh groundwater in storage, and degrades water quality. Seawater intrusion will not induce land subsidence. Seawater intrusion in shallow sediments will impact the water quality of interconnected surface water and groundwater adjacent to the coast.

Effects on Beneficial Uses and Users of Groundwater

Significant and unreasonable seawater intrusion would impact beneficial uses and users of groundwater in the Subbasin by limiting the volume of fresh groundwater available for municipal and industrial supplies, requiring additional treatment to be developed for groundwater produced from the City of Santa Monica's production wells, and limiting the operational capacity and flexibility of groundwater quality management projects. Significant and unreasonable seawater intrusion would result in higher water costs for all users in the Subbasin.

Criteria Used to Determine Undesirable Results Related to Seawater Intrusion

Seawater intrusion has occurred historically in limited areas of the Ballona aquifer, as determined by chloride concentrations greater than 500 mg/L in groundwater samples (see Section 2.4.3). Seawater intrusion has not been observed historically in the Silverado aquifer, which is the primary drinking water aquifer in the Subbasin, despite periods of time during which groundwater elevations were below sea level. There is no correlation between groundwater levels and chloride concentration in the observed data. Additionally, the existing numerical model of the Subbasin is sensitive to parameters that impact the rate of simulated seawater intrusion without impacting simulated groundwater levels (see Section 3.2.1 Chronic Lowering of Groundwater Levels). Therefore, modeled groundwater levels are also not a good indicator of seawater intrusion. Therefore, groundwater levels cannot be used as a proxy for seawater intrusion at this time and the minimum threshold for seawater intrusion is instead defined using measured chloride concentrations.

Because groundwater elevations do not currently correlate with chloride concentrations, where measured, chloride concentrations in the Subbasin will be used to determine whether significant and unreasonable seawater intrusion occurs.

Although seawater intrusion may result from declining groundwater elevations within the Subbasin, the primary aquifers within the San Pedro Formation outcrop several miles offshore, at the shelf break. Prior to development of groundwater resources in the Subbasin, freshwater would have flowed offshore driven by higher groundwater elevations onshore than off. Therefore, the groundwater stored in these aquifers offshore provides a buffer between today's groundwater production and instantaneous onshore seawater intrusion impacts.

Seawater intrusion has been documented within the Ballona aquifer however, current chloride concentrations are below the Basin Plan Objective of 200 mg/L in the Ballona and Silverado aquifers and seawater intrusion is not impacting beneficial uses of groundwater in the principal aquifers (see Section 2.4.3 Seawater Intrusion). Additional monitoring wells are recommended for the area between Marina del Rey and the Charnock wellfield in order to provide chloride concentration trends closer to the coast that could act as an early warning for potential seawater intrusion.

Until additional monitoring wells are installed in the Subbasin, the City of Santa Monica's production wells will be used to monitor for seawater intrusion. The Subbasin may experience an undesirable result if chloride concentrations at the City of Santa Monica's Charnock and Olympic Wellfields reach 500 mg/L, which corresponds with the lower limit of brackish groundwater chloride concentrations. This concentration was selected because of the potential impacts to beneficial uses and users of groundwater that could as a result of chloride concentrations that exceed 500 mg/L. These impacts include additional maintenance and cost for the City of Santa Monica's groundwater production facilities, which may experience increased risk of corrosion and will require additional energy expenditures to remove higher concentrations of chloride from the groundwater.

The minimum threshold concentration of chloride is higher than the secondary MCL for chloride, which is 250 mg/L, and higher than the Basin Plan Objective for chloride, which is 200 mg/L. However, the City of Santa Monica is already treating all groundwater to drinking water standards as a result of historical anthropogenic contamination of the Subbasin and has the ability to reduce chloride concentrations in groundwater through its treatment facilities. Therefore, all water served by the City of Santa Monica will continue to meet Title 22 drinking water standards, even if chloride concentrations in the groundwater increase.

3.2.4 Significant and Unreasonable Degradation of Water Quality

Potential Causes of Significant and Unreasonable Degradation of Water Quality Related to Groundwater Production

Degradation of groundwater quality caused by groundwater production is an undesirable result that is not occurring within the Subbasin and is not likely to occur within the Subbasin. The primary recharge to the Subbasin occurs via infiltration of precipitation and runoff in the Santa Monica Mountains. The quality of the water that recharges the Subbasin is equal to or greater water quality than the existing groundwater in the Subbasin, which has experienced degradation of groundwater quality from industrial contamination. As a result of this historical contamination, the groundwater produced at the primary wellfields in the Subbasin requires treatment before it can be served as drinking water. Where not impacted by historical industrial contamination, the occurrence of inorganic constituents in groundwater is consistent with natural recharge, independent of anthropogenic activities (see Section 2.4.4.2 Current and Historical Groundwater Quality).

Where contaminants have impacted the City of Santa Monica production wellfields, the City has constructed facilities that treat the groundwater to drinking water standards before distribution. Additional facilities are planned as part of the City's Sustainable Water Master Plan, the implementation of which will increase groundwater production from the Olympic Wellfield (City of Santa Monica 2018). These treatment facilities will, over time, improve the groundwater quality of the Subbasin, by removing the existing contaminants from the groundwater. The City of Santa Monica is committed to the full restoration of the groundwater quality in the Subbasin through its active groundwater treatment program.

Relationship Between Degradation of Groundwater Quality and Other Sustainability Indicators

Degradation of groundwater quality is not related to chronic lowering of groundwater levels within the freshwater aquifers of the Subbasin, significant and unreasonable reduction of groundwater in storage, significant and unreasonable land subsidence related to groundwater withdrawal, or significant and unreasonable reduction of interconnected surface water and groundwater. Degradation of groundwater quality will occur if significant and unreasonable seawater intrusion occurs in the Subbasin.

Effects on Beneficial Uses and Users of Groundwater

If significant and unreasonable degradation of water quality resulting from groundwater production were to occur in the Subbasin, uses and users of groundwater may be impacted because the cost to treat and serve the groundwater may increase. However, the current groundwater quality has been highly impacted by historical industrial contamination and is already being treated prior to distribution to the public. This existing treatment is not paid for by water users, but rather by the parties responsible for the historical contamination.

Criteria Used to Determine Undesirable Results Related to Degradation of Groundwater Quality Related to Groundwater Production

Because there is no historical evidence of groundwater production causing significant and unreasonable degradation of groundwater quality in the Subbasin, natural recharge is of equal or greater quality than the current groundwater in the Subbasin, groundwater level minimum thresholds will prevent groundwater production from occurring in deeper formations with potentially reduced groundwater quality, industrial contamination of the Subbasin occurred prior to 2015, and the City of Santa Monica is actively remediating this contamination under the regulatory oversight of the SWRCB, DDW, and RWQCB, this GSP does not define additional undesirable results for groundwater degradation within the Subbasin. The City of Santa Monica and the GSA will continue to review groundwater quality data generated to meet the existing regulatory requirements in the Subbasin. These data will be incorporated into the periodic evaluation of the GSP and will be used to assess whether undesirable results for groundwater quality may need to be established in the future.

3.2.5 Significant and Unreasonable Land Subsidence Resulting from Groundwater Withdrawal

Potential Causes of Significant and Unreasonable Land Subsidence Related to Groundwater Production

Land Subsidence resulting from groundwater withdrawal in the Subbasin is a sustainability indicator that is applicable to the Subbasin, but significant and unreasonable land subsidence resulting from groundwater withdrawal is not currently occurring within the Subbasin (see Section 2.4.5 Subsidence). Groundwater levels that are below historical conditions may cause land subsidence because groundwater acts to reduce the effective stress needed to maintain pore-structures in the aquifer. As groundwater levels decline, pressure on the aquifer matrix increases, which may cause the pore-structure to collapse, causing the land surface to subside. Fine grained sediments such as silts and clays are most prone to subsidence resulting from pore pressure declines as a result of groundwater production.

Relationship Between Land Subsidence Related to Groundwater Withdrawal and Other Sustainability Indicators

Land subsidence related to groundwater withdrawal in the Subbasin is directly related to chronic lowering of groundwater levels if groundwater levels drop below historical lows and these declines occur within fine-grained sediments prone to subsidence. Land subsidence related to groundwater withdrawal in the Subbasin is also influenced by seawater intrusion, which tends to maintain pressure in the sedimentary pore space, thereby limiting the potential for subsidence. Significant and unreasonable seawater intrusion is discussed in Section 3.2.3, Seawater Intrusion. Land subsidence related to groundwater withdrawal in the Subbasin is not related to degradation of water quality or reduction of interconnected surface water and groundwater.

Effects on Beneficial Uses and Users of Groundwater

Land subsidence resulting from groundwater withdrawal in the Subbasin that substantially interferes with surface land uses has the potential to impact beneficial uses and users of groundwater in the Subbasin by negatively impacting surface infrastructure including roads, pipelines, and buildings. In the urban environment of the Subbasin infrastructure impacts from differential changes in the land surface elevation include shifting and cracking of building foundations, damaged or less efficient sewer lines, cracked roadways, and water conveyance utilities. Once damage has occurred, the cost to fix the infrastructure can be substantial and would impact the Subbasin stakeholders who would have to pay for repairs to damaged infrastructure.

Criteria Used to Determine Undesirable Results Related to Land Subsidence Related to Groundwater Production

Historical records of land subsidence in the Subbasin do not indicate that past groundwater production from the principal aquifers and aquitards of the Subbasin has caused land subsidence that substantially interfered with surface land uses. Subsidence related to groundwater production from the principal aquifers and aquitards of the Subbasin has not occurred the primary aquifers in the Subbasin are composed of fine sands and gravels, which hold their structure through changes in groundwater elevation and are less prone to subsidence. There are clay layers associated with the Bellflower aquitard that overlie the primary production aquifers of the Subbasin. These layers have already experienced groundwater elevation changes that would have reduced the effective stress and caused settling of the particles in the past, and are also prone to seawater intrusion, which maintains pore pressure in the shallow sediment and limits subsidence. Additional declines in groundwater elevation within the production aquifers will not induce subsidence in these shallow sediments. Consequently, the Subbasin is at low risk for inelastic land subsidence resulting from groundwater withdrawal (see Section 2.4.5, Land Subsidence).

Although at a low risk for land subsidence induced by groundwater withdrawal, it should be noted that the Subbasin is prone to tectonically induced land subsidence, which cannot be prevented. Therefore, monitoring for land subsidence in the Subbasin must include an understanding of the background rate of land surface elevation change as a result of tectonic forces in order to distinguish between tectonically induced land subsidence and land subsidence induced by groundwater withdrawal.

The undesirable result for land subsidence related to groundwater production within the Subbasin is defined as inelastic land subsidence resulting from groundwater withdrawals from the Subbasin's principal aquifers that substantially interferes with surface land uses or infrastructure. Currently, the groundwater elevation minimum thresholds for chronic declines in groundwater levels and significant and unreasonable reduction of groundwater storage will be used to prevent significant and unreasonable land subsidence resulting from groundwater withdrawal in the principal aquifers. These elevations limit groundwater declines within the Silverado aquifer to levels that remain above thick subsurface clay layers. Therefore, future declines in groundwater elevation will only occur within sand and gravel aquifers that are not prone to land subsidence as a result of reduction in the effective stress. Although groundwater elevation thresholds that prevent chronic declines in groundwater levels will be used as a proxy for direct measurement of land subsidence rates in the Subbasin, the GSA will continue to monitor land subsidence using publicly available InSAR and / or GPS data. If land subsidence linked to groundwater withdrawal from the principal aquifers is established in the future, the City of Santa Monica and the GSA will evaluate the need to select specific groundwater level thresholds for land subsidence.

3.2.6 Significant and Unreasonable Reduction of Interconnected Surface Water and Groundwater

Potential Causes of Significant and Unreasonable Reduction of Interconnected Surface Water and Groundwater

Significant and unreasonable reduction of interconnected surface water and groundwater is an undesirable result that is not occurring within the Subbasin and is unlikely to occur in the Subbasin. The Subbasin is characterized by channels that are lined with concrete to facilitate flood protection (ACOE 1982). Where channels are lined, there is little opportunity for interconnection except for outflow of groundwater through weep holes and channel drains and no opportunity for the establishment of GDEs due to the absence of consistent substrate. Where unlined, discharge areas are primarily estuary environments which receive water from both marine and freshwater sources.

Relationship Between Significant and Unreasonable Reduction of Interconnected Surface Water and Groundwater and Other Sustainability Indicators

Significant and unreasonable reduction of interconnected surface water and groundwater would occur if chronic lowering of groundwater levels occurred in the Bellflower aquitard in the vicinity of the two GDE units identified in the Subbasin. However, there is no groundwater production from the Bellflower aquitard, and the shallow groundwater in the Bellflower aquitard is disconnected from the underlying Ballona and Silverado aquifers, which support groundwater production.

Significant and unreasonable reduction of interconnected surface water and groundwater is not linked to reduction of groundwater in storage, which can occur within the principal aquifers of the Subbasin, seawater intrusion, degradation of water quality, or land subsidence.

Effects on Beneficial Uses and Users of Groundwater

Significant and unreasonable reduction of interconnected surface water and groundwater in the vicinity of the two GDE units would have the potential to impact beneficial uses and users of groundwater in the Subbasin by converting current freshwater habitat to saltwater or brackish water habitat (see Section 2.4.7 Groundwater Dependent Ecosystems). This may occur if groundwater elevations are lowered within or adjacent to the two GDEs in the Subbasin, both of which are adjacent to the Pacific Ocean. However, in preparation for anticipated sea level rise as a result of climate change, and in response to historical degradation of the existing BWER habitat, CDFW is planning to undertake a restoration project for the BWER, the largest identified GDE in the Subbasin (CDFW 2019). This project will alter current distribution of estuarine aquatic and associated upland habitats (CDFW 2019). Therefore, the beneficial uses and users of groundwater in the BWER are slated to change over the duration of the project and the potential impacts to potential future beneficial uses and users of groundwater cannot be assessed at this time.

Criteria Used to Determine Undesirable Results Related to Land Subsidence Related to Groundwater Production

Potential wetlands, shallow groundwater (less than 30 feet[1]), and GDEs have been identified in the PCH Unit and BWER in the Subbasin (see Section 2.4.7, Groundwater Dependent Ecosystems). Depletion of groundwater supporting these areas is not currently occurring and will not occur as a result of groundwater production for three primary reasons. First, the groundwater that supports the two identified GDE habitats occurs within the Bellflower aquitard, a shallow surface layer that is hydraulically disconnected from the underlying Ballona and Silverado aquifers in much, though not all, of the Subbasin (see Section 2.3.2, Principal Aquifers and Aquitards). Second, both the BWER and the PCH GDE unit are over one mile from the primary production wells in the Subbasin and water level changes observed in the vicinity of the production wellfield are not observed in shallow groundwater wells adjacent to the Pacific Ocean. Third, future development of groundwater resources near the coast is not planned due to the combined risk of inducing sweater intrusion, which has occurred historically in shallow groundwater production wells west of Lincoln Boulevard, and the risk of infrastructure disruption by sea level rise. If any future projects do propose to develop shallow groundwater resources within one mile of documented

1 30-foot depth is identified by the Nature Conservancy as representative of groundwater conditions that may sustain common phreatophytes and wetland ecosystems (Rohde et al. 2018).

wetlands or GDEs, they must evaluate their potential to cause significant and unreasonable depletion of interconnected surface water and groundwater, including potential impacts to GDEs, in order to demonstrate compliance with this GSP.

Because the identified GDE habitat in the Subbasin is not supported by groundwater in the Ballona or Silverado aquifers, where the majority of the groundwater in the Subbasin is produced, and no groundwater production is planned for the Bellflower aquitard within one mile of the existing habitat, specific undesirable results related to interconnected surface water and groundwater are not defined in this GSP. However, in the event that future groundwater production is planned within a mile of the BWER, additional investigations should be performed to assess whether the planned production may cause significant and unreasonable depletion of interconnected surface water and groundwater that negatively impacts GDEs.

3.2.7 Defining Undesirable Results

Groundwater conditions in the Subbasin are currently monitored with a network of over 93 wells in the GSP monitoring network, and an additional 108 wells with known screen intervals in the Ballona and Silverado aquifers (see Section 3.5.2 Description of Existing Monitoring Network). Eight of the GSP monitoring network wells were selected as representative monitoring points (RMPs) for groundwater elevations in the Subbasin and ten were selected for seawater intrusion (Figure 3-2; see Section 3.5.6 Representative Monitoring). The two sets of wells do not overlap, because seawater intrusion is being measured by chloride concentration in the groundwater at the City of Santa Monica’s production wells, at which chloride concentrations have been measured for over 20 years, while the groundwater elevation RMPs are dedicated monitoring wells that measure static groundwater level conditions in the aquifers. Although minimum thresholds used to assess whether the Subbasin is experiencing undesirable results were only selected at the eight groundwater level, and ten seawater intrusion RMPs, groundwater elevation and groundwater quality measurements will continue to be collected from the broader monitoring network.

Undesirable results in the Subbasin will be identified by comparing groundwater elevation and concentrations from the 18 RMPs to the respective minimum threshold for the applicable sustainability indicator (Table 3-1). Undesirable results related to chronic declines in groundwater elevation, significant and unreasonable loss of groundwater in storage, and significant and unreasonable land subsidence resulting from groundwater withdrawal will be determined using the ten groundwater elevation RMPs (Table 3-1). Undesirable results related to significant and unreasonable seawater intrusion will be determined using ten of the 18 RMPs (Table 3-1).

Table 3-1. Representative Monitoring Points in the Subbasin

RMP Casing Name	Groundwater Monitoring Program[a]	Screen Interval (s) (ft bgs)	Sustainability Indicator(s)[b] Monitored
RMW-3	CASGEM; Charnock R	179.5—199.5	Levels, Storage, Subsidence
RMW-8	CASGEM; Charnock R	240—269.5	Levels, Storage, Subsidence
RMW-9	CASGEM; Charnock R; Charnock E	164—184	Levels, Storage, Subsidence
RMW-28	CASGEM; Charnock R	157—172	Levels, Storage, Subsidence
OB-7	CASGEM; Olympic	215—246	Levels, Storage, Subsidence
OB-9B	CASGEM; Olympic	202.15—222.15	Levels, Storage, Subsidence
OB-9C	CASGEM; Olympic	305.33—335.33	Levels, Storage, Subsidence
OB-17C	CASGEM; Olympic	295.6—325.6	Levels, Storage, Subsidence
Arcadia No. 4	DDW	85-218	Seawater Intrusion
Arcadia No. 5	DDW	122—222	Seawater Intrusion

Table 3-1. Representative Monitoring Points in the Subbasin

RMP Casing Name	Groundwater Monitoring Program[a]	Screen Interval (s) (ft bgs)	Sustainability Indicator(s)[b] Monitored
Santa Monica No. 1	DDW	151—250	Seawater Intrusion
Santa Monica No. 3	DDW	210—270; 300—380; 410—430; 490—530	Seawater Intrusion
Santa Monica No. 4	DDW	200—410; 470—540	Seawater Intrusion
Charnock No. 16	DDW	230—390	Seawater Intrusion
Charnock No. 18	DDW	240—455	Seawater Intrusion
Charnock No. 19	DDW	200—450	Seawater Intrusion
Charnock No. 20	DDW	242—295; 315—385	Seawater Intrusion
City Hall Well	—	60—90; 120—160	Seawater Intrusion

Notes:

[a] The majority of the RMPs are associated with existing groundwater monitoring programs discussed further in Section 2.1.2 Water Resources Monitoring and Management Programs. CASGEM = California Statewide Groundwater Elevation Monitoring; Charnock R = Charnock Groundwater Management Program; Charnock E = Charnock Early Warning Groundwater Quality Monitoring; DDW = Division of Drinking Water; Olympic = Olympic Wellfield Groundwater Monitoring Program

[b] Levels = Chronic Decline in Groundwater Levels, Subsidence = Land Subsidence resulting from groundwater withdrawals, Storage = Reduction of Groundwater Storage

3.2.7.1 Groundwater Elevation Undesirable Results

Groundwater elevations measured at wells RMW-3, RMW-8, RMW-9, RMW-28, OB-7, OB-9B, OB-9C, and OB-17C will be used to assess whether an undesirable result associated with chronic lowering of groundwater levels ("Levels", Table 3-1), significant and unreasonable reduction of groundwater storage ("Storage", Table 3-1), and significant and unreasonable land subsidence related to groundwater withdrawals ("Subsidence", Table 3-1) has occurred in the Subbasin (Figure 3-2). These eight wells were chosen based on their proximity to areas of active groundwater production, well construction, records of measurement, and inclusion in existing monitoring programs in the Subbasin (see Section 3.5.6 Representative Monitoring). Historical groundwater elevations at these wells are representative of groundwater conditions in each of the wellfields and reflect the observed changes in groundwater levels and experienced in the Subbasin between 1985 and 2019 (Figure 3-3).

Because groundwater levels are locally impacted by municipal and industrial extractions and operations of groundwater quality management projects, a groundwater level minimum threshold exceedance at a single well is not considered undesirable. In addition, because groundwater levels in the Subbasin respond to changing production patterns and periods of elevated groundwater recharge, minimum threshold exceedances during a single monitoring event would not be indicative of undesirable results in the Subbasin.

Undesirable results for chronic lowering of groundwater levels, significant and unreasonable reduction of groundwater in storage, and significant and unreasonable land subsidence resulting from groundwater withdrawals are defined as groundwater elevations that are below the minimum threshold at five out of the eight groundwater level representative monitoring points for two consecutive spring monitoring events.

3.2.7.2 Seawater Intrusion Undesirable Results

Chloride concentrations will be measured at ten RMPs to characterize undesirable results associated with significant and unreasonable seawater intrusion (Table 3-1). Nine of these ten wells are active groundwater production wells operated by the City of Santa Monica (Figure 3-2). The tenth well, located in the vicinity of the Santa Monica City Hall will be added to the monitoring network in order to provide a well that is closer to the coast.

Since the late 1980s, the chloride concentration in groundwater samples collected from wells in the Charnock, Olympic, and Arcadia wellfields has ranged from approximately 53 mg/L at Charnock No. 18 to 252 mg/L at well Charnock No. 13 (Figure 2-39). With the exception of the first two samples collected from Charnock 13, chloride concentrations at the City of Santa Monica's production wells have all been below the basin plan objective of 200 mg/L (see Section 2.4.4 Groundwater Quality).

The Subbasin would be experiencing undesirable results related to significant and unreasonable seawater intrusion if the concentration of chloride exceeds 500 mg/L at six of the ten water quality representative monitoring points for two consecutive annual groundwater quality sampling events.

3.3 Minimum Thresholds

This section describes the minimum thresholds established for chronic lowering of groundwater levels, significant and unreasonable reduction of groundwater in storage, significant and unreasonable land subsidence, and significant and unreasonable seawater intrusion. Minimum thresholds for degradation of groundwater quality and interconnected surface water are not established in this GSP (see Sections 3.2.4 Significant and Unreasonable Degradation of Groundwater Quality and 3.2.6 Significant and Unreasonable Depletion of Interconnected Surface Water and Groundwater).

Table 3-2. Minimum Thresholds

RMP Casing Name	Chronic Decline in Groundwater Levels (ft MSL)	Significant and Unreasonable Reduction of Groundwater Storage (ft MSL)	Significant and Unreasonable Land Subsidence Related to Groundwater Withdrawal (ft MSL)	Significant and Unreasonable Seawater Intrusion (Chloride – mg/L)
RMW-3	-175	-175	-175	—
RMW-8	-165	-165	-165	—
RMW-9	-165	-165	-165	—
RMW-28	-160	-160	-160	—
OB-7	5	5	5	—
OB-9B	20	20	20	—
OB-9C	-95	-95	-95	—
OB-17C	-85	-85	-85	—
Arcadia No. 4	—	—	—	500
Arcadia No. 5	—	—	—	500
Santa Monica No. 1	—	—	—	500
Santa Monica No. 3	—	—	—	500
Santa Monica No. 4	—	—	—	500
Charnock No. 16	—	—	—	500

Table 3-2. Minimum Thresholds

RMP Casing Name	Chronic Decline in Groundwater Levels (ft MSL)	Significant and Unreasonable Reduction of Groundwater Storage (ft MSL)	Significant and Unreasonable Land Subsidence Related to Groundwater Withdrawal (ft MSL)	Significant and Unreasonable Seawater Intrusion (Chloride – mg/L)
Charnock No. 18	—	—	—	500
Charnock No. 19	—	—	—	500
Charnock No. 20	—	—	—	500
City Hall Well	—	—	—	500

Notes:
Interconnected surface water-groundwater and degradation of groundwater quality related to groundwater production minimum thresholds are not established because they are not undesirable results applicable to the Subbasin.

The minimum thresholds discussed below are groundwater elevations and chloride concentrations that avoid undesirable results (Table 3-2). As discussed in Section 3.2.7 Defining Undesirable Results, undesirable results are defined as:

- Pumping groundwater elevations below 50% of the combined thicknesses of the Silverado and Sunnyside aquifers.
- Chloride concentrations that exceed 500 mg/L at the City of Santa Monica's production wellfields.

Groundwater level minimum thresholds were established based on historical groundwater elevation data, well construction information, previous investigations, an analysis of projected groundwater levels based on simulation results from the LACPGM, and discussions with stakeholders regarding well operation requirements and potential impacts from minimum threshold levels. The projected groundwater levels used in the analysis of minimum thresholds were simulated over the 61-year period from water year 2016 to 2076 and incorporate the impact of future climate change scenarios (see Section 2.5.6.3 Projected Water Budget).

Seawater intrusion minimum thresholds were established based on current and historical groundwater quality data, the concentration threshold for brackish groundwater, a review of state and federal water quality standards, and discussions with stakeholders.

The data reviewed and analyzed during determination of minimum thresholds for chronic declines in groundwater levels, significant and unreasonable reduction of groundwater in storage, land subsidence related to groundwater withdrawal that substantially interferes with surface land uses, and significant and unreasonable seawater intrusion are discussed in the following sections.

3.3.1 Chronic Lowering of Groundwater Levels

3.3.1.1 Method Used to Establish the Minimum Threshold

Minimum threshold groundwater elevations established at the eight groundwater elevation RMPs are based on correlations established between groundwater elevations in the City of Santa Monica production wells and static groundwater levels in nearby monitoring wells. The undesirable result for chronic declines in groundwater elevation is pumping groundwater levels that fall below the mid-point of the combined thickness of the Silverado and Sunnyside aquifers. In the Charnock wellfield, this corresponds to a pumping groundwater level of approximately -

300 ft MSL, while in the Olympic Wellfield this corresponds to a pumping groundwater level of approximately -330 ft MSL. The corresponding static groundwater levels at the RMPs in the Charnock wellfield range from -175 ft MSL to -160 ft MSL (Table 3-2). At the Olympic Wellfield the corresponding static groundwater levels at the RMPs range from -75 ft MSL to 10 ft MSL. The groundwater level minimum thresholds provide operational flexibility for stakeholders in the Subbasin while ensuring ongoing beneficial use of groundwater by maintaining 50% of the groundwater available for municipal and industrial supplies in the Silverado and Sunnyside aquifers. By definition, the minimum threshold groundwater elevations will prevent chronic lowering of groundwater levels because they provide a lower limit on groundwater elevation declines within the Subbasin.

Projected groundwater levels calculated using the LACPGM model indicate that at a production rate of 9,000 AFY, groundwater elevations at the RMPs will decline and recover based on the volume of recharge available in the Subbasin (Figure 3-1). Groundwater elevations at the end of each of the future scenarios are projected to be higher than they are at the beginning of the scenario. Therefore, chronic lowering of groundwater levels is not anticipated to occur within the Subbasin.

Over the GSP planning and implementation horizon, the groundwater elevation minimum thresholds allow for groundwater extractions that exceed historical levels while protecting against long-term aquifer supply depletion. Groundwater elevations measured at each of the RMPs will be reported to DWR in the annual reports that will follow the submittal of this GSP. As funding becomes available, it is recommended that each of these wells be instrumented with a pressure transducer capable of recording daily groundwater levels. The groundwater elevation in each well will be compared to the minimum threshold to determine whether the Subbasin is experiencing undesirable results associated with chronic declines of groundwater levels.

3.3.1.2 Relationship to Other Sustainability Indicators

Reduction of Groundwater in Storage. The minimum thresholds for chronic declines in groundwater level are the same as those for reduction of groundwater in storage. Therefore, they will not interfere with the ability of the Subbasin to avoid undesirable results related to reduction of groundwater in storage.

Seawater Intrusion. The minimum thresholds for chronic declines in groundwater level are separate from the chloride concentrations that will be used to determine whether or not the Subbasin is experiencing undesirable results from seawater intrusion. In the event that groundwater levels at the RMPs remain above the minimum thresholds for chronic declines in groundwater level, while chloride concentrations at the RMPs exceed the minimum thresholds, the GSA will take action to mitigate the impact of seawater intrusion. Therefore, the minimum thresholds for chronic declines in groundwater elevation will not interfere with the ability of the Subbasin to avoid undesirable results related to seawater intrusion.

Degradation of Groundwater Quality. This GSP does not define additional undesirable results, beyond those that impacted the Subbasin prior to 2015, for groundwater degradation within the Subbasin. The minimum thresholds for chronic declines in groundwater level were selected to avoid negatively impacting existing groundwater remediation activities in the Subbasin.

Land Subsidence Related to Groundwater Production. The minimum thresholds for chronic declines in groundwater level are the same as those for land subsidence related to groundwater production in the Subbasin. Therefore, they will not interfere with the ability of the Subbasin to avoid undesirable results related to land subsidence caused by groundwater production from the Subbasin.

Interconnected Surface Water and Groundwater. This GSP does not define specific undesirable results for interconnected surface water and groundwater because the only identified GDEs in the Subbasin are adjacent to the coast and supported by shallow groundwater that occurs within the Bellflower aquitard. This shallow groundwater is disconnected from the primary aquifers in the Subbasin. Therefore, the minimum thresholds for chronic declines in groundwater level will not impact the GDEs in the Subbasin.

3.3.1.3 Effects on Neighboring Basins

West Coast Basin adjudicated area. If groundwater elevations in the Santa Monica Subbasin reach the minimum thresholds for chronic declines in groundwater levels, flow from the Santa Monica Subbasin to the West Coast Basin adjudicated area may diminish or reverse. On average, between 1985 and 2015 numerical groundwater model results suggest that approximately 1,900 AFY flowed from the Santa Monica Subbasin to the West Coast Basin adjudicated area. The current conditions are lower, with numerical modeling results suggesting that approximately 1,000 AF flowed from the Santa Monica Subbasin to the West Coast Basin adjudicated area in 2015. Future groundwater production is anticipated to reverse these flows, resulting in annual inflows to the Santa Monica Subbasin of approximately 400 AFY. In the event that water levels in the Santa Monica Subbasin reach the minimum thresholds for chronic declines in groundwater levels these flows may be larger. Refinement of the numerical groundwater model is required to investigate the likelihood of these flow changes and the potential impacts to the West Coast Basin adjudicated area. The magnitude of these changes, however, is not anticipated to limit the ability of the West Coast Basin watermaster to sustainably manage this adjudicated area.

Hollywood Subbasin. The Hollywood Subbasin is separated from the Santa Monica Subbasin by the Newport-Inglewood fault. This fault limits the flow of water between the two subbasins. Therefore, the minimum thresholds for chronic declines in groundwater elevation are not anticipated to impact the Hollywood Subbasin.

Central Subbasin. The Central Subbasin is separated from the Santa Monica Subbasin by the Newport-Inglewood fault. This fault limits the flow of water between the two subbasins. Therefore, the minimum thresholds for chronic declines in groundwater elevation are not anticipated to impact the Central Subbasin.

3.3.1.4 Effects on Beneficial Uses and Users of Groundwater

Municipal Well Operators and Public and Private Water Purveyors. The chronic lowering of groundwater level minimum thresholds were selected to protect the long-term beneficial use of the Subbasin's groundwater for municipal well operators. The minimum thresholds may require new municipal wells that are deeper than existing municipal wells over time. The City of Santa Monica, which is the only municipal well owner operating in the Subbasin has planned for that contingency and will incorporate the minimum thresholds into the design of future wells that will replace existing, aging wells in the Subbasin.

Local Land Use Planning Agencies. With the exception of the City of Santa Monica, none of the local land use planning agencies rely on groundwater produced from the Subbasin. Therefore, the minimum thresholds for chronic lowering of groundwater levels will not impact existing water use or land use plans developed by these agencies. The minimum thresholds for chronic lowering of groundwater levels will, however, protect against long-term depletion and undesirable results in the Subbasin, thereby maintaining the groundwater resources for use in the future.

Environmental Users. The environmental communities that rely on groundwater in the Subbasin do not rely on groundwater that is connected to the primary production aquifers, but rather on shallow groundwater that occurs within the Bellflower aquitard. Water levels in the Bellflower aquitard are influenced by localized precipitation and proximity to the Pacific Ocean. These water levels are not correlated with groundwater levels in the production aquifers. Therefore, the minimum thresholds selected for chronic lowering of groundwater levels, which are selected for representative monitoring points in the Ballona and Silverado aquifers, will not impact environmental users of groundwater in the Subbasin.

Disadvantaged Communities. The chronic lowering of groundwater level minimum thresholds were selected to protect the long-term beneficial use of the Subbasin's groundwater for municipal groundwater production. There are no private domestic wells in the Subbasin and the only disadvantaged communities that rely on groundwater in the Subbasin are connected to the City of Santa Monica's water distribution system. Because the chronic lowering of groundwater level minimum thresholds protect the beneficial use of groundwater by the City of Santa Monica, these thresholds will protect the beneficial use of groundwater for disadvantaged communities.

3.3.1.5 Relevant Federal, State, or Local Standards

There are no federal, state, or local standards for chronic lowering of groundwater levels.

3.3.1.6 Method for Quantitative Measurement of Minimum Thresholds

Groundwater elevations will be measured at the RMPs in accordance with the Best Management Practices (BMPs) published by DWR on monitoring protocols and discussed further in Section 3.5.6 Protocols for Data Collection and Monitoring (DWR 2016a).

3.3.2 Significant and Unreasonable Reduction of Groundwater in Storage

3.3.2.1 Method Used to Establish the Minimum Threshold

Minimum threshold groundwater elevations established at the eight groundwater elevation RMPs coincide with pumping groundwater levels at the mid-point of the Silverado and Sunnyside aquifers (Table 3-2). Pumping groundwater levels that are below the mid-point of the Silverado and Sunnyside aquifers would be an undesirable result. The same data and criteria used to evaluate undesirable results associated with chronic lowering of groundwater levels were used to define significant and unreasonable reduction of groundwater storage.

Pumping groundwater elevations at the mid-point of the Silverado and Sunnyside aquifers are lower than historical low groundwater levels. The operational requirements of groundwater quality management projects, historical groundwater conditions in the Subbasin, and local well construction information were used to evaluate the aquifer saturation at which undesirable results may occur. This analysis suggests that maintaining groundwater levels above the mid-point of the Silverado and Sunnyside aquifers will protect against long-term aquifer supply depletion and provide necessary operational flexibility for municipal, industrial, and private groundwater users.

Future projected conditions generated with the LACPGM indicate that groundwater elevations are expected to remain above the groundwater level minimum thresholds throughout the future simulation period (Figure 3-1). Correspondingly, there is no projected cumulative storage loss during the projected period. However, the future projections include a reversal of flow leaving the Subbasin to the West Coast Basin, and potential seawater intrusion. The cumulative change of freshwater in storage over the simulation period could be as high as 128,000

AF (see Section 2.5.6 Quantification of Current, Historical, and Projected Water Budget). For comparison, the cumulative loss of storage between 1985 and 2018 was estimated to be approximately 41,000 AF.

Groundwater levels measured at the eight RMPs used to set minimum thresholds for reduction of groundwater in storage will be reported to DWR in the annual reports that will follow the submittal of this GSP. As funding becomes available, it is recommended that each of these wells be instrumented with a pressure transducer capable of recording daily groundwater levels. The groundwater elevation in each well will be compared to the minimum threshold assigned in Table 3-2 to determine whether the Subbasin is experiencing undesirable results related to reduction in groundwater storage.

3.3.2.2 Relationship to Other Sustainability Indicators

The minimum thresholds for reduction of groundwater in storage are the same as those for chronic declines in groundwater level. Therefore, they will not interfere with the ability of the Subbasin to avoid undesirable results related to chronic declines in groundwater level, seawater intrusion, or land subsidence related to groundwater production in the Subbasin, as discussed in Section 3.3.1.2 Relationship to Other Sustainability Indicators. This GSP does not define additional undesirable results, beyond those that impacted the Subbasin prior to 2015, for groundwater degradation, or specific undesirable results for interconnected surface water and groundwater.

3.3.2.3 Effects on Neighboring Basins

The minimum thresholds for reduction of groundwater in storage are the same as those for chronic declines in groundwater level. Therefore the anticipated effects on neighboring basins will be the same as those discussed in Section 3.3.1.3 Effects on Neighboring Basins.

3.3.2.4 Effects on Beneficial Uses and Users of Groundwater

The minimum thresholds for reduction of groundwater in storage are the same as those for chronic declines in groundwater level. Therefore, the anticipated effects on beneficial uses and users of groundwater will be the same as those discussed in Section 3.3.1.4 Effects on Beneficial Uses and Users of Groundwater.

3.3.2.5 Relevant Federal, State, or Local Standards

There are no federal, state, or local standards for reduction of groundwater in storage.

3.3.2.6 Method for Quantitative Measurement of Minimum Thresholds

Groundwater elevations will be used as a proxy for groundwater in storage. These elevations will be measured at the RMPs in accordance with the Best Management Practices (BMPs) published by DWR on monitoring protocols and discussed further in Section 3.5.6 Protocols for Data Collection and Monitoring (DWR 2016a).

3.3.3 Significant and Unreasonable Seawater Intrusion

3.3.3.1 Method Used to Establish the Minimum Threshold

The minimum threshold chloride concentration established at the ten seawater intrusion RMPs is 500 mg/L, which coincides with the chloride concentration indicative of the onset of brackish water conditions (Table 3-2). The minimum threshold concentration of 500 mg/L was selected because replacing fresh groundwater with brackish groundwater at the Olympic and Charnock Wellfields, would be an undesirable result for the Subbasin. Chloride concentrations in the Subbasin are not correlated with groundwater elevations, therefore the seawater intrusion minimum threshold is distinct from the minimum thresholds established for chronic declines in groundwater elevation, significant and unreasonable groundwater in storage, and significant and unreasonable land subsidence.

Current chloride concentrations at the Charnock and Olympic Wellfields range from 67 to 166 mg/L (see Section 2.4.3 Seawater Intrusion). However, future simulations suggest that landward flow averaging approximately 2,100 AFY may occur across the western boundary of the Subbasin (see Section 2.5.5.3 Quantification of Projected Water Budget). There is uncertainty in both the volume of potential flow and the chloride concentration of the groundwater to the west of the Subbasin. Therefore, this GSP recommends installing additional monitoring wells for seawater intrusion in the area between Marina del Rey and the Charnock Wellfield. These wells will be used to help refine the model estimates of flow and can be added as RMPs for seawater intrusion after they have been installed.

Chloride concentrations measured at the ten RMPs used to set minimum thresholds for seawater intrusion will be reported to DWR in the annual reports that will follow the submittal of this GSP. The concentration of chloride in groundwater at each well will be compared to the minimum threshold chloride concentration assigned in Table 3-2 to determine whether the Subbasin is experiencing undesirable results related to seawater intrusion.

3.3.3.2 Relationship to Other Sustainability Indicators

Chronic Declines in Groundwater Level. The minimum thresholds for seawater intrusion are defined by chloride concentration, rather than groundwater elevation. In the event that chloride concentrations remain below the minimum thresholds for seawater intrusion, while groundwater elevations at the RMPs exceed the minimum thresholds for chronic declines in groundwater level, the GSA will take action to mitigate the impact of chronic declines in groundwater level. Therefore, the minimum thresholds for seawater intrusion will not interfere with the ability of the Subbasin to avoid undesirable results related to chronic declines in groundwater level.

Reduction of Groundwater in Storage. The minimum thresholds for reduction of groundwater in storage are the same as those for chronic declines in groundwater level. Because the minimum thresholds for seawater intrusion will not interfere with the ability of the Subbasin to avoid undesirable results related to chronic declines in groundwater level, they will not interfere with the ability of the Subbasin to avoid undesirable results related to reduction of groundwater in storage.

Degradation of Groundwater Quality. This GSP does not define additional undesirable results, beyond those that impacted the Subbasin prior to 2015, for groundwater degradation within the Subbasin. The minimum thresholds for seawater intrusion were selected to avoid impacting existing groundwater remediation activities in the Subbasin.

Land Subsidence Related to Groundwater Production. The minimum thresholds for land subsidence related to groundwater production in the Subbasin are the same as those for chronic declines in groundwater level. Because the minimum thresholds for seawater intrusion will not interfere with the ability of the Subbasin to avoid undesirable results related to chronic declines in groundwater level, they will not interfere with the ability of the Subbasin to avoid undesirable results related to land subsidence from groundwater production in the Subbasin.

Interconnected Surface Water and Groundwater. This GSP does not define specific undesirable results for interconnected surface water and groundwater because the only identified GDEs in the Subbasin are adjacent to the coast and supported by shallow groundwater that occurs within the Bellflower aquitard. This shallow groundwater is disconnected from the primary aquifers in the Subbasin. Therefore, the minimum thresholds for seawater intrusion in the primary aquifers will not impact the GDEs in the Subbasin.

3.3.3.3 Effects on Neighboring Basins

The minimum thresholds for seawater intrusion are defined as chloride concentrations within the Santa Monica Subbasin. These chloride concentrations will not impact the Hollywood or Central Subbasins, which lie to the east of the Santa Monica Subbasin. They will also not impact the West Coast Basin adjudicated area which has an active seawater intrusion barrier and is actively managed under the jurisdiction of a watermaster.

3.3.3.4 Effects on Beneficial Uses and Users of Groundwater

Municipal Well Operators and Public and Private Water Purveyors. The minimum thresholds for seawater intrusion were selected to protect the long-term beneficial use of the Subbasin's groundwater for municipal well operators. The minimum thresholds may require additional treatment for groundwater produced from the City of Santa Monica's wells over time. However, City of Santa Monica, which is the only municipal well owner operating in the Subbasin, has planned for that contingency and is already treating the groundwater produced from the Subbasin as a result of historical industrial contamination that occurred prior to 2015. Additional treatment will not interfere with the City of Santa Monica's ability to continue to serve safe, clean drinking water.

Local Land Use Planning Agencies. With the exception of the City of Santa Monica, none of the local land use planning agencies rely on groundwater produced from the Subbasin. Therefore, the minimum thresholds for seawater intrusion will not impact existing water use or land use plans developed by these agencies. The minimum thresholds for seawater intrusion will protect against long-term depletion and undesirable results in the Subbasin, thereby maintaining the groundwater resources for use in the future.

Environmental Users. The environmental communities that rely on groundwater in the Subbasin do not rely on groundwater that is connected to the primary production aquifers, but rather on shallow groundwater that occurs within the Bellflower aquitard. Water levels in the Bellflower aquitard are influenced by localized precipitation and proximity to the Pacific Ocean. These water levels are not correlated with groundwater levels in the production aquifers. Therefore, the minimum thresholds selected for seawater intrusion resulting from groundwater production in the primary aquifers, will not impact environmental users of groundwater in the Subbasin.

Disadvantaged Communities. The chronic lowering of groundwater level minimum thresholds were selected to protect the long-term beneficial use of the Subbasin's groundwater for municipal groundwater production. There are no private domestic wells in the Subbasin and the only disadvantaged communities that rely on groundwater in the Subbasin are connected to the City of Santa Monica's water distribution system. Because the chronic lowering of groundwater level minimum thresholds protect the beneficial use of groundwater by the City of Santa Monica, these thresholds will protect the beneficial use of groundwater for disadvantaged communities.

3.3.3.5 Relevant Federal, State, or Local Standards

There are no federal, state, or local standards for seawater intrusion.

3.3.3.6 Method for Quantitative Measurement of Minimum Thresholds

Chloride concentrations will be used as a proxy for seawater intrusion. These concentrations will be measured in groundwater samples collected from the RMPs in accordance with the Best Management Practices (BMPs) published by DWR on monitoring protocols and discussed further in Section 3.5.6 Protocols for Data Collection and Monitoring (DWR 2016a).

3.3.4 Significant and Unreasonable Degradation of Water Quality

Minimum thresholds for significant and unreasonable degradation of groundwater quality were not established for the Subbasin because the groundwater quality in the Subbasin was impacted by industrial activity prior to 2015. The City of Santa Monica is actively remediating this contamination under the regulatory oversight of the SWRCB, DDW, and RWQCB, and there is no evidence for groundwater quality degradation induced by groundwater production in the Subbasin. If future groundwater production is found to induce groundwater quality degradation, additional characterization of the source of that degradation, and subsequent reassessment of groundwater quality degradation minimum thresholds, may be required.

3.3.5 Significant and Unreasonable Land Subsidence Related to Groundwater Withdrawal

3.3.5.1 Method Used to Establish the Minimum Threshold

Minimum threshold groundwater elevations established at the eight groundwater elevation RMPs coincide with pumping groundwater levels at the mid-point of the Silverado and Sunnyside aquifers (Table 3-3). Pumping groundwater levels that are below the mid-point of the Silverado and Sunnyside aquifers would be an undesirable result. These groundwater levels are also used to define the groundwater levels below which significant and unreasonable land subsidence related to groundwater withdrawal may occur, as clay layers in the subsurface occur below these minimum threshold groundwater elevations.

Pumping groundwater elevations at the mid-point of the Silverado and Sunnyside aquifers are lower than historical low groundwater levels. However, these groundwater levels are not anticipated to induce significant and unreasonable land subsidence related to groundwater withdrawals, because these groundwater levels stay within the sands of the Silverado aquifer, and remain above the clay rich sediments that separate the Silverado from the Sunnyside aquifers. Clayey sediments are more prone to subsidence than are sandy sediments.

Furthermore, minimum thresholds for significant and unreasonable land subsidence related to groundwater withdrawal must be associated with groundwater elevations in the Santa Monica Subbasin, which is located in an active tectonic area. Subsidence that occurs as a result of tectonic forces cannot be separated from subsidence related to groundwater withdrawal with the current InSAR or UNAVCO data (see Section 2.4.5 Subsidence). While the City of Santa Monica's operational requirements may require some groundwater elevation declines in the future, projected groundwater elevations are expected to remain above the groundwater level minimum thresholds throughout the future simulation period (Figure 3-1). Given the projected groundwater conditions, and the geologic materials in which future groundwater elevation declines may occur, the minimum threshold for chronic declines in groundwater elevation is also used for land subsidence in this GSP.

Groundwater levels measured at the eight RMPs used to set minimum thresholds for chronic declines in groundwater elevation and reduction of groundwater in storage will be reported to DWR in the annual reports that will follow the submittal of this GSP. As funding becomes available, it is recommended that each of these wells be instrumented with a pressure transducer capable of recording daily groundwater levels. The groundwater elevation in each well will be compared to the minimum threshold assigned in Table 3-2 to determine whether the Subbasin may experience significant and unreasonable land subsidence related to groundwater withdrawal.

Additionally, the GSA proposes to monitor land subsidence using publicly available InSAR data which will be evaluated and reported to DWR contemporaneously with the GSP periodic reporting (approximately every 5 years). Because localized lowering of surface elevation may occur from causes other than land subsidence, including excavation or grading for construction, consideration will be given to the areal extent of the subsidence and any coincidence with infrastructure disruption and/or groundwater elevations below historical low elevations. If warranted, inelastic land subsidence will be re-evaluated as an undesirable result.

3.3.5.2 Relationship to Other Sustainability Indicators

The minimum thresholds for land subsidence related to groundwater production in the Subbasin are the same as those for chronic declines in groundwater level. Therefore, they will not interfere with the ability of the Subbasin to avoid undesirable results related to chronic declines in groundwater level, reduction of groundwater in storage, or seawater intrusion in the Subbasin, as discussed in Section 3.3.1.2 Relationship to Other Sustainability Indicators. This GSP does not define additional undesirable results, beyond those that impacted the Subbasin prior to 2015, for groundwater degradation, or specific undesirable results for interconnected surface water and groundwater.

3.3.5.3 Effects on Neighboring Basins

The minimum thresholds for land subsidence related to groundwater production in the Subbasin are the same as those for chronic declines in groundwater level. Therefore, the anticipated effects on neighboring basins will be the same as those discussed in Section 3.3.1.3 Effects on Neighboring Basins.

3.3.5.4 Effects on Beneficial Uses and Users of Groundwater

The minimum thresholds for land subsidence related to groundwater production in the Subbasin are the same as those for chronic declines in groundwater level. Therefore, the anticipated effects on beneficial uses and users of groundwater will be the same as those discussed in Section 3.3.1.4 Effects on Beneficial Uses and Users of Groundwater.

3.3.5.5 Relevant Federal, State, or Local Standards

There are no federal, state, or local standards for land subsidence related to groundwater production in the Subbasin.

3.3.5.6 Method for Quantitative Measurement of Minimum Thresholds

Groundwater elevations will be used as a proxy for land subsidence related to groundwater production in the Subbasin. These elevations will be measured at the RMPs in accordance with the Best Management Practices (BMPs) published by DWR on monitoring protocols and discussed further in Section 3.5.6 Protocols for Data Collection and Monitoring (DWR 2016a).

3.3.6 Significant and Unreasonable Reduction of Interconnected Surface Water and Groundwater

Minimum thresholds for significant and unreasonable reduction of interconnected surface water and groundwater were not established for the Subbasin because the surface water that supports GDEs in the Subbasin occurs within the Bellflower aquitard, which is not directly connected to the Ballona and Silverado aquifers in the vicinity of the primary production wellfields (see Sections 2.4.7 Groundwater Dependent Ecosystems and 3.2.6 Interconnected Surface Water). If future groundwater production is planned for the Bellflower aquitard within 1 mile of the identified GDEs, additional characterization of interconnected surface water, and subsequent reassessment of interconnected surface water minimum thresholds, will be required.

3.4 Measurable Objectives

Measurable objectives are "quantifiable goals for the maintenance and improvement of specified groundwater conditions that have been included in an adopted Plan to achieve the sustainability goal for the basin" (23 CCR §351. Definitions). Based on the sustainability goal (see Section 3.1 Sustainability Goal) and undesirable results (see Section 3.2 Undesirable Results) in the Subbasin, measurable objectives were set for the sustainability indicators relevant to the Subbasin.

Table 3-3. Measurable Objectives

RMP Casing Name	Chronic Decline in Groundwater Levels (ft MSL)	Significant and Unreasonable Reduction of Groundwater Storage (ft MSL)	Significant and Unreasonable Land Subsidence Related to Groundwater Withdrawal (ft MSL)	Significant and Unreasonable Seawater Intrusion (Chloride – mg/L)
RMW-3	-115	-115	-115	—
RMW-8	-110	-110	-110	—
RMW-9	-110	-110	-110	—
RMW-28	-105	-105	-105	—
OB-7	30	30	30	—
OB-9B	45	45	45	—
OB-9C	-40	-40	-40	—
OB-17C	-30	-30	-30	—
Arcadia No. 4	—	—	—	200
Arcadia No. 5	—	—	—	200
Santa Monica No. 1	—	—	—	200
Santa Monica No. 3	—	—	—	200
Santa Monica No. 4	—	—	—	200

Table 3-3. Measurable Objectives

RMP Casing Name	Chronic Decline in Groundwater Levels (ft MSL)	Significant and Unreasonable Reduction of Groundwater Storage (ft MSL)	Significant and Unreasonable Land Subsidence Related to Groundwater Withdrawal (ft MSL)	Significant and Unreasonable Seawater Intrusion (Chloride – mg/L)
Charnock No. 16	—	—	—	200
Charnock No. 18	—	—	—	200
Charnock No. 19	—	—	—	200
Charnock No. 20	—	—	—	200
City Hall Well	—	—	—	200

Notes:
Interconnected surface water-groundwater and degradation of groundwater quality related to groundwater production minimum thresholds are not established because they are not undesirable results applicable to the Subbasin.

Historical groundwater levels, well construction details, projected municipal/ industrial and other groundwater demands, previous investigations and projected groundwater level declines were analyzed during the selection of the measurable objectives for chronic declines in groundwater levels, groundwater in storage, and land subsidence related to groundwater withdrawal. The groundwater level measurable objectives, which range from 20 to 60 feet higher than the groundwater level minimum thresholds, provide a reasonable margin of operational flexibility under adverse conditions, by allowing for changes to groundwater production to occur before the groundwater levels reach an elevation at which undesirable results would occur.

Seawater intrusion chloride concentration measurable objectives were established using the Basin Plan Objective for chloride concentrations in the Subbasin. The Basin Plan Objective for chloride concentration is 200 mg/L and is based on the historical water quality in the Subbasin (RWQCB 2019).

A description of the data reviewed and analyzed during determination of the measurable objectives for chronic declines in groundwater levels, reduction of groundwater in storage, seawater intrusion, and land subsidence related to groundwater withdrawal are discussed in the following sections.

3.4.1 Chronic Lowering of Groundwater Levels

The measurable objectives for groundwater levels are static groundwater elevations in the eight groundwater level RMPs that correspond to pumping groundwater elevations in the production wellfields that are 100 feet higher than the minimum threshold groundwater elevation. The pumping groundwater levels are within 50 feet of the top of the Silverado aquifer, and are over 300 feet above the base of the Sunnyside aquifer. These pumping groundwater levels are also approximately 50 feet below the historical low groundwater elevation in the Subbasin at each of the City of Santa Monica's groundwater production wells.

Groundwater elevations in the production wells that are 100 feet higher than the minimum threshold groundwater elevations were selected as the basis for the measurable objective water levels because they are anticipated to provide the City of Santa Monica with a five to ten year buffer of water supply between when groundwater elevations reach the measurable objective water level and when they reach the minimum threshold water level, based on declines in groundwater elevation observed in the production wells between 2015 and 2020. Groundwater elevations between the measurable objective and minimum threshold prevent undesirable results, will be monitored to determine if projects or management actions may need to be implemented as groundwater elevations approach the minimum threshold, and provide sufficient time for planning. Therefore, the measurable objective water levels provide for operational flexibility in the Subbasin, while also preventing undesirable results.

The static groundwater levels at the RMPs that correspond to a pumping groundwater level of -200 ft MSL in the Charnock wellfield range from -105 ft MSL to -115 ft MSL (Table 3-3). At the Olympic Wellfield the corresponding static groundwater levels at the RMPs range from -40 ft MSL to 45 ft MSL. Current groundwater elevations in the Subbasin are 10 to 50 feet higher than the measurable objective groundwater elevation at the RMPs.

Projected groundwater levels calculated using the LACPGM model indicate that at a production rate of 9,200 AFY, groundwater elevations at the RMPs will decline and recover based on the volume of recharge available in the Subbasin (Figure 3-1). It should be noted that the starting groundwater elevations in the numerical model simulations are not an exact match to the historical water levels in the vicinity of the Charnock and Olympic Wellfields. The model was calibrated to water levels in monitoring wells that are not adjacent to the production wellfields and the screen intervals of the representative monitoring wells adjacent to the production wellfields do not necessarily correspond with an exact layer in the numerical model. Therefore, the projected groundwater levels in the numerical model likely reflect a mixed hydraulic response. The USGS is currently working with the City of Santa Monica to develop a refined model of the Subbasin, which will address the discrepancies in predicted and observed water levels identified as part of this GSP.

While the predicted groundwater elevations in the future model scenarios are not expected to precisely match the observed groundwater elevations, the predictive simulations can still be used to assess trends in groundwater elevations. At the end of each of the future scenarios, groundwater elevations are projected to be higher than they are at the beginning of the scenario. Current groundwater elevations are between 40 and 50 feet higher than the measurable objective groundwater elevations near the Charnock Wellfield, and are 15 to 20 feet higher than the measurable objective groundwater elevation near the Olympic Wellfield. The projected water levels at the monitoring points near the Charnock Wellfield decline initially, but recover throughout the simulation, with a total variation of 15 to 20 feet between the high and low elevation (Figure 3-1). Near the Olympic Wellfield, projected variability in groundwater elevation is approximately 20 feet in the shallower wells (Wells OB-7 and OB-9B) and closer to 10 feet in the deeper wells (Wells OB-9C and OB-17C). Therefore, although groundwater elevations will vary in the future they are anticipated to remain above the measurable objective during the planning and implementation horizon for this GSP.

In the event that groundwater elevations do decline below the measurable objective, the minimum threshold groundwater levels are 25 to 50 feet lower than the measurable objective groundwater levels at the RMPs. This allows for operational flexibility for the stakeholders in the Subbasin and, should groundwater levels decline below the measurable objectives, provides sufficient time for groundwater producers to react before groundwater levels reach the minimum thresholds.

Interim Milestones for Groundwater Levels

Interim milestones for chronic lowering of groundwater levels were not established because groundwater levels in the Subbasin are currently higher than the measurable objective groundwater levels.

3.4.2 Reduction of Groundwater in Storage

The measurable objectives for groundwater in storage are static groundwater levels that correspond to a pumping groundwater level at the Charnock and Olympic Wellfields of approximately -200 feet MSL (see Section 3.4.1

Groundwater Levels). Historical groundwater elevations have remained above this threshold without causing undesirable results in the Subbasin, while still allowing for beneficial use of the groundwater by stakeholders. This has been true even during this historic drought conditions experienced by the Subbasin between 2011 and 2016. Thus, the established groundwater level measurable objectives have been shown to ensure sufficient groundwater supply for ongoing beneficial use in the Subbasin during adverse conditions without causing significant and unreasonable loss of groundwater storage.

Interim Milestones for Reduction of Groundwater Storage

Interim milestones for groundwater levels (the indicator for groundwater in storage) were not selected because groundwater levels in the Subbasin are currently higher than the established measurable objective groundwater levels.

3.4.3 Seawater Intrusion

The measurable objectives for seawater intrusion are chloride concentrations in groundwater at the ten seawater intrusion RMPs of 200 mg/L (Table 3-3). Chloride concentrations measured in 2018 at the nine of the ten[2] RMPs were below the measurable objective concentration, which corresponds to the Basin Plan Objective concentration for chloride in the groundwater (Figure 2-39; RWQCB 2019). Because the measurable objective for seawater intrusion is a chloride concentration that equals the Basin Plan Objective for chloride and the Basin Plan Objective was selected by the RWQCB to be protective of beneficial use of groundwater in the Subbasin, the measurable objective will, by definition, be protective of beneficial groundwater use in the Subbasin. Furthermore, the measurable objectives chloride concentration is 300 mg/L less than the minimum threshold chloride concentration, which provides operational flexibility for stakeholders in the Subbasin by allowing time for groundwater producers to reduce or offset groundwater production before the chloride concentrations reach the minimum thresholds.

Interim Milestones for Reduction of Groundwater Storage

Interim milestones for seawater intrusion were not selected because chloride concentrations in the Subbasin are currently lower than the established measurable objective chloride concentrations.

3.4.4 Degraded Water Quality

Measurable objectives for degradation of groundwater quality were not established for the Subbasin because the groundwater quality in the Subbasin was impacted by industrial activity prior to 2015. The City of Santa Monica is actively remediating this contamination under the regulatory oversight of the SWRCB, DDW, and RWQCB, and there is no evidence for groundwater quality degradation induced by groundwater production in the Subbasin. Additionally, the City of Santa Monica routinely tests groundwater samples for all title 22 constituents. This sampling is required to continue in the future because the City of Santa Monica is a provider of drinking water within the City's service area. If future groundwater production is found to induce groundwater quality degradation, additional characterization of the source of that degradation, and subsequent reassessment of groundwater quality degradation measurable objectives, may be required.

2 Chloride concentration was not measured at the City Hall well in 2018. The City Hall well is being added to the monitoring network for this GSP.

3.4.5 Land Subsidence Related to Groundwater Withdrawal

Inelastic land subsidence related to groundwater withdrawal is not presently, nor is it likely to become an undesirable result within the Subbasin. The measurable objectives for land subsidence corresponding to inelastic land subsidence related to groundwater withdrawal are the groundwater elevations selected as the measurable objectives for chronic declines in groundwater levels and reduction of groundwater in storage (Table 3-3). These groundwater elevations are approximately equal to the historical low groundwater elevations in the Olympic Wellfield but are up to 60 feet lower than the historical low groundwater elevations in the Charnock wellfield (Figure 3-1). As previously noted, the Subbasin is designated as a low risk area for future subsidence (DWR 2014). Accordingly, groundwater level objectives below historical lows, but within the Silverado aquifer at the Charnock wellfield are not anticipated to induce subsidence that interferes with land use.

3.4.6 Depletions of Interconnected Surface Water

Measurable objectives for significant and unreasonable reduction of interconnected surface water and groundwater were not established for the Subbasin because the surface water that supports GDEs in the Subbasin occurs within the Bellflower aquitard, which is not directly connected to the Ballona and Silverado aquifers in the vicinity of the primary production wellfields (see Sections 2.4.7 Groundwater Dependent Ecosystems and 3.2.6 Interconnected Surface Water). If future groundwater production is planned for the Bellflower aquitard within 1 mile of the identified GDEs, additional characterization of interconnected surface water, and subsequent reassessment of interconnected surface water minimum thresholds, may be required.

3.5 Monitoring Network

3.5.1 Monitoring Network Objectives

The objective of the monitoring network in the Subbasin is to track and monitor parameters that demonstrate groundwater conditions, and associated factors that influence groundwater conditions. In order to accomplish this objective, the monitoring network in the Subbasin must be capable of:

- Monitoring changes in groundwater conditions
- Monitoring groundwater conditions relative to the sustainable management criteria
- Quantifying annual changes in water budget components

The Subbasin has an existing network of wells used to monitor groundwater conditions. This network includes both dedicated monitoring wells and production wells. Additionally, surface conditions are monitored at eight weather stations and one stream gauge within the Subbasin see Section 2.1.2 Water Resources Monitoring and Management Programs). The current network of groundwater wells and related surface conditions is capable of representing groundwater conditions and the surface processes that influence those conditions in the Subbasin. The network will continue to be used to monitor groundwater conditions to assess long and short-term trends in groundwater elevation and groundwater quality.

3.5.2 Groundwater Monitoring Network

There are approximately 2,044[3] wells in the Subbasin. Of these, ten are City of Santa Monica production wells and 83 are monitoring wells overseen by the City of Santa Monica as part of programs developed to address groundwater contamination and groundwater production at the City's Charnock and Olympic Wellfields (Figure 3-4 and Table 3-4). Of the remaining wells, 108 wells that are a part of the investigation and remediation of the Playa Vista site in the southern Subbasin have known screen intervals within the Ballona and Silverado aquifers. These wells, while not formally included in the GSP monitoring network, are used to constrain groundwater conditions in the southern part of the Subbasin. For the purposes of this GSP, the 83 monitoring wells and 10 production wells overseen by the City of Santa Monica will compose the GSP implementation monitoring network and are referred to as the "GSP monitoring network."

Monitoring wells associated with groundwater remediation efforts that have not impacted the City of Santa Monica's wellfields, and are screened in the shallow subsurface or have unknown screen intervals, are not included in the GSP monitoring network because do not adequately characterize groundwater conditions in the Ballona and Silverado aquifers. Furthermore, these wells are under the jurisdiction of the individual responsible parties and the RWQCB, not the GSA member agencies. When possible and where relevant, the GSA will utilize groundwater elevation and quality data collected from wells associated with RWQCB cleanup sites in the Subbasin to inform the overall understanding of groundwater conditions in the relevant production aquifers.

Of the 93 wells in the GSP monitoring network, all are monitored for groundwater elevation, 60 are monitored for groundwater quality, and 10 are monitored for production (Table 3-4).

Table 3-4. GSP Monitoring Network Summary by Location and Measurement Type

Number of Wells by Measurement Types				
Production Areas	*Extraction-Level-Quality*	*Level-Quality*	*Level*	*Total*
Arcadia	3	0	1	**4**
Olympic	2	27	3	**32**
Charnock	5	23	29	**57**
Total	**10**	**50**	**33**	**93**

The wells in the GSP monitoring network are found in the three areas of active groundwater production in the Subbasin and are screened in both the Ballona and Silverado aquifers (Table 3-5; Figure 3-4). In the Charnock regional monitoring network there are 27 "shallow" monitoring wells, 23 Upper Silverado wells, and 2 lower Silverado wells associated. The shallow monitoring wells are associated with the Ballona aquifer and the Lakewood Formation (City of Santa Monica 2007). In the Olympic Wellfield monitoring network, there are 14 "B-zone" monitoring wells, and 16 "C-zone" monitoring wells. The B-zone aquifer is correlated with the Lakewood Formation and the C-zone aquifer is correlated with the Silverado aquifer (City of Santa Monica 2015).

The existing network of groundwater production and monitoring wells is capable of delineating the groundwater conditions in the areas of the Subbasin that are impacted by the City of Santa Monica groundwater production wells and has been used for this purpose for the past 20 years. The current groundwater well network will be used to monitor groundwater conditions moving forward in order to continue to assess long-term trends in groundwater elevation and quality, and groundwater in storage, in the Subbasin. Recommendations for future improvements to the monitoring network are discussed in Section 3.5.8 Assessment and Improvement of Monitoring Network.

[3] This is the total number of wells in the GAMA Groundwater Information System database, (https://gamagroundwater.waterboards.ca.gov/gama/gamamap/public/) downloaded March 2020. The status of the vast majority of these wells is categorized in the database as "unknown" and some of these wells may have been destroyed.

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Table 3-5. GSP Monitoring Network Wells

Common Well Name	State Well Identification (SWID)	Latitude	Longitude	Well Use	Aquifer	Groundwater Monitoring Networks			Monitoring Program				
						Elevation	*Quality*	*Production*	*Charnock Regional Monitoring*	*Charnock Early Warning*	*Olympic*	*DDW*	*CASGEM*
Arcadia Wellfield													
Santa Monica No. 1	01S15W31E001S	34.043148	-118.4996	Production	Silverado	X	X	X	—	—	—	X	—
Santa Monica No. 5	01S15W30P001S	34.049807	-118.4941	Monitoring	Silverado	X	—	—	—	—	—	—	X
Arcadia No. 4	01S15W32A005S	34.043656	-118.4663	Production	Silverado	X	X	X	—	—	—	X	—
Arcadia No. 5	01S15W32A006S	34.043472	-118.4662	Production	Silverado	X	X	X	—	—	—	X	—
Charnock Wellfield													
Charnock No. 13	—	34.016885	-118.425	Production	Silverado	X	X	X	—	—	—	X	—
Charnock No. 16	—	34.017516	-118.4253	Production	Silverado	X	X	X	—	—	—	X	—
Charnock No. 18	—	34.0162	-118.4272	Production	Silverado	X	X	X	—	—	—	X	—
Charnock No. 19	—	34.016106	-118.425	Production	Silverado	X	X	X	—	—	—	X	—
Charnock No. 20	—	34.015744	-118.4261	Production	Silverado	X	X	X	—	—	—	X	—
MW-1	—	34.015603	-118.4266	Monitoring	Shallow	X	X	—	X	—	—	—	—
MW-2	—	34.01787	-118.4251	Monitoring	Shallow	X	X	—	X	—	—	—	—
MW-3	—	34.017278	-118.4246	Monitoring	Shallow	X	—	—	X	—	—	—	—
MW-4	—	34.016559	-118.4246	Monitoring	Shallow	X	—	—	X	—	—	—	—
RMW-3	—	34.018273	-118.4257	Monitoring	Upper Silverado	X	X	—	X	—	—	—	X
RMW-4A	—	34.018345	-118.4255	Monitoring	Shallow	X	—	—	X	—	—	—	X
RMW-5	—	34.013338	-118.4188	Monitoring	Upper Silverado	X	—	—	X	—	—	—	—
RMW-6	—	34.013459	-118.4189	Monitoring	Upper Silverado	X	X	—	X	—	—	—	—
RMW-7	—	34.013265	-118.4187	Monitoring	Shallow	X	—	—	X	—	—	—	—
RMW-8	—	34.014672	-118.4236	Monitoring	Lower Silverado	X	X	—	X	—	—	—	X
RMW-9	—	34.014609	-118.4236	Monitoring	Upper Silverado	X	X	—	X	X	—	—	X
RMW-10	—	34.014634	-118.4236	Monitoring	Shallow	X	—	—	X	X	—	—	X
RMW-11	—	34.013918	-118.4204	Monitoring	Upper Silverado	X	X	—	X	—	—	—	X
RMW-12	—	34.013877	-118.4204	Monitoring	Shallow	X	—	—	X	—	—	—	X
RMW-13	—	34.015245	-118.4228	Monitoring	Upper Silverado	X	X	—	X	—	—	—	—
RMW-14	—	34.015865	-118.4233	Monitoring	Upper Silverado	X	X	—	X	—	—	—	—
RMW-15	—	34.015888	-118.4233	Monitoring	Lower Silverado	X	X	—	X	—	—	—	—
RMW-16A	—	34.015796	-118.4232	Monitoring	Shallow	X	—	—	X	—	—	—	—
RMW-17	—	34.016479	-118.4238	Monitoring	Upper Silverado	X	X	—	X	—	—	—	—
RMW-18	—	34.016511	-118.4238	Monitoring	Shallow	X	—	—	X	—	—	—	—
RMW-19	—	34.012876	-118.4196	Monitoring	Upper Silverado	X	X	—	X	X	—	—	—
RMW-20	—	34.012901	-118.4196	Monitoring	Shallow	X	—	—	X	X	—	—	—
RMW-21	—	34.014182	-118.422	Monitoring	Upper Silverado	X	X	—	X	—	—	—	—
RMW-22	—	34.014204	-118.422	Monitoring	Shallow	X		—	X	—	—	—	X
RMW-23	—	34.015106	-118.4213	Monitoring	Upper Silverado	X	X	—	X	—	—	—	—
RMW-24	—	34.015082	-118.4213	Monitoring	Shallow	X	—	—	X	—	—	—	—
RMW-25	—	34.012208	-118.4198	Monitoring	Shallow	X	—	—	X	—	—	—	—
RMW-27	—	34.015215	-118.4228	Monitoring	Shallow	X	—	—	X	—	—	—	—
RMW-28	—	34.016025	-118.4222	Monitoring	Upper Silverado	X	X	—	X	—	—	—	X
RMW-29	—	34.016007	-118.4222	Monitoring	Shallow	X	—	—	X	—	—	—	X

Table 3-5. GSP Monitoring Network Wells

						Groundwater Monitoring Networks			Monitoring Program				
Common Well Name	State Well Identification (SWID)	Latitude	Longitude	Well Use	Aquifer	*Elevation*	*Quality*	*Production*	*Charnock Regional Monitoring*	*Charnock Early Warning*	*Olympic*	*DDW*	*CASGEM*
RMW-30	—	34.015773	-118.4207	Monitoring	Upper Silverado	X	X	—	X	—	—	—	—
RMW-31	—	34.015796	-118.4207	Monitoring	Shallow	X	—	—	X	—	—	—	—
RMW-32	—	34.014539	-118.426	Monitoring	Upper Silverado	X	—	—	X	—	—	—	—
RMW-33	—	34.014515	-118.426	Monitoring	Shallow	X	—	—	X	—	—	—	—
RMW-48	—	34.01448	-118.4208	Monitoring	Shallow	X	—	—	X	—	—	—	X
RMW-49	—	34.014447	-118.4208	Monitoring	Upper Silverado	X	X	—	X	—	—	—	—
RMW-50	—	34.01513	-118.4202	Monitoring	Upper Silverado	X	X	—	X	—	—	—	—
RMW-51	—	34.015106	-118.4202	Monitoring	Shallow	X	—	—	X	—	—	—	—
RMW-52	—	34.014589	-118.4186	Monitoring	Upper Silverado	X	X	—	X	—	—	—	—
RMW-53	—	34.014566	-118.4186	Monitoring	Shallow	X	—	—	X	—	—	—	—
RMW-54	—	34.013109	-118.4224	Monitoring	Upper Silverado	X	X	—	X	X	—	—	—
RMW-55	—	34.013085	-118.4224	Monitoring	Shallow	X	—	—	X	X	—	—	—
RMW-56	—	34.012325	-118.4224	Monitoring	Upper Silverado	X	—	—	X	—	—	—	X
RMW-57	—	34.012336	-118.4224	Monitoring	Shallow	X	—	—	X	—	—	—	X
RMW-58	—	34.01306	-118.4235	Monitoring	Upper Silverado	X	—	—	X	—	—	—	—
RMW-59	—	34.013079	-118.4235	Monitoring	Shallow	X	—	—	X	—	—	—	—
RPZ-4	—	34.017975	-118.4135	Monitoring	Shallow	X	—	—	X	X	—	—	—
RPZ-5	—	34.017954	-118.4135	Monitoring	Upper Silverado	X	X	—	X	X	—	—	—
RPZ-6	—	34.026662	-118.4214	Monitoring	Upper Silverado	X	X	—	X	X	—	—	X
RPZ-7	—	34.026641	-118.4214	Monitoring	Shallow	X	—	—	X	X	—	—	—
RPZ-8	—	34.015028	-118.4168	Monitoring	Upper Silverado	X	X	—	X	X	—	—	—
RPZ-9	—	34.015055	-118.4169	Monitoring	Shallow	X	—	—	X	X	—	—	—
Olympic Wellfield													
Santa Monica No. 3	02S15W04C002S	34.031121	-118.4602	Production	Silverado	X	X	X	X	—	—	X	—
Santa Monica No. 4	02S15W04A001S	34.03044	-118.4634	Production	Silverado	X	X	X	X	—	—	X	—
GW-30-3	—	34.028401	-118.4648	Monitoring	C	X	X	—	—	—	X	—	—
GW-30-5	—	34.028401	-118.4648	Monitoring	C	X	X	—	—	—	X	—	—
GW-30-6	—	34.028401	-118.4648	Monitoring	B	X	X	—	—	—	X	—	—
KMW-12	—	34.028048	-118.468	Monitoring	C	X	X	—	—	—	X	—	—
MW-11	—	34.028829	-118.4674	Monitoring	B	X	X	—	—	—	X	—	—
OB-1	—	34.028011	-118.4666	Monitoring	C	X	X	—	—	—	X	—	—
OB-2	—	34.029887	-118.4701	Monitoring	C	X	X	—	—	—	X	—	—
OB-3	—	34.031466	-118.4679	Monitoring	C	X	X	—	—	—	X	—	—
OB-4	—	34.030364	-118.471	Monitoring	B	X	X	—	—	—	X	—	X
OB-5	—	34.031798	-118.4731	Monitoring	B	X	X	—	—	—	X	—	X
OB-6C	—	34.028051	-118.4737	Monitoring	C	X		—	—	—	X	—	X
OB-6D	—	34.028051	-118.4737	Monitoring	C	X	X	—	—	—	X	—	—
OB-7	—	34.03143	-118.468	Monitoring	B	X	X	—	—	—	X	—	X
OB-8	—	34.030603	-118.4662	Monitoring	B	X	X	—	—	—	X	—	—
OB-9B	—	34.030458	-118.4635	Monitoring	B	X	—	—	—	—	X	—	X
OB-9C	—	34.030458	-118.4635	Monitoring	C	X	—	—	—	—	X	—	X

Table 3-5. GSP Monitoring Network Wells

Common Well Name	State Well Identification (SWID)	Latitude	Longitude	Well Use	Aquifer	Groundwater Monitoring Networks			Monitoring Program				
						Elevation	*Quality*	*Production*	*Charnock Regional Monitoring*	*Charnock Early Warning*	*Olympic*	*DDW*	*CASGEM*
OB-10B	—	34.030453	-118.4745	Monitoring	B	X	X	—	—	—	X	—	—
OB-10C	—	34.030453	-118.4745	Monitoring	C	X	X	—	—	—	X	—	—
OB-11B	—	34.032261	-118.465	Monitoring	B	X	X	—	—	—	X	—	—
OB-11C	—	34.032261	-118.465	Monitoring	C	X	X	—	—	—	X	—	—
OB-12B	—	34.032803	-118.4626	Monitoring	B	X	X	—	—	—	X	—	—
OB-12C	—	34.032803	-118.4626	Monitoring	C	X	X	—	—	—	X	—	—
OB-13C	—	—	—	Monitoring	C	X	X	—	—	—	X	—	—
OB-14B	–	34.029027	-118.4607	Monitoring	B	X	X	—	—	—	X	—	—
OB-14C	–	34.029027	-118.4607	Monitoring	C	X	X	—	—	—	X	—	—
OB-15B	–	34.029035	-118.47	Monitoring	B	X	X	—	—	—	X	—	—
OB-15C	–	34.029035	-118.47	Monitoring	C	X	X	—	—	—	X	—	X
OB-16B	–	34.029151	-118.4665	Monitoring	B	X	X	—	—	—	X	—	—
OB-17B	–	34.030267	-118.4653	Monitoring	B	X	X	—	—	—	X	—	X
OB-17C	–	34.030267	-118.4653	Monitoring	C	X	X	—	—	—	X	—	X

Sources: City of Santa Monica 2007, City of Santa Monica 2015, City of Santa Monica 2019, City of Santa Monica 2020b, City of Santa Monica 2020c.

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3.5.2.1 Groundwater Elevation

GSP Monitoring Network

Within the GSP monitoring network, groundwater elevation monitoring is currently conducted for the Olympic Wellfield Groundwater Monitoring Program, the Charnock Groundwater Management Program, and CASGEM (Table 3-5). Groundwater elevations are measured quarterly for the wells in the Olympic Wellfield Groundwater Monitoring Program and semi-annually (two times per year) for the wells in the Charnock Groundwater Management Program. Ten of the wells in the Olympic Wellfield Groundwater Monitoring Program, and 14 of the wells in the Charnock Groundwater Management Program are also used as CASGEM monitoring wells for the Subbasin. Additionally, the CASGEM monitoring network includes one well in the Arcadia Production Area. Under the CASGEM program, the City of Santa Monica, reports semi-annual (two times per year) groundwater elevations to DWR for inclusion in the CASGEM database (Table 3-6). Although 11 of the CASGEM wells are sampled quarterly, 10 of which are associated with the Olympic Wellfield Monitoring Program and the remaining well, Santa Monica 5, is in the Arcadia Production Area, water levels from these wells are only reported to DWR twice per year.

Table 3-6. Groundwater Elevation Monitoring Schedule

Monitoring Program					
	Olympic	*Charnock*	*CASGEM**	*Production*	*Playa Vista*
Monitoring Frequency	*# of Wells*				
Annual	—	—	—	—	11
Semi-Annual	—	50	14	—	83
Quarterly	30	—	11	—	14
Monthly	—	—	—	10	—

Note:
* CASGEM wells are a subset of the Olympic and Charnock monitoring program wells.

Monitoring Wells Outside the GSP Monitoring Network – Playa Vista Site

In addition to the GSP monitoring network, there are 88 wells screened in the Ballona aquifer and 20 wells screened in the Silverado aquifer at the Playa Vista Site (Playa Capital Company 2020). Groundwater elevations are measured annually at seven of the Silverado aquifer wells, semi-annually (two times per year) at eleven of the Silverado aquifer wells, and quarterly (four times per year) at two of the Silverado aquifer wells (Playa Capital Company 2020). In the Ballona aquifer, groundwater elevations are measured quarterly in 12 wells, semi-annually (two times per year) in 72 wells, and annually in four wells. Playa Vista monitoring wells in the Ballona and Silverado aquifers were included in the assessment of the current and historical groundwater conditions in the Subbasin (see Section 2.4.1 Groundwater Elevation Data). The GSA will continue to use data from these wells to supplement the understanding of groundwater conditions in the Subbasin, but these wells are not included in the GSP monitoring network.

3.5.2.2 Seawater Intrusion

Groundwater quality is monitored at 10 production wells and 37 groundwater monitoring wells in the Charnock and Olympic Wellfields. The 10 active municipal supply wells are monitored monthly for VOCs, quarterly for physical and select chemical parameters, and every 3 years for general mineral and physical and inorganic constituents as part of Title 22 compliance (Table 3-7). The Olympic Wellfield Monitoring Program has 14 wells sampled quarterly for

VOCs in the Silverado aquifer and 8 sampled quarterly for VOCs in the Ballona aquifer. Chloride concentrations are not currently measured at any of the Olympic monitoring wells.

Groundwater quality samples are collected from 23 wells as part of the Charnock Groundwater Management Program. These wells are sampled for VOCs and fuel parameters Additionally, a subset of 12 of these wells is sampled for the full list of constituents under Title 22 California Code of Regulations. These 12 wells are sentry wells under the Early Warning Groundwater Quality monitoring program at the Charnock wellfield. Two sentry wells are sampled annually, four are sampled every two years, and the remaining six are sampled every three years.

Table 3-7. Groundwater Quality Monitoring Schedule

Monitoring Frequency	Title 22	Physical Parameters	Chemical Parameters	VOCs
Production Wells [a]				
Monthly	—	—	—	10
Quarterly	—	10	10	—
Every Three Years	10	—	—	—
Charnock Groundwater Management Program [b]				
Semiannual	—	12	—	12*
Annually	—	6	—	6
Every Three Years	—	5	—	5
Charnock Sentry Wells [c]				
Annual	2	—	—	—
Every Two Years	4	—	—	—
Every Three Years	6	—	—	—
Olympic Wellfield Monitoring Program [d]				
Quarterly	—	22	—	22

Notes:

* Includes additional fuel parameters, *for list of all parameters*:

[a] City of Santa Monica 2020a

[b] City of Santa Monica 2020b

[c] City of Santa Monica 2019

[d] City of Santa Monica 2020b

Monitoring Wells Outside the GSP Monitoring Network – Playa Vista Site

In addition to the GSP monitoring network, 19 wells screened in the Silverado aquifer and 88 wells screened in the Ballona aquifer are sampled for groundwater quality at the Playa Vista site. All of the wells are monitored for VOCs, 4 wells are monitored for 1,4-Dioxane, and 1 well is monitored for a large suite of parameters including: TPH, total manganese, total iron, dissolved organic carbon, methane, ethene, ethane, sulfate, nitrate, nitrite, chloride, alkalinity, carbon dioxide, and hydrogen sulfide. Of the 107 wells, 11 are sampled annually, 83 are sampled semi-annually, and 14 are sampled quarterly.

Playa Vista monitoring wells in the Ballona and Silverado aquifers were included in the assessment of the current and historical groundwater conditions in the Subbasin (see Section 2.4.3 Seawater Intrusion). The GSA will continue to use data from these wells to supplement the understanding of groundwater conditions in the Subbasin, but these wells are not included in the GSP monitoring network.

3.5.3.3 Groundwater Extraction

The City of Santa Monica monitors monthly groundwater extraction at the 10 active municipal supply wells in the Charnock, Olympic, and Arcadia wellfields. In addition to the City of Santa Monica groundwater production wells, there are at least seven private wells associated with three golf courses and the Holy Cross Catholic Cemetery in the Subbasin. Groundwater production rates from these wells, if measured, are not currently publicly available. While the current groundwater extraction monitoring network is sufficient to capture the majority of the groundwater production from the Subbasin, improvements to this network are discussed in Section 3.5.8 Assessment and Improvement of Monitoring Network.

3.5.3 Surface Conditions Monitoring

The primary surface conditions that impact groundwater conditions in the Subbasin are surface water flows and precipitation. The monitoring networks for both surface conditions are discussed in this section.

Surface Water

Surface flows in the Subbasin are monitored by a single stream gauge located on Ballona Creek and maintained by the County of Los Angeles. Surface water flows in Ballona Creek have been recorded daily since October 1931 and hourly since November 1992. Surface flows in Ballona Creek are disconnected from the underlying groundwater aquifers upstream of this stream gauge, as Ballona Creek is a lined storm water channel upstream of the gauge. Santa Monica Canyon and Rustic Canyon Channels, the two other primary drainages in the Subbasin, are also lined storm water channels. Therefore, the historical and existing spatial and temporal coverage from the single surface water flow gauge provides adequate coverage for the short-term, seasonal, and long-term surface flow conditions in the Subbasin.

Precipitation

There are eight currently active weather stations in the Subbasin (See Section 2.1.2.1 Precipitation and Streamflow). The precipitation gauges are maintained, and the data collected, by the County of Los Angeles, NOAA and DWR.

Precipitation in the Subbasin has been recorded for more than a century. Although the locations of individual precipitation gauges have changed through time, with some gauges being removed from service and others added, there is overlap between the records collected from the various gauges. Therefore, a continuous precipitation record can be constructed for the Subbasin to demonstrate long-term trends. More recent data, collected with greater frequency, can be used to demonstrate short-term and seasonal trends in precipitation.

In addition to providing adequate temporal coverage of the Subbasin, the current network of precipitation gauges provides sufficient spatial coverage to document precipitation in the Subbasin and to connect the precipitation measurements to both streamflow and groundwater conditions. Additional precipitation monitoring locations are not currently recommended for characterizing surface conditions in the Subbasin.

3.5.4 Monitoring Network Relationship to Sustainability Indicators

The existing groundwater network will be used to monitor and document changes in groundwater conditions related to the four sustainability indicators relevant to the Subbasin. This network includes the wells that have been designated as RMPs for reporting purposes to DWR. Minimum thresholds and measurable objectives were established for the RMPs (Table 3-2 and Table 3-3). An assessment of groundwater conditions and the potential for undesirable results will be based on the conditions measured at the RMPs. The broader groundwater monitoring network, including the RMPs, will be used to document conditions in the Subbasin and provide support for recommendations and findings based on the conditions recorded at the RMPs.

3.5.4.1 Chronic Lowering of Groundwater Levels

The groundwater monitoring network must accomplish the following to adequately monitor conditions related to chronic lowering of groundwater levels:

- Track short-term, seasonal, and long-term trends in groundwater elevation.
- Demonstrate groundwater elevations in mid-March and mid-October for the aquifer system.
- Record groundwater elevations at RMPs for which minimum thresholds and measurable objectives have been identified.

Spatial Coverage

The Subbasin monitoring well density for groundwater elevation is currently approximately 2 wells per square mile (Subbasin is approximately 50-square miles). While there is no definitive rule for the density of groundwater monitoring points needed in a basin, for comparison the monitoring well density recommended by CASGEM Groundwater Elevation Monitoring Guidelines ranges from 1 to 10 wells per 100 square miles (DWR 2010). Additional California DWR guidelines recommend a well network with a density of 1 observation per 16 square miles (DWR 2010, 2016b). Therefore, the density of wells in the monitoring network for the Subbasin meets the criteria for adequate coverage for chronic lowering of groundwater levels; however, well density alone does not ensure collection of sufficient data to detect changes in groundwater conditions. Spatial (both lateral and vertical) and temporal representation need to be considered in assessment of the ability of the monitoring network to demonstrate short-term, seasonal, and long-term trends.

The current groundwater monitoring network is densely clustered in 3 areas: Olympic Wellfield, Charnock Wellfield, and the Playa Vista Area (Figure 3-5). Additional monitoring wells are needed in the area between Marina del Rey and the Charnock wellfield, and as data gaps are addressed, more monitoring wells may be recommended. In the future, to the extent possible, additional dedicated monitoring wells will be incorporated into the existing monitoring network (see Section 3.5.8, Assessment and Improvement of Monitoring Network). The wells could include existing wells or new monitoring wells and will provide information on groundwater conditions in geographic locations and/or at depths where data gaps have been identified.

Temporal Coverage

Groundwater elevation data will be collected from the network of groundwater wells to provide groundwater elevation conditions in the spring and fall of each year. Further discussion of the monitoring schedule is provided in Section 3.5.5, Monitoring Network Implementation.

3.5.4.2 Reduction of Groundwater in Storage

To monitor conditions related to reduction of groundwater storage, the groundwater monitoring network must be structured to accomplish the following:

- Track short-term, seasonal, and long-term trends in groundwater in storage.
- Calculate year-over-year (mid-March to mid-March) change in storage.
- Provide data from which lateral hydraulic gradients within the aquifer can be calculated.

The requirements for documenting reduction in groundwater storage are similar to those for chronic lowering of groundwater levels (see Section 3.5.5.1), because these two sustainability indicators are interrelated. The primary difference between the two sets of requirements is the need to document potential gradients between aquifers. These gradients influence the movement of groundwater between aquifers, which in turn influences storage in the aquifer.

Upon GSP adoption, estimated volumes of annual change in storage will be reported by in annual reports. These volumes may come from model estimates or a standardized method to calculate the change in storage that relies solely on water elevations within each aquifer, rather than on a numerical model.

The spatial and temporal density of groundwater elevation data necessary to document groundwater storage changes in the aquifers of the Subbasin is the same as that necessary to document groundwater elevation changes. The current network of wells is capable of documenting changes to both sustainability indicators.

3.5.4.3 Seawater Intrusion

To monitor conditions related to seawater intrusion, groundwater elevations will be measured, and groundwater quality samples will be collected, in such a way as to accomplish the following:

- Track short-term, seasonal, and long-term trends in groundwater elevation and chloride concentrations.
- Record chloride concentrations in RMPs for which minimum thresholds and measurable objectives have been identified.

While gathering additional data on groundwater elevations may help establish a relationship between groundwater elevation and chloride concentration, chloride concentration in groundwater is the metric by which seawater intrusion will be assessed (see Section 3.3 Minimum Thresholds and Section 3.4 Measurable Objectives).

Spatial Coverage

The groundwater wells at which chloride concentrations will be measured are located over 1 mile inland from the coast. Although the density of wells used to document chloride concentrations in the Subbasin is adequate, additional monitoring wells closer to the coast, in the area between Marina del Rey and the Charnock wellfield could be used to improve spatial coverage for groundwater elevation and quality monitoring related to seawater intrusion

Water Quality Constituents

Groundwater samples will continue to be collected and analyzed for chloride in order to assess trends in groundwater quality related to seawater intrusion. The only wells in which chloride concentration is regularly monitored are the City of Santa Monica production wells. The network of existing wells is capable of providing an adequate assessment of groundwater quality trends for chloride until additional monitoring wells can be constructed.

Temporal Resolution

Historically, groundwater quality samples have been collected with insufficient temporal resolution to identify seawater intrusion in the aquifers of the Subbasin. Annual groundwater quality samples are required to document changes in chloride and TDS concentration associated with seawater intrusion.

3.5.4.4 Degraded Water Quality

Degradation of groundwater quality from industrial contamination has occurred historically within the Subbasin but there is no historical evidence of groundwater production causing significant and unreasonable degradation of water quality in the Subbasin. The City of Santa Monica is actively remediating this industrial groundwater contamination under the regulatory oversight of the SWRCB, DDW, and RWQCB, and the monitoring networks developed for those programs have been approved by the relevant regulatory agency. Therefore, this GSP does not create an additional water quality monitoring program in the Subbasin. The City of Santa Monica and the SMBGSA will continue to review groundwater quality data generated to meet the existing regulatory requirements in the Subbasin. These data will be incorporated into the periodic evaluation of the GSP and will be used to assess whether undesirable results for groundwater quality may need to be established in the future.

3.5.4.5 Land Subsidence

Groundwater elevations are being used as a proxy for land subsidence in the Subbasin. Based on the subsurface geology and projected groundwater levels in the Subbasin, specific land subsidence monitoring is not anticipated to be required. However, as part of the 5-year GSP evaluation process, the GSA will review and analyze land subsidence data made available by DWR and UNAVCO to ensure that the groundwater elevation thresholds provide adequate protection against significant and unreasonable land subsidence in the Subbasin.

Spatial Coverage

The current groundwater monitoring network is densely clustered in the areas adjacent to the groundwater production wellfields (Figure 3-5). This spatial distribution is adequate to assess the potential for land subsidence related to groundwater withdrawals in the Subbasin.

Temporal Coverage

Groundwater elevation data will be collected from the network of groundwater wells to provide groundwater elevation conditions in the spring and fall of each year. This temporal distribution is adequate to track trends in groundwater elevation and correlate these trends to any observed trends in direct measurements of land subsidence.

3.5.4.6 Depletions of Interconnected Surface Water

Surface waters within the Subbasin are not connected to the primary groundwater production aquifers in the Subbasin (see Section 2.4.6 Groundwater-Surface Water Connections), and no known groundwater production occurs within the Bellflower aquitard within a mile of the BWER. Therefore, specific sustainability criteria for interconnected surface water have not been defined in this GSP and no specific monitoring for depletion of interconnected surface water is required. However, surface water flows will continue to be monitored as described in Section 3.5.3 Surface Conditions Monitoring.

3.5.5 Monitoring Network Implementation

3.5.5.1 Groundwater Elevation Monitoring Schedule

Following the guidance provided by DWR (DWR 2016a), groundwater elevation measurements will be collected from all accessible wells in the monitoring network two times per year in order to capture the spring high and fall low groundwater levels (Table 3-8). Spring groundwater levels should be collected during the month of March and fall groundwater levels should be collected during the month of October. By conducting the groundwater sampling for each seasonal event within a single month time period, the groundwater level data can be used to generate groundwater elevation contours and assess the hydraulic gradient. Data collection over longer time periods are less useful for analyzing the hydraulic gradient and groundwater elevation contours that are intended to represent a discrete period of time.

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Table 3-8. GSP Monitoring Schedule

Common Well Name	State Well Identification (SWID)	Latitude	Longitude	Well Use	Aquifer	Existing Groundwater Monitoring Frequency			Groundwater Monitoring Method		
						Elevation	*Quality*	*Production*	*Elevation*	*Quality*	*Production*
Arcadia Wellfield											
Santa Monica No. 1	01S15W31E001S	34.043148	-118.4996	Production	Silverado	Monthly	Monthly	Monthly	Steel tape	Dedicated Pump	Totalizer
Santa Monica No. 5	01S15W30P001S	34.049807	-118.4941	Monitoring	Silverado	Quarterly	—	—	—	Dedicated Pump	Totalizer
Arcadia No. 4	01S15W32A005S	34.043656	-118.4663	Production	Silverado	Monthly	Monthly	Monthly	Steel tape	Dedicated Pump	Totalizer
Arcadia No. 5	01S15W32A006S	34.043472	-118.4662	Production	Silverado	Monthly	Monthly	Monthly	Steel tape	Dedicated Pump	Totalizer
Charnock Wellfield											
Charnock No. 13	—	34.016885	-118.425	Production	Silverado	Monthly	Monthly	Monthly	Steel tape	Dedicated Pump	Totalizer
Charnock No. 16	—	34.017516	-118.4253	Production	Silverado	Monthly	Monthly	Monthly	Steel tape	Dedicated Pump	Totalizer
Charnock No. 18	—	34.0162	-118.4272	Production	Silverado	Monthly	Monthly	Monthly	Steel tape	Dedicated Pump	Totalizer
Charnock No. 19	—	34.016106	-118.425	Production	Silverado	Monthly	Monthly	Monthly	Steel tape	Dedicated Pump	Totalizer
Charnock No. 20	—	34.015744	-118.4261	Production	Silverado	Monthly	Monthly	Monthly	Steel tape	Dedicated Pump	Totalizer
MW-1	—	34.015603	-118.4266	Monitoring	Shallow	Semiannual	Annual	—	Sounder	—	—
MW-2	—	34.01787	-118.4251	Monitoring	Shallow	Semiannual	Annual	—	Sounder	—	—
MW-3	—	34.017278	-118.4246	Monitoring	Shallow	Semiannual	—	—	Sounder	—	—
MW-4	—	34.016559	-118.4246	Monitoring	Shallow	Semiannual	—	—	Sounder	—	—
RMW-3	—	34.018273	-118.4257	Monitoring	Upper Silverado	Semiannual	Annual	—	Sounder	Purge and low flow	—
RMW-4A	—	34.018345	-118.4255	Monitoring	Shallow	Semiannual	—	—	Sounder	—	—
RMW-5	—	34.013338	-118.4188	Monitoring	Upper Silverado	Semiannual	—	—	Sounder	—	—
RMW-6	—	34.013459	-118.4189	Monitoring	Upper Silverado	Semiannual	Annual	—	Sounder	Purge and low flow	—
RMW-7	—	34.013265	-118.4187	Monitoring	Shallow	Semiannual	—	—	Sounder	—	—
RMW-8	—	34.014672	-118.4236	Monitoring	Lower Silverado	Semiannual	Every 3 Years	—	Sounder	Purge and low flow	—
RMW-9	—	34.014609	-118.4236	Monitoring	Upper Silverado	Semiannual	Semiannual	—	Sounder	Purge and low flow	—
RMW-10	—	34.014634	-118.4236	Monitoring	Shallow	Semiannual	—	—	Sounder	—	—
RMW-11	—	34.013918	-118.4204	Monitoring	Upper Silverado	Semiannual	Annual	—	Sounder	Purge and low flow	
RMW-12	—	34.013877	-118.4204	Monitoring	Shallow	Semiannual	—	—	Sounder	—	—
RMW-13	—	34.015245	-118.4228	Monitoring	Upper Silverado	Semiannual	Semiannual	—	Sounder	Purge and low flow	—
RMW-14	—	34.015865	-118.4233	Monitoring	Upper Silverado	Semiannual	Semiannual	—	Sounder	Purge and low flow	—
RMW-15	—	34.015888	-118.4233	Monitoring	Lower Silverado	Semiannual	Every 3 Years	—	Sounder	Purge and low flow	—
RMW-16A	—	34.015796	-118.4232	Monitoring	Shallow	Semiannual	—	—	Sounder	—	—
RMW-17	—	34.016479	-118.4238	Monitoring	Upper Silverado	Semiannual	Semiannual	—	Sounder	Purge and low flow	—
RMW-18	—	34.016511	-118.4238	Monitoring	Shallow	Semiannual	—	—	Sounder	—	—
RMW-19	—	34.012876	-118.4196	Monitoring	Upper Silverado	Semiannual	Annual	—	Sounder	Purge and low flow	—
RMW-20	—	34.012901	-118.4196	Monitoring	Shallow	Semiannual	—	—	Sounder	—	—
RMW-21	—	34.014182	-118.422	Monitoring	Upper Silverado	Semiannual	Semiannual	—	Sounder	Purge and low flow	—
RMW-22	—	34.014204	-118.422	Monitoring	Shallow	Semiannual	-	—	Sounder	—	—
RMW-23	—	34.015106	-118.4213	Monitoring	Upper Silverado	Semiannual	Semiannual	—	Sounder	Purge and low flow	—
RMW-24	—	34.015082	-118.4213	Monitoring	Shallow	Semiannual	—	—	Sounder	—	—
RMW-25	—	34.012208	-118.4198	Monitoring	Shallow	Semiannual	—	—	Sounder	—	—
RMW-27	—	34.015215	-118.4228	Monitoring	Shallow	Semiannual	—	—	Sounder	—	—
RMW-28	—	34.016025	-118.4222	Monitoring	Upper Silverado	Semiannual	Semiannual	—	Sounder	Purge and low flow	—
RMW-29	—	34.016007	-118.4222	Monitoring	Shallow	Semiannual	—	—	Sounder	—	—
RMW-30	—	34.015773	-118.4207	Monitoring	Upper Silverado	Semiannual	Semiannual	—	Sounder	Purge and low flow	—
RMW-31	—	34.015796	-118.4207	Monitoring	Shallow	Semiannual	—	—	Sounder	—	—

Table 3-8. GSP Monitoring Schedule

Common Well Name	State Well Identification (SWID)	Latitude	Longitude	Well Use	Aquifer	Existing Groundwater Monitoring Frequency			Groundwater Monitoring Method		
						Elevation	*Quality*	*Production*	*Elevation*	*Quality*	*Production*
RMW-32	—	34.014539	-118.426	Monitoring	Upper Silverado	Semiannual	—	—	Sounder	—	—
RMW-33	—	34.014515	-118.426	Monitoring	Shallow	Semiannual	—	—	Sounder	—	—
RMW-48	—	34.01448	-118.4208	Monitoring	Shallow	Semiannual	—	—	Sounder	—	—
RMW-49	—	34.014447	-118.4208	Monitoring	Upper Silverado	Semiannual	Semiannual	—	Sounder	Purge and low flow	—
RMW-50	—	34.01513	-118.4202	Monitoring	Upper Silverado	Semiannual	Semiannual	—	Sounder	Purge and low flow	—
RMW-51	—	34.015106	-118.4202	Monitoring	Shallow	Semiannual	—	—	Sounder	—	—
RMW-52	—	34.014589	-118.4186	Monitoring	Upper Silverado	Semiannual	Semiannual	—	Sounder	Purge and low flow	—
RMW-53	—	34.014566	-118.4186	Monitoring	Shallow	Semiannual	—	—	Sounder	—	—
RMW-54	—	34.013109	-118.4224	Monitoring	Upper Silverado	Semiannual	Semiannual	—	Sounder	Purge and low flow	—
RMW-55	—	34.013085	-118.4224	Monitoring	Shallow	Semiannual	—	—	Sounder	—	—
RMW-56	—	34.012325	-118.4224	Monitoring	Upper Silverado	Semiannual	—	—	Sounder	—	—
RMW-57	—	34.012336	-118.4224	Monitoring	Shallow	Semiannual	—	—	Sounder	—	—
RMW-58	—	34.01306	-118.4235	Monitoring	Upper Silverado	Semiannual	—	—	Sounder	—	—
RMW-59	—	34.013079	-118.4235	Monitoring	Shallow	Semiannual	—	—	Sounder	—	—
RPZ-4	—	34.017975	-118.4135	Monitoring	Shallow	Semiannual	—	—	Sounder	—	—
RPZ-5	—	34.017954	-118.4135	Monitoring	Upper Silverado	Semiannual	Every 3 Years	—	Sounder	Purge and low flow	—
RPZ-6	—	34.026662	-118.4214	Monitoring	Upper Silverado	Semiannual	Every 3 Years	—	Sounder	Purge and low flow	—
RPZ-7	—	34.026641	-118.4214	Monitoring	Shallow	Semiannual	—	—	Sounder	—	—
RPZ-8	—	34.015028	-118.4168	Monitoring	Upper Silverado	Semiannual	Every 3 Years	—	Sounder	Purge and low flow	—
RPZ-9	—	34.015055	-118.4169	Monitoring	Shallow	Semiannual	—	—	Sounder	—	—
Olympic Wellfield											
Santa Monica No. 3	02S15W04C002S	34.031121	-118.4602	Production	Silverado	Monthly	Monthly	Monthly	Steel tape	Dedicated Pump	Totalizer
Santa Monica No. 4	02S15W04A001S	34.03044	-118.4634	Production	Silverado	Monthly	Monthly	Monthly	Steel tape	Dedicated Pump	Totalizer
GW-30-3	—	34.028401	-118.4648	Monitoring	C	Quarterly	Quarterly	—	Sounder	Installed dedicated sampling pump	—
GW-30-5	—	34.028401	-118.4648	Monitoring	C	Quarterly	—	—	Sounder	—	—
GW-30-6	—	34.028401	-118.4648	Monitoring	B	Quarterly	—	—	Sounder	—	—
KMW-12	—	34.028048	-118.468	Monitoring	C	Quarterly	Quarterly	—	Sounder	Bailer	—
MW-11	—	34.028829	-118.4674	Monitoring	B	Quarterly	Quarterly	—	Sounder	Installed dedicated sampling pump	—
OB-1	—	34.028011	-118.4666	Monitoring	C	Quarterly	Quarterly	—	Sounder	Bailer	—
OB-2	—	34.029887	-118.4701	Monitoring	C	Quarterly	Quarterly	—	Sounder	Installed dedicated sampling pump	—
OB-3	—	34.031466	-118.4679	Monitoring	C	Quarterly	Quarterly	—	Sounder	Installed dedicated sampling pump	—
OB-4	—	34.030364	-118.471	Monitoring	B	Quarterly	Quarterly	—	Sounder	Installed dedicated sampling pump	—
OB-5	—	34.031798	-118.4731	Monitoring	B	Quarterly	Quarterly	—	Sounder	Installed dedicated sampling pump	—
OB-6C	—	34.028051	-118.4737	Monitoring	C	—	—	—	—	—	—
OB-6D	—	34.028051	-118.4737	Monitoring	C	Quarterly	Quarterly	—	Sounder	Installed dedicated sampling pump	—
OB-7	—	34.03143	-118.468	Monitoring	B	Quarterly	Quarterly	—	Sounder	Installed dedicated sampling pump	—

Table 3-8. GSP Monitoring Schedule

Common Well Name	State Well Identification (SWID)	Latitude	Longitude	Well Use	Aquifer	Existing Groundwater Monitoring Frequency			Groundwater Monitoring Method		
						Elevation	*Quality*	*Production*	*Elevation*	*Quality*	*Production*
OB-8	–	34.030603	-118.4662	Monitoring	B	Quarterly	Quarterly	–	Sounder	Installed dedicated sampling pump	–
OB-9B	–	34.030458	-118.4635	Monitoring	B	Quarterly	–	–	Sounder	–	–
OB-9C	–	34.030458	-118.4635	Monitoring	C	Quarterly	–	–	Sounder	–	–
OB-10B	–	34.030453	-118.4745	Monitoring	B	Quarterly	Quarterly	–	Sounder	Installed dedicated sampling pump	–
OB-10C	–	34.030453	-118.4745	Monitoring	C	Quarterly	Quarterly	–	Sounder	Installed dedicated sampling pump	–
OB-11B	–	34.032261	-118.465	Monitoring	B	Quarterly	Quarterly	–	Sounder	Installed dedicated sampling pump	–
OB-11C	–	34.032261	-118.465	Monitoring	C	Quarterly	Quarterly	–	Sounder	Installed dedicated sampling pump	–
OB-12B	–	34.032803	-118.4626	Monitoring	B	Quarterly	Quarterly	–	Sounder	Installed dedicated sampling pump	–
OB-12C	–	34.032803	-118.4626	Monitoring	C	Quarterly	Quarterly	–	Sounder	Installed dedicated sampling pump	–
OB-13C	–	–	–	Monitoring	C	Quarterly	Quarterly	–	Sounder	Installed dedicated sampling pump	–
OB-14B	–	34.029027	-118.4607	Monitoring	B	Quarterly	Quarterly	–	Sounder	Installed dedicated sampling pump	–
OB-14C	–	34.029027	-118.4607	Monitoring	C	Quarterly	Quarterly	–	Sounder	Installed dedicated sampling pump	–
OB-15B	–	34.029035	-118.47	Monitoring	B	Quarterly	Quarterly	–	Sounder	Installed dedicated sampling pump	–
OB-15C	–	34.029035	-118.47	Monitoring	C	Quarterly	Quarterly	–	Sounder	Installed dedicated sampling pump	–
OB-16B	–	34.029151	-118.4665	Monitoring	B	Quarterly	Quarterly	–	Sounder	Installed dedicated sampling pump	–
OB-17B	–	34.030267	-118.4653	Monitoring	B	Quarterly	Quarterly	–	Sounder	Installed dedicated sampling pump	–
OB-17C	–	34.030267	-118.4653	Monitoring	C	Quarterly	Quarterly	–	Sounder	Installed dedicated sampling pump	–
Additional Subbasin Wells											
1290P*	02S015W13P007S	33.994694	-118.406216	Monitoring		Semiannually	Annual	–	Sounder	Purge and low flow	–
Airport 1*	–	34.013662	-118.456065	Monitoring		Semiannually	Annual	–	Sounder	Purge and low flow	–
City Hall Well*	–	34.012105	-118.492062	Monitoring		Semiannually	Annual	–	Sounder	Purge and low flow	–

Notes:
* These wells are not currently monitored regularly for groundwater elevation and groundwater quality but will be added to the monitoring network as part of the GSP implementation.

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3.5.5.2 Groundwater Storage Monitoring Schedule

Groundwater storage is directly related to groundwater elevation. Consequently, the schedule for monitoring groundwater storage is the same as that for monitoring groundwater elevations.

3.5.5.3 Seawater Intrusion Monitoring Schedule

The City of Santa Monica will continue to conduct groundwater quality sampling throughout the Subbasin. Chloride concentration will be measured annually in groundwater samples collected from the City of Santa Monica production wells. Additionally, if possible, the City of Santa Monica will collect groundwater samples from a well located at the City of Santa Monica City Hall. Samples from this well will also be analyzed for chloride to augment the existing monitoring network.

3.5.5.4 Groundwater Extraction Monitoring Schedule

Monitoring of groundwater extraction rates from the City of Santa Monica's production wells takes place continuously, using flowmeters and telemetry equipment installed on individual wellheads. Monthly totals of pumped water are transmitted to a central database. Groundwater extraction monitoring is also recommended for all wells that produce greater than 2 AFY of groundwater per year from the Subbasin. A monitoring schedule will be adopted for these wells as they are identified and equipped with a flowmeter to record extracted groundwater volumes.

3.5.6 Protocols for Data Collection and Monitoring

Protocols for collecting groundwater level measurements and water quality samples, as well as downloading transducers and logging the boreholes of newly drilled wells, are included in the Monitoring Protocols Best Management Practices (BMPs) published by DWR (DWR 2016a). Consistent with the *Monitoring Protocols, Standards, and Sites Best Management Practices* BMP, depth to groundwater measurements are currently taken from surveyed reference points at the top of the well casing or sounding tube and are measured to a minimum accuracy of 0.1 foot. Currently depth to groundwater measurements are collected over a period of several months. Moving forward, efforts will be made to minimize the timeframe over which depth to groundwater measurements are collected such that the spring groundwater levels will be collected during the month of March, and the fall depth to groundwater measurements are collected during the month of October. The *Monitoring Protocols, Standards, and Sites Best Management Practices* BMP recommends depth to groundwater measurement be collected within as short a time as possible (DWR 2016b).

The City of Santa Monica collects groundwater quality samples in accordance with standard operating procedures for each groundwater quality monitoring program. Samples are collected, using low-flow purge and sample techniques or a mobile or dedicated pump after depth to groundwater has been recorded, and a minimum of three (3) well volumes of water have been purged from the well. Groundwater quality samples are collected in dedicated bottles and are transported to the City of Santa Monica's on-site state-certified laboratory. The City of Santa Monica will continue to use the existing groundwater quality monitoring protocols when collecting groundwater quality samples as part of the reporting requirements for this GSP.

3.5.7 Representative Monitoring

3.5.7.1 Groundwater Elevation, Groundwater in Storage, and Land Subsidence Related to Groundwater Withdrawal RMPs

Eight wells: RMW-3, RMW-8, RMW-9, RMW-28, OB-7, OB-9B, OB-9C, and OB-17 were selected to be RMPs for groundwater elevations in the Subbasin. Linear correlations between groundwater elevations at an RMP and groundwater elevations at nearby production wells were assessed in order to determine whether groundwater elevations measured at the RMPs were representative of aquifer conditions. Screen interval, length of groundwater level measurement record, and location were also reviewed while selecting the RMPs. Groundwater elevation trends at the eight groundwater elevation RMPs were determined to be representative of the groundwater elevations and trends in the Charnock and Olympic groundwater production areas and adequate for characterizing groundwater conditions related to groundwater production in the Subbasin (Figure 3-3).

Groundwater elevation is related to groundwater in storage through the LACPGM (USGS 2021). Therefore, use of groundwater elevation as a proxy for groundwater in storage is adequate to assess groundwater conditions in the Subbasin. Groundwater elevation is also used as a proxy for land subsidence induced by groundwater production. Land subsidence in the Subbasin has the potential to occur both as a result of tectonic forcing and as a result of groundwater withdrawal, although the Subbasin is considered to be at a low risk for land subsidence resulting from groundwater withdrawal (see Section 2.4.5 Subsidence). As a result of the potential for tectonic subsidence, measuring groundwater elevations is a better proxy for land subsidence induced by groundwater withdrawals than measuring total land subsidence, because the tectonic and groundwater elevation components of the total subsidence measurement cannot be separated from each other.

The GSA will evaluate the ongoing representativeness of the current RMPs during the 5-year GSP evaluation and update process. Current RMPs may be removed in the event that groundwater elevations at that RMP are found to no longer represent groundwater conditions in the surrounding aquifer, or if changes are made to access agreements or well construction. In the event that an RMP must be removed from the list, the GSA will undertake a review of potential replacement wells in the vicinity.

3.5.7.2 Seawater Intrusion RMPs

Ten wells: Arcadia 4, Arcadia 5, Santa Monica 1, Santa Monica 3, Santa Monica 4, Charnock 16, Charnock 18, Charnock 19, Charnock 20, and the City Hall well were selected to be RMPs for seawater intrusion in the Subbasin. Chloride concentrations at the seawater intrusion RMPs are similar, ranging from 67 mg/L at Charnock 18 to 166 mg/L at Charnock 20 in 2019 (Figure 2-38). These wells are screened in the Silverado aquifer and adequately represent chloride concentrations in the Subbasin. The Subbasin is not currently experiencing groundwater quality impairment from chloride, and the groundwater quality RMPs were selected to act as sentinel wells that would provide data to assess whether chloride concentration trends are increasing as a result of seawater intrusion.

As discussed above, the representativeness of the chloride concentration data collected from the City of Santa Monica production wells and the City Hall well, will be evaluated during the 5-year GSP evaluation and update process. Current RMPs may be removed in the event that groundwater quality data at that RMP are found to no longer represent groundwater quality in the surrounding aquifer. In the event that an RMP must be removed from the list, the GSA will undertake a review of potential replacement wells in the vicinity of the RMP that was removed.

This GSP recommends adding at least two groundwater quality RMPs in the area between Marina del Rey and the Charnock wellfield. During implementation of the GSP, the City of Santa Monica will evaluate the feasibility of installing these additional wells and review potential funding partners to assist with the costs of the well installation.

3.5.8 Assessment and Improvement of Monitoring Network

3.5.8.1 Temporal Data Gaps in Groundwater Level Measurements

The DWR Monitoring Protocol BMP (DWR 2016a) states the following:

> Groundwater elevation data … should approximate conditions at a discrete period in time. Therefore, all groundwater levels in a basin should be collected within as short a time as possible, preferably within a 1 to 2-week period.

The DWR Monitoring Networks BMP (DWR 2016b) states the following:

> Groundwater levels will be collected during the middle of October and March for comparative reporting purposes.

Groundwater elevation monitoring currently occurs over a longer time period than the two-week window recommended by the DWR guidance documents. The City of Santa Monica will review the feasibility of collecting groundwater elevations over a shorter time period, working toward groundwater elevations that are collected during a two-week window in March to represent spring groundwater conditions, and a two-week window in October to represent fall groundwater conditions. However, the timing of groundwater level measurements in the Subbasin is also constrained by existing groundwater monitoring and remediation programs. Therefore, groundwater elevations may be measured over longer time periods than suggested by DWR guidance for SGMA purposes during the initial implementation of the GSP.

Installation of pressure transducers capable of recording daily groundwater conditions in the RMPs wells could alleviate the need for staff to take manual measurements from every well in the monitoring network within a two-week window. Pressure transducers could be downloaded after the two-week window has passed and recorded data from within the two-week window would be incorporated into groundwater elevation maps and calculations of groundwater in storage. In the event that funding becomes available and pressure transducers can be installed in select monitoring wells, the recommended two-week window during which groundwater elevations should be collected is March 9 to 22 for the spring and October 9 to 22 for the fall.

3.5.8.2 Spatial Data Gaps in Water Level Measurements

Additional monitoring wells could be used to improve spatial coverage for groundwater elevation measurements in the areas of the Subbasin where no existing monitoring wells are located. Wells that are added to the network should be dedicated monitoring wells screened in a single aquifer.

Currently three new wells have been identified as either future or potential new wells for the monitoring network (Figure 3-6). Santa Monica No. 8 is a new production well that has been constructed but is not yet active. Well 1290P is a Los Angeles County Department of Public Works monitoring well that is measured twice a year. The City Hall Well is a well owned by the City of Santa Monica and has not been regularly monitored but is recommended for inclusion as an RMP for seawater intrusion. Additionally, this GSP recommends investigating options for collecting groundwater samples for chloride analysis at the Santa Monica airport and installing two new groundwater monitoring wells in the area between Marina del Rey and the Charnock wellfield.

3.5.8.3 Groundwater Extraction Metering

Currently groundwater extraction volumes are metered at the City of Santa Monica production wells. Groundwater extractions at the remaining wells in the Subbasin, including wells that supply the Holy Cross Catholic Cemetery and the Riviera Country Club, Brentwood Country Club, and Los Angeles Country Club golf courses are not publicly available. In order to better characterize the aquifer response to groundwater production, GSA is planning to require meters be installed (or offer to install meters) on all wells that produce greater than 2 AFY from the Subbasin.

3.5.8.4 Seawater Intrusion Monitoring

Additional monitoring wells could be used to improve spatial coverage for groundwater elevation and quality monitoring related to seawater intrusion in the coastal areas of the Subbasin where no existing monitoring wells are located. The City Hall Well and two additional wells between Marina del Rey and the Charnock wellfield would provide spatial information to better characterize chloride concentrations and the potential for seawater intrusion in the Subbasin.

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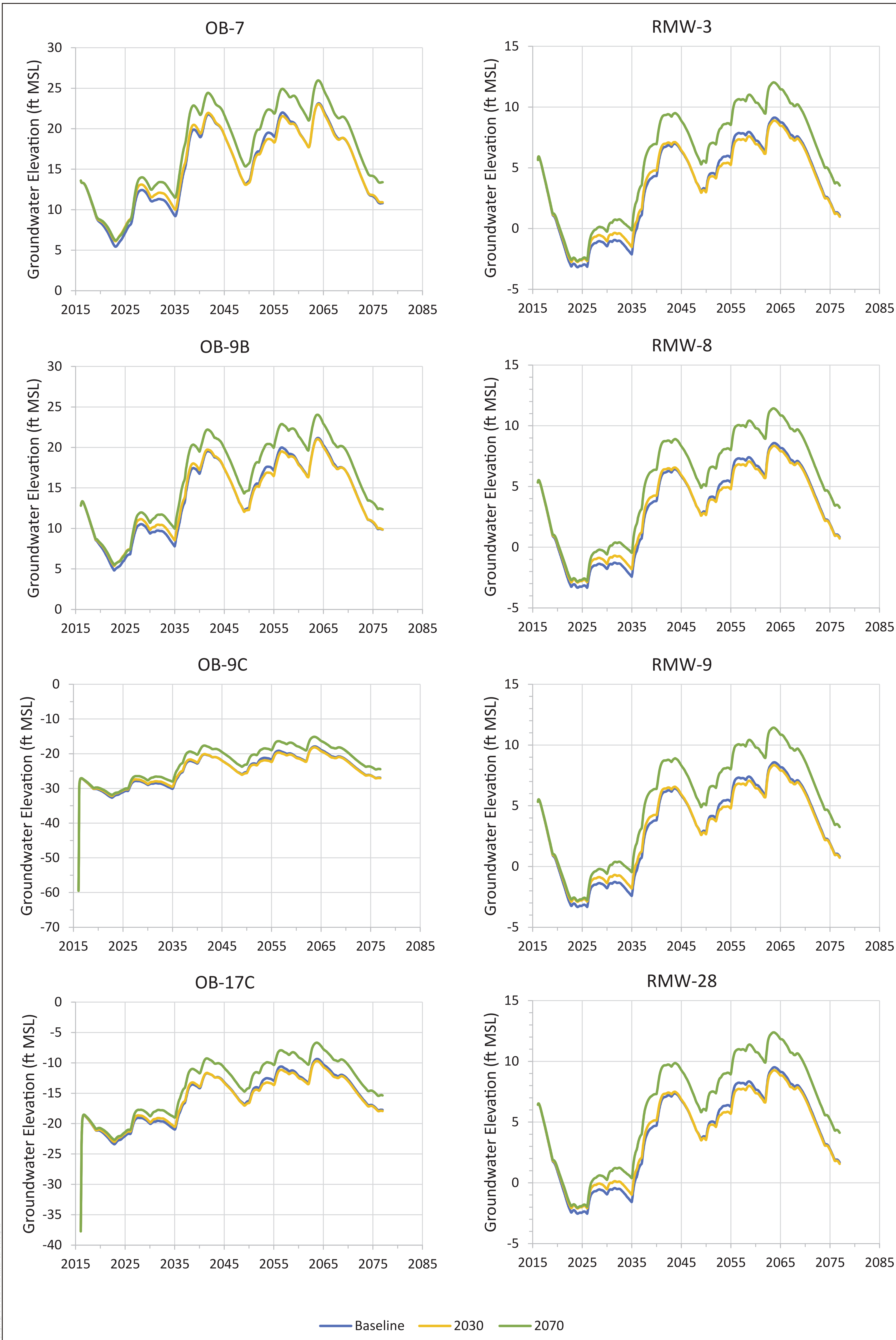

FIGURE 3-1

Projected Groundwater Elevations at the RMPs

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Legend

Santa Monica Subbasin (4-011.01)

Representative Monitoring Points

Sustainability Indicator

- Levels, Storage, Subsidence
- Seawater Intrusion

RMP Casing Name	Chronic Decline in Groundwater Levels (ft MSL)	
	Minimum Threshold	Measurable Objective
RMW-3	-175	-115
RMW-8	-165	-110
RMW-9	-165	-110
RMW-28	-160	-105
OB-7	5	30
OB-9B	20	45
OB-9C	-95	-40
OB-17C	-85	-30

RMP Casing Name	Seawater Intrusion (Chloride – mg/L)	
	Minimum Threshold	Measurable Objective
Arcadia No. 4	500	200
Arcadia No. 5	500	200
Santa Monica No. 1	500	200
Santa Monica No. 3	500	200
Santa Monica No. 4	500	200
Charnock No. 16	500	200
Charnock No. 18	500	200
Charnock No. 19	500	200
Charnock No. 20	500	200
City Hall Well	500	200

SOURCE:Geotracker GAMA; City of Santa Monica

DUDEK

0 1 2 Miles

FIGURE 3-2

Representative Monitoring Points

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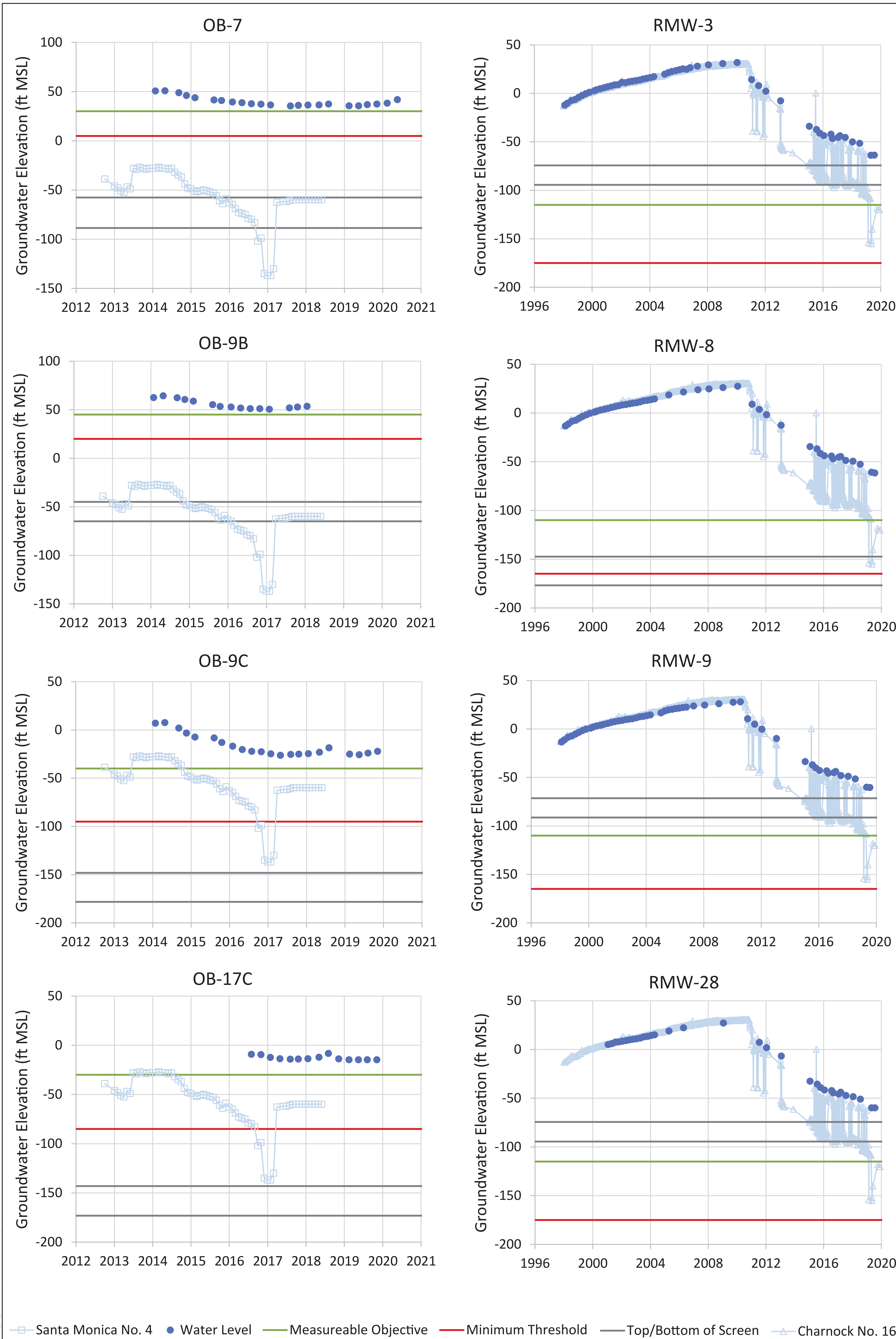

SOURCE: City of Santa Monica

FIGURE 3-3

Historical Groundwater Elevations at the RMPs

Groundwater Sustainability Plan for the Santa Monica Subbasin

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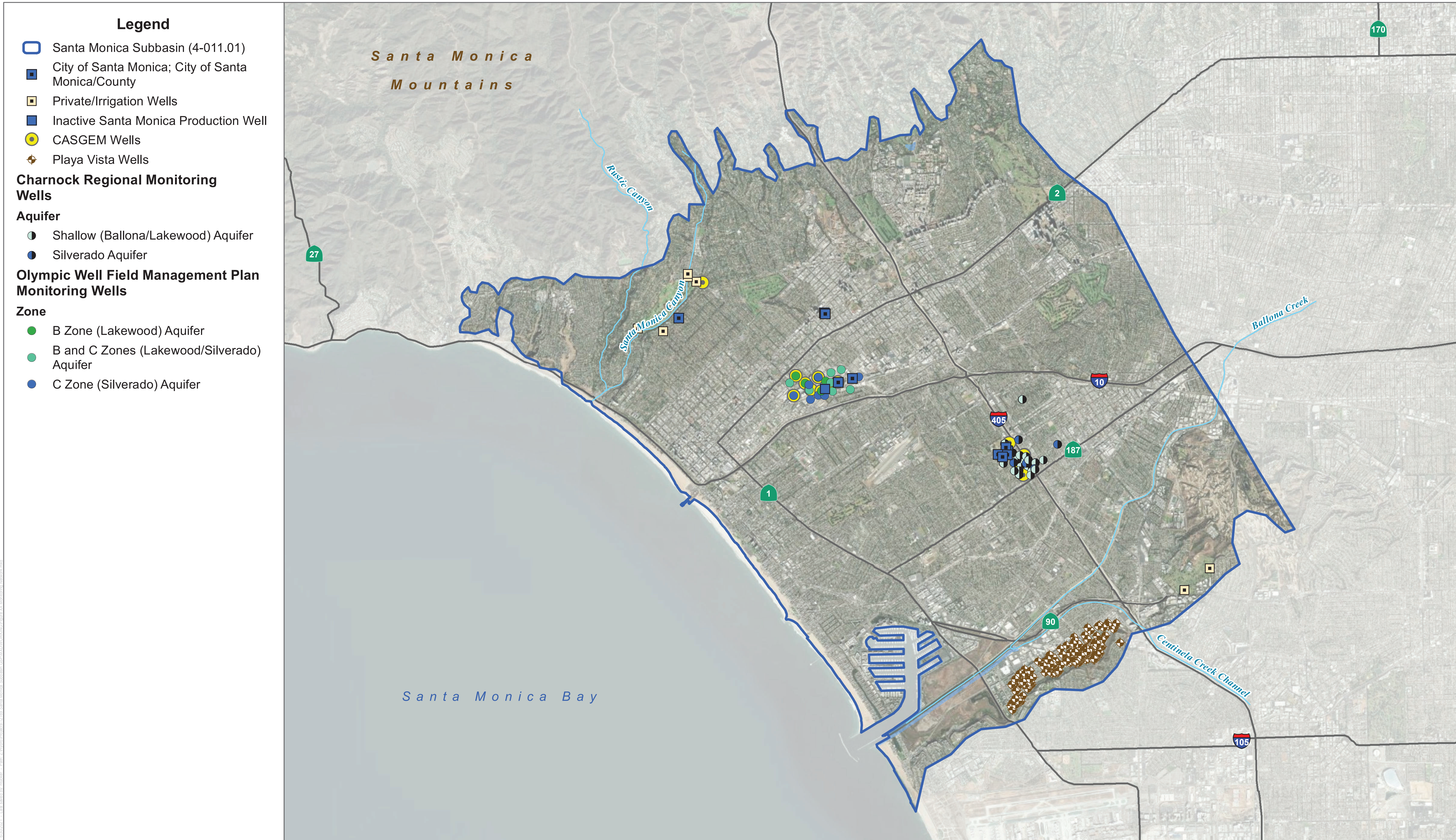

SOURCE:Geotracker GAMA; City of Santa Monica

DUDEK

0 1 2 Miles

FIGURE 3-4

Groundwater Monitoring Network

Groundwater Sustainability Plan for the Santa Monica Subbasin

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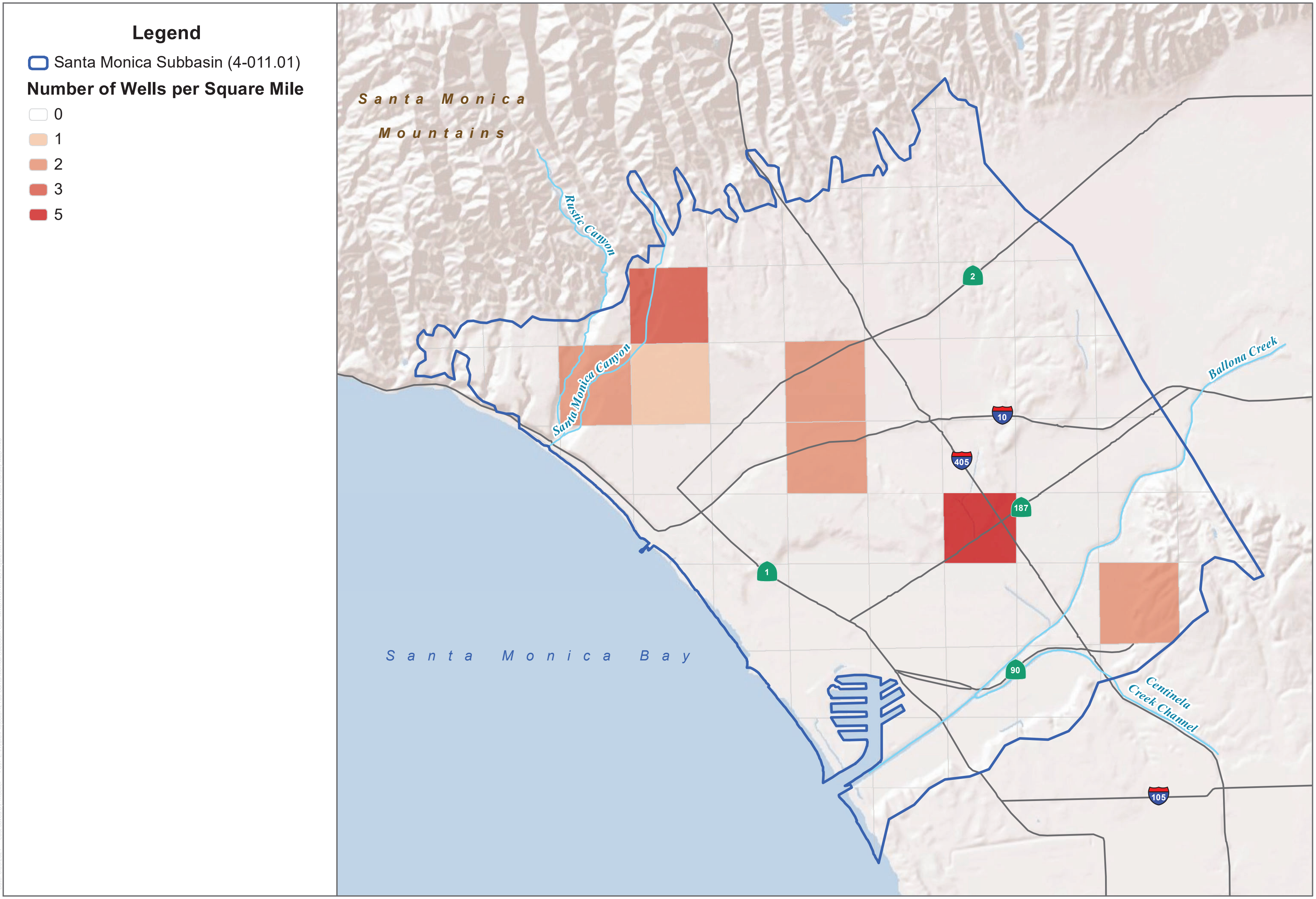

SOURCE: ESRI; DWR; USGS; City of Santa Monica

DUDEK

0 0.5 1 Miles

FIGURE 3-5

Production Well Density

Groundwater Sustainability Plan for the Santa Monica Subbasin

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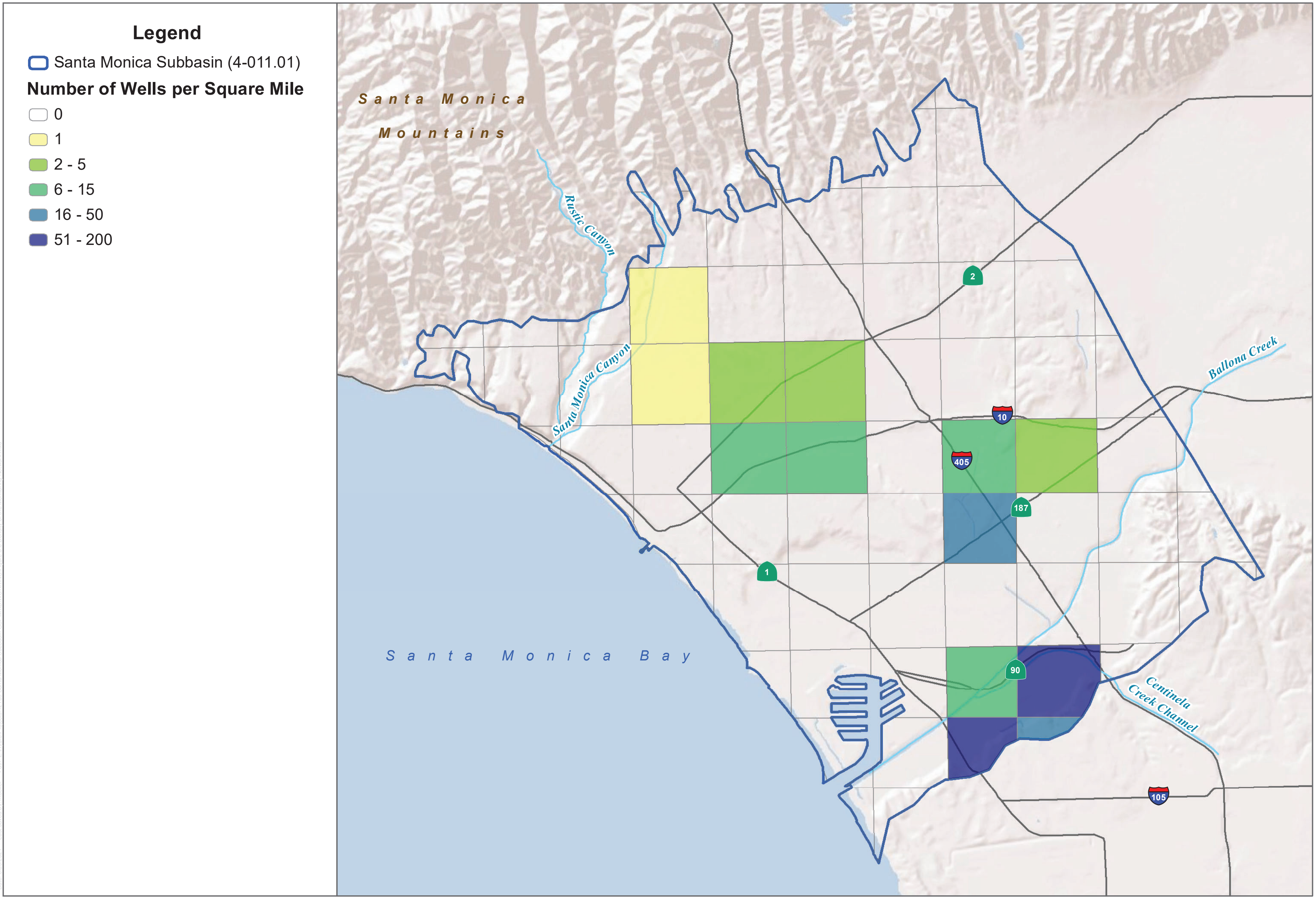

SOURCE: ESRI; Geotracker GAMA; USGS; City of Santa Monica

DUDEK

FIGURE 3-6

Density of the Monitoring Network

Groundwater Sustainability Plan for the Santa Monica Subbasin

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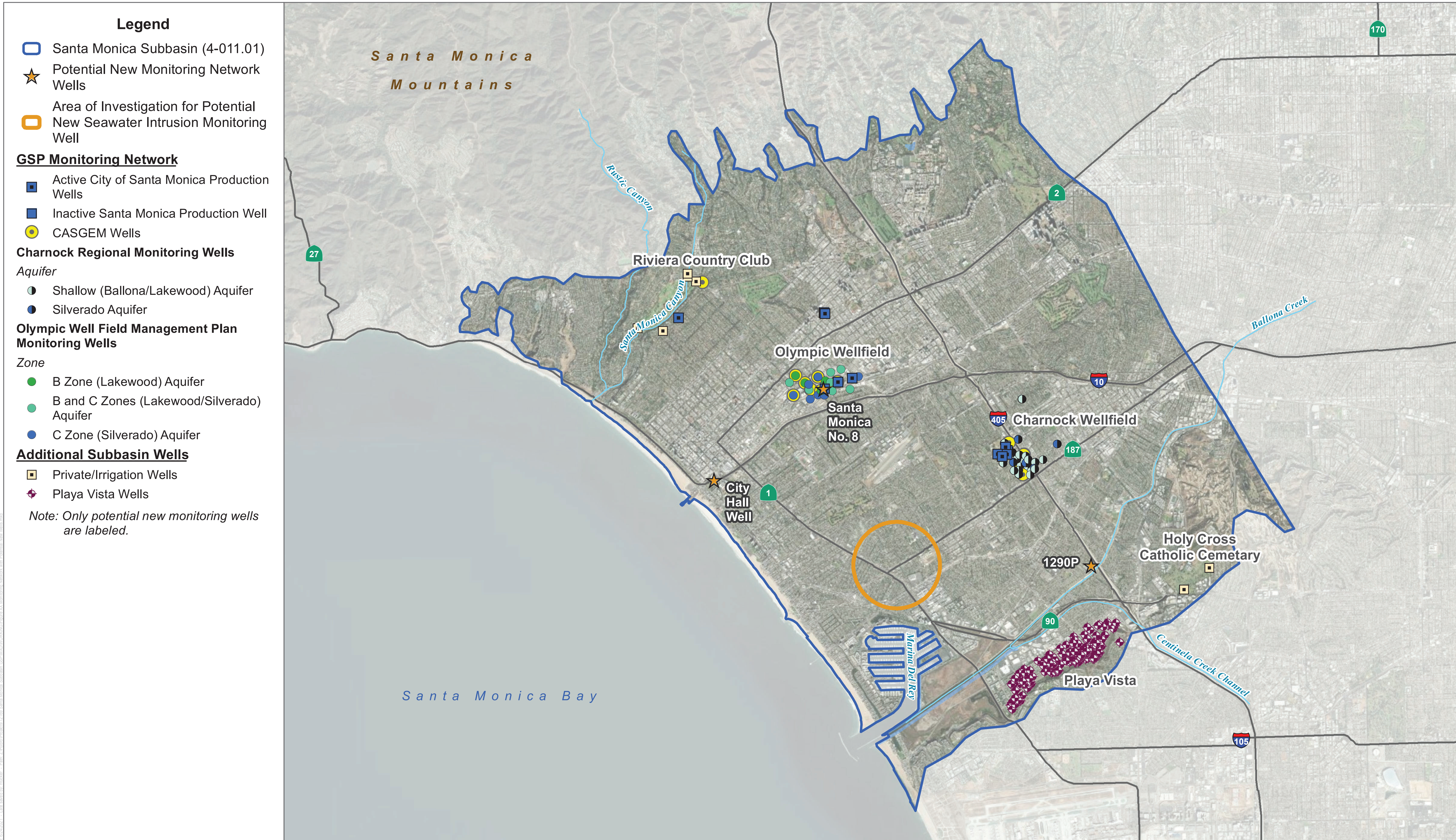

SOURCE:Geotracker GAMA; City of Santa Monica

DUDEK

0 1 2 Miles

FIGURE 3-7

Future/Potential New Monitoring Network Wells

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