ALTERNATIVE SUPPLY ASSURANCE PIPELINE PROJECT (ASAPP) FEASIBILITY STUDY: CONCEPTUAL DESIGN, YIELDS AND BENEFITS TO GROUNDWATER

United Water Conservation District

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GROUNDWATER DEPARTMENT
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THIS REPORT IS PRELIMINARY AND SUBJECT TO MODIFICATION BASED UPON FUTURE ANALYSIS AND EVALUATIONS

EXECUTIVE SUMMARY

In order to reduce groundwater overdraft on the Oxnard Plain and the resulting seawater intrusion, United Water Conservation District (United) is looking to acquire alternative water supplies (AWS) to supplement local water sources. For maximum efficiency in reducing pumping on the Oxnard Plain, delivery of surface water and imported water via pipelines to coastal areas should be prioritized over recharge in the Oxnard Forebay to the extent possible. The Alternative Supply Assurance Pipeline Project (ASAPP) investigated several alternatives for maximizing surface water deliveries from Lake Piru to the Oxnard Plain. These alternatives included an interim recharge and storage in Piru or Fillmore basins then extraction and pipeline delivery of the stored water to the Oxnard Plain or direct delivery of water from Lake Piru to the Oxnard Plan via pipeline.

United's preferred conceptual alternative for delivery of AWS and natural flows stored in Lake Piru to the Oxnard Plain is a 50 cfs pipeline that ties in to the Santa Felicia Dam (SFD) outlet works and terminates in United's diversion canal below the Freeman Diversion, and will primarily deliver water for surface water deliveries to agricultural areas. This alternative maximizes yield and operational flexibility, optimizes conjunctive use on the Oxnard Plain and eliminates the need for underground storage and the subsequent pumping of water back up to the land surface. When conveyed by pipeline, water deliveries can be matched to the demand for surface water on the Oxnard Plain. Proposed operations of Lake Piru with ASAPP would be significantly different from current operations that allow conservation releases generally occurring during late summer and fall, assuming sufficient water is stored in Lake Piru. With ASAPP, a portion of the water stored in Lake Piru would still be released to the lower Piru Creek as part of a traditional conservation release. These releases would supply the Piru, Fillmore and Santa Paula basins with their historic share of water supplies and their entitled share of State Water imports. The remainder of the water stored in Lake Piru would be conveyed via the proposed new pipeline for surface water deliveries on the Oxnard Plain. Pipeline releases would only occur when the demand on the Oxnard Plain cannot be met by Santa Clara River flows at the Freeman Diversion. Pipeline deliveries to recharge basins at United's Saticoy or El Rio facilities would also occur when Lake Piru is near or at capacity in order to reduce losses due to spills.

For the purpose of developing the conceptual design and the preliminary cost estimates, a pipeline alignment mostly in the County right-of-way was selected. The proposed pipeline would cross under the Santa Clara River near Piru and remain south of the river until reaching the Freeman Diversion headworks. At the concept level, the total cost of a pipeline with a capacity of 50 cubic feet per second (CFS) is estimated at 103 million dollars.

Project yields were calculated for the baseline scenario (simulated current operations without pipeline), and compared to ASAPP scenarios with various pipeline capacities (20 cfs, 50 cfs, 75 cfs), volumes of AWS, and surface water delivery infrastructure on the Oxnard Plain, including the Pumping Trough Pipeline (PTP) system and the Pleasant Valley (PV) system. Two annual

volumes of AWS were considered based on reasonable assumptions, however, no firm AWS has yet been acquired by United. Table ES-1 presents the modeled increases in surface water deliveries for the preferred alternative with 50 cfs capacity, for three of the scenarios analyzed in this study. Scenario S1 assumes modest volumes of AWS (2,854 acre feet per year [AF/yr]) and the use of existing surface water delivery infrastructure (PTP and PV). S3 assumes larger volumes of AWS (5,862 AF/yr) and some expansion of the capacity of the PTP and PV systems so that all demands in the PTP and PV system geographical areas can be met. S4 also assumes larger volumes of AWS (5,912 AF/yr) as well as a significant expansion of the surface water delivery infrastructure into the coastal zone of the southern Oxnard Plain. Yields associated with expanded surface water delivery infrastructure were assessed because delivery of higher volumes of AWS as surface water is not feasible without the infrastructure expansion due to insufficient demand in the current PTP and PV service area (based on historic demand).

With ASAPP, surface water deliveries increases (compared to baseline) are 6,207 AF/yr for S1 and 15,251 AF/yr for S2. ASAPP delivers more water to the Oxnard Plain during drought periods when the demand is high and conventional conservation releases from Lake Piru may not reach the Freeman Diversion. With more water reserved for pipeline deliveries, the proposed ASAPP operations reduce average recharge in the Oxnard Forebay by 3,851 AF/yr for S1 and 9,416 AF/yr for S2. Overall, ASAPP is very efficient in delivering AWS imports and natural runoff stored in Lake Piru as direct surface water deliveries to the Oxnard Plain. These deliveries will result in equivalent reductions in pumping in the areas where surface water is delivered and will increase the sustainable yield of the Oxnard Plain.

Table ES-1. Summary of ASAPP scenarios S1, S3 and S4 and changes in surface water deliveries and Forebay recharge compared to baseline operations (without pipeline and AWS imports).

Scenario	Surface water delivery infrastructure	AWS imports (AF/yr)	Increase in surface water deliveries (AF/yr)	Reduction in recharge (AF/yr)
S1- Surface water delivery at 50 cfs to the existing infrastructure	PTP/PV (existing)	2,854	6,207	3,851
S3 – Surface water delivery at 50 cfs and expansion of the existing infrastructure to include all service area demand	PTP/PV expansion	5,862	11,716	6,855
S4 - Surface water delivery at 50 cfs and expansion of the existing infrastructure to S3 + coastal zone	PTP/PV expansion + coastal	5,912	15,251	9,416

United's Ventura Regional Groundwater Flow Model (VRGWFM) was used to analyze benefits to groundwater conditions in terms of groundwater elevations and fluxes along the coast. Modeled water levels are presented for eight key well locations on the Oxnard Plain representing both the Upper Aquifer System (UAS) and the Lower Aquifer System (LAS). ASAPP has little impact on groundwater levels for locations in the UAS, with less than 5 feet of predicted difference in average groundwater levels between ASAPP scenarios and baseline in most cases (Figure ES-1). ASAPP operations increase groundwater levels more significantly in the LAS, and especially near Point Mugu and in the PTP service area (wells that supplement surface water supply in the PTP and PV pipelines are screened in the LAS). At the latter two locations, average increases between 14 to 18 ft (S1) and 28 to 39 ft (S4) are predicted (Figure ES-1). Modeled onshore fluxes were reduced with ASAPP compared to the baseline operations, especially in the south coast area where ASAPP surface water deliveries occur and pumping reductions are the greatest (Figure ES-2). Reductions in onshore coastal fluxes in the southern Oxnard Plain increase progressively from scenarios S1 (28% UAS, 11% LAS) to S3 (75% UAS, 26% LAS) to S4 (85% UAS, 46% LAS).

In conclusion, surface water and groundwater modeling predicts that the ASAPP preferred alternatives achieve significant increases in surface water deliveries to the Oxnard Plain, resulting in reduced groundwater overdraft and seawater intrusion. It is expected that the purchase of alternative water supplies and the strategic delivery through ASAPP operations will provide significant benefits towards meeting sustainable yield criteria on the Oxnard Plain.

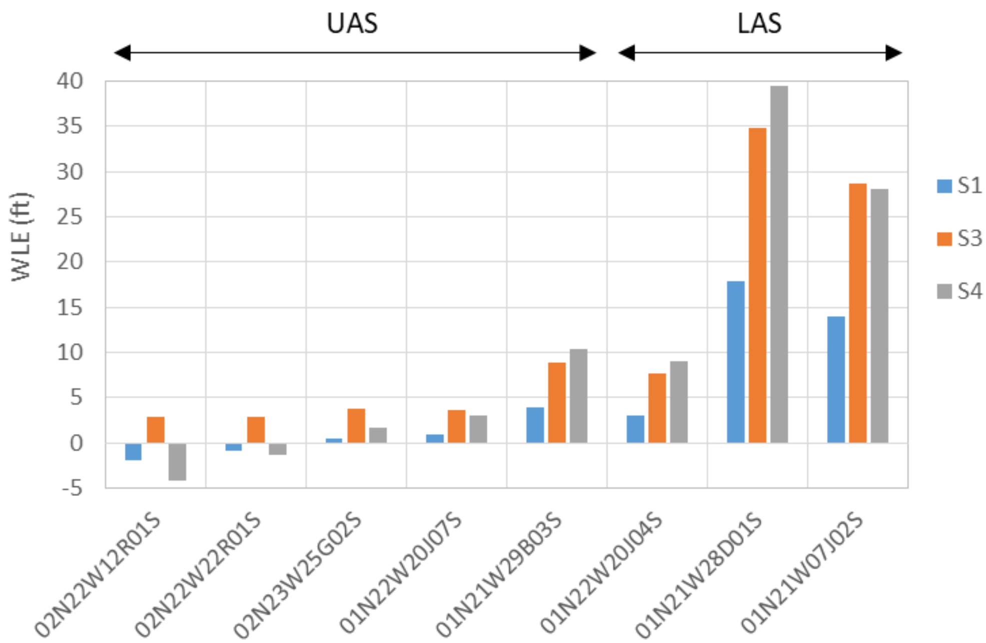
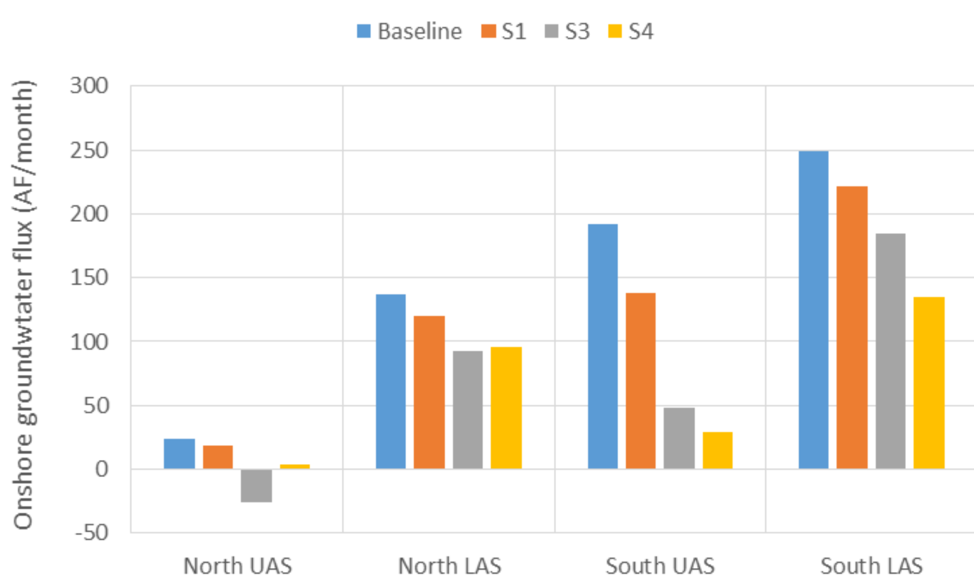


Figure ES-1. Average change in groundwater elevation (WLE) in selected wells for scenarios S1, S3 and S4 compared to the baseline scenario (simulated current operations without pipeline). WLEs are presented for 8 well locations, and grouped according to the depth of the well screens (UAS or LAS).



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2 INTRODUCTION

United Water Conservation District (United) manages water resources in the lower Santa Clara River watershed using facilities, including the Santa Felicia Dam, the Freeman Diversion, the Saticoy and El Rio recharge facilities and the Pumping-Trough-Pipeline (PTP) and Pleasant Valley (PV) surface water delivery systems (Figure 1.1). Lake Piru was formed with the construction of the Santa Felicia Dam, and as of 2015 had a capacity of approximately 82,000 AF of storage for natural runoff from the Piru Creek watershed as well as water purchased from the State Water Project (via the California Department of Water Resources' (DWR) Lake Pyramid facility). United currently performs conservation releases from Lake Piru during most years, with the purpose of replenishing the upper basins of the Santa Clara River (Piru, Fillmore and Santa Paula basins), replenishing the Oxnard Forebay, and providing surface water deliveries to United's agricultural customers via the PTP and PV pipeline systems. Historic average annual conservation release volumes are approximately 26,000 AF/yr, of which on average 45% infiltrates as groundwater recharge in the Piru basin, 15% infiltrates in the Fillmore basin, and 40% reaches the lower basins for recharge and surface water deliveries. The Freeman Diversion facility is used to divert water from the Santa Clara River for recharge and surface water deliveries. Historic average diversions (including conservation releases) since the construction of the Freeman Diversion in 1991 are approximately 62,000 AF/yr, with 48,000 AF/yr devoted to groundwater recharge and 14,000 AF/yr delivered by pipeline to agricultural users. United's recharge activities support a substantial portion of the groundwater extractions on the Oxnard Plain and Pleasant Valley, which totals approximately 94,000 AF/yr (2015-2017 average).

Groundwater elevations on the Oxnard Plain commonly decline during periods of below-average rainfall, resulting in water levels below sea level near the coast and episodes of lateral seawater intrusion. The aquifers of the Upper Aquifer System (UAS) and Lower Aquifer System (LAS) on the Oxnard coastal plain are currently substantially depleted following persistent drought conditions beginning in the year 2012 (UWCD, 2019). DWR designates the Oxnard Plain and Pleasant Valley basins subject to critical overdraft (DWR, 2019). United estimates the long-term average annual overdraft in the Oxnard Plain and Forebay groundwater basins to be about 20,000 to 25,000 AF/yr (UWCD, 2015).

In order to reduce overdraft on the Oxnard Plain and the resulting seawater intrusion, United is looking into securing alternative water supplies to supplement local sources, and effectively delivering this additional water to the Oxnard Plain. Effective delivery consists of maximizing surface water deliveries in order to reduce pumping on the southern Oxnard Plain where pumping has the greatest impact on coastal groundwater gradients (United, 2017), and maximizing deliveries when they're needed most (i.e. during dry years).

The Alternative Supply Assurance Pipeline Project (ASAPP) is intended to provide effective delivery of alternate water supplies to the Oxnard Plain. This report presents the alternatives analyzed, selection of the preferred concept-level alternative, estimated project yield at the Freeman Diversion, benefits to groundwater elevations in selected wells on the Oxnard Plain, and benefits to coastal groundwater fluxes along the coastline.

3 HYDROLOGY MODELS

A series of linked spreadsheet models and a numeric groundwater flow model were used to model United's operations and quantify the yields and groundwater benefits for ASAPP over a 71-year period. Historic hydrology from water year 1944 to 2014 was used for all models, except in some cases where the hydrologic record was adjusted to better reflect current conditions (e.g., differences in reservoir operations, wastewater plant discharges). Potential effects of climate change were not considered in the analyses. All spreadsheet models were calculated and calibrated in daily time steps, in Excel software. A brief description of the models and major assumptions are presented here, more detailed information is available in other published reports.

3.1 LAKE PIRU RESERVOIR MODEL

The Lake Piru reservoir model is a water balance model calculating water levels and storage in Lake Piru based on historic data or assumed scenarios for inputs and outputs. Water inputs include inflows from Middle Piru Creek watershed (natural flows, State Water imports, releases from Lake Pyramid) and rainfall; outputs include releases through the SFD outlet works (conservation releases, migration releases, habitat releases), releases through the proposed ASAPP pipeline, spills and evaporation.

Important assumptions and inputs for ASAPP modeling include:

- Lake Piru storage capacity is based on a 2006 bathymetry survey (83,244 AF). The Lake Piru storage capacity decreased to 82,000 AF based on a 2015 bathymetry survey, which was not incorporated in the model. The gradual decrease in storage capacity will somewhat increase the volume of spills over SFD, but is not expected to significantly alter the findings of this study.
- Historic inflows from Middle Piru Creek were used, which includes periods when Lake Pyramid operations were different from current operations.
- United has a State Water Project Table A allocation of 3,150 AF. Annual allocations of Table A water were based on DWR's modeling of the State Water Project's existing delivery capability (as of 2017, including current flow regulations and adjusted to account for land-use changes), which was available for water years 1944 to 2003 (California Department of Water Resources, 2018). Actual allocations were used from 2004 onwards. In order to match historic operations, it was assumed that United does not purchase Table A water during wet years.
- Habitat and migration releases are performed according to the Santa Felicia Water Release Plan (United Water Conservation District, 2012).

- Scenarios with ASAPP operations assume that conventional water conservation releases occur through the existing outlet works and are initiated in May.
- ASAPP operations are performed to meet the demand for water on the PTP and PV systems (without or with expansion) on the Oxnard Plain, after accounting for the availability of surface water (natural runoff) at Freeman Diversion to satisfy the PTP and PV system demands. The demand is modeled by the Oxnard Plain Surface Water Distribution Model.
- For modeling ASAPP scenarios, a running account is kept of the stored water volume for pipeline releases and for conventional release to upper basins. The upper basins receive 65% of natural inflows (based on historic average), and 15% of imports of State Water Project water (based on proportion of property tax assessment). The remainder of the inflows and imports are included in the accounting for pipeline operations. Conservation releases to the upper basins are performed annually assuming a positive account balance exists, and the minimum carry-over storage requirement is met (20,000 AF during dry years, 30,000 AF during normal years and 50,000 during wet years; reflecting United's strategy to maintain more water storage in Lake Piru when available storage in the Oxnard Forebay is lower). Releases to the ASAPP pipeline are performed based on the PTP and PV system demands that cannot be met by SCR water diverted at Freeman. Any unused balances carry over to the next year. In wet years, spills from Lake Piru are subtracted from the ASAPP account.

3.2 UPPER BASINS SURFACE WATER MODEL

The Upper Basins Surface Water Model calculates surface flows, recharge to groundwater and rising groundwater for the reach of the Santa Clara River overlying the Piru, Fillmore and Santa Paula basins. Model inputs include releases from Lake Piru (via Piru Creek; obtained from the Lake Piru reservoir model), Santa Clara River flows from Los Angeles County, tributary flows (Hopper Creek, Sespe Creek, Santa Paula Creek), and available storage in Piru and Fillmore basins. Model outputs include available storage in the Piru and Fillmore basins, and river flows at the Freeman Diversion. Empirical relationships are used to model the following processes: recharge to groundwater in the Piru and Fillmore basins, rising groundwater at the Piru/Fillmore and Fillmore/Santa Paula basin boundaries, underflow between Piru and Fillmore basins, and losses in surface flows across Santa Paula basin. The model essentially calculates the change in available storage in Piru and Fillmore basins for a scenario compared to historic trends (based on a water mass balance for each reach), and subsequently adjusts fluxes for recharge, rising groundwater and underflow for the scenario based on the calculated available storage.

Important assumptions for ASAPP modeling include:

- Modeled Santa Clara River flows from LA County assume the current rate of discharge from the Valencia Water Reclamation Plant. Therefore, flows prior to 1968 (before construction of facility) were adjusted to simulate wastewater discharge of 15 cfs.
- A correction factor of 1.2 was applied to gaged stream flows from major tributaries (Hopper Creek, Sespe Creek, and Santa Paula Creek) to improve model calibration. The correction factor accounts for inflows from other minor tributaries and bank storage.

3.3 HYDROLOGY OPERATIONS SIMULATION MODEL (HOSS)

The HOSS is a hydrology-based operations model that simulates diversions and flow magnitudes in the Santa Clara River downstream of the Freeman Diversion, and the amount of water that is lost or gained to/from groundwater in the "critical reach" of the SCR in the Oxnard Forebay (R2, 2016). The HOSS is based upon several decades of historical flow gage data, groundwater conditions in the Forebay, and diversion flow rates.

For ASAPP modeling, total river flow entering the Freeman Diversion is imported from the Upper Basins Surface Water Model. Diversion operations follow Scenario 6, as proposed by United in its Administrative Draft Multiple Species Habitat Conservation Plan (United Water Conservation District, 2018a). Scenario 6 operations are designed to provide adequate bypass flows for fish migration while minimizing reductions in diversions, and represent a realistic scenario for future diversion operations.

3.4 OXNARD PLAIN SURFACE WATER DISTRIBUTION MODEL

The Oxnard Plain Surface Water Distribution model is a water routing model that simulates amounts of groundwater recharge in United's recharge basins and supply to surface water delivery systems, based on a series of adjustable hydrologic inputs (e.g. total river flow, diversions) and operational assumptions. The Surface Water Distribution Model calculates recharge and surface water deliveries to United's facilities, using the daily diversions output from the HOSS model. The surface water model outputs are used as inputs for the groundwater model described in Section 2.5. Since some modeled operations in the Surface Water Distribution Model depend on groundwater levels, iterative runs were performed where outputs from the Surface Water Distribution Model (spreading at recharge basins and calculated groundwater extractions) were used in the groundwater model, and groundwater level outputs from the groundwater model run (three wells were used to determine available storage in the Oxnard Forebay and groundwater mounding in the Saticoy Facility) were then used to re-run the same scenario in the Surface Water Distribution Model. The analyses were repeated until monthly fluxes for surface water deliveries and recharge were converging and within 100 – 200 AF between consecutive runs, which was considered sufficient accuracy for this study.

Water resource inputs to the Surface Water Distribution Model include diversion amounts, pumping from Saticoy wells and Conejo Creek diversions. Operational assumptions govern how the distribution of water resources is prioritized among recharge basins and surface water deliveries, and change based on season and hydrologic conditions (dry, normal or wet years). It is assumed that diverted water can supply all recharge basins and surface water delivery systems, while supplies from the Saticoy wells are restricted to surface water delivery pipelines, and supplies from Conejo Creek diversions are restricted to the Pleasant Valley (PV) surface water delivery pipeline. Infrastructure limitations restrict the maximum daily recharge in each basin and surface water deliveries, and additionally infiltration rates in the Saticoy and El Rio basins are gradually decreased based on cumulative recharge volumes. Infiltration rates in the Saticoy and El Rio basins become limiting only when the basins are filled to capacity.

A more detailed description of this model, including model assumptions and validation results are described in United's Open-File Report 2016-03 (United Water Conservation District, 2016a).

3.5 VENTURA REGIONAL GROUNDWATER FLOW MODEL (VRGWFM)

The VRGWFM uses outputs from the Oxnard Plain surface water distribution model to calculate groundwater levels and water fluxes at the basin boundaries.

United has developed the Ventura Regional Groundwater Flow Model, a numerical groundwater flow model for the aquifers underlying the Oxnard coastal plain. A numerical model grid was developed using MODFLOW-NWT, with 2,000-foot uniform grid spacing and 13 layers representing the seven recognized aquifers and six aquitards present in the model area. The current active domain of the VRGWFM includes the Oxnard Forebay, Mound, Oxnard Plain, Pleasant Valley, and West Las Posas basins, part of the Santa Paula basin, and the submarine (offshore) outcrop areas of the principal aquifers that underlie these basins. The active model domain spans approximately 282 square miles, of which 60% (169 square miles) is onshore and 40% (113 square miles) is offshore. The simulation period for calibration was January 1985 through December 2015, with 372 monthly stress periods with variable recharge and pumping rates. Calibration results indicate that the model is well calibrated throughout most of the Oxnard Forebay, Oxnard Plain, and Pleasant Valley basins. The model is not quite as well calibrated in the Mound basin, portions of the West Las Posas basin and the northeast margin of the Pleasant Valley basin; however, these areas are of minor relevance for modeling the effects of potential changes to Freeman Diversion operations on groundwater levels across most of the Oxnard coastal plain. A detailed description of the VRGWFM, calibration and external peer-review is available at www.unitedwater.org (United Water Conservation District, 2018b).

4 PHASE 1 FEASIBILITY ANALYSIS

The Phase 1 feasibility analysis compares different conceptual alternatives for conveying AWS to the Oxnard Plain. The analysis compares operations, yield at the Freeman Diversion, timing of delivery and concept-level cost for five alternatives, and two pipeline capacities for each alternative. Final ranking of alternatives also considered environmental/permitting requirements and quagga mussel management.

4.1 ALTERNATIVES

The Phase 1 feasibility analysis included one alternative with a pipeline for conveyance of imported water, and three alternatives with a well field for extraction of stored imported water and a pipeline for conveyance (Figure 3.1). Alternatives with well field rely on temporary storage of released water in Piru and Fillmore basins, and the subsurface migration of stored groundwater to the well field location. Downgradient movement of groundwater depends on the groundwater gradient, and may be slow during times of drought when gradients are flatter. Potential well fields were located in areas of rising groundwater in order to minimize well depths and water lifts. The pipeline-only alternative delivers imported water directly from SFD to the Freeman Diversion.

Alternative 1.1: No project alternative

United releases imported alternative water supplies from Lake Piru and uses natural conveyance in the channel of the Santa Clara River to transport imported water to the upper basins and the Freeman Diversion.

Alternative 1.2. Well field in Fillmore basin and pipeline to Freeman Diversion (full pipeline, “FP”).

The well field is located in the area of rising groundwater in the Fillmore basin, and a pipeline delivers extracted water the full distance to the Freeman Diversion. United identified two potential well field locations for this alternative, one near the downstream basin boundary and one near the Sespe Creek confluence, with pipeline lengths of approximately 7 and 10 miles, respectively.

Alternative 1.3: Well field in Piru basin and pipeline to Freeman Diversion (FP).

The potential well field is located in the area of rising groundwater near the downstream boundary of the Piru basin. An approximately 19-mile long pipeline delivers extracted water the full pipeline distance to the Freeman Diversion.

Alternative 1.4: Well field in Piru basin and pipeline to Fillmore/Santa Paula basin boundary (partial pipeline, “PP”).

The well field is located in the area of rising groundwater near the downstream boundary of Piru basin. An approximately 10-mile long pipeline delivers extracted water to an outfall on the Santa Clara River in the area of rising groundwater near the downstream boundary of Fillmore basin. Water conveyance from this point to the Freeman Diversion occurs as surface flows in the Santa Clara River. Losses to groundwater across Santa Paula basin are relatively low, given that confined aquifer conditions occur in most of the basin (United Water Conservation District, 2019), and recharge is likely limited to the eastern portion of the basin (Santa Paula Basin Experts Group, 2003).

Alternative 1.5: Pipeline from Santa Felicia Dam to Freeman Diversion.

An approximately 26-mile long pipeline delivers water imported to Lake Piru directly to the Freeman diversion canal.

4.2 OPERATIONS, DIVERSION TIMING, YIELDS AND COST

Hydrology spreadsheet models were used to calculate diversion timing and yields after import of Alternative Water Supplies. This section presents the assumptions for operations, source of AWS and hydrology models, as well as model outputs and concept-level cost estimates.

4.2.1 OPERATIONAL ASSUMPTIONS

The Phase 1 feasibility analysis assumes that all AWS are imported into United’s service area from DWR’s Lake Pyramid via middle Piru Creek and Lake Piru, and released from SFD as part of a conservation release in the fall. An alternative import route via Castaic Lake was not considered in this study because of the limited options for water storage there and losses to groundwater outside United’s service area when releasing to Castaic Creek. For import of State Water Project Article 21 water, it was assumed that deliveries to Lake Piru are possible between November 1 and March 31. Currently, the delivery window for releases from Lake Pyramid to Lake Piru is restricted between November 1 and February 28 in order to protect arroyo toad critical habitat during their breeding season. The breeding season is believed to start later some years, particularly wet years.

4.2.2 ALTERNATIVE WATER SUPPLIES

The purpose of ASAPP is the efficient and timely conveyance of imported water supplies to areas of critical need. Currently, United has a State Water allocation of 3,150 AF (Table A). This water supply is used as the baseline for scenario comparisons. For the Phase 1 feasibility analysis, it was assumed that United would be able to acquire and purchase 18,150 AF of Table A allocation, the entirety of Ventura County's Table A entitlements. Alternative water supplies are defined as the difference between the 18,150 AF of Table A water and the baseline scenario supply of 3,150 AF per year. Note that there is currently no agreement between United and Casitas Municipal Water District or the City of Ventura for any kind of transfer of Table A allocation.

An analysis of the historic availability of Ventura County's Table A water was performed, and potential past purchases of Table A water were modeled using the Lake Piru model by assuming that purchases of Table A water occur when all of the following conditions are fulfilled: (i) during dry and normal rainfall years, (ii) when less than 31,000 AF is available for a conservation release, and (iii) when available storage in the Oxnard Forebay exceeds 20,000 AF. Under these assumptions, United would not order Table A water during wet years, or when significant amounts of water are already stored in Lake Piru and the Oxnard Forebay. Under these criteria, AWS imports would occur on a fairly regular basis, with modeled average AWS imports totaling 5,540 AF/yr (Figure 3.2).

4.2.3 DIVERSION YIELD AND TIMING

Phase 1 project alternatives were compared by calculating storage in the Piru and Fillmore groundwater basins, diversions at Freeman, and deliveries through the pipeline (if applicable) for the alternative water supply scenario. The following models were used for the analysis:

- Lake Piru Model. The baseline scenario assumes State Water imports to Lake Piru based on United's allocation of 3,150 AF. The ASAPP alternatives analysis assumes imports based on AWS of an additional 15,000 AF of Table A water (for a total of 18,150 AF).
- Upper Basins Surface Water Model. Outputs from the Lake Piru Model were routed through the Surface Water Model to calculate storage in the groundwater basins and river flows at the Freeman Diversion.
- HOSS model. Outputs from the Surface Water Model were used to calculate diversions based on the proposed Operational Scenario 6 in United's administrative draft MSHCP, dated September 7, 2018. The Phase 1 feasibility analysis does not specify if diverted AWS will be used for recharge or surface water deliveries. That part of the analysis was done as part of Phase 2.

Figure 3.3A shows groundwater storage in Piru and Fillmore basins and water deliveries at the Freeman diversion when releasing alternative water supplies under Alternative 1.1 (no project). Cumulative amounts of released water steadily increase, as water is released on an almost annual basis (black line). During the dry period between model years 1946 and 1968, a significant amount of released water remained stored in the groundwater basins, with up to about 30,000 AF in Piru basin (blue line) and 21,000 AF in Fillmore basin (red line). During the same time period, deliveries at the Freeman Diversion lag behind releases (orange line). From model years 1968 to

2017, volumes of imported water stored in the basins were lower, but still significant during drier periods.

Figure 3.3B shows a comparison of groundwater storage and deliveries (diversions and pipeline) for Alternative 1.4. In this case, the released AWS is extracted from the Piru basin for delivery to the Freeman Diversion whenever it is available. The total deliveries at the Freeman Diversion track the volume of imported water well, with less than 1 year of delay in water delivery for most of the modeling period, even during drought years. The delay in AWS deliveries was 2-5 years during periods of drought for Alternative 1.1, but almost exclusively less than 1 year for Alternative 1.4. Delays in delivery of AWS during dry periods were 2-4 years for Alternative 1.2, and < 2 years for alternatives 1.3 and 1.4 (Table 3.1). Alternative 1.2 relies on subsurface transport of groundwater to the Fillmore basin, and therefore delays are longer than for Alternatives 1.3 and 1.4. Alternative 1.5 consistently delivered water within the same year it is imported, as the only limitation in delivery speed is the pipeline capacity and demand.

Project yields were calculated as the volume of AWS imports delivered at the Freeman Diversion. Potential yield losses included stream flow losses across Santa Paula basin (diversions, evapotranspiration and recharge) as well as environmental bypass flow requirements at the Freeman Diversion. Alternatives that deliver more water through a pipeline reduced these yield losses. In addition, yield losses due to bypass flow requirements are affected by differences in the timing of delivery of AWS water at the Freeman Diversion between the various alternatives. Diversion yields and delivery delays during drought periods are summarized for each alternative in Table 3.1. Yield increase is calculated as the yield compared to the no project alternative. For Alternative 1.5, the pipeline is assumed to be 100% efficient and yield is the same as the volume of imported water.

Table 3.1. Diversion yield and timing for ASAP Phase 1 feasibility analysis.

	Pipe Capacity (cfs)	**Diversion Yield (AF/yr)**	**Yield increase (AF/yr)**	**Delivery delay drought (yrs)**
Alternative 1.1 – none	n/a	3,651	n/a	5+
Alternative 1.2 – Fillmore well field FP	10	4,471	820	2 – 4
	20	4,511	860	2 – 4
Alternative 1.3 – Piru well field FP	10	4,793	1,142	< 2
	20	4,912	1,261	< 2
Alternative 1.4 – Piru well field PP	10	3,978	327	< 2
	20	4,137	486	< 2
Alternative 1.5 – SFD pipeline	20	5,412	1,761	< 1
	50	5,412	1,761	< 1

4.2.4 CONCEPT-LEVEL DESIGN AND COST ESTIMATE

A conceptual design and cost estimate was prepared by United's engineering staff (Appendix B). A conceptual cost-benefit assessment was performed by dividing the current project construction cost by a 50-year project lifetime and by the annual diversion yield (assuming no additional costs for financing). For Alternative 1.2, two potential well field locations were included, resulting in two estimates for construction cost and cost-benefit.

Table 3.2. Summary of concept level engineering design and cost.

	Well field depth (ft)	Capacity (cfs)	Pipeline size (inch)	Pipeline material	Construction cost (M $)	Cost-benefit ($/AF)
Alternative 1.1 – none	n/a	n/a	n/a	n/a	n/a	n/a
Alternative 1.2 – Fillmore well field FP		10	16	PVC	16.3 – 24.3	398 - 593
		20	27	CCP	30.6 – 37.2	712 - 865
Alternative 1.3 – Piru well field FP		10	16	PVC	34.5	604
		20	27	CCP	60.9	966
Alternative 1.4 – Piru well field PP		10	16	PVC	20.9	1,278
		20	27	CCP	37.1	1,527
Alternative 1.5 – SFD pipeline		20	27	CCP	66.5	755
		50	42	CCP	101.3	1,150

4.3 COMPARISON OF ALTERNATIVES

Alternatives were compared by ranking from 1 (low) to 5 (high) for the following criteria:

- Yield at Freeman Diversion. Ranking scores increase with higher yields (Table 3.1). Yields were given a higher weight given ASAPP's goal of improving water supplies to the Oxnard Plain. Yields are compared based on 20 cfs capacity for all alternatives.
- Timing of delivery at Freeman Diversion. Ranking scores increase with shorter delivery delays (Table 3.1). Timing of delivery was given a higher weight given ASAPP's goal of improving water supplies to the Oxnard Plain during drought periods.
- Operational flexibility. Alternatives were ranked higher with increased flexibility timing and quantity of releases from Lake Piru and deliveries to the Oxnard Plain. Alternatives with well fields ranked lower because water can only be extracted after downgradient migration within the groundwater basins. Operational flexibility was given a higher weight given United's preference for operational control, including the opportunities for potential future inter-basin transfers and water conveyance to other agencies.
- Concept-level cost estimate. Ranking scores increase with lower construction cost estimates (Table 3.2). Costs are compared based on 20 cfs capacity for all alternatives.
- Environmental/permitting. Ranking scores decreased for pipeline construction due to additional permitting requirements, and also for operation of a well field due to potential effects on groundwater-dependent ecosystems near the basin boundaries.

- Quagga mussel concerns. Ranking scores decreased for alternatives that offer fewer options for managing the quagga mussel infestation in Lake Piru.

Weighted average ranks are highest for Alternative 1.5 (20 cfs and 50 cfs) and Alternative 1.3, reflecting ASAPP goals of improving water supplies to the Oxnard Plain during drought periods. Given the increased operational flexibility for Alternative 1.5 (20 and 50 cfs capacity), the latter was selected for further study in the Phase 2 feasibility analysis.

Table 3.3. Ranking of alternatives for Phase 1 feasibility analysis.

	Weight Factor	A1.1. None	A1.2. Fillmore well field FP	A1.3 Piru well field FP	A1.4. Piru well field PP	A1.5. SFD pipeline	
						20 cfs	50 cfs
Yield	2	1	3	4	2	5	5
Timing of delivery	2	1	2	4	4	5	5
Operational flexibility	2	1	2	3	2	4	5
Cost	1	5	3	2	3	2	1
Environmental/permitting	1	5	1	1	1	2	2
Quagga mussel	1	2	5	5	5	1	1
Weighted average		3.0	3.8	5.0	4.2	5.8	5.7

5 PHASE 2 FEASIBILITY ANALYSIS

The Phase 2 feasibility analysis consists of a more detailed analysis of design, operations and yield (recharge as well as surface water deliveries) for a pipeline the full distance from Santa Felicia Dam to the Freeman Diversion. Different scenarios were analyzed with regards to pipeline capacity, alternative water supply and surface water demands on the Oxnard Plain.

5.1 PHASE 2 SCENARIOS

The Phase 2 feasibility analysis considered three alternatives for pipeline capacity (20, 50 and 75 cfs). For each pipeline capacity, different scenarios were analyzed for alternative water supply and surface water demand on the Oxnard Plain. Scenarios are summarized in Table 4.1.

The AWS scenarios were calculated as follows:

<u>5000 DN</u>

United purchases 5,000 AF of water during Dry and Normal (DN) years (See Appendix A), resulting in average imports of 2,100 AF/yr for the 1944 – 2017 modeling period. The 5,000 AF purchase was considered to be a reasonable assumption for the volume of water United could acquire and put to beneficial use. The 5,000 AF purchases are in addition to United's routine Table A purchases (current 3,150 AF allocation).

Art 21

United purchases Article 21 water when it is available, except during wetter years when sufficient local supplies are available. Due to both the infrequent availability of Article 21 water and United's purchasing decisions, modeled Article 21 imports varied greatly over time. Article 21 imports only occurred during 5 of the 71 model years, with average annual imports of 3,081 AF/yr (Appendix A, Figure 4.1).

Article 21 water imports were calculated using Article 21 availability forecasts obtained from State Water Contractors (assuming Cal WaterFix is constructed) and assuming that Article 21 water is purchased by United when each of the following conditions are met: (i) available storage in Oxnard Forebay basin exceeds 25,000 AF, (ii) available storage in Piru basin exceeds 20,000 AF, (iii) less than 52,000 AF of water stored is in Lake Piru, (iv) Lake Piru inflows are less than 15,000 AF/month. When Article 21 water is available, there is still significant uncertainty regarding how much of the requested Article 21 water will ultimately be made available to United, given that the total Ventura County Table A allocation is only about 0.5% of the total allocations for all the State Water Contractors. Therefore, the supply estimates presented here have a high uncertainty.

The surface water demands scenarios were calculated as follows (Figure 4.2):

Historic

Surface water demands were modeled based on historic use patterns. The demand includes agricultural users that are currently able to receive surface water deliveries from the PTP and PV systems. Surface water demands are estimated at 8,314 AF/yr for PTP, and 18,506 AF/yr for PV.

Service Area

Surface water demands were calculated based on average pumping in the PTP and PV service area during the 2015 – 2017 period, when no surface water deliveries were provided by United. Total irrigation demands are estimated at 13,200 AF/yr for the PTP service area, and 21,100 AF/yr for the PV service area. This scenario with increased demands for surface water deliveries was analyzed to increase the effectiveness and benefits of the ASAPP pipeline. The scenario would require improvements to the distribution pipelines within both the PTP and PV service areas.

Coastal

Surface water demands were calculated based on average pumping in the coastal zone of the southern Oxnard Plain during the 2015 – 2017 period, when no surface water deliveries are currently provided by United. Demands are estimated at 10,000 AF/yr. This scenario with increased demands for surface water deliveries was analyzed to increase the effectiveness and benefits of the ASAPP pipeline. The scenario with coastal zone demands would require expansion of the PTP system or other surface water delivery pipelines into the coastal zone.

Table 4.1. Scenarios used in the ASAPP Phase 2 feasibility analysis.

Scenario	Pipeline capacity (cfs)	AWS	SW demand
Baseline	n/a	n/a	Historic
S1-20	20	5000 DN	Historic
S1-50	50	5000 DN	Historic
S1-75	75	5000 DN	Historic
S2-20	20	5000 DN + Art 21	Historic
S2-50	50	5000 DN + Art 21	Historic
S2-75	75	5000 DN + Art 21	Historic
S3-20	20	5000 DN + Art 21	Service area
S3-50	50	5000 DN + Art 21	Service area
S3-75	75	5000 DN + Art 21	Service area
S4-20	20	5000 DN + Art 21	Service area + coastal
S4-50	50	5000 DN + Art 21	Service area + coastal
S4-75	75	5000 DN + Art 21	Service area + coastal

5.2 OPERATIONS

Historically, United has released water stored in Lake Piru through a conservation release, where surface water flows down lower Piru Creek and the Santa Clara River. These releases result in varying benefits to the upper (SCR valley) and lower (coastal plain) groundwater basins, depending mostly on basin conditions and release strategy. The portion of the release that reaches the Freeman Diversion is partly delivered as surface water to growers, and partly distributed to recharge basins in the Oxnard Forebay.

With ASAPP, the operation of Lake Piru would change significantly. In order to meet the goals of ASAPP while also maintaining the historic benefits to the upper basins, the following operations are proposed:

1. United continues to store natural flows from the Piru Creek watershed in Lake Piru for subsequent conservation releases.
2. United increases its purchases of Alternative Water Supplies. Note that AWS have not yet been identified or secured. Options include additional Table A allocations, Article 21 water, water transfers and other water purchases.
3. United continues to release water to the Piru and Fillmore basins. These releases are designed to maintain historic benefits to the upper basins, including Santa Paula basin, which receives indirect benefits through its interconnection with Fillmore basin. Historic benefits for natural inflows were calculated for the upper basins based on historic releases for the period 1999 – 2017, and amount to 15,300 AF for wet years, 17,400 AF

for normal years, and 8,500 AF for dry years. Annual release amounts are determined based on a percentage of natural inflows associated with each water year type. On average, 65% of natural inflows will be released to the upper basins. Additionally, 15% of AWS will also be released to the upper basins, based on the relative share of property taxes paid for State Water in these areas. Releases to lower Piru Creek would occur at discharge rates sufficiently low to ensure that all released water percolates in the upper basins.

4. The volume of water reserved for release via a pipeline to the lower basins consists of 35% of natural inflows (on average), and 85% of AWS (based on property tax assessment). This water will be stored in Lake Piru to feed the demand for surface water deliveries on the Oxnard Plain. The water reserved for pipeline releases may be stored in Lake Piru for periods longer than one year, in case demands on the Oxnard Plain are low. ASAPP operations would reduce recharge to groundwater in the Oxnard Forebay, in favor of surface water deliveries to agricultural pipelines. Increased surface water deliveries to the pipelines would offset pumping near the coast on the Oxnard Plain, and would therefore be more beneficial to the Oxnard Plain and Pleasant Valley basins (United Water Conservation District, 2017).
5. In order to reduce losses of stored water to the ocean during Lake Piru spill events, pipeline releases will occur when the storage in Lake Piru exceeds 82,000 AF. These releases would be used for groundwater recharge in the Oxnard Forebay, as there will likely be little demand for surface water at such times.

The impacts of ASAPP on Lake Piru operations and water storage are illustrated in Figure 4.3. Without ASAPP (panel A), annual conservation releases would occur in the fall, at rates up to 400 cfs, and lake storage decreases significantly with each release. With ASAPP (panel B), conservation releases still occur during most years, but at lower rates (up to 200 cfs) and lower volumes, to provide the upper basins their historic benefit. Lake storage remains high during wetter periods (i.e. 2010 to mid-2012), as demand for surface water is relatively low. During periods of high demand for surface water (i.e. mid-2012 to 2014), pipeline releases are continuous, and lake storage gradually declines.

5.3 CONCEPTUAL DESIGN AND COST

A conceptual design and cost estimate for a 50 cfs and a 75 cfs capacity pipeline was performed by Civiltec Engineering. The proposed alignment of the pipeline is shown in Figure 4.4. The first 0.5 mile of pipeline below United’s SFD property would cross private land, but then the pipeline would mostly be built in County right-of-way. The proposed pipeline crosses under the Santa Clara River at Torrey Road, and then stays south of the river for the remainder of the way to the Freeman Diversion near Todd Road in the Santa Paula basin. The last 3.8 miles of pipeline will also cross private land, including approximately one mile immediately above the Freeman Diversion which may need to be constructed within the floodplain of the Santa Clara River.

Total project cost is estimated at $103 million for a 50 cfs pipeline and $129 million for a 75 cfs pipeline. Preliminary cost estimates are provided in Appendix B.

5.4 YIELDS

Project yields were calculated for the baseline scenario (no pipeline), and for various ASAPP scenarios with different pipeline capacities, amounts of AWS, and surface water demands (Table 4.1). For the Phase 2 feasibility study, surface water distribution on the Oxnard Plain was modeled as well, and yields were analyzed by comparing recharge and surface water deliveries for each scenario. A summary of State Water Project (SWP) imports, water deliveries to the Oxnard Plain (total deliveries, surface water deliveries and groundwater recharge) for each scenario is provided in Table 4.2.

All ASAPP scenarios assume some level of AWS, therefore total SWP imports are always higher than for the baseline scenario. For each scenario, SWP imports increase slightly with increasing pipeline capacity, as water levels in Lake Piru are general somewhat lower for the latter, allowing for more water imports under certain conditions.

Table 4.2. Summary of ASAPP Phase 2 yield analysis.

Scenario	SWP imports (AF/yr)	Total deliveries (AF/yr)	Surface water (AF/yr)	Recharge (AF/yr)	Surface water increase vs. baseline (AF/yr)	Recharge increase vs. baseline (AF/yr)
Baseline	998	62,663	50,672	11,991	n/a	n/a
S1-20	3,768	61,908	45,192	16,716	4,725	-5,480
S1-50	3,852	65,019	46,821	18,198	6,207	-3,851
S1-75	3,852	66,122	47,749	18,373	6,382	-2,923
S2-20	6,707	61,784	45,311	16,474	4,483	-5,361
S2-50	6,821	65,501	47,233	18,268	6,277	-3,439
S2-75	6,821	66,880	48,532	18,348	6,357	-2,140
S3-20	6,737	61,784	45,311	16,474	8,839	-8,281
S3-50	6,860	65,501	47,233	18,268	11,716	-6,855
S3-75	6,894	66,880	48,532	18,348	11,525	-5,871
S4-20	6,793	63,221	42,391	20,830	12,061	-10,518
S4-50	6,910	67,524	43,817	23,707	15,251	-9,416
S4-75	7,039	68,317	44,801	23,516	15,464	-8,545

The differences in AWS, net yield, surface water deliveries and groundwater recharge, as compared to baseline operations, are shown in Figure 4.5 for each scenario and the various pipeline capacities. Net yield is calculated as the sum of the changes in surface water deliveries and groundwater recharge, and indicates the net volume of additional water that would be delivered to the Oxnard Plain compared to the baseline scenario.

The following observations can be made:

<u>ASAPP effectively increases surface water deliveries</u>

Increases in surface water deliveries compared to baseline are as great as 6,400 AF/yr for S1 and S2, 11,700 AF/yr for S3, and 15,500 AF/yr for S4. Surface water deliveries significantly exceed AWS imports, which are approximately 2,830 AF for S1, and 5,800 to 5,900 AF for S2, S3 and S4. This is because ASAPP delivers surface water to the Oxnard Plain when there is demand, and stores available water in Lake Piru when demand is lower than supply (as opposed to releasing lake water for groundwater recharge under the baseline scenario). Consequentially, recharge to the Oxnard Forebay decreases for all ASAPP scenarios compared to the baseline scenario.

<u>Increasing pipeline capacity increases surface water deliveries and net yield</u>

For a 20 cfs pipeline, net yield is significantly lower than AWS imports, which is caused by increased spill frequencies due to higher lake levels compared to baseline. Surface water deliveries increase significantly by increasing pipeline capacity to 50 cfs from 20 cfs, but little additional increase is achieved by increasing pipeline capacity to 75 cfs. With a 50 cfs or 75 cfs pipeline, spill losses are reduced, as reflected by lower reductions in recharge and increases in net yields. While a 75 cfs pipeline provides the greatest water resources benefits, a 50 cfs pipeline may provide a better balance between cost and benefits, given it is approximately 20% ($ 26 million) less costly and provides almost the same benefit to surface water deliveries.

<u>Efficient delivery of large volumes of AWS requires expansion of surface water delivery infrastructure on Oxnard Plain</u>

Scenario S2 imports more than twice the volume of AWS compared to S1 (5,800 AF/yr vs. 2,800 AF/yr), however, water resources benefits are about equal for both scenarios (increases in surface water deliveries of up to ~6,000 AF/yr and increase in net yield of up to ~4,000 AF/yr). This occurs because the surface water demand on the Oxnard Plain is not sufficient to draw down Lake Piru before additional rainfall causes spills, and loss of the additional imported water under S2.

Therefore, S3 and S4 were evaluated, with both scenarios expanding the area of surface water deliveries on the Oxnard Plain, thus increasing the demand for surface water. These increased demands significantly increased ASAPP yields, with surface water deliveries increasing up to approximately 12,000 AF/yr for S3 and 15,000 AF/yr for S4. Net yield increases up to 6,000 AF/yr for S3 and 7,000 AF/yr for S4. Expanding the surface water delivery system would require additional capital improvements, the cost of which have not yet been estimated.

ASAPP deliveries are significantly higher during drought periods compared to wet periods

Average annual increases in surface water deliveries and net yield as compared to baseline operations are compared by water year type (dry, normal, wet) in Figure 4.6. For S1, surface water deliveries and net yield to the Oxnard Plain are significantly higher during dry years than during normal and wet years. For S3 and S4, the differences in surface water deliveries during dry vs. normal and wet years are increasingly smaller, however net yield remains significantly lower during medium and wet years. S3 and S4 assume increased imports of AWS, and therefore there is more water available for surface water deliveries during dry and normal years, after the dry-year demands have been met.

5.5 BENEFITS TO OXNARD PLAIN GROUNDWATER BASIN

The VRGWFM was used to analyze benefits to groundwater for scenarios S1 (50 cfs), S3 (75 cfs) and S4 (75 cfs), compared to the baseline scenario. S2 was not analyzed because it was not effective in delivering AWS to the Oxnard Plain. Groundwater benefits were analyzed by quantifying modeled changes in groundwater levels at selected locations in the UAS and LAS, and changes in onshore fluxes of groundwater in the coastal zone, which indicate the extent of seawater intrusion. In order to facilitate interpretation of groundwater benefits, a summary of rainfall trends during the model period and modeled water deliveries to the Oxnard Plain is presented first.

5.5.1 RAINFALL AND WATER DELIVERIES

Hydrology and groundwater models use the historic hydrology from 1944 to 2014 for forward modeling from 2020 to 2090. Based on historic rainfall at the Santa Paula station (#245), and the 5-year average rainfall in particular, extended drier and wetter-periods can be identified (Figure 4.7). The forward model period for years 2025 to 2045 consists of an extended dry period, with 5-year average rainfall below the long-term average of 17 inches. For the forward model period 2046 to 2086, the 5-year average rainfall generally exceeds 17 inches, except for a drier period between 2064 and 2069. At the end of the forward modeling period (2086 to 2090), the 5-yr average rainfall again falls below the long-term average.

The quantities of imported water delivered to the Oxnard Plain (recharge and surface water deliveries) are compared for each scenario in Figure 4.8, using the modeled difference in cumulative net yield compared to baseline. During years when a scenario delivers more water to the Oxnard Plain than the baseline scenario, the cumulative net yield increases. If the water deliveries are the same or lower than for the baseline scenario, the cumulative net yield curve will be flat or declining. Deliveries for S1 are significantly higher than baseline between 2026 and 2046, and again between 2065 and 2068, but are not much different than the baseline, or in some cases are less, during other years. For S1, periods of additional water deliveries compared to the baseline coincide with drought periods. In contrast, for S3 and S4 water deliveries are significantly higher compared to the baseline for most model years, except for the wettest model periods (e.g. 2054 - 2057, 2068 - 2072).

5.5.2 GROUNDWATER ELEVATIONS

Groundwater elevations were obtained from the VRGWFM for 8 locations (Table 4.3, Figure 4.9). A summary of the average difference in groundwater levels compared to the baseline scenario is provided in Figure 4.10. ASAPP has little impact on groundwater levels for locations in the UAS, with less than 5 ft of difference in average groundwater levels between pipeline scenarios and the baseline in most cases. For the Point Mugu location (well 01N21W29B03S), S3 and S4 increase average groundwater levels in the UAS by 8 to 10 ft. ASAPP increases groundwater levels more significantly in the LAS, and especially near Point Mugu and in the PTP service area. At the latter two locations, average increases of 14 to 18 ft (S1), 29 to 35 ft (S3), and 28 to 39 ft (S4) are predicted. Greater impacts to LAS water levels are realized in the scenarios that deliver more water to the irrigation pipelines, as these wells rely on LAS pumping to meet demand when surface water is unavailable.

Table 4.3. Locations for hydrograph analysis: State Well Numbers, well screen depth (Upper or Lower Aquifer System) and location description.

State Well No.	Well screen depth	Location description
02N22W12R01S	UAS	Forebay
02N22W22R01S	UAS	Forebay
02N23W25G02S	UAS	Northwest Oxnard Plain
01N22W20J07S	UAS	Port Hueneme
01N21W29B03S	UAS	Point Mugu
01N22W20J04S	LAS	Port Hueneme
01N21W28D01S	LAS	Point Mugu
01N21W07J02S	LAS	PTP service area

Hydrographs show significant fluctuations in modeled groundwater levels at each location, regardless of scenario (Figure 4.11). ASAPP increases groundwater levels most significantly in the LAS and also the UAS near Point Mugu, as evidenced by diverging hydrographs in Figure 4.11 E to H. Time series showing the difference in modeled groundwater levels between each of the pipeline scenarios and the baseline scenario are plotted in Figure 4.12.

For most UAS locations, pipeline scenarios are predicted to have modest effects on groundwater elevations, and differences in groundwater levels between baseline and ASAPP scenarios are mostly less than 10 ft in any given month (Figure 4.12 A to E). The greatest groundwater level increases in the UAS were predicted for the location near Point Mugu, with increases often times in the 10 to 15 ft range (Figure 4.12 E). Groundwater level increases compared to baseline are more pronounced during the drier period between 2025 and 2050 (Figure 4.12 A-D). Decreases in groundwater levels can also be observed in some cases in the wetter periods after 2050, most notably in the Forebay (Figure 4.12 A-B), but also to a lesser degree at UAS locations in the Northwest Oxnard Plain and near Port Hueneme (Figure 4.12 C-D).

In general, pipeline scenarios are predicted to increase groundwater elevations more significantly in the LAS. Differences in groundwater levels between baseline and ASAPP scenarios frequently exceed 20 ft (for S2) and 30 ft (for S3) at the Point Mugu and PTP service area locations (Figure 4.12 G-H). For S1, increases in groundwater levels occur mostly between 2025 – 2055, and 2064 - 2069, consistent with the increased amounts of water deliveries during these periods. For S3 and S4, increases in groundwater levels are more consistent throughout the modeling period, due to the increased deliveries of water for these scenarios, except for the driest periods.

5.5.3 SEAWATER INTRUSION

Net onshore fluxes of groundwater were calculated separately for the "north coast" and "south coast" of the Oxnard Plain coastal zone (Figure 4.9). The north coast area extends from the Santa Clara River estuary to Channel Islands Harbor, and the south coast area from Channel Islands Harbor to Point Mugu. Onshore fluxes in the north coast are considered to be less problematic for seawater intrusion as these consist mostly of freshwater, in contrast with onshore fluxes in the south coast area where seawater intrusion is well documented (United Water Conservation District, 2016b). On average, ASAPP reduces onshore fluxes compared to the baseline, especially in the south coast area where ASAPP surface water deliveries occur (Table 4.4 and Figure 4.13). Reductions in onshore coastal fluxes in the south area increase progressively from S1 (28% UAS, 11% LAS) to S3 (75% UAS, 26% LAS) to S4 (85% UAS, 46% LAS).

Time series of monthly groundwater fluxes are plotted in Figure 4.14. ASAPP causes little reduction in onshore fluxes in the north coast UAS (Figure 4.14 A), but more significant reductions in onshore fluxes in the north area LAS, especially for S3 and S4 (Figure 4.14 B). Significantly greater reductions in onshore fluxes are predicted for the south coast area, for both the UAS and LAS (Figure 4.14 C, D). For S1, onshore fluxes are reduced during the drier periods only (e.g., 2025 to 2045, 2053 to 2055), when ASAPP deliveries are high. Scenarios S3 and S4 more consistently reduce seawater intrusion throughout the modeling period, except during the driest periods (e.g., 2053/54, 2067/68). UAS fluxes characterize flow in the Oxnard and Mugu aquifers and do not include discharge that commonly occurs in the (unconfined and shallow) semi-perched aquifer.

Table 4.4. Average net groundwater fluxes in the coastal zone (AF/month). Positive fluxes are towards the Oxnard Plain.

Average Net Groundwater Fluxes (AF/month)									
	UAS			LAS			UAS+LAS		
	North	South	All	North	South	All	North	South	All
Baseline	23	192	216	137	249	386	161	441	602
S1	18	138	156	120	221	341	138	359	498
S3	-26	48	21	92	185	277	66	233	299
S4	3	29	32	96	135	231	99	164	264

5.5.4 IMPLICATIONS FOR SUSTAINABLE YIELD

The Oxnard Plain basin is classified as a critically overdrafted basin, and a groundwater sustainability plan (GSP) needs to be submitted to the Department of Water Resources by January 31, 2020. The Fox Canyon Groundwater Management Agency (FCGMA) acts as the Groundwater Sustainability Agency (GSA) for this basin, and is currently leading the process of quantifying sustainable yield on the Oxnard Plain for inclusion in the GSP. FCGMA is not considering ASAPP for the first GSP submittal, in part due to the uncertainties with regard to the amounts of alternative water supplies that might be purchased by United. Nonetheless, the diversion yields and groundwater benefits presented in this report indicate that ASAPP could help increase the water supply in the area, while also increasing sustainable yield (by shifting pumping away from the coastal area [UWCD, 2017]).

For example, S1 assumes new water imports of 2,854 AF/yr, but increases in surface water deliveries in the PTP/PV service area by 6,207 AF/yr. These new sources of surface water will directly offset LAS pumping that would otherwise occur in the PTP and PV systems. Under scenarios S3 and S4, pumping reductions are predicted to be much greater (11,716 AF/yr and 15,251 AF/yr, respectively). Since increased surface water deliveries under the ASAPP scenarios are accompanied by a reduction in groundwater recharge in the Oxnard Forebay, a more detailed determination effects of ASAPP on sustainable yield, along with other projects and potential pumping reductions, will need to be modeled using the VRGWFM.

6 CONCLUSIONS

This reports presents an analysis of yields and groundwater benefits for the Alternative Supply Assurance Pipeline Project (ASAPP). Various alternatives for delivery of water stored in Lake Piru (natural runoff and alternative water supplies) to the Oxnard Plain were analyzed. A pipeline from Santa Felicia Dam to the Freeman Diversion headworks was selected as the preferred conceptual alternative, with a 50 cfs capacity pipeline providing a good balance between cost and benefit. ASAPP operations are intended to prioritize deliveries to the PTP and PV surface water delivery systems over recharge in the Oxnard Forebay.

With ASAPP, modeled surface water deliveries increase by 6,207 AF/yr to 15,251 AF/yr, depending on the assumptions for alternative water supplies and infrastructure improvements on the Oxnard Plain. The latter infrastructure improvements were designed to meet all pumping demands in the PTP and PV service areas (Scenario 3), or all pumping demands in the PTP/PV service area and the coastal zone (Scenario 4). Those surface water deliveries would largely offset LAS pumping in the areas where the surface water is delivered. For the scenario with higher amounts of AWS imports (6,207 AF/yr), expansion of surface water delivery infrastructure would be required for effective delivery of AWS as surface water to the Oxnard Plain.

United's regional groundwater flow model predicts significant increases in groundwater elevations and reductions in lateral seawater intrusion compared to baseline for all ASAPP scenarios. ASAPP increases groundwater levels more significantly in the LAS, and especially near Point Mugu and within the PTP service area. At the latter two locations, average increases between 14 to 18 ft (S1) and 28 to 39 ft (S4) are predicted. Modeled onshore fluxes were reduced with ASAPP compared to the baseline, especially in the south coast area where ASAPP surface water deliveries occur and pumping reductions are the greatest. Reductions in onshore coastal fluxes in the south area increase progressively from S1 (28% UAS, 11% LAS) to S3 (75% UAS, 26% LAS) to S4 (85% UAS, 46% LAS). It is expected that ASAPP will therefore provide significant benefits to meeting sustainable yield on the Oxnard Plain.

In order to perform a cost-benefit analysis for scenarios S3 and S4, a cost estimate for the infrastructure expansion is required. However, the ASAPP can be constructed and operated without infrastructure expansion on the Oxnard Plain as a first phase. If future AWS supplies exceed those that can be effectively delivered as surface water (as with S1), excess AWS could be applied to groundwater recharge in the Forebay, which would also improve benefits to the Oxnard Plain compared to predictions for S1 (but not a scenario analyzed in this report). An expansion of the surface water delivery systems could then be considered for a second phase.

This report describes costs and water resources benefits of ASAPP, under the assumption that ASAPP is used almost exclusively by United for supplying surface water to the Oxnard Plain. However, ASAPP presents significant opportunities for partnerships with other public agencies or private parties, e.g. for the purchase and import of State Water and for water trading. To take advantage of partnerships, the conceptual project may require modifications to operations, pipeline size, pipeline alignment, or require additional pipelines and/or turnouts.

Prior to a more complete assessment of the feasibility of ASAPP, the following concerns will need to be addressed:

- Lake Piru is currently infested with invasive quagga mussels. United has been implementing a quagga mussel monitoring and control plan, consisting of monitoring, implementing containment measures, quagga mussel population control and adaptive management. United will need to determine if surface water with some level of quagga contamination will cause problems for growers if delivered to the Oxnard Plain via a pipeline, or if mussel eradication or treatment of delivered water will be required.
- Verify if the proposed operations with ASAPP are allowed under United's water right for surface storage in Lake Piru.
- ASAPP operations for Scenarios 3 and 4 assume that Article 21 water can be imported from Lake Pyramid during the month of March. Currently, the delivery window for releases from Lake Pyramid to Lake Piru is restricted to November 1 – February 28 in order to protect arroyo toad critical habitat during breeding season. United will need to coordinate with DWR and potentially the Federal Energy Regulatory Commission (FERC) to modify some of the restrictions on water releases from Lake Pyramid.

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FIGURES

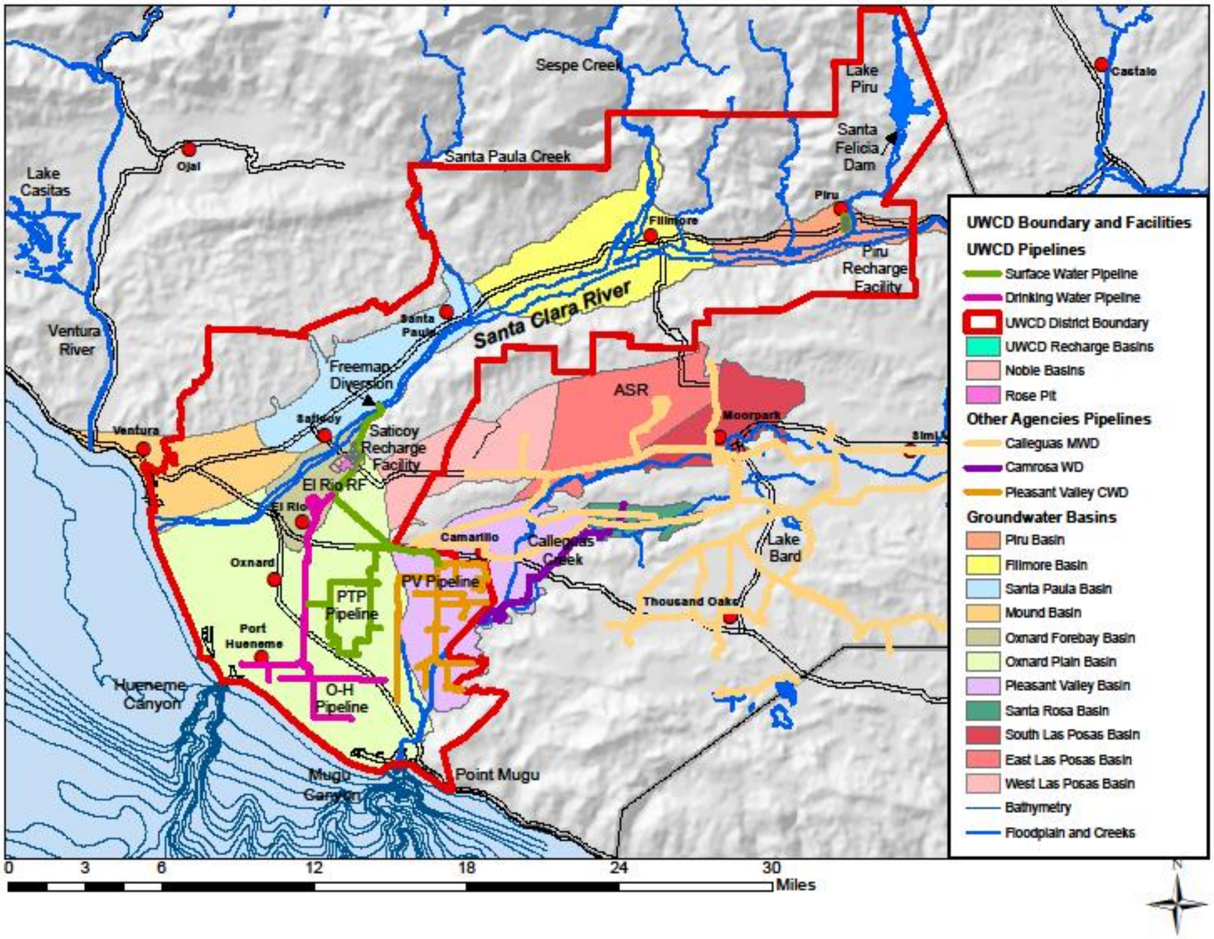

Figure 1.1. United's District boundaries, major recharge and conveyance facilities and groundwater basins.

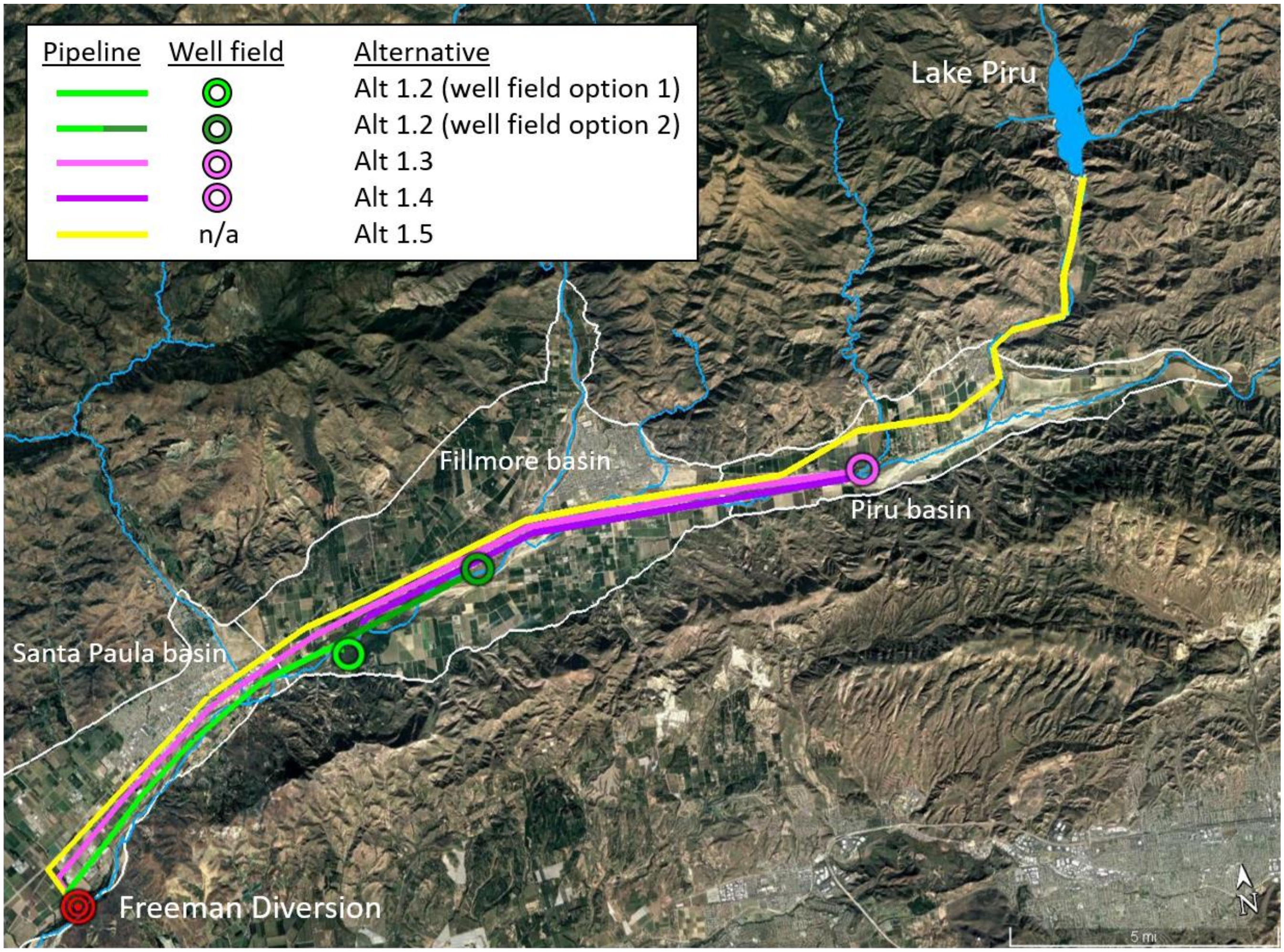

Figure 3.1. Alternatives analyzed in Phase 1 feasibility analysis.

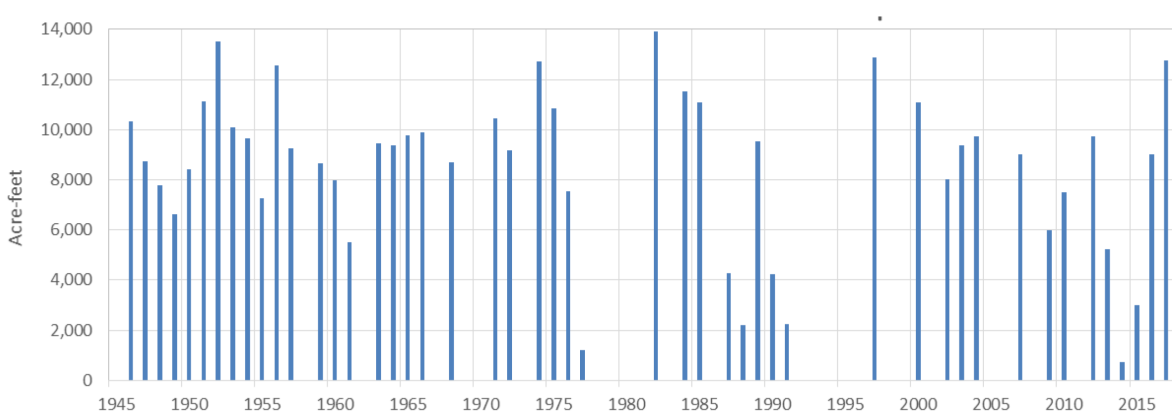

Figure 3.2. Annual alternative water supply (AWS) imports assumed for the Phase 1 feasibility analysis.

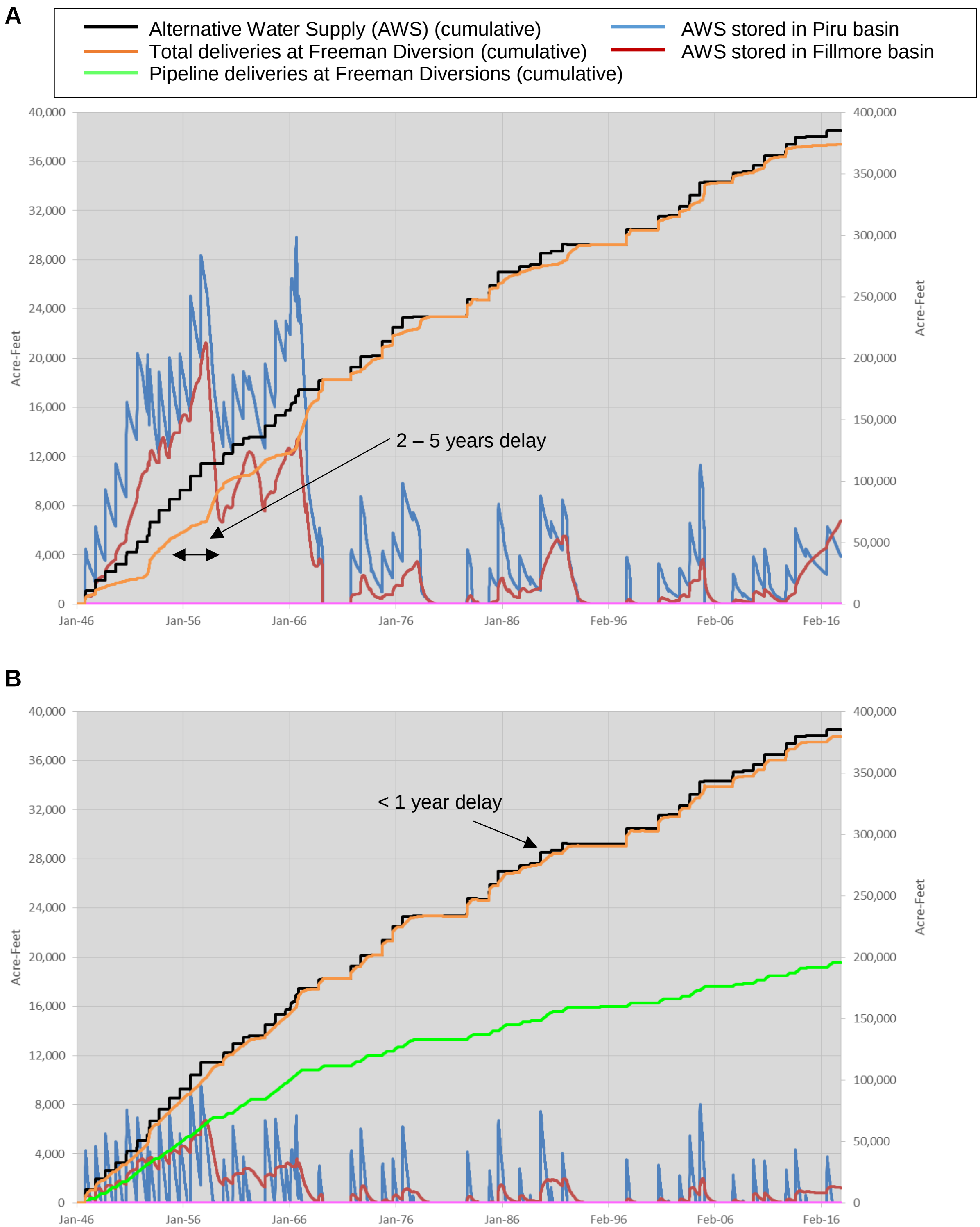

Figure 3.3. Modeled cumulative alternative water supply (AWS) releases and deliveries to Freeman Diversion, and AWS volume stored in Piru and Fillmore basins (1945 – 2017), for ASAPP Alternative 1.1 (plot A) and Alternative 1.4 (plot B).

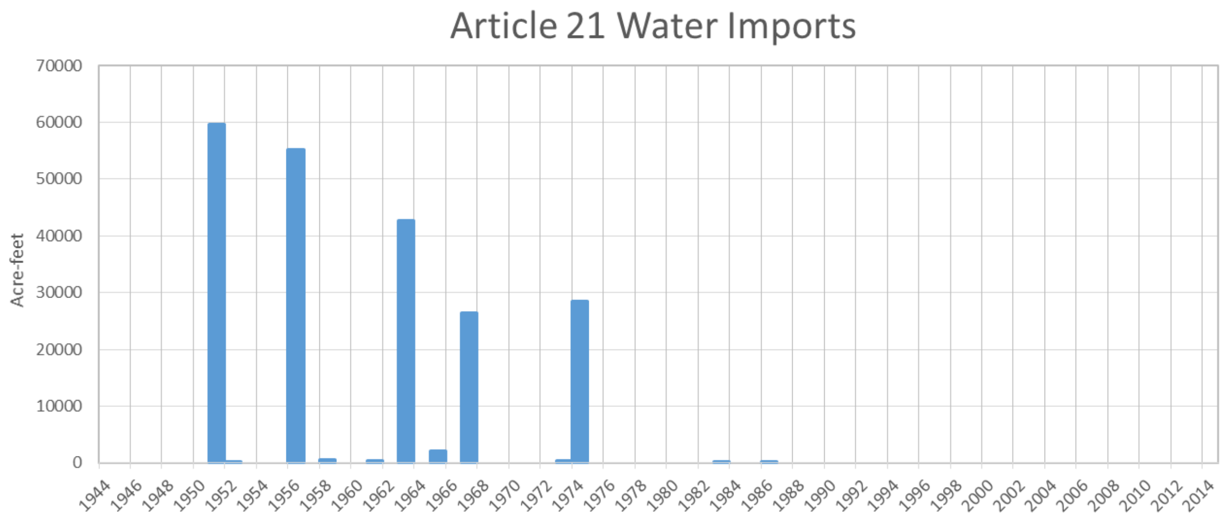

Figure 4.1. Modeled imports of Article 21 water for Phase 2 feasibility analysis.

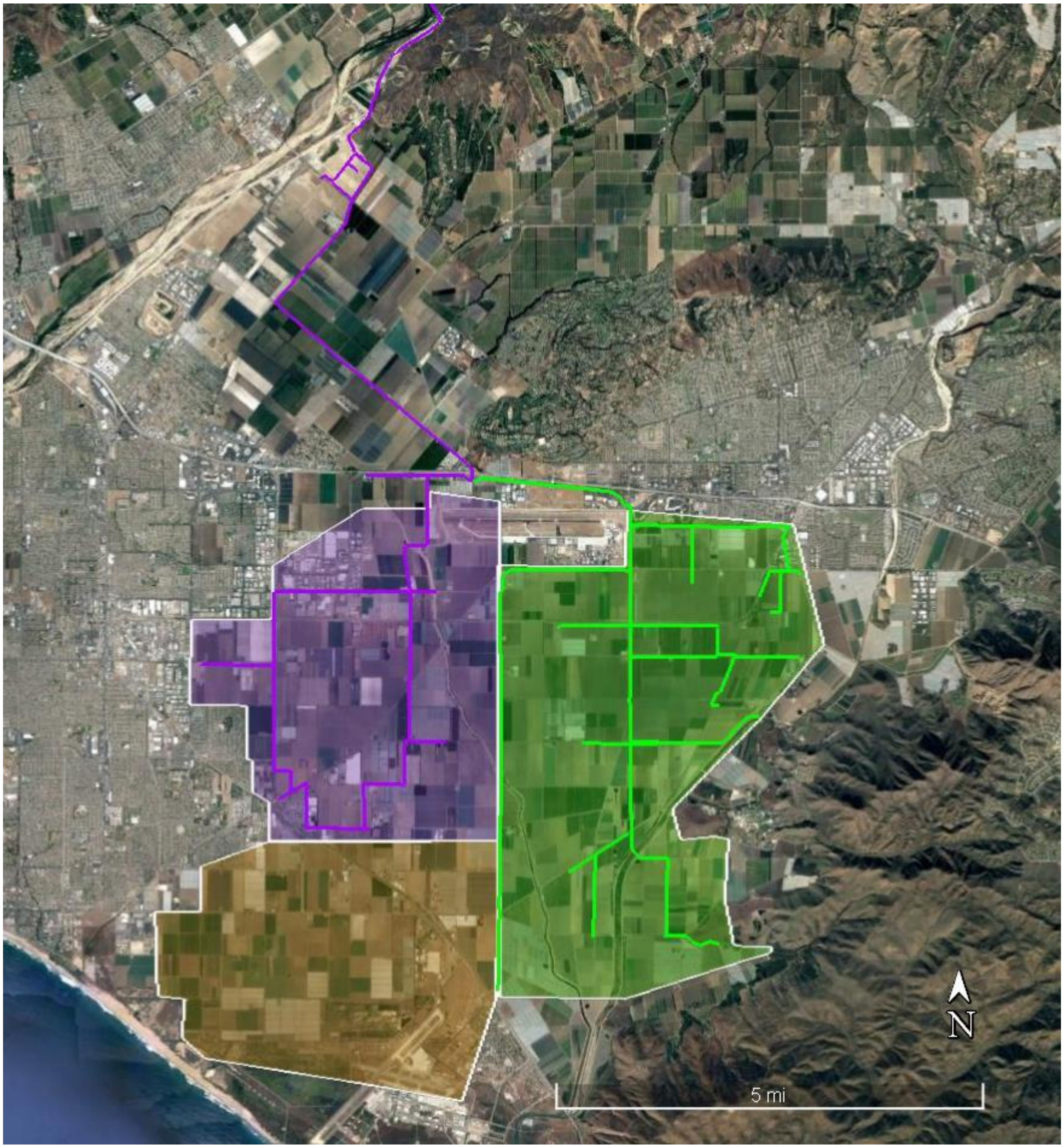

Figure 4.2. Approximate land area targeted for surface water deliveries under the Service Area (purple and green colored areas) and Coastal Zone (orange colored area) demand scenarios. The PTP and PV surface water delivery systems are indicated by solid purple and green lines.

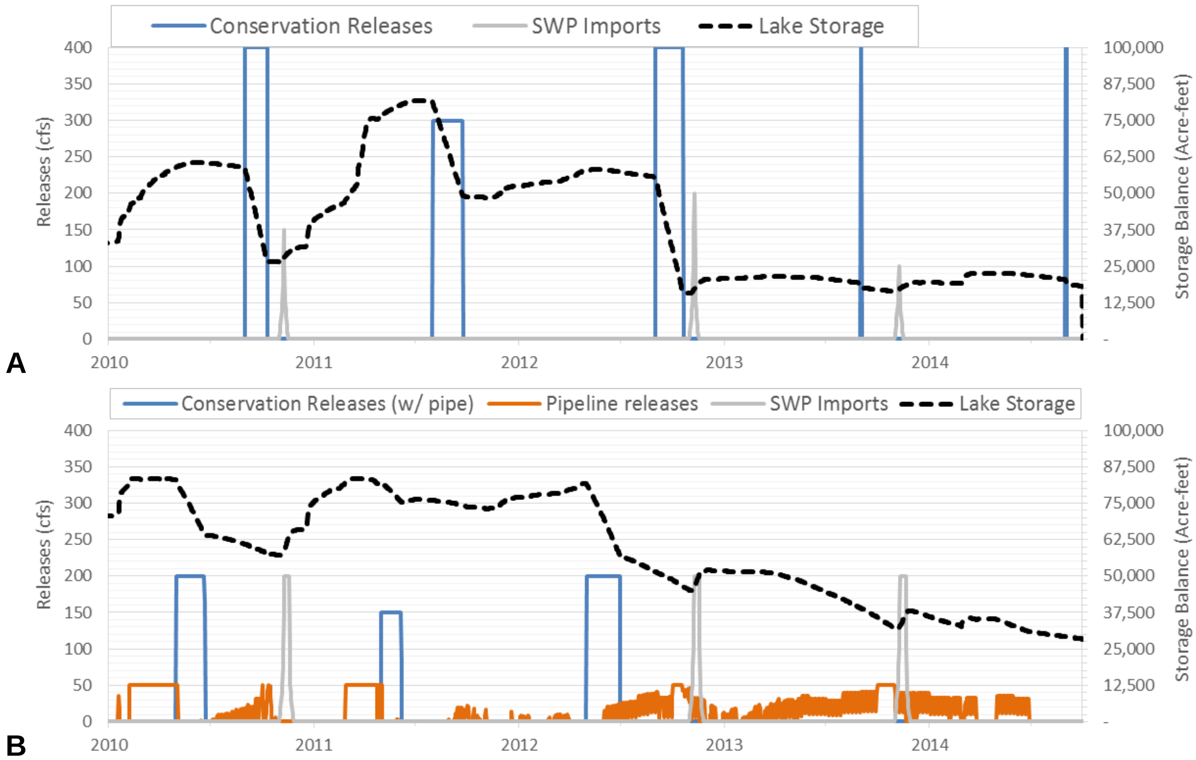

Figure 4.3. Example of SFD operations without (plot A) and with ASAPP (plot B). ASAPP operations depicted here are based on a scenario S2-50.

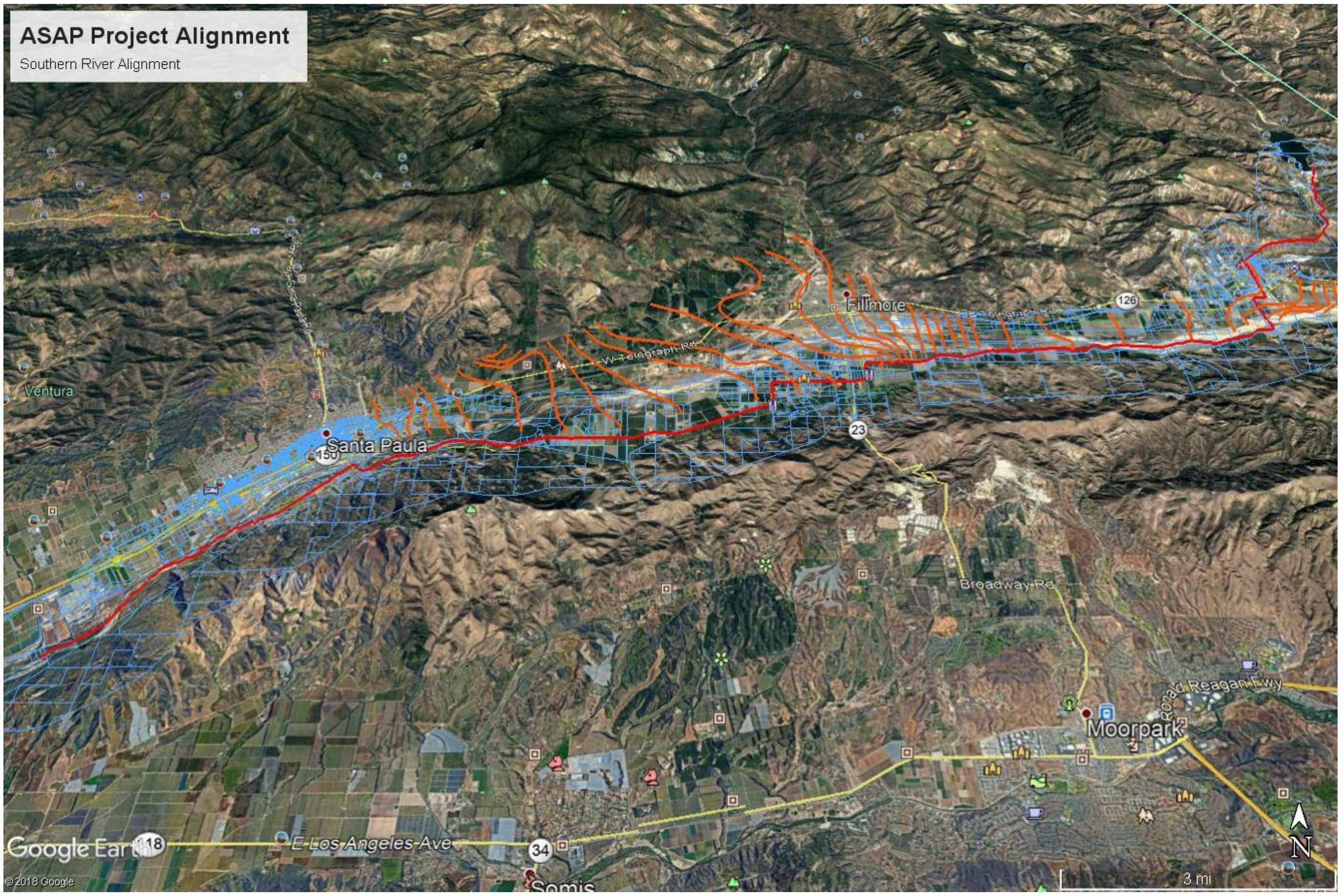

Figure 4.4. Proposed alignment of ASAPP pipeline (red line).

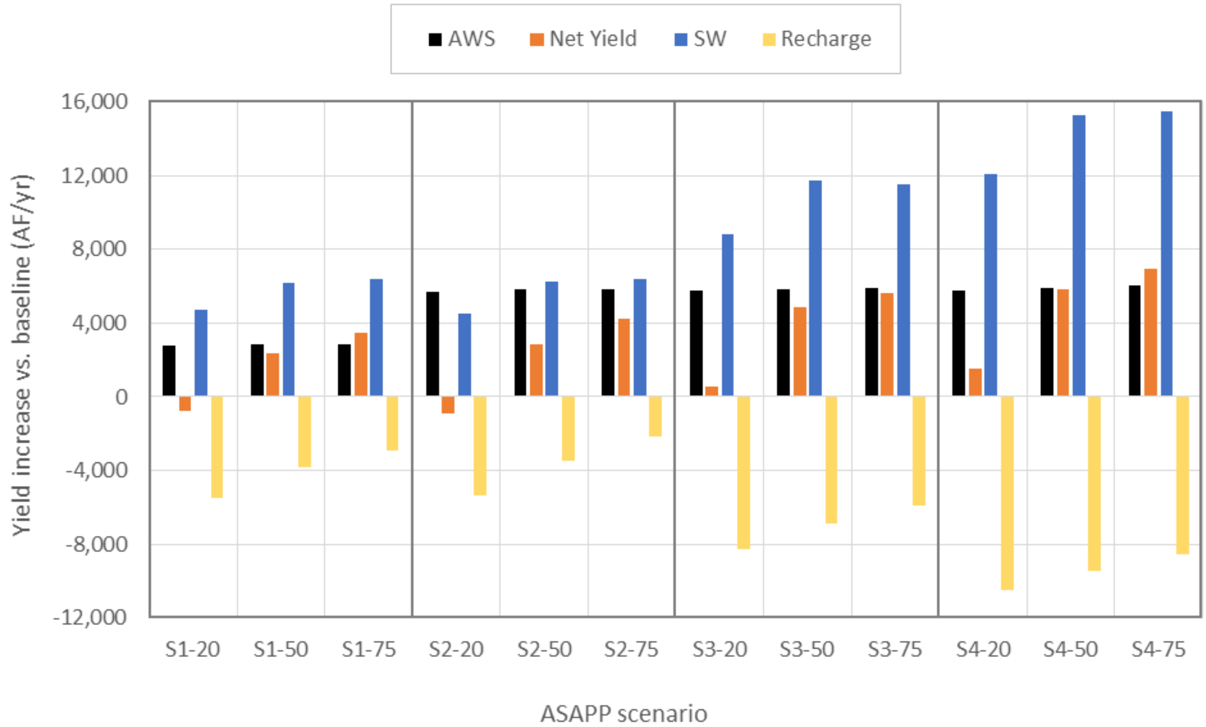

Figure 4.5. Phase 2 ASAPP yield analysis, consisting of alternative water supplies (AWS), net yield, surface water deliveries (SW), and recharge for Scenario 1, 2, 3, and 4 (S1 - S4). Pipeline capacity (cfs) is indicated for each scenario by suffix -20, -50, or -75.

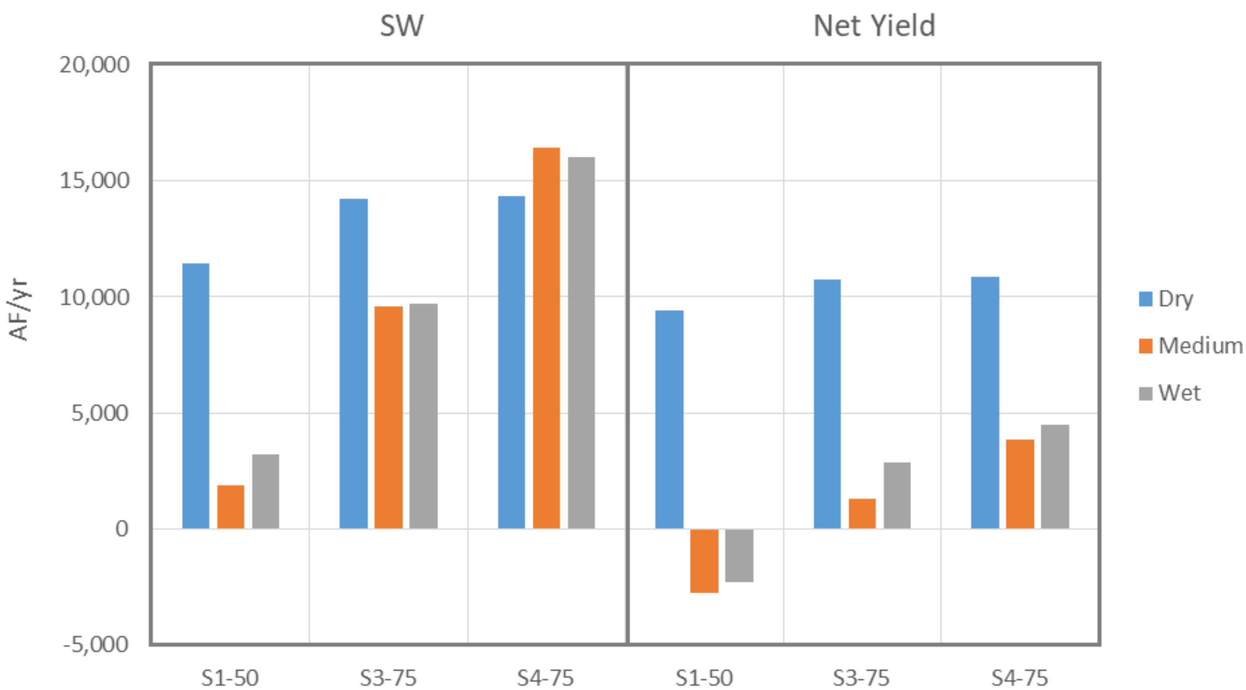

Figure 4.6. Average annual increases in surface water deliveries (SW) and net yield for scenarios S1, S3 and S4, grouped per water year type (dry, normal, wet).

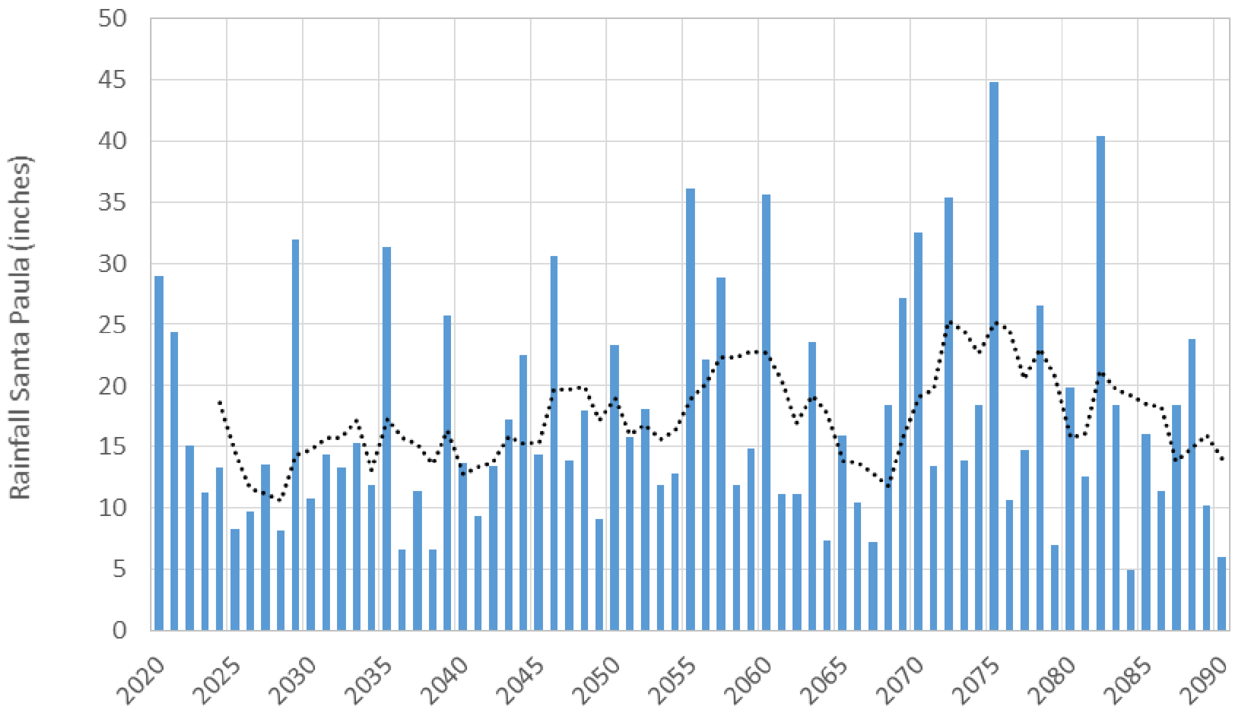

Figure 4.7. Annual rainfall at Santa Paula station (#245) for the ASAPP modeling period. The rolling 5-year average is indicated by the dotted black line.

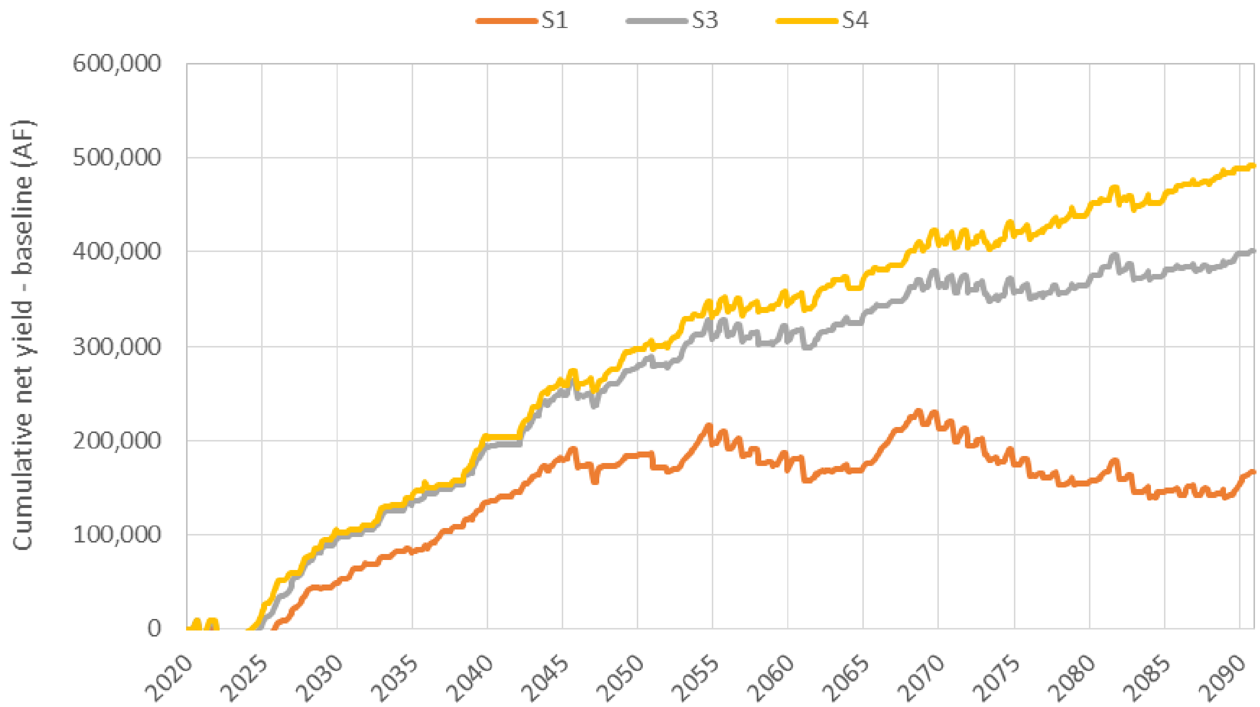

Figure 4.8. Cumulative net yield for ASAPP pipeline scenarios (S1, S2 and S4) compared to the baseline scenario.

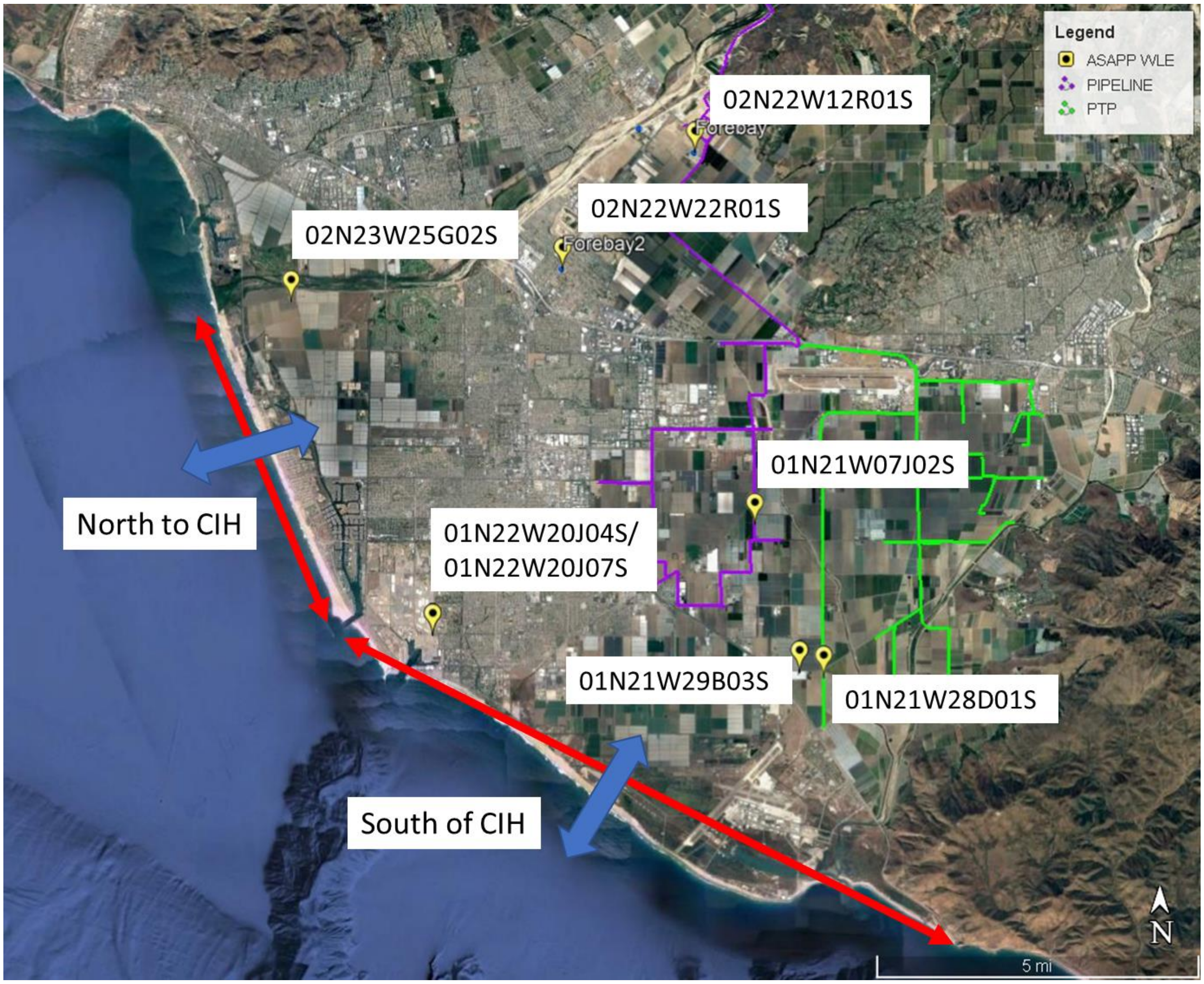

Figure 4.9. Locations for comparing groundwater levels and seawater intrusion for ASAPP scenarios. Well locations are indicated by yellow symbols and State Well Number. Seawater intrusion is calculated separately for the Oxnard Plain coastal zone north and south of the Channel Islands Harbor (CIH) entrance. Approximate extent of each zone is indicated by the red arrows.

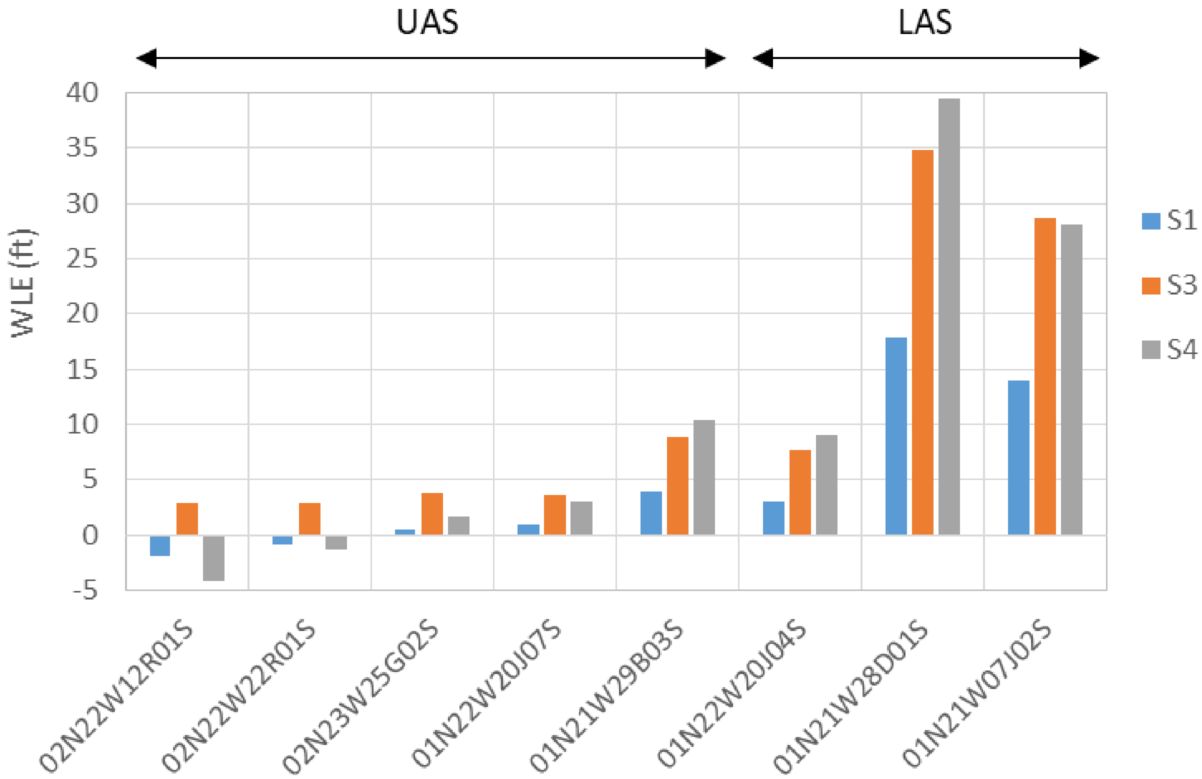

Figure 4.10. Average change in groundwater elevation (WLE) for scenarios 1, 3 and 4 compared to the baseline scenario. WLEs are presented for 8 well locations, and grouped according to the depth of the well screens (UAS or LAS).

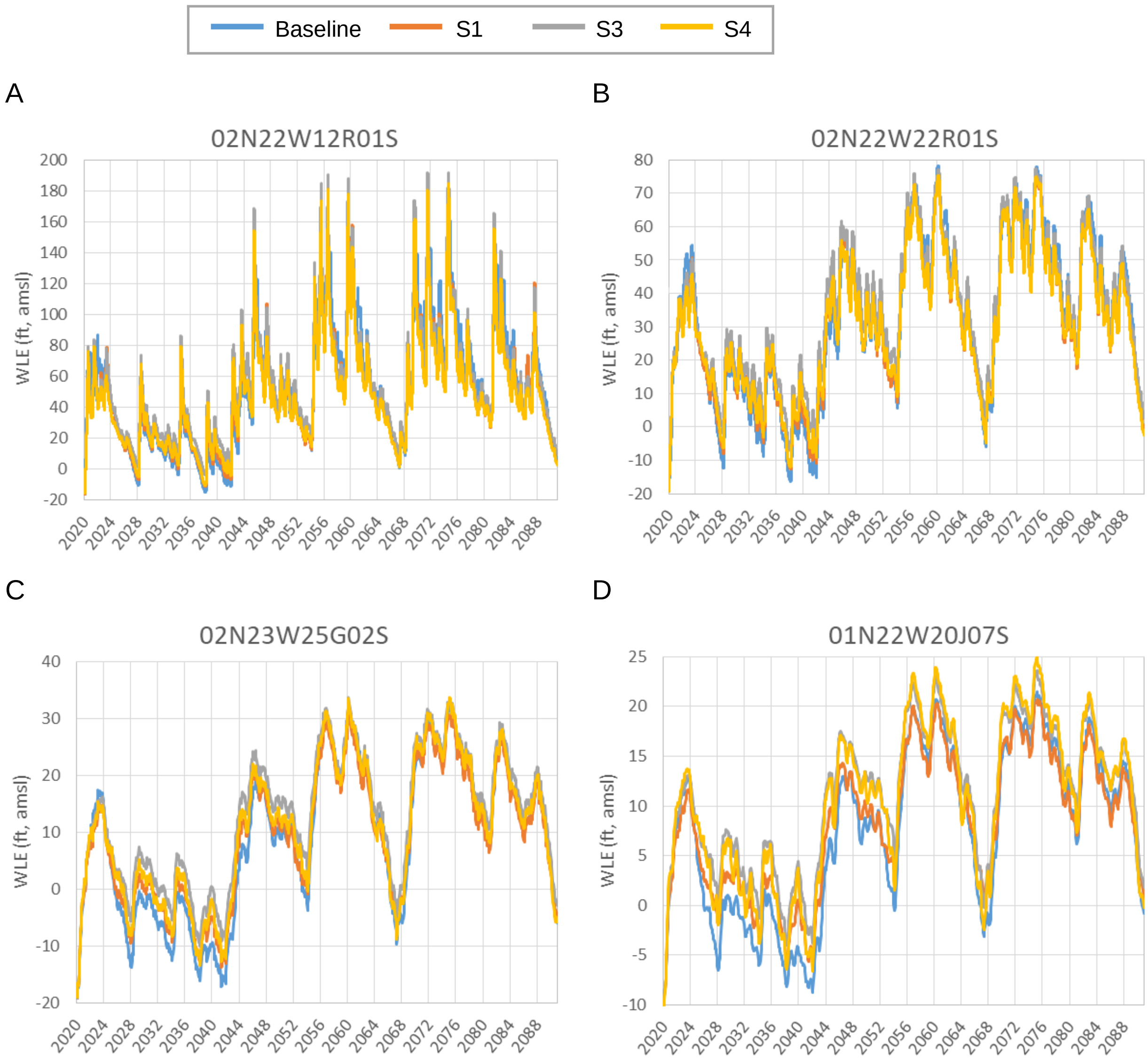

Figure 4.11. Modeled groundwater elevations (WLE) for baseline scenario and scenarios S1, S3, and S4. Panels A to E display WLE in the Upper Aquifer System (UAS) wells; panels F to H display WLE in the Lower Aquifer System (LAS) wells.

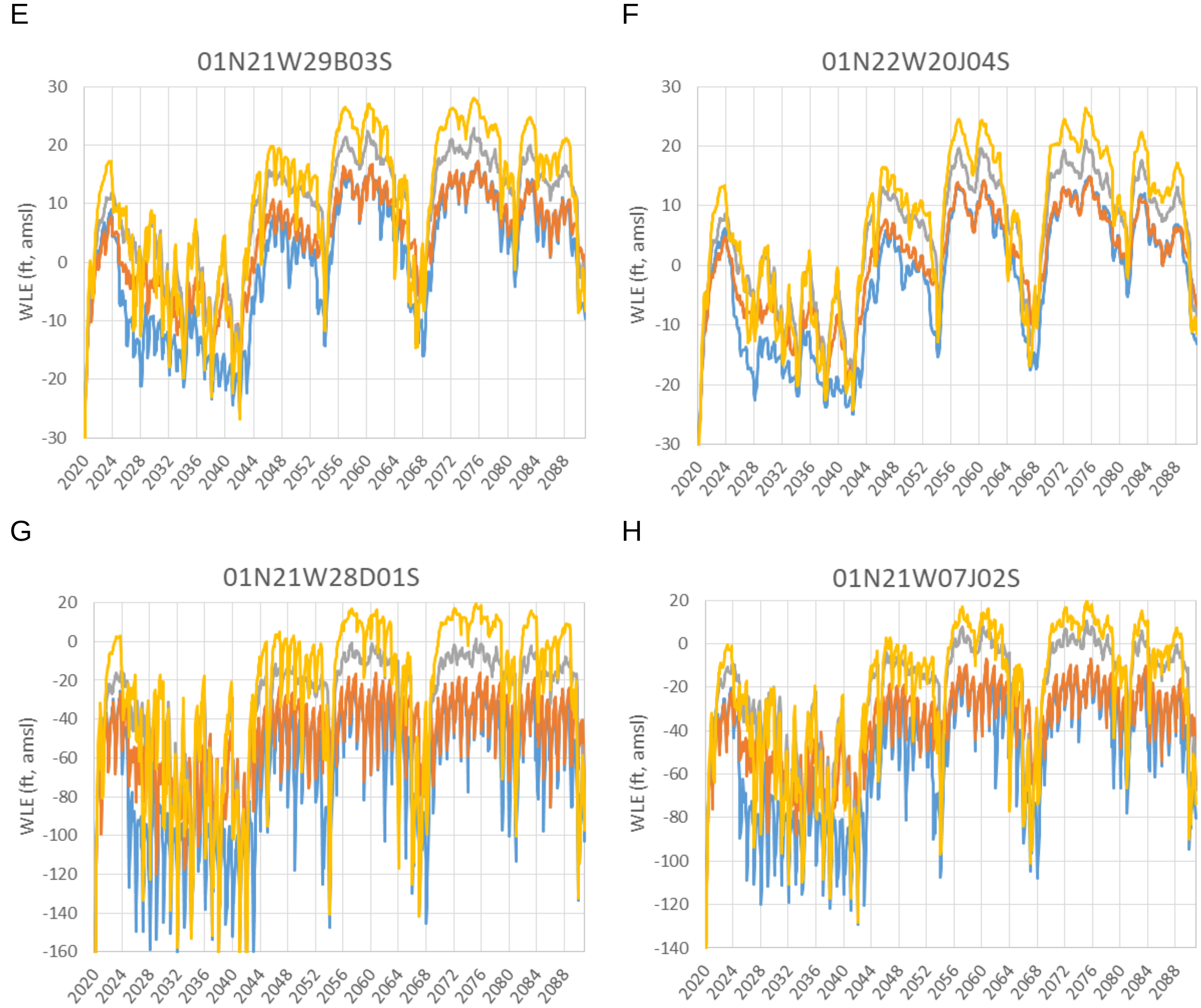

Figure 4.11. (Continued)

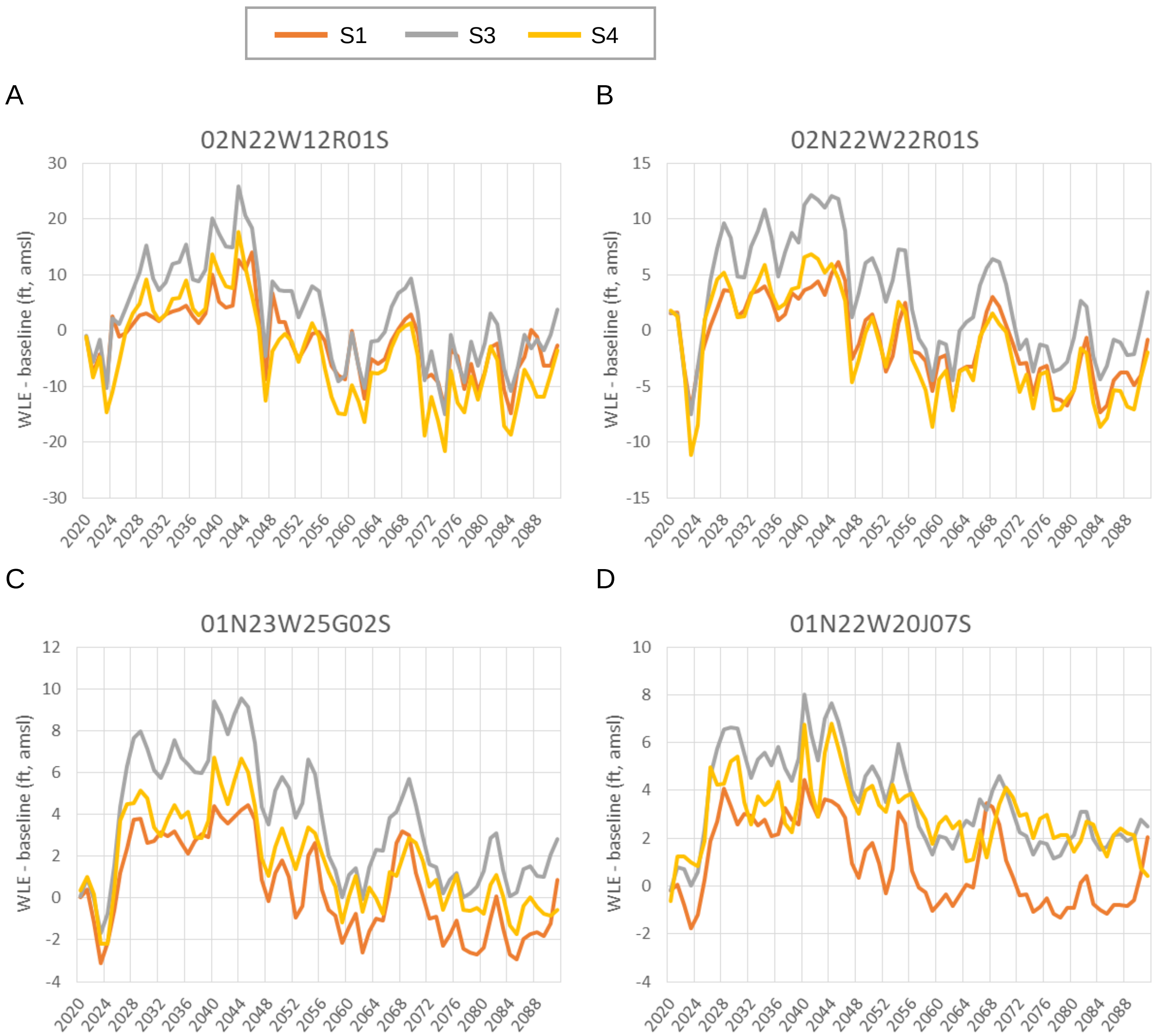

Figure 4.12. Difference in modeled annual average groundwater elevations (WLE) between baseline scenario and scenarios S1, S3, and S4 (WLE scenario minus WLE baseline).

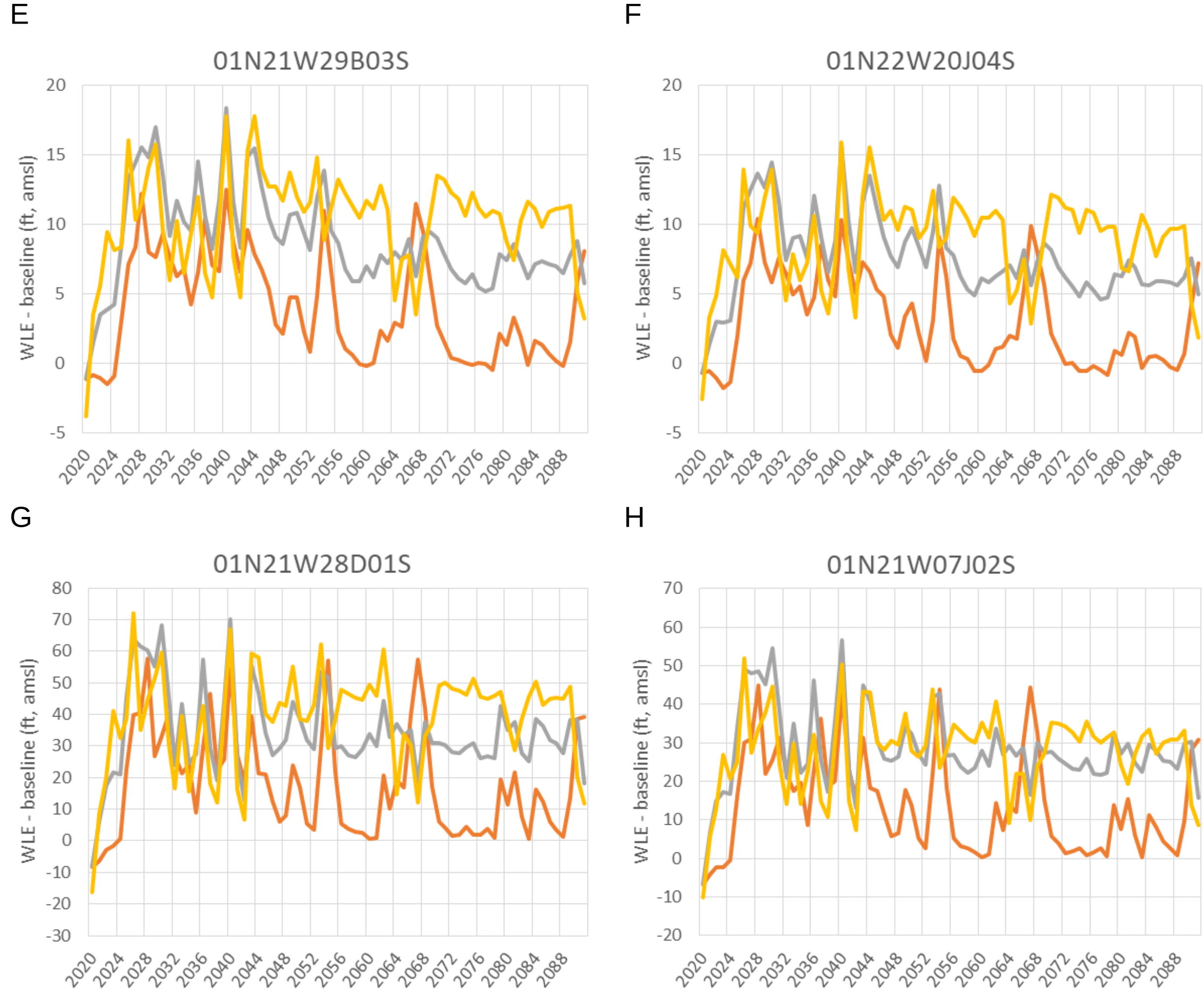

Figure 4.12. (Continued).

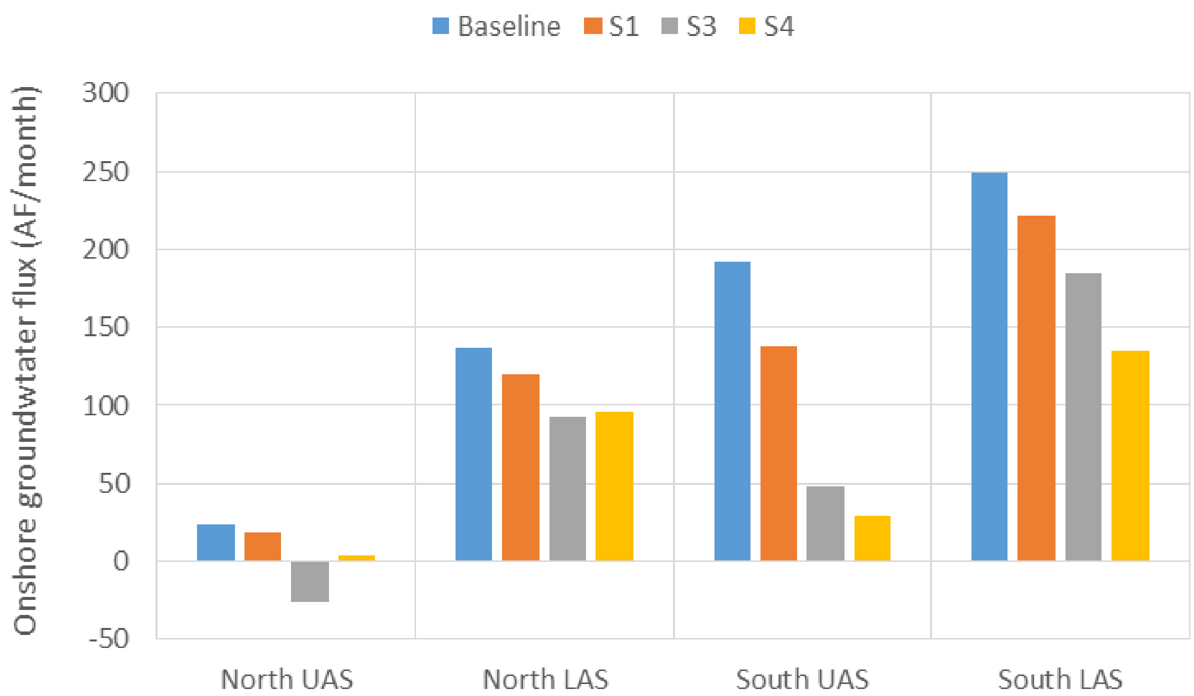

Figure 4.13. Average net groundwater fluxes in the coastal zone (positive fluxes are onshore). The coastal zone is divided into the north coast and south coast at Channel Islands Harbor.

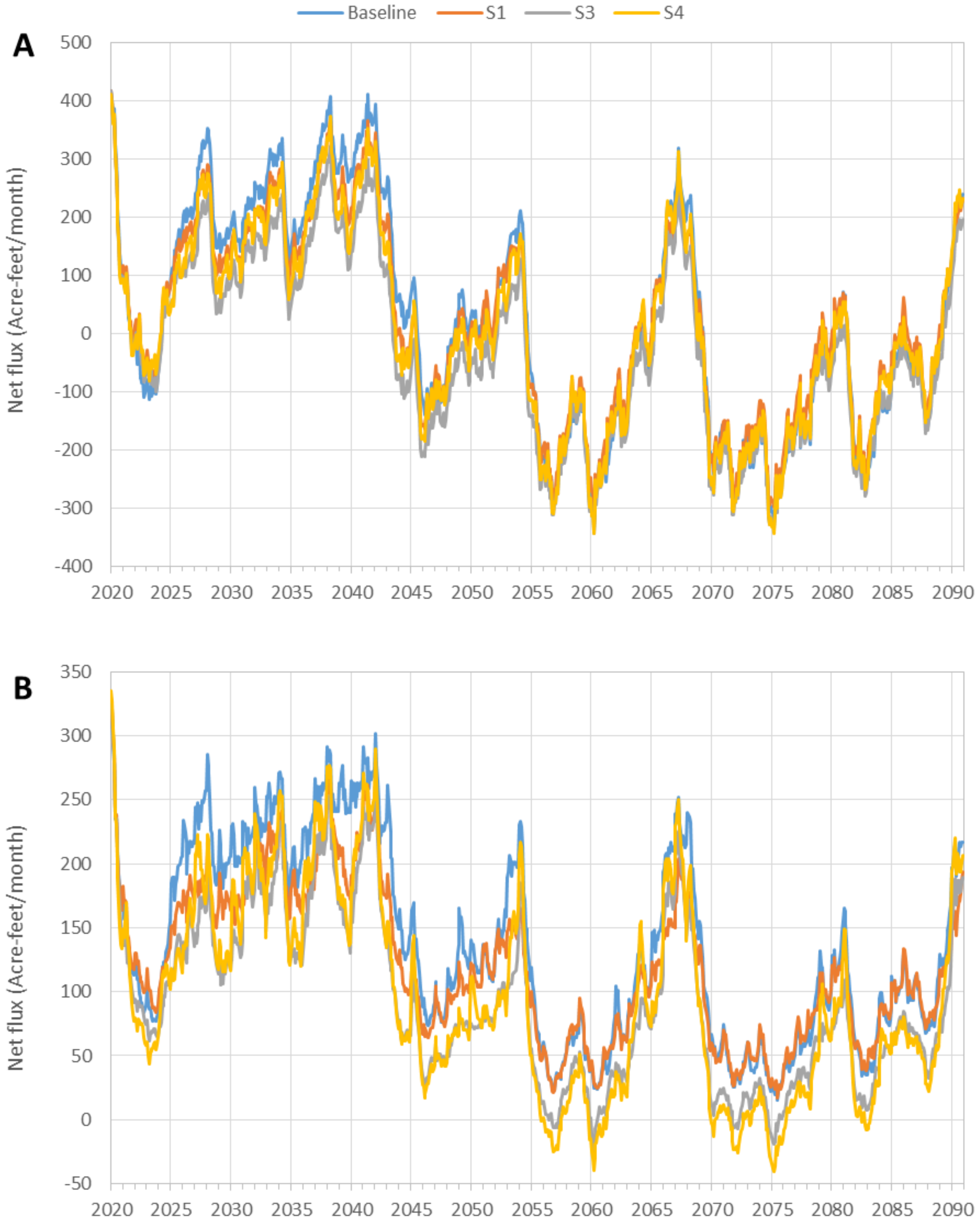

Figure 4.14. Net groundwater fluxes in the coastal zone: north area UAS (plot A), north area LAS (plot B), south area UAS (plot C), south area LAS (plot D).

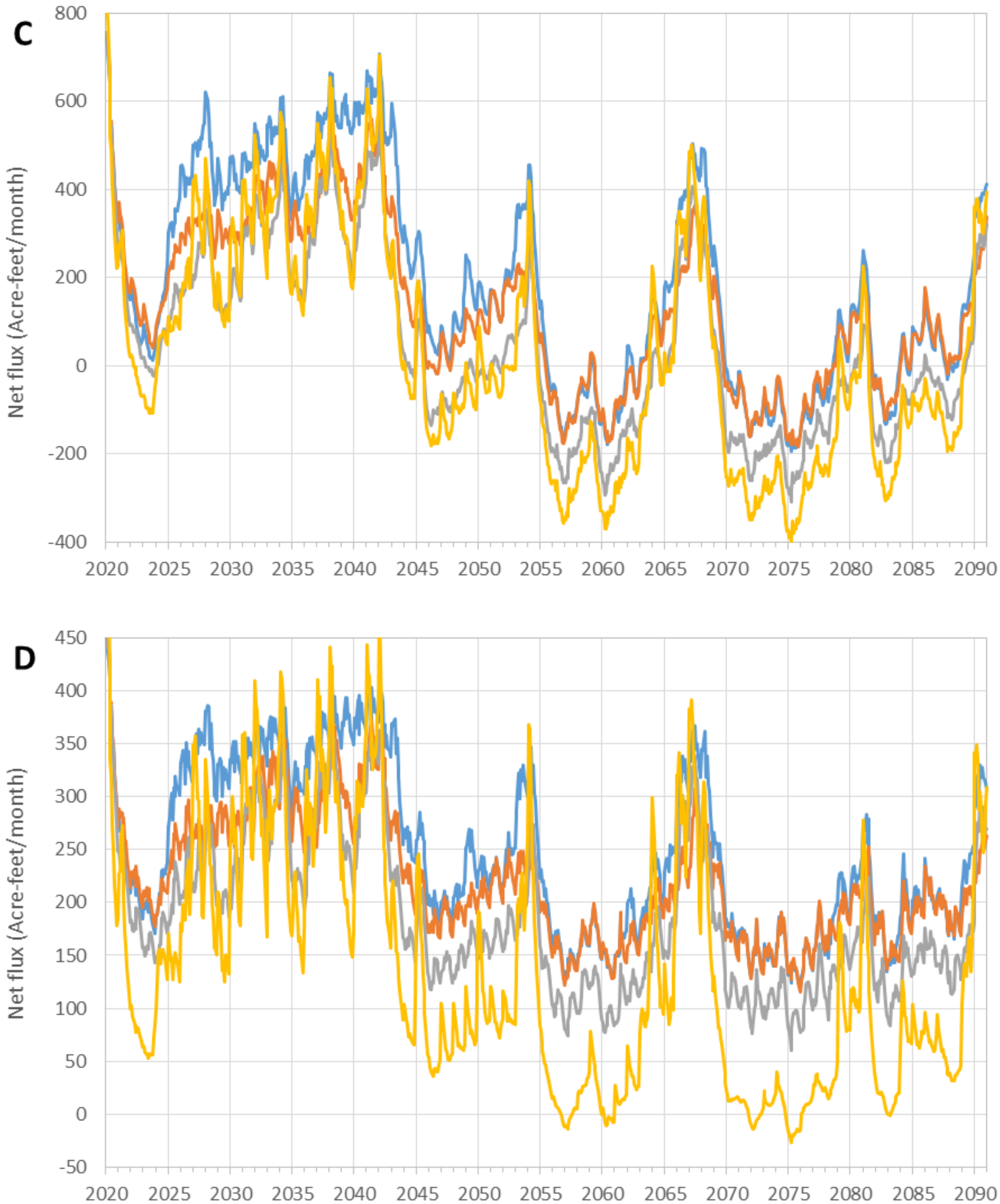

Figure 4.14. (Continued).

APPENDIX A

Table A1. Water year types and modeled United water purchases for the modeling period 1944-2014, for the phase 1 feasibility analysis (baseline scenario and 18,150 AF Table A scenario) and the phase 2 feasibility analysis (baseline scenario, 5000 DN scenario, Article 21 scenario).

		Phase 1		Phase 2		
WY Type	**WY**	**3,150 AF Table A (baseline)**	**18,150 AF Table A**	**3,150 AF Table A (baseline)**	**5000 DN imports (AF)**	**Article 21 imports (AF)**
Wet	1944	0	0	0	0	0
Medium	1945	0	12270	0	5000	0
Medium	1946	2,169	12500	2251	5000	0
Medium	1947	1,835	10570	1855	5000	0
Dry	1948	1,637	9433	1458	5000	0
Dry	1949	1,392	8023	1458	5000	0
Dry	1950	1,768	10186	1855	5000	0
Dry	1951	2,339	13478	2251	5000	59581
Wet	1952	2,835	0	0	0	110
Dry	1953	2,123	12231	1855	5000	0
Dry	1954	2,023	11659	1855	5000	0
Dry	1955	1,529	8808	1458	5000	0
Dry	1956	2,641	15217	2648	5000	55216
Dry	1957	1,945	11209	1855	5000	0
Wet	1958	0	0	0	0	487
Dry	1959	1,818	10474	0	5000	0
Dry	1960	1,674	9645	1458	5000	0
Dry	1961	1,155	6653	1160	5000	370
Wet	1962	0	0	0	0	0
Dry	1963	1,984	11432	1855	5000	42621
Dry	1964	1,965	11324	1855	5000	0
Dry	1965	2,053	11831	1855	5000	2125
Wet	1966	2,076	0	0	0	0
Wet	1967	0	0	0	0	26459
Dry	1968	1,822	10499	0	5000	0
Wet	1969	0	0	0	0	0
Medium	1970	0	14093	0	5000	0
Medium	1971	2,191	12623	2251	5000	0
Dry	1972	1,928	11107	1855	5000	0
Wet	1973	0	0	0	0	475
Medium	1974	2,670	15386	2648	5000	28500
Medium	1975	2,277	13121	2251	5000	0
Dry	1976	1,583	9121	1458	5000	0
Dry	1977	256	1474	0	5000	0
Wet	1978	0	0	0	0	0
Wet	1979	0	0	0	0	0
Wet	1980	0	0	0	0	0
Medium	1981	0	10521	1855	5000	0

Medium	1982	2,924	16850	2648	5000	0
Wet	1983	0	0	0	0	111
Medium	1984	2,418	13934	0	5000	0
Dry	1985	2,331	13432	2251	5000	0
Wet	1986	0	0	0	0	29
Dry	1987	894	5149	962	5000	0
Medium	1988	466	2687	536	5000	0
Dry	1989	2,002	11538	1855	5000	0
Dry	1990	889	5122	962	5000	0
Medium	1991	468	2697	536	5000	0
Wet	1992	0	0	0	0	0
Wet	1993	0	0	0	0	0
Medium	1994	0	8347	0	5000	0
Wet	1995	0	0	0	0	0
Medium	1996	0	13219	2251	5000	0
Medium	1997	2,706	15590	2648	5000	0
Wet	1998	0	0	0	0	0
Medium	1999	0	14159	0	5000	0
Medium	2000	2,329	13420	2251	5000	0
Wet	2001	0	0	0	0	0
Dry	2002	1,686	9714	1458	5000	0
Medium	2003	1,971	11357	1855	5000	0
Dry	2004	2,048	11798	1855	5000	0
Wet	2005	0	0	0	0	0
Wet	2006	0	0	0	0	0
Dry	2007	1,890	10890	1855	5000	0
Wet	2008	0	0	0	0	0
Medium	2009	1,260	7260	1160	5000	0
Medium	2010	1,575	9075	1458	5000	0
Wet	2011	0	0	0	0	0
Dry	2012	2,048	11798	1855	5000	0
Dry	2013	1,103	6353	1160	5000	0
Dry	2014	158	908	0	5000	0

APPENDIX B

Phase 1 Cost Estimates

Assumptions:

		$/Linear Ft **
Pipe:	16-Inch	120
	27-Inch	225
	42-Inch	376

** RS Means CCD 2016 USED

***Price per Acre based on Farmland/Near River Property that doesn't have viable usage

Excavation & Haul:

Pipe Size	Miles	Cu. Yds.	$/Cu. Yds.	Cost
16 & 27	7	32853	20	$ 657,060
16 & 27	10	70400	20	$ 1,408,000
16 & 27	19	133760	20	$ 2,675,200
16 & 27	26	183040	20	$ 3,660,800
42	26	244053	20	$ 4,881,060

Wells costs are $1.5 million each, based on recent construction projects

Easement for 16 & 27-inch is based on a 10-foot wide easement @ $5000 per Acre

Easement for 42-inch is based on a 15-foot wide easement @ $5000 per Acre

Engineering Administration will be added to the capital cost on a 20% basis

A 25% contingency will be added to the total cost.

Alternative 1.2 Cost Estimate: 4,500 gpm/10 cfs Santa Paula Basin 16" Pipe, 7 miles

	Wells	Cost/Well			
	2	1,500,000	$ 3,000,000		
Directional Drill					
	LF	$/LF	Mobilization	Total	
	1800	150	50000	$ 320,000	
Capitol Cost					
	Wells + Pipe+ Directional Drill + Haul				
	$ 3,000,000	$ 4,435,200	$ 320,000	$ 657,060	$ 8,412,260
	CC* Engineering Administration + Easement				
	$ 10,094,712.0	$ 60,606	$ 10,155,318		
	CEQA + total				
	$ 13,155,318				
	Contingency add				
	$ 16,444,148				

Alternative 1.2 Cost Estimate: 4,500 gpm/10 cfs Santa Paula Basin 16" Pipe, 10 miles

	Wells	Cost/Well			
	2	1500000	$ 3,000,000		
Directional Drill					
	LF	$/LF	Mobilization	Total	
	3932	725	50000	$ 2,900,700	
Capitol Cost					
	Wells + Pipe+ Directional Drill + Haul				
	$ 3,000,000	$ 6,336,000	$ 2,900,700	$ 1,408,000	$ 13,644,700
	CC* Engineering Administration + Easement				
	$ 16,373,640.0	$ 60,606	$ 16,434,246		
	CEQA + total				
	$ 19,434,246				
	Contingency add				
	$ 24,292,808				

Alternative 1.2 Cost Estimate: 9,000 gpm/20 cfs Santa Paula Basin 27" Pipe, 7 miles

	Wells	Cost/Well			
	4	1500000	$ 6,000,000		
Directional Drill					
	LF	$/LF	Mobilization	Total	
	3932	725	50000	$ 2,900,700	
Capitol Cost					
	Wells + Pipe+ Directional Drill + Haul				
	$ 6,000,000	$ 8,316,000	$ 2,900,700	$ 657,060	$ 17,873,760
	CC* Engineering Administration + Easement				
	$ 21,448,512.0	$ 60,606	$ 21,509,118		
	CEQA + total				
	$ 24,509,118				
	Contingency add				
	$ 30,636,398				

Alternative 1.2 Cost Estimate: 9,000 gpm/20 cfs Santa Paula Basin 27" Pipe, 10 miles

	Wells	Cost/Well			
	4	1500000	$ 6,000,000		
Directional Drill					
	LF	$/LF	Mobilization	Total	
	3932	725	50000	$ 2,900,700	
Capitol Cost					
	Wells + Pipe+ Directional Drill + Haul				
	$ 6,000,000	$ 11,880,000	$ 2,900,700	$ 1,408,000	$ 22,188,700
	CC* Engineering Administration + Easement				
	$ 26,626,440.0	$ 320,000	$ 26,946,440		
	CEQA + total				
	$ 29,946,440				
	Contingency add				
	$ 37,433,050				

Alternative 1.3 Cost Estimate: 4,500 gpm/10 cfs Piru to Freeman 16" Pipe, 19 miles

	Wells	Cost/Well			
	2	1500000	$ 3,000,000		
Directional Drill					
	LF	$/LF	Mobilization	Total	
	7000	150	50000	$ 1,100,000	
Capitol Cost					
	Wells + Pipe+ Directional Drill + Haul				
	$ 3,000,000	$ 12,038,400	$ 1,100,000	$ 2,675,200	$ 18,813,600
	CC* Engineering Administration + Easement				
	$ 22,576,320.0	$ 115,152	$ 22,691,472		
	CEQA + total				
	$ 27,691,472				
	Contingency add				
	$ 34,614,339				

Alternative 1.3 Cost Estimate: 9,000 gpm/20 cfs Piru to Freeman 27" Pipe, 19 miles

	Wells	Cost/Well			
	4	1500000	$ 6,000,000		
Directional Drill					
	LF	$/LF	Mobilization	Total	
	7000	725	50000	$ 5,125,000	
Capitol Cost					
	Wells + Pipe+ Directional Drill + Haul				
	$ 6,000,000	$ 22,572,000	$ 5,125,000	$ 2,675,200	$ 36,372,200
	CC* Engineering Administration + Easement				
	$ 43,646,640.0	$ 115,152	$ 43,761,792		
	CEQA + total				
	$ 48,761,792				
	Contingency add				
	$ 60,952,239				

Alternative 1.4 Cost Est: 4,500 gpm/10 cfs Piru-Fillmore Basin pipeline 16-inch PVC 10 mile crossing Sespe

	Wells	Cost/Well			
	2	$ 1,500,000	$ 3,000,000		
Directional Drill					
	LF	$/LF	Mobilization	Total	
	4000	150	$50,000	$ 650,000	
Capitol Cost					
	Wells + Pipe+ Directional Drill + Haul				
	$ 3,000,000	$ 6,336,000	$ 650,000	$ 1,408,000	$ 11,394,000
	CC* Engineering Administration + Easement				
	$ 13,672,800.0	$ 60,606	$ 13,733,406		
	CEQA + total				
	$ 16,733,406				
	Contingency				
	$ 20,916,758				

Alternative 1.4 Cost Estimate: 9,000 gpm/20 cfs Piru-Fillmore 27" Pipe, 10 miles

	Wells	Cost/Well			
	4	1500000	$ 6,000,000		
Directional Drill					
	LF	$/LF	Mobilization	Total	
	4000	725	50000	$ 2,950,000	
Capitol Cost					
	Wells + Pipe+ Directional Drill + Haul				
	$ 6,000,000	$ 11,880,000	$ 2,950,000	$ 1,408,000	$ 22,238,000
	CC* Engineering Administration + Easement				
	$ 26,685,600.0	$ 60,606	$ 26,746,206		
	CEQA + total				
	$ 29,746,206				
	Contingency add				
	$ 37,182,758				

Alternative 1.5 Cost Estimate: 9,000 gpm/20 cfs SFD to Freeman 27" Pipe, 26 miles

	Wells	Cost/Well			
	0	1500000	$ -		
Directional Drill					
	LF	$/LF	Mobilization	Total	
	7500	725	50000	$ 5,487,500	
Capitol Cost					
	Wells + Pipe+ Directional Drill + Haul				
	$ -	$ 30,888,000	$ 5,487,500	$ 3,660,800	$ 40,036,300
	CC* Engineering Administration + Easement				
	$ 40,043,560.0	$ 157,576	$ 48,201,136		
	CEQA + total				
	$ 53,201,136				
	Contingency add				
	$ 66,501,420				

Alternative 1.5 Cost Estimate: 22,500 gpm/50 cfs SFD to Freeman 42" Pipe, 26 miles

	Wells	Cost/Well			
	0	1500000	$ -		
Directional Drill					
	LF	$/LF	Mobilization	Total	
	7500	900	50000	$ 6,800,000	
Capitol Cost					
	Wells + Pipe+ Directional Drill + Haul				
	$ -	$ 51,617,280	$ 6,800,000	$ 4,881,060	$ 63,298,340
	CC* Engineering Administration + Easement				
	$ 75,958,008.0	$ 157,576	$ 76,115,584		
	CEQA + total				
	$ 81,115,584				
	Contingency add				
	$ 101,394,480				

Phase 2 Cost Estimates

50 CFS South River Pipeline Alignment					
		Unit	2016 Unit Cost	QTY	2018 Cost
Total Cost					**$ 102,950,147.84**
01 General Requirements					**$ 57,011,206.07**
1.4	Contingencies	LS	20%		$ 17,158,357.97
	Easment Acquisition	SF	$ 2,000.00	422,400	$ 1,837,557.67
1.3	Yearly Escalation	LS	4%		$ 6,218,832.01
	Environmental Compliance/Mitigation	LS	5%		$ 2,296,947.09
	Engineering	LS	12%		$ 5,512,673.01
1.1	General Conditions	LS	4.7%		$ 2,159,130.26
1.101	Mobilization	LS	5.0%		$ 2,296,947.09
1.1031	Permits, Licenses & Fees	$ Per Every 1000$	$ 3.92		$ 180,080.65
1.1043011	Office Trailer	Month	$ 885.73	16	$ 14,171.68
1.1045021	Temp Barrier bolted to paving for public safety	LF	$ 108.91	5,280	$ 575,044.80
	Traffic Control	LS	1.5%		$ 689,084.13
	Material Handling Equipment	LS	5%		$ 2,296,947.09
	Insurances, comprehensive	LS	2%		$ 918,778.84
	Non-Manual Labor, distributables benefits, payroll tax, worker's comp	LS	1%		$ 459,389.42
	Non-Distributable Labor and Supervision	LS	3%		$ 1,378,168.25
1.2	Bonds	LS	1.34%		$ 615,581.82
	Profit	LS	10%		$ 4,593,894.18
	Overhead	LS	2%		$ 918,778.84
	Construction Management and Administration	LS	15%		$ 6,890,841.27
02 Sitework					**$ 45,938,941.78**
2.1101031	Remove Pavement, Asphaltic Concrete	SF	$ 0.25	1,320,000	$ 330,000.00
2.1101033	Sawcut	LF	$ 0.81	132,000	$ 106,920.00
2.1104021	Remove Trees 10"-14"	EA	$ 646.78	20	$ 12,935.60
2.1104031	Remove Trees 20" above	EA	$ 3,401.42	5	$ 17,007.10
2.2001021	Clear and grub large area, no disposal	SF	$ 0.03	105,600	$ 3,168.00
2.2001051	scarify and compact top 6"	SF	$ 0.06	105,600	$ 6,336.00
2.2001061	rough grade, machine	SF	$ 0.03	105,600	$ 3,168.00
2.2002011	Rdwy cut & fill, earth	CY	$ 1.11	160,844	$ 178,537.33

2.2002041	Rock and earth conglomerates	CY	$ 2.02	13,689	$	27,651.56
2.2003031	Site Cut and Fill	CY	$ 2.42	9,778	$	23,662.22
2.2006151	Straw Wattles	LF	$ 1.89	10,560	$	19,958.40
2.4005011	Dewatering well system 12" cased and graded	VF	$ 101.83	1,056	$	107,532.48
2.7606071	Hydroseeding	SF	$ 0.03	105,600	$	3,168.00
2.9501131	Dredging, earthwork, unclassified	CY	$ 5.08	4,889	$	41,480.19
2.5106091	Concrete Pipe, Reinf, Class 3 Gaskets, 36"	LF	$ 188.50	145,200	$	27,370,200.00
2.5001151	Pipe Jacking, 54"	LF	$ 2,798.00	2,500	$	6,995,000.00
2.5310041	Steel Casing, 54"	LF	$ 684.00	2,500	$	1,710,000.00
2.5504011	Manholes, 4' diameter x 6-8' deep	EA	$ 23,722.65	1 46.00	$	3,463,506.90
2.6001041	Asphaltic Concrete, 3", 8" Base, 10" Sub	SF	$ 3.66	1,320,000	$	4,831,200.00
2.6007181	Striping, thermoplactic, yellow, 8"	LF	$ 3.60	126,720	$	456,192.00
2.6007161	Striping, thermoplactic, white, 4"	LF	$ 1.46	126,720	$	185,011.20
2.7602131	Tree, 15 Gallon, Double Staked	EA	$ 70.08	100	$	7,008.00
2.7602181	Tree, 48" Boxed, guyed	EA	$ 1,964.94	20	$	39,298.80

75 CFS South River Pipeline Alignment					
		Unit	2016 Unit Cost	QTY	2018 Cost
Total Cost					**$ 129,368,000.36**
01 General Requirements					**$ 71,552,656.98**
1.4	Contingencies	LS	20%		$ 21,561,333.39
	Easement Acquisition	SF	$ 2,000.00	422,400	$ 2,312,613.74
1.3	Yearly Escalation	LS	4%		$ 7,814,374.31
	Environmental Compliance/Mitigation	LS	5%		$ 2,890,767.17
	Engineering	LS	12%		$ 6,937,841.21
1.1	General Conditions	LS	4.7%		$ 2,717,321.14
1.101	Mobilization	LS	5.0%		$ 2,890,767.17
1.1031	Permits, Licenses & Fees	$ Per Every 1000$	$ 3.92		$ 226,636.15
1.1043011	Office Trailer	Month	$ 885.73	16	$ 1 4,171.68
1.1045021	Temp Barrier bolted to paving for public safety	LF	$ 108.91	5,280	$ 575,044.80
	Traffic Control	LS	1.5%		$ 867,230.15
	Material Handling Equipment	LS	5%		$ 2,890,767.17
	Insurances, comprehensive	LS	2%		$ 1,156,306.87
	Non-Manual Labor, distributable benefits, payroll tax, worker's comp	LS	1%		$ 578,153.43
	Non-Distributable Labor and Supervision	LS	3%		$ 1,734,460.30
1.2	Bonds	LS	1.34%		$ 774,725.60
	Profit	LS	10%		$ 5,781,534.34
	Overhead	LS	2%		$ 1,156,306.87
	Construction Management and Administration	LS	15%		$ 8,672,301.51
02 Sitework					**$ 57,815,343.38**
2.1101031	Remove Pavement, Asphaltic Concrete	SF	$ 0.25	1,320,000	$ 330,000.00
2.1101033	Sawcut	LF	$ 0.81	132,000	$ 106,920.00
2.1104021	Remove Trees 10"-14"	EA	$ 646.78	20	$ 2,935.60
2.1104031	Remove Trees 20" above	EA	$ 3,401.42	5	$ 7,007.10
2.2001021	Clear and grub large area, no disposal	SF	$ 0.03	158,400	$ 4,752.00
2.2001051	scarify and compact top 6"	SF	$ 0.06	158,400	$ 9,504.00
2.2001061	rough grade, machine	SF	$ 0.03	158,400	$ 4,752.00
2.2002011	Rdwy cut & fill, earth	CY	$ 1.11	248,160.00	$ 275,457.60
2.2002041	Rock and earth conglomerates	CY	$ 2.02	21,120	$ 4 2,662.40

2.2003031	Site Cut and Fill	CY	$ 2.42	16,427	$	3 9,752.53
2.2006151	Straw Wattles	LF	$ 1.89	10,560	$	1 9,958.40
2.4005011	Dewatering well system 12" cased and graded	VF	$ 101.83	1,056	$	107,532.48
2.7606071	Hydroseeding	SF	$ 0.03	105,600	$	3,168.00
2.9501131	Dredging, earthwork, unclassified	CY	$ 5.08	8,213	$	5 8,368.36
2.5106091	Concrete Pipe, Reinf, Class 3 Gaskets, 48"	LF	$ 242.28	145,200	$	35,179,056.00
2.5001151	Pipe Jacking, 66"	LF	$ 4,159.52	2,500	$	10,398,800.00
2.5310041	Steel Casing, 66"	LF	$ 889.00	2,500	$	2,222,500.00
2.5504011	Manholes, 4' diameter x 6-8' deep	EA	$ 23,722.65	146.00	$	3,463,506.90
2.6001041	Asphaltic Concrete, 3", 8" Base, 10" Sub	SF	$ 3.66	1,320,000	$	4,831,200.00
2.6007181	Striping, thermoplactic, yellow, 8"	LF	$ 3.60	126,720	$	456,192.00
2.6007161	Striping, thermoplactic, white, 4"	LF	$ 1.46	126,720	$	185,011.20
2.7602131	Tree, 15 Gallon, Double Staked	EA	$ 70.08	100	$	7,008.00
2.7602181	Tree, 48" Boxed, guyed	EA	$ 1,964.94	20	$	3 9,298.80