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COUNTY OF RIVERSIDE
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J. Alvarez

SUPERIOR COURT OF THE STATE OF CALIFORNIA

FOR THE COUNTY OF RIVERSIDE

Coordination Proceeding Special Title (Cal. Rules of Court, rule 3.550) MOJAVE BASIN AREA WATER CASES	JCCP NO.: 5265 Lead Case No. CIV 208568 Assigned for All Purposes to the Honorable Harold W. Hopp, Dept. 1
CITY OF BARSTOW, et al., Plaintiff, v. CITY OF ADELANTO, et al., Defendant.	**DECLARATION OF ROBERT H. ABRAMS IN SUPPORT OF GOLDEN STATE WATER COMPANY'S OPPOSITION TO MOJAVE WATER AGENCY'S MOTION TO ADJUST FREE PRODUCTION ALLOWANCE FOR WATER YEAR 2024-2025** [Filed concurrently with Golden State Water Company's Opposition; Declarations of Toby B. Moore and Stephanie Hastings, and Notice of Lodging] Date: June 4, 2024 Time: 8:30 am Dept.: 1

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I, Robert H. Abrams, Ph.D, declare:

1. I am a Senior Principal Hydrogeologist at aquilogic, Inc. ("**aquilogic**") with more than 25 years of experience in water supply, water management, water quality, subsurface fluid flow and solute transport, and modeling. During my career as a hydrogeologist, I have been involved in a broad range of projects related to groundwater supply development and management, including under groundwater adjudications. Except as otherwise stated, I have personal knowledge of the following facts, and, if called upon to testify thereto, I could and would competently do so.

2. I am a California Professional Geologist (No. 8703) and California Certified Hydrogeologist (No. 931). I also am a Licensed Geologist in North Carolina (No. 2639). I received my Bachelor of Science in geology from San Francisco State University, and a Master of Science and Ph.D. in hydrogeology from Stanford University. A copy of my professional curriculum vitae is attached hereto as **Exhibit 1**.

3. Aquilogic was hired by the law firm of Brownstein Hyatt Farber Schreck, LLP to assist Golden State Water Company ("**GSWC**") with technical hydrology and hydrogeology analyses associated with GSWC's operations in the Centro Subarea of the Mojave Basin, including implementation of the Judgment in this action.

4. I am providing this declaration in support of GSWC's Opposition to the Mojave Water Agency's Motion to Adjust Free Production Allowance for Water Year 2024–2025 (the "**Motion**").

5. Part of aquilogic's scope of work includes review of historical stream flow data, analysis of the hydrology and hydrogeology of the Transition Zone,[1] and review of the Watermaster's recent update of the Production Safe Yield ("**PSY**") calculation for each of the Subareas. I supervised and performed the analysis set forth in the February 23, 2024 memorandum from Anthony Brown and Robert H. Abrams to Stephanie Hastings titled: "Progress Report and Mojave Basin Transition Zone Water Budget" (Notice of Lodging, Exh. 1; see also Declaration of Stephanie Hastings, ¶¶ 5–6) ("**aquilogic Memorandum**"). The aquilogic Memorandum is attached

[1] All capitalized terms not defined here have the same meaning as set forth in the Judgment.

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hereto as **Exhibit 2**.

6. In support of my work, I reviewed and am familiar with the Judgment in this action. Under the Judgment, the Mojave Basin Area is divided into five hydrologically connected Subareas (Alto, Baja Centro, Este, and Oeste). The Judgment establishes a Physical Solution wherein Producers in each Subarea have obligations to ensure surface water inflows and subsurface inflows reach the neighboring downstream or downgradient Subarea. The Alto Subarea is upstream of the Centro Subarea. The Transition Zone is the farthest downstream portion of the Alto Subarea and forms a boundary with the Centro Subarea. The Mojave Basin Area is characterized by desert conditions. Many reaches of the Mojave River are dry for extended periods. The majority of natural Mojave River flow occurs during and immediately following periods of intense storms, which can be separated in time by years to decades.

7. Also in support of my work, I reviewed and am familiar with: (a) the Alto & Centro Water Supply Update ("**Alto & Centro PSY Update**") and the Transition Zone Water Supply Update ("**Transition Zone PSY Update**") (collectively, "**2024 PSY Update**") (Motion, Exh. C, Exh. 5, App. A & B); and (b) the April 12, 2024 Memorandum from Robert Wagner, et. al. to Lee McElhaney ("**Watermaster Response**") (Motion, Exh. D).

8. The amount of surface water inflow entering the Centro Subarea cannot be measured directly because there is no stream gage at or near the boundary between the Transition Zone portion of the Alto Subarea and the downstream Centro Subarea. Instead, Watermaster estimates the surface water inflow to the Centro Subarea using a water budget that relies on several estimated components. A water budget is a mathematical analysis that compares the inflows and outflows of a water system. A water budget analysis, however, is only as good as measurement data and underlying assumptions. Based on my review of the Watermaster's Annual Reports prepared pursuant to the Judgment and the 2024 PSY Update, it is my understanding that some components of the Watermaster Engineer's water budget for the Transition Zone are not updated annually.

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9. For example, as noted on Table 1 of the Alto & Centro PSY Update, the following water budget components for the Transition Zone are based on direct measurements: (1) surface water inflows, (2) imports, and (3) agricultural and urban consumptive use (i.e., measured groundwater pumping less estimated return flows). And, the following water budget components are calculated estimates: (1) groundwater discharge to Transition Zone, (2) subsurface inflow, (3) Este/Oeste inflow, (4) surface water outflow, (5) subsurface outflow, and (6) consumptive use by phreatophytes (plant life). Table 1 of the Watermaster Response contains a similar mix of measurements and estimates for its water budget.

10. It is my opinion that the 2024 PSY Update *may* overestimate outflow from the Transition Zone. (Notice of Lodging, Exh. 1; [aquilogic Memorandum]; Exh. 2, pp. 1, 5.) Consequently, inflow to the Centro Subarea may also be overestimated.

11. The 2024 PSY Update estimates outflow from the Transition Zone based on the Lower Narrows stream gage, located at the internal Alto Subarea boundary between the upper Alto Subarea and the Transition Zone, and certain assumptions about the hydrology of the Transition Zone. This approach results in uncertainty given the lack of outflow measurements at or near the Transition Zone boundary.

12. Although a stream gage does not presently exist at the Transition Zone boundary with the Centro Subarea, from March 1966 through September 1970, the Wild Crossing stream gage was located near the Helendale Fault, which delineates the boundary between the two Subareas. In addition, the Hodge gage, near Hinkley Road located farther down the Mojave River, has been present and active for several short periods since 1930.

13. The Wild Crossing and Hodge gages were both discontinued because of unstable controls and changing stage-discharge relations that did not allow for acceptable discharge records. Nevertheless, the Wild Crossing streamflow data is the best available data of Mojave River flows during its 4.5-year data record from March 1966 through September 1970 and provides a useful comparison to evaluate whether present estimates are reasonable.

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14. The Watermaster Engineer contends that the above-referenced Wild Crossing streamflow data are unreliable due to its short measurement period and its discontinuation. (See Watermaster Response, p. 2.) However, the Hodge gage, which the Watermaster Engineer relies on for its estimates, was discontinued for the same reasons as the Wild Crossing gage, and it was only reestablished in late 2022.

15. In a river channel, streamflow losses can occur if the elevation of the stream surface is higher than the adjacent groundwater levels. This is common in arid environments where stream flows infiltrate into the river channel. Such losses represent recharge to the groundwater flow system and are often called "net stream recharge." Other types of streamflow losses include anthropogenic diversions and evaporation from the water surface.

16. Groundwater pumping can withdraw (and thereby reduce) net stream recharge from the groundwater flow system. Phreatophytes are plants that obtain water from groundwater, rather than from soil moisture. Riparian phreatophytes also can consume stream flow, but net stream recharge must occur first for the water to be accessible to these plants. Phreatophyte consumptive uses change over time and thus should be re-evaluated regularly based on changing conditions.

17. Analysis of stream flows between Lower Narrows and Wild Crossing suggests significant streamflow losses (an average of approximately 51, 500 acre-feet per year ("**AFY**")) occurred in the Transition Zone from March 1966 through September 1970. Because most of the Mojave River stream flow occurs during storm periods, evaporation from the water surface is minimal compared to net stream recharge.

18. Median groundwater pumping in the Transition Zone from March 1966 through September 1970 was approximately equal to median net stream recharge during this period—suggesting that most of the streamflow losses in the Transition Zone were due to net stream recharge.

19. Watermaster currently assumes that groundwater storage change in the Transition Zone is zero because groundwater levels in key monitoring wells have been relatively stable. This assumption allows Watermaster to calculate surface water inflow to the Centro Subarea, despite the absence of measured data at the boundary between the Alto and Centro Subareas, using the

following water budget:

> surface water inflow into the Centro Subarea = (stream flow at the Lower Narrows gage) + (discharge from the Victor Valley Wastewater Reclamation Authority treatment plant) – (consumptive groundwater pumping + consumptive use by phreatophytes).

20. Current groundwater pumping in the Transition Zone is substantially less than during the March 1966 through September 1970 period, but this decreased pumping does not appear to have a corresponding effect on surface water inflows into the Centro Subarea in the Watermaster Engineer's water budget for the Transition Zone, which is reflected in the 2024 PSY Update. Given the decreased pumping, current net stream recharge may be greater than current pumping, suggesting that greater streamflow losses could be occurring in the Transition Zone.

21. Under these circumstances, it ***may be*** true that there is no change in groundwater in storage in the Transition Zone, yet significant streamflow losses may still be occurring. The potentially unpumped net stream recharge could diffusely flow from the Mojave River to other areas of the Transition Zone or flow out of the Transition Zone as subsurface flow. Streamflow losses reduce the amount of surface water that flows downstream. Due to the uncertainty about the fate of the streamflow losses, surface water inflow to the Centro Subarea may be overestimated by Watermaster.

22. As a hypothetical, if there were no pumping in the Transition Zone, the change in groundwater storage would also be zero. The water not pumped would contribute to groundwater outflow from the Transition Zone and increased surface water inflow to the Centro Subarea. Similar circumstances would occur due to the more recent decrease in pumping, however, the available data and information—e.g., declining levels in the Centro Subarea—do not indicate that additional surface water inflows or subsurface flows flow into the Centro Subarea from the Transition Zone.

23. It is important to note that net stream recharge in the Transition Zone provides a benefit to the Alto Subarea—and the Alto Subarea Producers—not the Centro Subarea.

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24. In summary, the 2024 PSY Update does not address the potentially complex groundwater flow dynamics that occur in the Transition Zone, as described above and in the aquilogic Memorandum, and thus may overestimate inflows into the Centro Subarea from the Transition Zone.

25. The Watermaster Engineer states that the Mojave River streamflow losses are more likely due to groundwater pumping than net stream recharge. (See Watermaster Response, at p. 5.) As noted above, however, net stream recharge must occur before that water can be removed from the groundwater flow system by groundwater pumping. In addition, the Watermaster Engineer's estimated higher historical average of pumping (27,885 AFY) between 1966 and 1970 does not fully explain the estimated average stream losses of 51,500 AFY during this period. This discrepancy further highlights the uncertainty created when using an estimated historical average (51,500 AFY) rather than an historical median (33,234 AFY) to calculate a Transition Zone water budget.

26. The Watermaster Response contends that the different in average annual streamflows was likely due to greater pumping between the Lower Narrows and Wild Crossing gages. (See Watermaster Response, p. 5.) The Watermaster Engineer, however, only provides a cursory analysis of aerial images to supports this point.

27. The Watermaster Engineer states that "loss in stream flows observed along the [Transition Zone] during the 1960s was attributed to consumptive uses in the [Transition Zone] rather than groundwater recharge from stream flows." (See Watermaster Response, at p. 11.) However, an assumed condition of no change in Transition Zone groundwater storage is, alone, *not sufficient* to conclude that surface water inflow to the Centro Subarea is equal to the stream flow at the Lower Narrows plus the Watermaster Engineer's estimated Transition Zone water budget.

28. To ensure the most accurate estimate of outflow from the Transition Zone, and thus inflow to the Centro Subarea, I recommend that the Watermaster Engineer conduct a detailed analysis of the surface water inflow to the Centro Subarea and update that analysis at least every year. This analysis should include: (a) installing a new stream gage near the Helendale Fault; (b) developing a detailed water budget for the Transition Zone that uses best available information and

science and employs current scientific and engineering standards;[2] and (c) analyzing drawdown in key production wells in the Barstow area.

29. The above-referenced water budget for the Transition Zone should include, at a minimum, the following:

a. Compile and review available previous work by others on groundwater flow and water budgets in the Alto and Centro Subareas, including the Transition Zone;

b. Evaluate the usefulness of the United States Geological Survey ("**USGS**") Basin Characterization Model ("**BCM**")[3] and the Parameter-elevation Regressions on Independent Slopes Model ("**PRISM**")[4] dataset for application to the Transition Zone water budget;

c. Evaluate groundwater levels in the Transition Zone from Water Year 1931–present, with particular focus on the Water Year 1966–1970 and Water Year 1994–2022 periods, to support the analyses described in the aquilogic Memorandum by:

i. Estimating evapotranspiration by generally accepted industry methods, including the use of satellite data (e.g., METRIC[5]) and areal images, and compare with previous studies;

ii. Compiling all available water level data for the Transition Zone;

iii. Evaluating the water level data in terms of changes in well hydrographs and spatial water-level distributions over time; and

iv. Determining if groundwater levels in the Transition Zone increased, decreased, or remained the same during the Water Year 1966–1970 period to evaluate the impacts of stream recharge during the period when the Wild

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[2] An example of the level of rigor that should be employed was developed by the California Department of Water Resources to implement the Sustainable Groundwater Management Act of 2014.

[3] USGS, California Basin Characterization Model" A Dataset of Historical and Future Hydrologic Response to Climate Change, https://ca.water.usgs.gov/projects/reg_hydro/basin-characterization-model.html (last accessed on May 18, 2024).

[4] Northwest Alliance for Computational Science and Engineering, PRISM Climate Date https://prism.oregonstate.edu/ (last accessed on May 18, 2024).

[5] Acronym for "Mapping Evapotranspiration at high Resolution with Internalized Calibration."

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Crossing Gage existed;

d. Use the existing USGS model and the updated Watermaster hydrogeological model (if and when available) to further evaluate the Water Year 1966–1970 period by:

i. Updating the USGS model to include recent groundwater extractions and extend the model in time, if not already completed;

ii. Evaluating Transition Zone changes in groundwater storage, stream recharge, effects of evapotranspiration, groundwater extractions, and surface and groundwater flow into the Centro Subarea

e. Critically evaluate results and available previous work to determine the best estimate of the Transition Zone water budget;

f. Identify data gaps and limitations in the analyses; and

g. Thoroughly document the analyses and prepare both draft and final reports that are available for review and comment by all stakeholders and the Court.

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I declare, under penalty of perjury, under the laws of the State of California, that the foregoing is true and correct. Executed on May 20, 2024 at San Carlos, California.

Robt H Abrams

ROBERT H. ABRAMS

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EXHIBIT 1

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CURRICULUM VITAE
May 2024

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Disciplines
Hydrogeology, Water Resources, Geology, Geostatistics, Analytical and Numerical Modeling, Water Quality, Groundwater and Vadose Zone Fluid Flow, Contaminant Fate and Transport.

Education
Ph.D. Hydrogeology, Stanford University, 1999
M.S. Hydrogeology, Stanford University, 1996
B.S. Geology, San Francisco University, 1991

Professional Registrations
Professional Geologist, California (No. 8703)
Certified Hydrogeologist, California (No. 931)
Licensed Geologist, North Carolina (No. 2639)

Professional Experience
Bob has over 25 years of professional experience in groundwater resource development, groundwater sustainability, groundwater banking, groundwater quality, and model design and evaluation. He has worked for the California Geological Survey, the United States Geological Survey (USGS), Stanford University, San Francisco State University, consulting firms, and as an independent consultant to public and private clients. Recent projects have included evaluation of seawater intrusion impacts to water supply wells; vadose zone characterization and modeling; vadose zone and groundwater persistence of per- and polyfluoroalkyl substances (PFAS) and other contaminants; technical review and investigation of hydrogeological concepts and processes in multiple groundwater basins; evaluation of subsidence investigations; development and evaluation of water budgets, development and review of integrated groundwater/surface water hydrologic models; and preparation and review of California Sustainable Groundwater Management Act (SGMA) Groundwater Sustainability Plans (GSPs). Bob currently serves on seven Technical Advisory Committees (TACs) in four California Department of Water Resources Bulletin 118 groundwater basins/subbasins.

Project Experience

Summary of Selected Recent Projects

- Ongoing evaluation of hydrogeology, groundwater flows, and water budgets in the Mojave Basin – *Golden State Water Company/Brownstein Hyatt Farber Schreck, LLP*.
- Ongoing evaluation of hydrogeology, groundwater flows, water budgets, and basin boundaries in the Cuyama Basin – *Best Best & Krieger LLP*.
- Participating member of the Cuyama Basin Groundwater Sustainability Agency Technical Forum – *Best Best & Krieger LLP*.
- Consultant to a large group of Salinas Valley growers regarding multiple hydrogeological concerns related to GSPs and other water supply issues – *Salinas Basin Water Alliance/Brownstein Hyatt Farber Schreck, LLP*.
- Participating member of the Groundwater TAC (GTAC) for the Salinas Valley Basin. The GTAC provides advice and guidance on a range of ongoing groundwater issues and projects, including model development, seawater intrusion, and other hydrogeological issues – *Salinas Basin Groundwater Sustainability Agency, Salinas, California, representing the Salinas Basin Water Alliance*.
- Participating member of the Sustainable Management Criteria TAC (SMC TAC) for the Salinas Valley Basin, Upper Valley and Forebay Subbasins. The SMC TAC provides advice and guidance regarding implementation of projects and management actions – *Salinas Basin Groundwater Sustainability Agency, Salinas, California, representing the Salinas Basin Water Alliance*.
- Participating member of the Drought TAC (DTAC) for the Salinas Valley Basin. The DTAC is charged with developing standards and guiding principles for determining reservoir release schedules and operations of Nacimiento and San Antonio Reservoirs during multiyear droughts, as well as developing the release schedules during such droughts – *Monterey County Water Resources Agency, Salinas, California, representing Grower-Shipper Association of Central California.*
- Participating member of the Habitat Conservation Plan TAC (HCP TAC) for the Salinas Valley Basin. The HCP TAC provides advice and guidance regarding scenarios to be evaluated during development of the HCP, as well as related HCP matters – *Monterey County Water Resources Agency, Salinas, California, representing the Salinas Basin Water Alliance.*
- Participant of the Borrego Springs Watermaster TAC (BSW TAC). The BSW TAC provides consensus advice and guidance to the Borrego Springs Watermaster regarding implementation of the Stipulated Judgment – *T2 Borrego LLC*.
- Voting member of the Las Posas Valley Basin Watermaster TAC (LPV TAC). The LPV TAC provides advice and guidance regarding implementation of the LPV Adjudication Judgment – *LPV Watermaster*, *West Constituency Groups*.

- Evaluated the performance of an aquifer storage and recovery (ASR) project in the Las Posas Valley Basin and conducted other hydrogeological analyses – *Large Landowners Group, an interested party in the Las Posas Valley Basin adjudication process*.
- Designed and implemented custom computer programs to construct and test a facsimile of the USGS Central Valley Hydrologic Model (CVHM), which runs in Groundwater Vistas (GV), a graphical user interface. The computer programs generate input data for the facsimile model from CVHM output and CVHM MODFLOW packages that are not supported by GV. The facsimile model produces results that are nearly identical to CVHM – *Confidential Client*.
- Developed a methodology to combine vadose zone and groundwater flow and transport modeling to estimate the persistence in the subsurface of dissolved 1,2,3-trichloropropane from multiple fertilizer application areas using custom computer programs using HYDRUS, MODFLOW, and MODPATH. Four regions in California were successfully analyzed with this methodology (settlements and jury awards). For the Central Valley region, the CVHM facsimile model (described above) was used – *Miller and Axline; SL Environmental Law Group.*
- Developed and applied an enhanced version of the methodology described above to evaluate the subsurface persistence of PFAS at multidistrict litigation bellwether sites and other sites – *multiple law firms*.
- Co-wrote the Chapter Groundwater Sustainability Plan for the Westside Water Authority in Kern County. Used extremely sparse data and modeling results from C2VSimFG-Kern to estimate current and future water budgets and groundwater availability – *Westside Water Authority*.
- Conducted environmental impact assessment simulations using the CVHM facsimile model described above to evaluate drawdown and subsidence caused by a proposed brackish groundwater water treatment project in Kern County – *Westside Water Authority*.
- Critically evaluated subsidence estimates along the Tule Subbasin portion of the Friant-Kern Canal (FKC) by reviewing historical USGS reports, InSAR data, geomechanical modeling, and the Tule Subbasin Groundwater Flow Model – *Confidential Client*.
- Critically evaluated groundwater flow and solute transport models for three coal ash disposal sites in North Carolina to determine if the models simulated flow and transport properly and sufficiently to allow the sites' owner to claim no offsite groundwater quality impacts above water quality standards – *Southern Environmental Law Center*.
- Invited to participate in the Deep Aquifer Roundtable, a formal meeting attended by Salinas Valley hydrogeology experts to discuss approaches to monitoring and protecting the deepest portions of the Salinas Valley aquifer system – *Monterey County Water Resources Agency, Salinas, California*.
- Served on the TAC for the development of the Salinas Valley Integrated Hydrologic Model, a new MODFLOW model constructed by Monterey County and the U.S. Geological Survey – *Monterey County Water Resources Agency, Salinas, California representing Grower-Shipper Association of Central California*.

Summary of Other Selected Water Supply Projects

- Developed a new Integrated Water Flow Model (IWFM) groundwater-surface water model, based on the Central-Valley-wide C2VSim model, for Stanislaus County to assess impacts in terms of foreseeable land-use changes and installation of new wells – *Stanislaus County, Regional Groundwater-Surface Water Model for PEIR, Modesto, California.*
- Assisted Stanislaus County with evaluation of new major well permit applications based on a then-recently passed groundwater ordinance requiring evaluation under CEQA for potential pumping-induced impacts to the groundwater basin, such as lowered water levels in existing wells, land subsidence, and significant groundwater or surface water depletion – *Stanislaus County, Well Permit CEQA Analysis, Modesto, California*.
- Evaluated well efficiency test results for multiple years and multiple wells for a Salinas Valley grower and food processor. Quantitative and statistical analyses were used to assess well performance and make recommendations for potential well maintenance and repair activities – *Nunes Vegetables, Salinas, California*.
- Reviewed and analyzed published reports and data from international and national seawater intrusion mitigation efforts to assess the feasibility, level of effort required, volumes of water required, and costs of implementation in the Salinas Valley of a seawater intrusion injection barrier using recycled water – *Tanimura & Antle, Salinas, California*.
- Conducted a technical evaluation and provided detailed comments regarding the hydrologic analysis undertaken for the draft environmental impact report/environmental impact statement for the proposed Monterey Peninsula Water Supply Project (MPWSP) - *Third-Party Evaluation of Hydrologic Analysis Conducted for Monterey Peninsula Water Supply Project, City of Marina, California*.
- Developed two local-scale groundwater flow (MODFLOW) and solute transport models (MT3DMS) for subregions within the USGS regional Antelope Valley MODFLOW model domain to evaluate the performance of a new groundwater bank. Updated geologic characterization was based on recent investigations by the USGS and sparse well logs – *Antelope Valley-East Kern Water Agency (AVEK), Groundwater Banking and Blending Study, Palmdale, California.*
- Developed and calibrated groundwater flow (MODFLOW) and solute transport models (MT3DMS) to assess water sources for a new 20 MGD water treatment plant using a new detailed geologic model. Assessed the extent of the deep target aquifer; evaluated the risk of groundwater contamination from an overlying heavy industrial area; evaluated proposed well locations and long-term performance; defined the wellhead protection area; and optimized wellfield performance – *City of Longview, Design and Construction of a New Groundwater Source and Treatment Facility, Longview, Washington.*

- Developed and implemented groundwater flow models (MODFLOW) to evaluate the impact on nearby wells of compressed air injection into a depleted natural-gas reservoir – *Pacific Gas and Electric (subcontractor to Jacobson James and Associates), Compressed Air Energy Storage Pilot Project, San Joaquin County, California.*
- Evaluated (with SEAWAT) the degree to which irrigation wells were drawing seawater inland and if groundwater withdrawals contributed to anoxic conditions in certain reaches of a river hydraulically connected to the aquifer – *El Sur Ranch, Seawater Intrusion and Impact of Irrigation Wells, Monterey County, California*.
- Developed a hydrostratigraphic model of the Mesquite Lake groundwater subbasin from existing well logs and nearby USGS studies for input to a new groundwater flow model (MODFLOW), which was used to assess the volume of water available for a new municipal water treatment plant – *Twentynine Palms Water District, Groundwater Study for the Mesquite Lake Subbasin, Twentynine Palms, California.*
- Developed a calibrated, steady-state analytical groundwater flow model for the Rialto-Colton Basin to delineate source areas for two impacted production wells for a CDPH 97-005 permit application – *West Valley Water District, Wellhead Treatment Project, Rialto, California.*
- Analyzed the results of aquifer tests of multiple water supply wells completed in a fractured-rock aquifer – *Lake Don Pedro Community Services District, California (subcontractor to SGI The Source Group)*.
- Analyzed the results of a complex aquifer-test dataset to determine aquifer properties and assess groundwater availability, characterized groundwater quality, and assessed regional impact of developing a new water supply – *Silver Oak Cellars (subcontractor to Taber Consultants), Aquifer Test Analysis and Groundwater Availability Study, Sonoma County, California.*
- Evaluated a well and a spring in terms of water quality, influence of surface water, source area, and zone of influence for a license application to operate a new private water supply – *Buster's on the Mountain (subcontractor to Taber Consultants), Hydrogeology Report for New Private Water Supply, Napa County, California*.
- Reviewed and critiqued for accuracy and completeness groundwater flow modeling, aquifer test results, and qualitative hydrogeological analyses to assess the feasibility of gravel mining adjacent to the upper reaches of a major river in Los Angeles and Ventura counties. In the second phase of the project, developed a new MODFLOW model to assess groundwater-surface water interactions – *Confidential Client (subcontractor to Todd Engineers), Groundwater Pumping Impacts on Streamflow, Los Angeles County, California.*
- Developed a complex geologic model in the fold-thrust terrane of the Las Posas Valley Basin in eastern Ventura County, which formed the foundation for preliminary wellfield design and estimation of available groundwater for desalter operations in a strictly managed aquifer – *Calleguas Municipal Water District, Somis Desalter Feasibility Study, Las Posas Basin, Ventura County, California*.

- Evaluated geologic, hydrologic, and hydrogeologic data to assess the suitability for establishing a groundwater banking operation and provided recommendations on further field-based and modeling studies deemed necessary to address data and knowledge gaps – *Los Angeles Department of Water and Power, Evaluation of Proposed Water Storage/Transfer Potential in Fremont Valley Basin, Fremont Valley, California.*
- Evaluated the groundwater component of an existing water-budget model; implemented changes to include the effects on water levels from climate and distant municipal pumping in deeper parts of the aquifer, to design an engineered wetland that used stormwater runoff and groundwater pumping to maintain lake levels – *San Francisco Public Utilities Commission, Lake Merced Water-Budget Model, San Francisco, California.*

Summary of Other Selected Water Quality Projects

- Determined the factors influencing nitrate concentrations in well-water from approximately 60 wells on 40 ranches and developed an enhanced groundwater monitoring program; analyzed diverse and complex data sets statistically and qualitatively to understand the geologic, hydrologic, and anthropogenic factors that variably influence well-water concentrations over short- and long-term timeframes; developed specific recommendations for wellhead protection – *Costa Farms, Analysis of Observed Nitrate Concentration Trends in Irrigation Wells, Soledad, California*.
- Statistically evaluated publicly available groundwater quality data from a set of regularly sampled water-supply wells to develop an alternative to installation of new monitoring wells for a land application area that received wastewater from a food processing plant – *Dole Fresh Vegetables, Salinas, California*.
- Conducted Monte Carlo hydraulic gradient analysis and stochastic 1D and 2D solute transport simulations (analytical solutions) based on regional groundwater maps and 13 years of monthly groundwater levels from dozens of production wells to determine the most likely methyl tert-butyl ether (MTBE) source areas; developed a customized GIS framework to evaluate source-area probability – *Monterey County Water Resources Agency, Salinas MTBE Investigation, Salinas, California.*
- Developed three-dimensional, variably saturated flow and reactive transport models (MODFLOW-SURFACT) to assess the groundwater impact from arsenic and boron in artificially recharged, partially treated oilfield produced water – *Cawelo Water District, Groundwater Banking Waste Discharge Requirements Support, Central Valley, California*.
- Developed, calibrated, and evaluated a calibrated transient model (MODFLOW and MT3DMS) of groundwater flow and solute transport to compare estimated timeframes to achieve remedial action objectives (RAOs) for three remedial alternatives at a land application site – *Hilmar Cheese Company, Groundwater Modeling for Cleanup and Abatement Order, Central Valley, California.*

- Reviewed the results of two modeling efforts to reassess contributions from responsible parties; developed a new metric, the Responsibility Factor (RF), and applied to existing input data; used the RFs to estimate relative contributions to the MEW Superfund site regional plume from several responsible parties – *Confidential Client (subcontractor to Montclair Environmental Management), Reassessment of Contributions to the MEW Superfund Site Regional Plume, Santa Clara County, California.*
- Conducted and compared mass flux calculations for TCE and PCE on behalf of a multi-PRP (potentially responsible part) group; compared calculations of mass flux through time upgradient and downgradient of several sites within the Omega Superfund site regional plume to estimate the contribution from each individual site for cost allocation among PRPs – *Confidential Client, Mass Flux Calculations for Cost Allocation, Omega Superfund Site, Santa Fe Springs, California.*
- Developed and calibrated a three-dimensional model (MODLFOW-SURFACT) of unsaturated zone and saturated zone flow and solute transport based on sparse discharge records and well observations to assess the fate of a legacy of contaminated soil water being mobilized by increased discharge to the subsurface – *California Dairies, Incorporated, Report of Waste Discharge, Central Valley, California.*
- Conceptualized, implemented, and calibrated a transient groundwater flow model (MODFLOW) for a major oil refinery; used linear programming to quantitatively minimize groundwater pumping and qualitatively optimize well placement for containment of subsurface LNAPL and BTEX-contaminated groundwater; analyzed multiple capture zones of various sizes for control of LNAPL hotspots and site-wide containment scenarios – *Sun Oil Company, Pumping-Rate Optimization and Capture Zone Analysis, Tulsa County, Oklahoma.*
- Developed a groundwater flow and reactive solute transport model (MODFLOW and RT3D) to evaluate the efficacy of a permeable reactive barrier using simulated sequential decay and transport of TCE and its daughter products – *Mohawk Laboratories, Analysis of Permeable Reactive Barrier, Sunnyvale, California.*
- Determined regional-scale risk to groundwater from potentially contaminating activities (PCA) in the Santa Clara Valley, Coyote, and Llagas subbasins, as part of a multifaceted effort; developed a regional-scale PCA-risk map and combined with intrinsic aquifer sensitivity to generate a groundwater vulnerability map, which formed the basis of a web-based GIS tool for evaluating development projects and land-use changes – *Santa Clara Valley Water District, Groundwater Vulnerability Study, Santa Clara, California.*
- Prepared a Remedial Investigation (RI) Summary report under CERCLA guidelines, which included development of a conceptual model that incorporated regional and local hydrostratigraphy, source-area history, details of previous remedial investigations, and characterization of the basin-wide perchlorate and TCE groundwater contamination – *West Valley Water District, NCP Compliance Documents, Rialto, California.*

- Estimated the volume of LNAPLs beneath a refinery by modifying analytical solutions for LNAPL recovery presented within API Publications 4682 and 4729, utilizing the van Genuchten relations for porous media to design a LNAPL recovery system – *Sun Oil Company, LNAPL Spatial Distribution, Tulsa County, Oklahoma.*
- Developed internal White Paper on DNAPL assessment techniques describing techniques and thresholds for assessing DNAPL mobility at a fueling facility – *BNSF, Remediation Design Support, Park County, Montana*.
- Developed and implemented groundwater flow and particle tracking models to evaluate well placement designs and optimize pumping rates for an in-situ groundwater recirculation and volatile organic compound (VOC) treatment zone – *BNSF, Remediation Design Support, Park County, Montana.*
- Analyzed slug test data for multiple tests using several techniques to assess parameter uncertainty for a bedrock aquifer, for submission to Montana Department of Environmental Quality – *BNSF, Site Characterization for Remedial Investigation, Park County, Montana.*
- Prepared report of waste discharge and request for waste discharge requirements for land application of onsite waste and storm water – *Confidential Client, Report of Waste Discharge, Los Angeles County, California.*
- Developed an unsaturated zone flow and transport model to assess the impact to groundwater of VOCs and metals present in the soil at a facility; developed a future 100-year scenario based on climate data from the past 100 years – *SMTEK, Former Chemical Facility, Orange County, California.*

Summary of Other Selected Litigation Support Projects

- Implemented detailed regional, three-dimensional conceptual model for a 35-year period (MODFLOW and MT3DMS). Geologic data, crop-based time-variant DBCP application rates, pumping, recharge basins, and flow and transport in the unsaturated and saturated zones were used to evaluate whether label-recommended use of DBCP caused contamination in municipal wells and to establish likely source areas for high-concentration hot spots – *Sedgwick, Detert, Moran, and Arnold, Regional-Scale Pesticide Contamination Litigation Support, Fresno, California.*
- Designed and implemented three-dimensional models (LEACHM, MODFLOW, and MT3DMS) of unsaturated and saturated fluid flow and solute transport for periods of up to 150-years using soils and geologic data, rainfall records, pumping, and plant operational history to assess whether off-site groundwater contamination was caused by unanticipated releases of coal tar at numerous sites in the Midwest – *Jones, Day, Reavis, and Pogue, Former Manufactured-Gas Plant Sites, Litigation Support, Los Angeles, California.*
- Evaluated the impact of different rainfall data disaggregation techniques on the results of fluid flow and solute transport simulations in the unsaturated zone. Various disaggregation strategies were applied to simulations of contaminant fate at three former manufactured-gas

plants – *Northern Indiana Public Service Company, Impact of Rainfall Data Disaggregation Techniques, Merrillville, Indiana.*

- Evaluated expert reports and thoroughly evaluated and verified a detailed water budget model. Assisted in preparation of expert report related to the application of the model – *Confidential Client, Water Budget Model Litigation Support, Pinal County, Arizona*.
- Evaluated expert reports and critiqued a detailed MODFLOW groundwater flow model for litigation of damages and fatalities from a landslide. Assisted in preparation of expert report – *Confidential Client, Landslide Initiation Litigation Support, British Columbia.*

Professional History

aquilogic, Inc., Senior Principal Hydrogeologist, October 2020 to present.
aquilogic, Inc., Senior Hydrogeologist, February 2018 to October 2020.
Jacobson James & Associates, Inc., Principal Hydrogeologist, October 2015 to December 2017.
Independent Consultant, December 2012 to September 2015.
Kennedy/Jenks Consultants, Associate Hydrogeologist, March 2009 to November 2012.
Independent Consultant, July 2005 to February 2009.
San Francisco State University, Lecturer/Adjunct Professor, September 2003 to February 2009.
SGI The Source Group, Inc., Senior Hydrogeologist, August 2002 to June 2005.
Stanford University, Research Associate, September 2000 to July 2002
Independent Consultant/Graduate Student, October 1995 to July 2000.
U.S. Geological Survey/Graduate Student, Hydrologist, June 1992 to September 1995.

Research

- Designed and implemented a new protocol and computer code to simulate the development of redox zones in contaminated aquifers. Simulated transport of dissolved constituents coupled to complex interactions between organic and inorganic compounds with consideration of reaction energetics, reaction-rate limitations, and advection and dispersion – *Stanford University/United States Geological Survey, Development and Fate of Redox Zones in Contaminated Aquifers, Falmouth, Massachusetts*.
- Evaluated interactions between surface water, soil-water, and groundwater with a three-dimensional model of coupled saturated-unsaturated subsurface and surface fluid flow. Incorporated detailed rainfall data into the model to determine the relative importance of different stormflow generation mechanisms – *Stanford University, Stormflow Generation, Chickasha, Oklahoma*.
- Conducted basin-scale modeling analysis of subsurface fluid flow in the Illinois Basin to evaluate the role of paleogroundwater flow versus fluid density in long-range, deep-basin petroleum migration – *United States Geological Survey, Basin-scale Analysis of Subsurface Fluid Flow, Illinois Basin*.
- Developed reactive solute transport models to evaluate zinc transport in a geochemically complex aquifer in Falmouth, MA. Coupled solute transport/geochemical modeling,

laboratory experiments, and a two-site surface complexation model were used to represent the pH-dependent adsorption of dissolved zinc on aquifer sediments – *United States Geological Survey, Zinc Transport in a Geochemically Complex Aquifer, Falmouth, Massachusett*s.

Peer-Reviewed Publications

Abrams, R.H. and K. Loague. 2000. A compartmentalized solute transport model for redox zones in contaminated aquifers, 2, Field-scale simulations. Water Resources Research 36, 2015-2029.

Abrams, R.H. and K. Loague. 2000. A compartmentalized solute transport model for redox zones in contaminated aquifers, 1, Theory and development. Water Resources Research 36, 2001-2013.

Abrams, R.H., K. Loague, and D.B. Kent. 1998. Development and testing of a compartmentalized reaction network model for redox zones in contaminated aquifers. Water Resources Research 34, 1531-1541.

Abrams, R.H. and K. Loague. 2000. Legacies from three former manufactured-gas plants: Impacts on groundwater quality. Hydrogeology Journal 8, 594-607.

Kent, D.B., R.H. Abrams, J.A. Davis, J.A. Coston, and D.R. LeBlanc. 2000. Modeling the influence of variable pH on the transport of zinc in a contaminated aquifer using semi-empirical surface complexation models. Water Resources Research 36, 3411-3425.

Kent, D.B., R.H. Abrams, J.A. Davis, and J.A. Coston. 1999. Modeling the influence of adsorption on the fate and transport of metals in shallow ground water--Zinc contamination in the sewage plume on Cape Cod, MA. Morganwalp, D.W., and Buxton, H.T., eds., USGS WRI Report 99-4018C, 361-370.

Loague, K., R.H. Abrams, S.N. Davis, A. Nguyen, and I.T. Stewart. 1998. A case study simulation of DBCP groundwater contamination in Fresno County, California: 2. Transport in the saturated subsurface. Journal of Contaminant Hydrology 29, 137-163.

Loague, K., D. Lloyd, A. Nguyen, S.N. Davis, and R.H. Abrams. 1998. A case study simulation of DBCP groundwater contamination in Fresno County, California: 1. Leaching through the unsaturated subsurface. Journal of Contaminant Hydrology 29, 109-136.

Loague, K. and R.H. Abrams. 1999. DBCP contaminated groundwater in Fresno County: Hot Spots and nonpoint sources. Journal of Environmental Quality 28, 429-445.

Coston, J. A., R. H. Abrams, and D. B. Kent. 1998. Selected inorganic solutes, in water quality data and methods of analysis for samples collected near a plume of sewage-contaminated ground water, Ashumet Valley, Cape Cod, Massachusetts, 1993-1994. USGS WRI Report 97-4269.

Loague, K., C.S. Heppner, R.H. Abrams, A.E. Carr, J.E. VanderKwaak, and B.A. Ebel. 2005. Further testing of the Integrated Hydrology Model (InHM): Event-based simulations for a small rangeland catchment located near Chickasha, Oklahoma. Hydrological Processes 19, 1373–1398.

Loague, K. and R.H. Abrams. 2001. Stochastic-conceptual analysis of near-surface hydrologic response. Hydrological Processes 15, 2715-2728.

Loague, K., G.A. Gander, J.E. VanderKwaak, R.H. Abrams, and P.C. Kyriakidis. 2000. Technical Addendum for "Simulating hydrologic response for the R-5 catchment: A never-ending story". Floodplain Management 2, 57-64.

Loague, K., G.A. Gander, J.E. VanderKwaak, R.H. Abrams, and P.C. Kyriakidis. 2000. Simulating hydrologic response for the R-5 catchment: A never-ending story. Floodplain Management 1, 57-83.

Grose, T.L.T. and R.H. Abrams, 1992. Geologic map of the Grasshopper Valley 15' quadrangle, Lassen County, California. California Department of Conservation, Division of Mines & Geology Open-File Report 93-07.

Grose, T.L.T. and R.H. Abrams. 1991. Geologic map of the Karlo 15' quadrangle, Lassen County, California. California Department of Conservation, Division of Mines & Geology Open-File Report 91-23.

EXHIBIT 2

aquilogic, Inc.
environment ● water ● strategy

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MEMORANDUM

To: Stephanie Hastings, Shareholder, Brownstein, Farber, Hyatt, Schreck, LLP
From: Anthony Brown, Principal-in-Charge, aquilogic, Inc.
Robert H. Abrams, Ph.D., P.G., CHg., Senior Principal Consultant, aquilogic, Inc.
Date: February 23, 2024

Subject: Progress Report and Mojave Basin Transition Zone Water Budget

Project No.: 018-10

Aquilogic, Inc. (**aquilogic**) has prepared this memorandum for two purposes. First, the memorandum documents preliminary work performed for the Golden State Water Company in the Mojave Basin pertaining to water outflow from the Transition Zone, which represents inflow the Centro Subarea (**Figure 1**). Preliminary work indicates this outflow may be overestimated by the Mojave Basin Watermaster (Watermaster). Consequently, inflow to the Centro Subarea may also be overestimated. Second, the memorandum outlines an approach to provide further assessment of this outflow/inflow, to be supported by data and analyses.

The Mojave Basin is subject to a Stipulated Judgment (Judgment) of water rights.[1] The Judgment stipulates that Alto Subarea Producers have an obligation to deliver 23,000 acre-feet per year (AFY) of Subsurface Flow[2] and Base Flow[3] to the Transition Zone. Watermaster appears to assume that surface water inflow to the Transition Zone provides the basis for estimating surface water inflow to the Centro Subarea.[4] However, there is no direct evidence to support this assumption. In fact, there is direct evidence that this assumption may be incorrect.

BACKGROUND

The Transition Zone is defined in the Judgment as part of the Alto Subarea. Watermaster assumes that the Alto Subarea Producers' obligation to the Transition Zone is satisfied by inflow to the Transition Zone from upstream portions of the Alto Subarea.[5] This inflow is comprised of Subsurface Flow and Base Flow. The obligation to the Transition Zone appears to be considered by Watermaster to also satisfy an obligation to the Centro Subarea. For example, the first annual report notes, "[s]*uch discharge records are used in the calculations of compliance by Alto*

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[1] Riverside (1996). Judgment after Trial, Mojave Basin Area Adjudication. City of Barstow et al. v. City of Adelanto et al. Riverside County Superior Court Case No. 208568. January 10.
[2] Subsurface Flow is defined in the Judgment as, "*Groundwater which flows beneath the earth's surface*."
[3] Base Flow is defined in the Judgment as, "*That portion of the total surface flow measured Annually at Lower Narrows which remains after subtracting Storm Flow*."
[4] After accounting for estimated gains/losses in the Transition Zone, such as sewage treatment plant outfall and estimated consumptive use, as stated or implied in multiple annual reports.
[5] Watermaster (1995). First annual report of the Mojave Basin Area Watermaster, 1993-1994, City of Barstow et al. v. City of Adelanto et al. Riverside County Superior Court Case No. 208568, Riverside County. February 28.

Subarea Producers with their obligation to the Centro Subarea."[6] Subsequent annual reports contain similar statements.

The Judgment specifies that 2,000 AFY of the Alto Producers' obligation to the Transition Zone is satisfied by Subsurface Flow. Watermaster assumes that groundwater inflow to the Centro Subarea from the Transition Zone is also 2,000 AFY.[7,8] Therefore, Watermaster appears to assume that 21,000 AFY of the obligation to the Centro Subarea must be satisfied by Base Flow from the Transition Zone.

Watermaster states that the change of groundwater storage in the Transition Zone is zero because water levels in key piezometers near both the upstream and downstream boundaries of the Transition Zone are relatively constant.[9] Because of this, Watermaster assumes Mojave River discharge measured at the Lower Narrows gage, adjusted by an estimated Transition Zone water balance, is essentially equivalent to Mojave River discharge entering the Centro Subarea[10] (**Figure 1**). However, there is no active stream gage at the upstream boundary of the Centro Subarea. Therefore, Watermaster's assumption regarding inflow to the Centro Subarea cannot be evaluated directly.

STREAM DISCHARGE

There are no stream gages in most of the Transition Zone. However, there is one long-term gage (i.e., water year [WY] 1931 to present) located at the upstream boundary of the Transition Zone (Lower Narrows gage) (**Figure 1**). Another long-term stream gage is located near the Centro Subarea-Baja Subarea boundary (Barstow gage). A stream gage has recently been re-established approximately eight miles downstream of the Transition Zone-Centro Subarea boundary (Hodge/Hinkley gage).

The Hodge/Hinkley and Barstow gages measure discharge across an ephemeral Mojave River channel that can be over 0.25 miles wide. Discharge is generally limited at these gages to Storm Flow (i.e., very little, if any, Base Flow is measured by these gages).[11] The wide channel leads to uncertainty in the stream discharge measurements from these gages because Storm Flows may

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[6] Watermaster (1995). First annual report of the Mojave Basin Area Watermaster, 1993-1994, City of Barstow et al. v. City of Adelanto et al. Riverside County Superior Court Case No. 208568, Riverside County. February 28.

[7] As stated or implied in multiple annual reports.

[8] However, it should be noted that the cross-sectional area for groundwater flow between the Transition Zone and the Centro Subarea potentially expands and contracts with varying volumes of Transition Zone recharge, which may increase or decrease the assumed 2,000 AFY of Subsurface Flow. Studies to understand the geometry of this potentially dynamic cross-sectional area are warranted but have not yet been undertaken by Watermaster.

[9] As stated or implied in multiple annual reports

[10] The Lower Narrows gage is located at the upstream boundary of the Transition Zone.

[11] Storm Flow is defined in the Judgment as "*That portion of the total surface flow originating from precipitation and runoff without having first percolated to Groundwater storage in the zone of saturation and passing a particular point of reckoning, as determined annually by the Watermaster*."

not always fill the entire width of the channel or may flow in parts of the channel away from the gage. Nevertheless, discharge measurements from these gages are the best available data.

From WY 1931 through WY 2023, Mojave River discharge at the Lower Narrows gage averaged 46,100 AFY. Discharge decreased by an average of 341 AFY over that period. From WY 1994 through WY 2023, Mojave River discharge at the Lower Narrows gage averaged 28,300 AFY. The decrease in average annual discharge over this period increased to 521 AFY.

As noted, there is no active stream gage at or adjacent to the Centro Subarea's upstream boundary. However, there was such a gage from March 1966 through WY 1970: the Wild Crossing gage (**Figure 1**).

DATA ANALYSIS

The Wild Crossing gage was discontinued because of unstable controls and changing stage-discharge relations that did not allow for acceptable discharge records.[12] However, stream discharge measured at the Wild Crossing gage is the best data available that can show the potential change in discharge between the upstream boundary of the Transition Zone and the upstream boundary of the Centro Subarea, despite its shortcomings and relatively short period of record. It should be noted that the Hodge/Hinkley gage was also discontinued two different times since 1932 because of unstable controls and changing stage-discharge relations. However, it was reestablished in 2022, which suggests high-quality data can be gathered at gage locations previously deemed problematic.

Stream Recharge to Groundwater

Figure 2 shows the annual discharge at the Lower Narrows gage, the Wild Crossing gage, and the Barstow gage for the period WY 1966 through WY 1970.[13] For the purposes of this analysis, net stream recharge to groundwater is approximated as the difference in discharge between successive gages.[14] Discharge at the Wild Crossing gage was lower than discharge at the Lower Narrows gage every year during this period. WY 1969 is particularly striking because annual stream discharge at the Wild Crossing gage (156,0000 AF) was 135,000 AF lower than discharge at the Lower Narrows gage (291,000 AF), a decrease of approximately 46 percent.[15]

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[12] Lines, G.C. (1996). Ground-water and surface-water relations along the Mojave River, Southern California: U.S. Geological Survey Water-Resources Investigations Report 95-4189, 43 p.

[13] The Wild Crossing gage was not active until March 1, 1966, thus may underestimate the annual discharge for WY 1966.

[14] This is a reasonable approximation, even though it ignores Base Flow and evapotranspiration, because most of the flow measured at the Wild Crossing gage and the Barstow gage are from episodic storm events. However, evapotranspiration along the stream course may require further evaluation.

[15] WY 1969 represents the largest amount of discharge on record for the Lower Narrows, Wild Crossing, and Barstow gages.

The consistent pattern of lower stream discharge at the Wild Crossing gage compared to the Lower Narrows gage during this period indicates that stream discharge at the Lower Narrows gage was more likely than not significantly greater than stream discharge entering the Centro Subarea. Furthermore, the consistent pattern indicates that significant net stream recharge to groundwater from the Mojave River likely occurred in the Transition Zone.

Figure 3 shows that the average annual stream discharge for WY 1966-1970 decreased substantially between the Lower Narrows and Wild Crossing gages (i.e., by approximately 51,500 AFY). The total average annual net stream recharge between the Lower Narrows gage and the Barstow gage for the WY 1966-1970 period was approximately 59,500 AFY (**Figure 3**). Thus, 86 percent of the total net stream recharge between the Lower Narrows and Barstow gages occurred between the Lower Narrows gage and the Wild Crossing gage, i.e., in the Transition Zone (**Figure 3**). Net stream recharge between the Wild Crossing gage and the Barstow gage (i.e., the Centro Subarea) represents only 14 percent of the total net stream recharge between the Lower Narrows and Barstow gages.

As noted, net stream recharge in the Transition Zone averaged approximately 51,500 AFY for WY 1966-1970. Also as noted, the Judgment specifies that Subsurface Flow into the Centro Subarea from the Transition Zone is 2,000 AFY. Thus, the fate of the Transition Zone net stream recharge is unclear without further analysis, which is discussed below.

Groundwater Extractions

Groundwater extraction data were obtained for 1951-1973 and WY 1994-2022 from the Mojave Water Agency (MWA).[16] Data were analyzed for 1966-1970 and WY 1994-2022 to determine annual groundwater extractions in the Transition Zone. Data from the earlier period were scanned from hard copy and digitized. Data from the later period were provided digitally. **Figures 4** and **5** show the wells for which extractions were reported for the 1966-1970 and WY 1994-2022 periods, respectively. Groundwater extractions were compared to stream recharge to assess if extractions may account for the fate of the Transition Zone stream recharge.

The upper panel of **Figure 6** compares the annual stream recharge in the Transition Zone to the annual reported groundwater extractions. As noted, the WY 1969 stream discharge and recharge were anomalously high. They are statistical outliers, which may cause the average value of stream recharge for WY 1966-1970 to be skewed high when compared to average groundwater extractions, which typically do not have extreme changes year to year.

Rather than comparing average values for this period, the median values of annual stream recharge (33,234 AFY) and annual groundwater extractions (30,287 AFY) for the 1966-1970 period were compared. The median values suggest that most of the Mojave River net stream

[16] Jeff Ruesch, Mojave Water Agency, email communications, July 2023.

recharge to groundwater in the Transition Zone during the 1966-1970 period was extracted by the approximately 260 wells completed in the Transition Zone at that time (**Figures 4** and **6**).

Transition Zone groundwater extractions in the 1966-1970 period may have facilitated higher net stream recharge by sufficiently changing the hydraulic gradient between the River and groundwater enough to induce stream recharge. This could occur even while water levels in key piezometers remain relatively constant. If so, the water-level data may appear to show that the change in groundwater storage in the Transition Zone is zero, when in fact the groundwater flow system is highly dynamic and may include significant net stream recharge.

The lower panel of **Figure 6** shows groundwater extractions in the Transition Zone for the 1966-1970 and WY 1994-2022 periods. The median value for 1966-1970 was 30,287 AFY. The median value for WY 1994-2022 was 11,522 AFY. This is a significant decrease in pumping, likely due to implementation of the Judgment. This decrease may suggest that recent and current net stream recharge in the Transition Zone is minimal compared to the WY 1966-1970 period.

However, a reasonable hypothesis is that significant net stream recharge continued to occur proportionately in the Transition Zone in the recent past and is currently occurring. The analysis described above suggests that groundwater extractions, on average, may remove an equivalent volume of net stream recharge from the Transition Zone. If so, surface water inflow to the Centro Subarea may be overestimated when based on the adjusted stream discharge measured at the Lower Narrows gage, because there may be unaccounted stream losses in the Transition Zone.

Additionally, the occurrence of Transition Zone stream losses and the effect of groundwater extractions and phreatophytes on streamflow losses and stream discharge in the Mojave Basin has been noted in previous reports prepared by others.[17,18] Furthermore, it should be noted that 15,095 AF of treated wastewater was discharged to the Transition Zone downstream of the Lower Narrows stream gage during WY 2022.[19]

OUTLINE OF PROPOSED WORK TO FURTHER EVALUATE THE TRANSITION ZONE WATER BUDGET

Watermaster was directed by the Court in 2022 to re-evaluate the Production Safe Yield (PSY) for each Subarea. **Aquilogic** believes a rigorous reevaluation must include a detailed

[17] Stamos, C.L., Martin, P., Nishikawa, T., and Cox, B.F. (2001). Simulation of ground-water flow in the Mojave River Basin, California. U.S. Geologic Survey Water-Resources Investigations Report 01-4002 Version 1.1.

[18] Todd Engineers (2013). Final report: Conceptual hydrogeologic model and assessment of water supply and demand for the Centro and Baja Management Subareas, Mojave River Groundwater Basin. Prepared by Todd Engineers and Kennedy/Jenks Consultants for the Mojave Water Agency. July.

[19] Watermaster (2023). Twenty-ninth annual report of the Mojave Basin Area Watermaster, water year 2021-2022, City of Barstow et al. v. City of Adelanto et al. Riverside County Superior Court Case No. 208568, Riverside County. May 1.

redetermination of the Transition Zone water budget. Material presented to date by Watermaster does not appear to have included a redetermined Transition Zone water budget.[20]

The analyses performed to date by **aquilogic** and others suggest that groundwater flow dynamics and the Transition Zone water budget are complex. The analyses provide a foundation for deeper evaluation of the Transition Zone water budget and its evolution through time. For example, the **aquilogic** analyses reported here can form components of an overall water budget evaluation. The objective of such an evaluation would be to provide an in-depth analysis of the volume of water that flows into the Centro Subarea annually.

A complete water budget would include all inflows, outflows, and the change of groundwater storage over time. Previous work by others can be leveraged to support development of a complete water budget. For example, the Judgment specifies that 2,000 AFY of groundwater flows into the Centro Subarea from the Transition Zone. This flow rate was specified before in-depth modeling was conducted by the U.S. Geological Survey (USGS) or MWA. A deeper analysis may reveal that this specified flow rate is too low or too high.

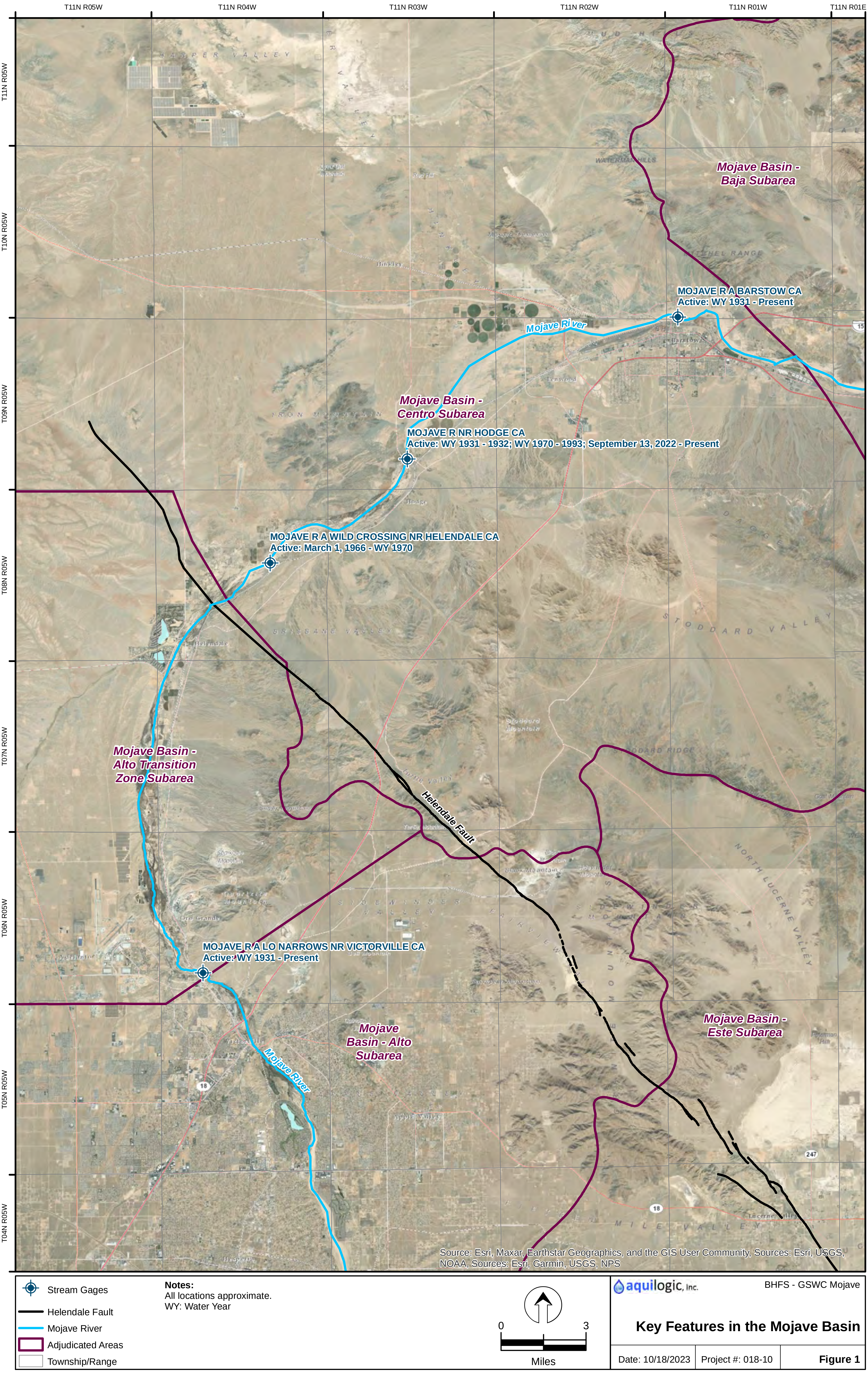
Groundwater flow into the Centro Subarea occurs in the Mojave River alluvium, in deeper horizons across the Helendale Fault, and other areas along the Transition Zone-Centro Subarea boundary (**Figure 1**). This flow rate is difficult to assess without using a groundwater flow model. A groundwater model can be used to contribute to a complete water budget evaluation by calculating the transient change in groundwater storage and groundwater flow rates that cannot otherwise be determined due to lack of data in key locations. **Aquilogic** strongly recommends that the current Mojave Basin groundwater flow model used by Watermaster be updated to include the entire basin, as soon as possible. In its current form, it is premature to use the model for any analyses involving the Transition Zone.

The water budget for the Transition Zone should be developed with sufficient detail and rigor to at least meet Sustainable Groundwater Management Act (SGMA) regulations for historic and current water budgets. A preliminary list of tasks to be performed includes, but may not be limited to, the following:

- Compile and review available previous work by others on groundwater flow and water budgets in the Alto and Centro Subareas, including the Transition Zone
- Evaluate the usefulness of the USGS Basin Characterization Model (BCM)[21] and the Parameter-elevation Regressions on Independent Slopes Model (PRISM)[22] dataset for application to the Transition Zone water budget

[20] Watermaster (2024). Groundwater Model and Production Safe Yield Update. Watermaster presentation prepared by Wagner and Bonsignore, Consulting Civil Engineers. Mojave Water Agency / Watermaster Board Meeting, January 24, 2024.
[21] https://ca.water.usgs.gov/projects/reg_hydro/basin-characterization-model.html
[22] https://prism.oregonstate.edu/

- Evaluate groundwater levels in the Transition Zone from WY 1931-present, with particular focus on the WY 1966-1970 and WY 1994-2022 periods to support the analyses described above
    - Estimate evapotranspiration by standard methods, including the use of satellite and areal images, and compare with previous studies
    - Compile all available water level data for the Transition Zone
    - Evaluate the water level data in terms of changes in well hydrographs and spatial water-level distributions over time
    - Determine if groundwater levels increased, decreased, or remained the same during the WY 1966-1970 period
- Use the USGS model and the updated MWA model (if and when available) to further evaluate the WY 1966-1970 period
    - Update the USGS model as needed, including groundwater extractions and potentially extending the model in time
    - Evaluate Transition Zone changes in groundwater storage, stream recharge, effects of evapotranspiration, groundwater extractions, and surface and groundwater flow into the Centro Subarea
- Critically evaluate results and available previous work to determine the best estimate of the Transition Zone water budget
- Identify data gaps and limitations in the analyses
- Effectively communicate the results to stakeholders
- Thoroughly document the analyses and prepare both draft and final reports

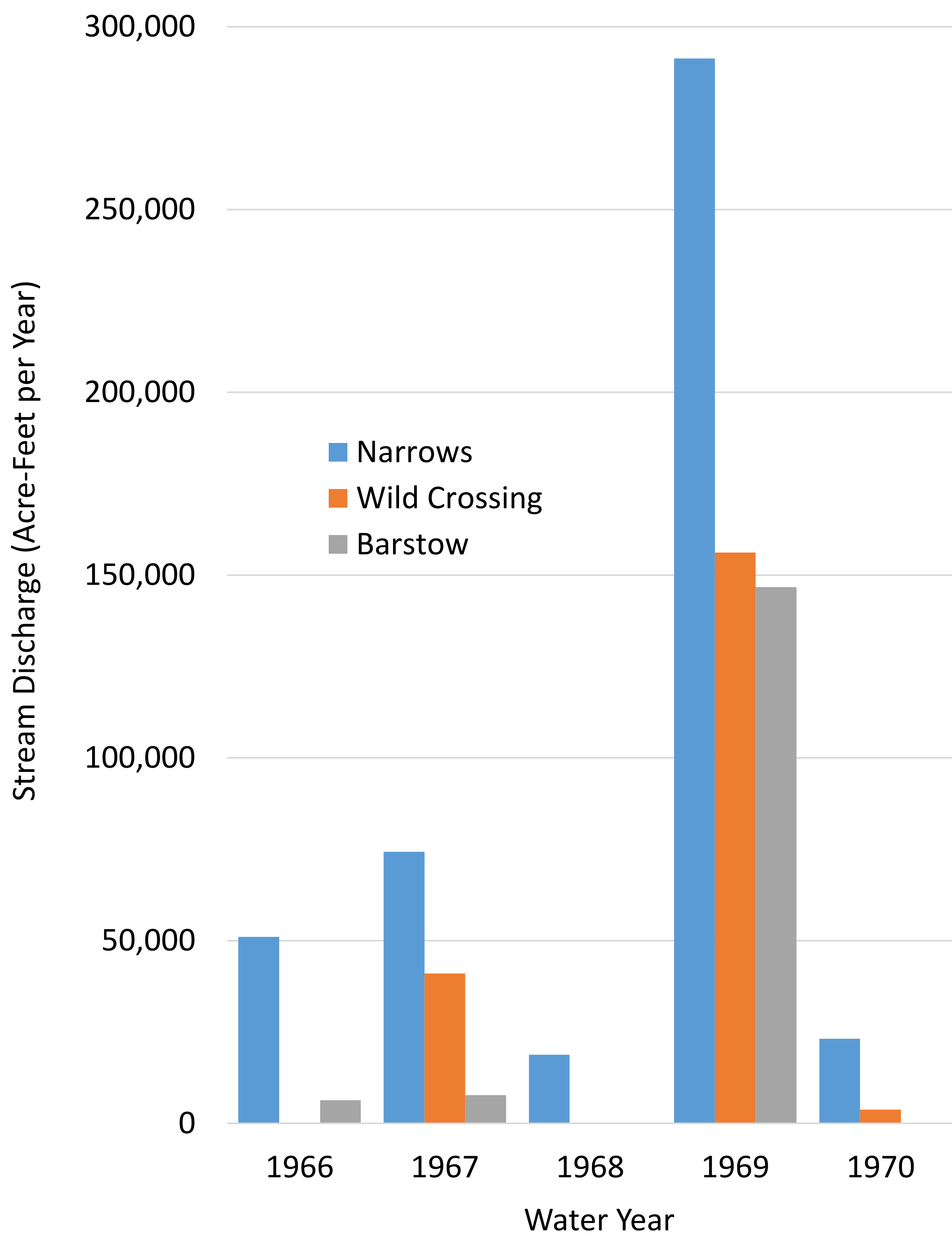


aquilogic, Inc.

BHFS - GSWC Mojave

Key Features in the Mojave Basin

Date: 10/18/2023 | Project #: 018-10 | **Figure 1**



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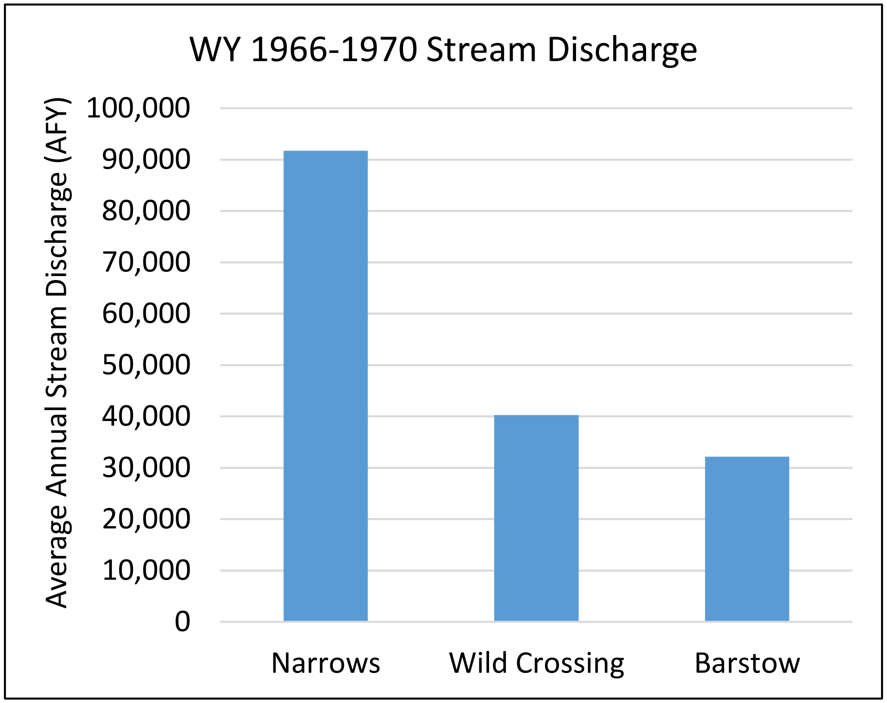
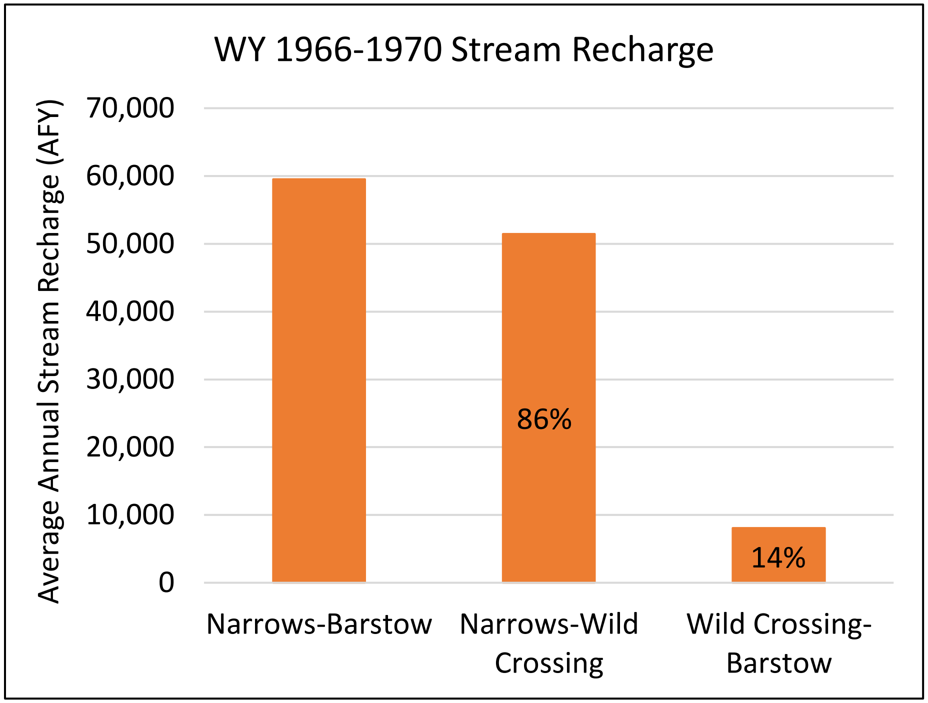
Stream Discharge along the Mojave River

Date: 10/25/2023	Project #: 018-10	**Figure 2**





AFY: Acre-Feet per Year
WY: Water Year

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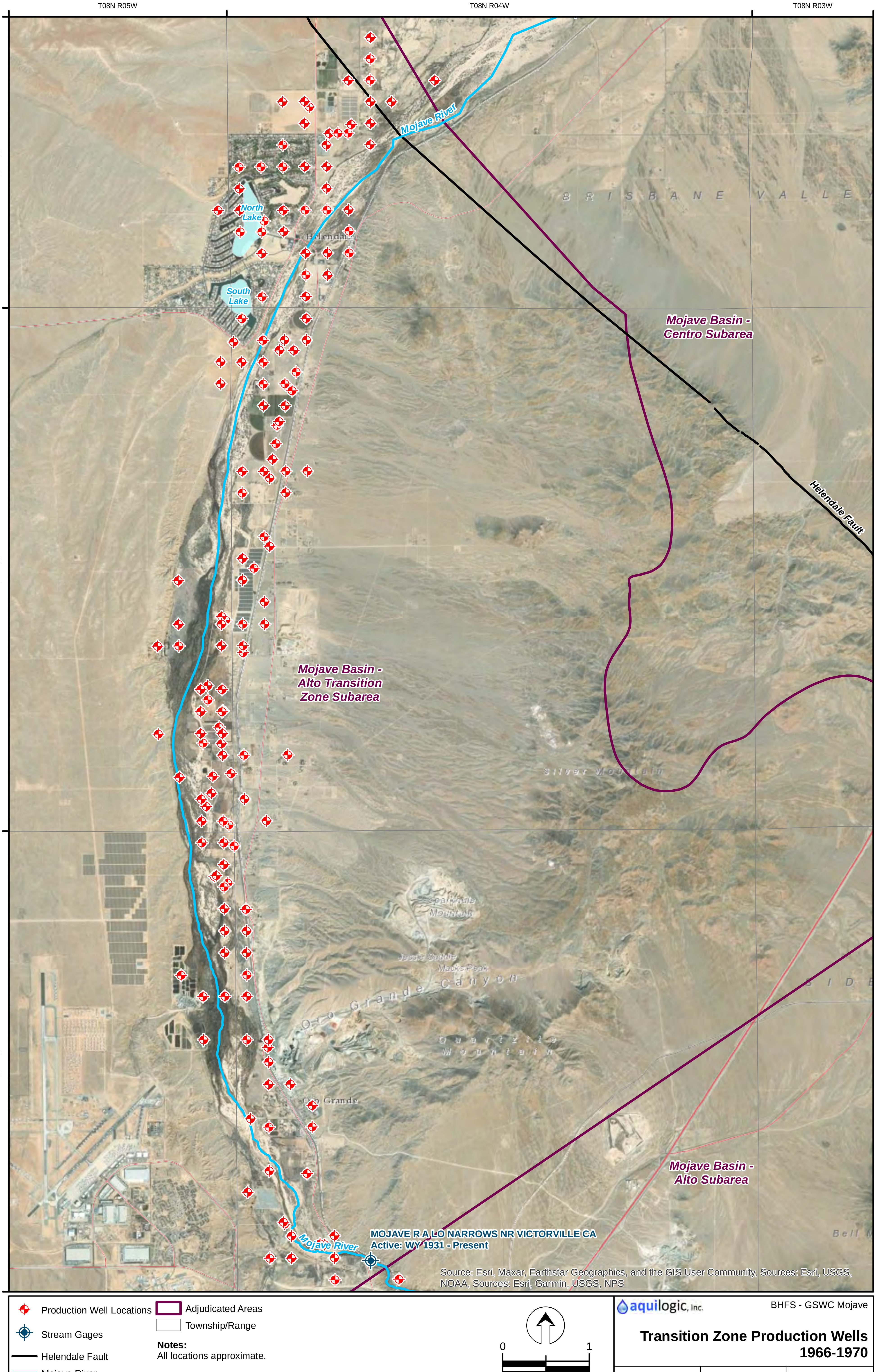
Stream Discharge and Recharge

Date: 2/23/2024 | Project #: 018-10 | **Figure 3**



Production Well Locations
Stream Gages
Helendale Fault
Mojave River
Adjudicated Areas
Township/Range

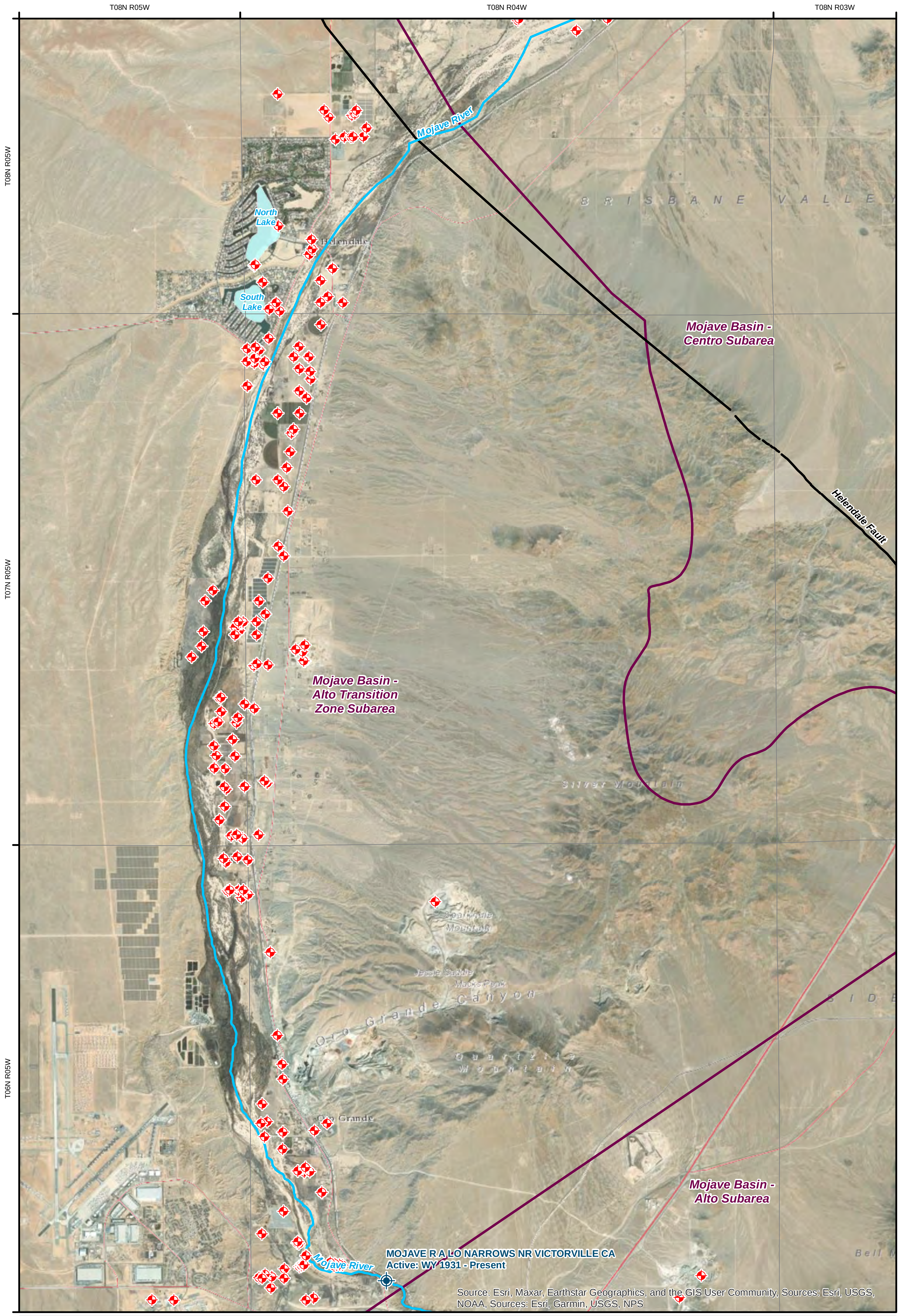
Notes:
All locations approximate.

aquilogic, Inc.

BHFS - GSWC Mojave

Transition Zone Production Wells 1966-1970

Date: 10/18/2023 | Project #: 018-10 | **Figure 4**



Production Well Locations
Stream Gages
Helendale Fault
Mojave River
Adjudicated Areas
Township/Range

Notes:
All locations approximate.
WY: Water Year

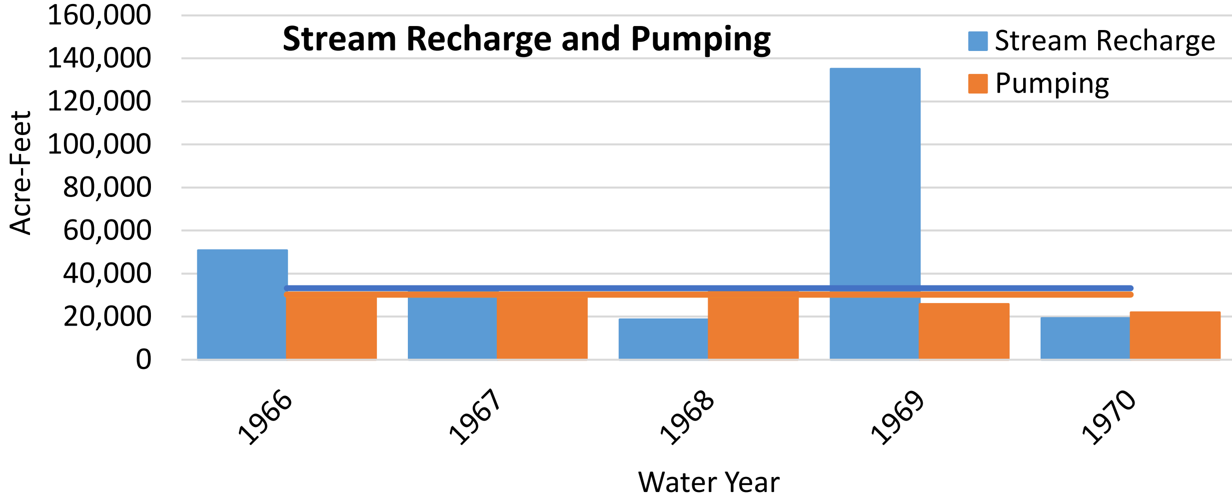
0 1
Miles

aquilogic, Inc.

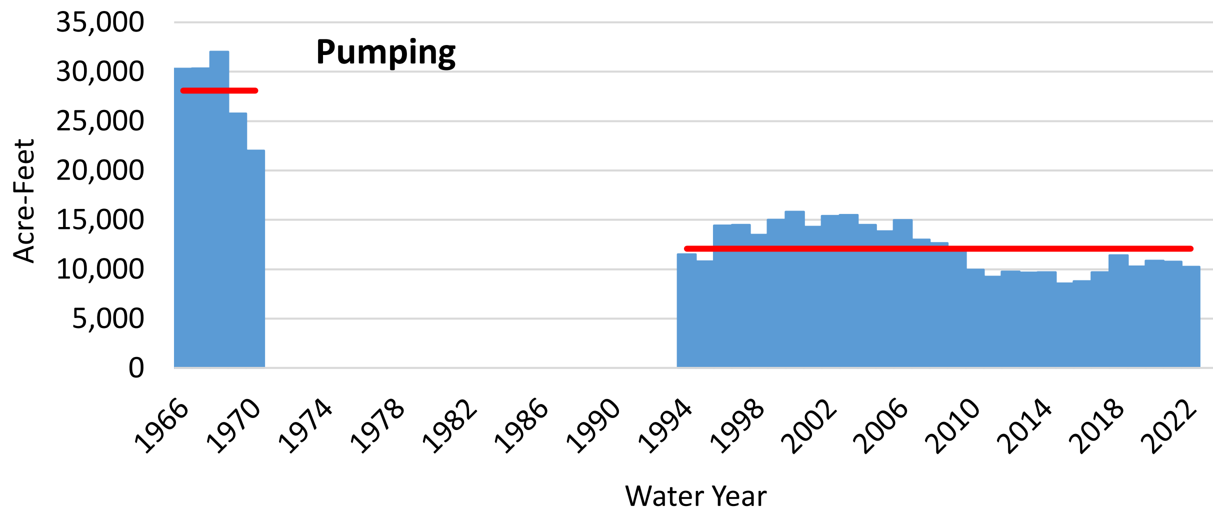
BHFS - GSWC Mojave

Transition Zone Production Wells
WY 1994 - 2022

Date: 10/18/2023	Project #: 018-10	**Figure 5**



1966-1970
Median Stream Recharge = 33,234 AFY
1966-1970
Median Pumping = 30,287 AFY



1966-1970
Median = 30,287 AFY

1994-2022
Median = 11,522 AFY

AFY: Acre-Feet per Year

aquilogic, Inc.

BHFS- GSWC Mojave

Average Annual Stream Transition Zone Recharge and Pumping

Date: 10/25/2023	Project #: 018-10	**Figure 6**

PROOF OF SERVICE

I am over the age of eighteen years and not a party to the within-entitled action. I am employed in Santa Barbara County, California. My business address is Brownstein Hyatt Farber Schreck, LLP, 1021 Anacapa Street, 2nd Floor, Santa Barbara, California 93101-2711. My electronic service address is Meldridge@bhfs.com. On May 21, 2024, I served a copy of the following document(s):

DECLARATION OF ROBERT H. ABRAMS IN SUPPORT OF GOLDEN STATE WATER COMPANY'S OPPOSITION TO MOJAVE WATER AGENCY'S MOTION TO ADJUST FREE PRODUCTION ALLOWANCE FOR WATER YEAR 2024-2025

☒ BY E-MAIL OR ELECTRONIC TRANSMISSION: I caused a copy of the document(s) listed above to be sent to the persons at the e-mail addresses listed below

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I declare under penalty of perjury under the laws of the State of California that the above is true and correct. Executed on May 21, 2024, at Santa Barbara, California.

Melissa Eldridge

PROOF OF SERVICE

STATE OF CALIFORNIA }
COUNTY OF SAN BERNARDINO}

I am employed in the County of the San Bernardino, State of California. I am over the age of 18 and not a party to the within action; my business address is 13846 Conference Center Drive, Apple Valley, California 92307.

On May 22, 2024, the document(s) described below were served pursuant to the Mojave Basin Area Watermaster's Rules and Regulations paragraph 8.B.2 which provides for service by electronic mail upon election by the Party or paragraph 10.D, which provides that Watermaster shall mail a postcard describing each document being served, to each Party or its designee according to the official service list, a copy of which is attached hereto, and which shall be maintained by the Mojave Basin Area Watermaster pursuant to Paragraph 37 of the Judgment. Served documents will be posted to and maintained on the Mojave Water Agency's internet website for printing and/or download by Parties wishing to do so.

Document(s) filed with the court and served herein are described as follows:

DECLARATION OF ROBERT H. ABRAMS IN SUPPORT OF GOLDEN STATE WATER COMPANY'S OPPOSITION TO MOJAVE WATER AGENCY'S MOTION TO ADJUST FREE PRODUCTION ALLOWANCE FOR WATER YEAR 2024-2025

_X_ (STATE) I declare under penalty of perjury under the laws of the State of California that the above is true and correct.

Executed on May 22, 2024 at Apple Valley, California.

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Attn: Katherine Hill (Khill9@comcast.net)
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Attn: Anne Roark
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Mission Viejo, CA 92691-

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Holway Jeffrey R and Patricia Gage (via email)
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Denver, CO 80202-1348

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Covina, CA 91722-0432

Attn: Sandra D. Hood
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Jackson, James N. Jr Revocable Living Trust
1245 S. Arlington Avenue
Los Angeles, CA 90019-3517

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Jackson, Ray Revocable Trust No. 45801
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906 Old Ranch Road
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Dammeron Valley, UT 84783-5211

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Jones Trust dated March 16, 2002 (via email)
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Jones, Joette
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Attn: Ray Gagné
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Attn: Lee Logsdon
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Mojave Basin Area Watermaster Service List as of May 22, 2024

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Mojave Basin Area Watermaster Service List as of May 22, 2024

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Mojave Basin Area Watermaster Service List as of May 22, 2024

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Mojave Basin Area Watermaster Service List as of May 22, 2024

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