9 Lessons Learned and Recommendations

The AID MZ archetype was developed to:

c. Establish a salt and nitrate management area (zone) consistent with the expected framework for developing a local/regional SNMP; and

d. Test the application of selected policies, data analysis methods, and salt and nitrate management approaches that are currently being considered by CV-SALTS.

Based on the results from the AID MZ archetype analysis, lessons learned and recommendations were identified for additional approaches and considerations that could be useful during the development and/or implementation of local/regional SNMPs. The lessons learned and recommendations are organized according to the following major elements of an SNMP, which are relevant to the AID MZ and future SNMPS and MZs.

7. Salt and nitrate management goals and objectives;
8. Boundary delineation;
9. Basin/subbasin characterization, including groundwater quality characterization (i.e., ambient groundwater quality, trends and assimilative capacity) and land cover and soils;
10. Tools for assessing salt and nitrate source loading, salt and nitrate fate and transport, and future assimilative capacity estimates;
11. Impact of a range of management scenarios on groundwater quality; and
12. Monitoring and other considerations related to ongoing salt and nitrate management.

9.1 SALT AND NITRATE MANAGEMENT GOALS AND OBJECTIVES

For the AID archetype, salt and nitrate management goals were developed in coordination with stakeholders using a targeted approached focusing on the highest priority issues within the area. Although the goals are non-binding, they assisted the stakeholders in providing a context within which to test the various salt and nitrate management options and/or policies that could be established for the AID MZ. The goals broadly focus on: 1) supporting sustainable management of surface water and groundwater supplies, and 2) protecting surface water and groundwater quality and beneficial uses.

It is recommended that groups developing local/regional SNMPs or MZs consider the following:

1. Conduct outreach efforts to ensure the appropriate stakeholders are part of the SNMP/MZ planning process.
2. Determine an appropriate planning horizon. As seen with the AID results, 10 and 20 year timelines were relatively short to evaluate the effectiveness of management scenarios. Other considerations include ranges from 10, 20, 50, and 100 years and/or comparisons amongst those timeframes. Pending the hydrogeologic setting, current groundwater quality conditions and future land and water use management strategies, long planning horizons may be beneficial.
3. Establish short and long-term goals in the context of currently observed conditions in the SNMP/MZ, monitoring needs, planned land use and water resources development and

management, and overall sustainable management and groundwater quality and beneficial use protection objectives.

4. Coordinate SNMP/MZ goals with other basin/subbasin goals (i.e., SGMA GSP, IRWMP, ILRP, etc.).
5. Consider goals that deal directly with protecting and/or improving groundwater quality in the vicinity of drinking water supplies for urban and rural communities.
6. Develop details at the scale needed to accomplish the desired SNMP/MZ objectives. It may be helpful to coordinate with SGMA GSAs related to development of quantifiable objectives, and interim milestones and thresholds to ensure such measures are reasonable and feasible on the timelines being proposed.

9.2 BOUNDARY DELINEATION

The delineation of a SNMP or MZ boundary should be defined to achieve the salt and nitrate management objectives at local/regional scales and can either be pre-selected without technical analyses or selected after technical analyses are conducted.

For the AID archetype, the boundary was pre-selected, thus this determination was based on a jurisdictional boundary instead of technical analyses. The archetype study area was expanded as a result of the ultimate interest in using a groundwater flow and transport model as a tool for assessing short and long-term salt and nitrate management strategies or scenarios. The AID MZ modeled area was greater in area than the MZ area based on hydrologic considerations and groundwater modeling requirements. The development of such modeling tools for future local entities interested in testing short and long-term salt and nitrate management scenarios will benefit from a more regional approach. This may include use of a modeling tool that allows consideration of a range of parameters and strategies. Modeling tools may have their own constraints; however, they can be used to inform other planning and implementation needs.

It is recommended that groups developing local/regional SNMPs or MZs consider the following:

1. Identify the key drivers for the delineation of the horizontal and vertical boundaries for the local SNMP (including the physical setting, political/institutional, regulatory, management, and/or existing or planned analysis tools). Additional factors to consider when delineating an MZ area are included in the Preliminary Draft SNMP, Appendix D (2016). Local and regional entities would benefit by selecting SNMP areas that align with other water resources planning efforts such as the Sustainable Groundwater Management Act 2014 (SGMA) Groundwater Sustainability Plans (GSPs) and/or Integrated Regional Water Management Plans (IRWMPs), which often have monitoring programs and/or other data collection efforts that may inform the SNMP. Similarly, other planning efforts that have resulted in knowledge about surface water and/or groundwater quality in a local/regional entity's area can provide important foundational information for the development of an MZ and/or local SNMP.
2. Consideration of factors such as current groundwater quality conditions and trends and future water resources management strategies can help inform the selection of the SNMP/MZ area. For example, an MZ that has too small a boundary may be constrained by the benefits recognized at a larger scale, such as with the implementation of groundwater recharge projects located outside the MZ area. Selection of a larger area

may afford additional management strategy and/or regulatory flexibility compared with smaller SNMP/MZ areas. On the other hand, too large an SNMP/MZ area may overly complicate the implementation of effective management strategies.

3. Develop a preliminary physical conceptualization of the SNMP/MZ area, such as defining the horizontal and vertical delineations of the upper, lower, and production zone areas of the aquifer system. More details on the physical delineation of the aquifer system may be needed for applying selected tools to analyze management scenarios. However, an initial understanding the groundwater quality for the SNMP/MZ area will help inform the overarching salt and nitrate management objectives and approaches.
4. Identify hydrogeologic factors associated with the structure of previous existing modeling platforms (e.g., land surface/loading models, existing groundwater models, etc.) that will need to be considered when newly defined MZs are created and whether such models are applicable for SNMP/MZ purposes.
5. Unless an SNMP/MZ area is aligned with the California Department of Water Resources (DWR) basin or subbasin boundaries (i.e., as currently designated or as may be approved under the SGMA boundary modification process), an SNMP/MZ area should not be referred to as a basin. The California Water Code makes reference to DWR basins in a very specific context, it would be confusing to create new “basins” or “subbasins” at the local level simply for the purposed of the SNMPs. As needed, areas of analysis for SNMPs could, alternatively, be referred to as subareas or MZs.

9.3 BASIN/SUBBASIN CHARACTERIZATION, INCLUDING GROUNDWATER QUALITY CHARACTERIZATION AND LAND COVER AND SOILS

9.3.1 Groundwater Quality Characterization

The acquisition of all available data, and, in particular, for wells of known construction, makes an important difference in the understanding of ambient groundwater quality, assimilative capacity, and historic trends.

For the AID archetype, a confidential database (CDWSAP) providing accurate locations of public supply wells and well construction information was obtained for the archetype analyses. While not exhaustive, the database contains an inventory of drinking water supply wells with accurate locations obtained by GPS, and the associated perforations and depth of the wells. This database was used to update locations of CDPH wells within the AID modeled area and to identify which portions of the aquifer system the water quality results represent for those wells that have well construction information. The ability to use this confidential information greatly improved the groundwater quality database in the model area vicinity.

Few water quality tests from irrigation wells were available for the AID modeled area. In lieu of direct measurements of irrigation wells, groundwater quality data for other well types were used in combination with the limited irrigation well water quality data to estimate groundwater quality for the production zone of the aquifer system.

While the groundwater quality dataset for the AID modeled area was deemed adequate for assessing ambient conditions and assimilative capacity, data gaps were present. There was adequate data coverage for the AID modeled area, but some areas have better coverage than others. In terms of historical data availability, there is a much greater amount of data available in recent years from 2000-2015.

Additional data gaps include the need for a better understanding of irrigation well water quality as well as location/construction information from more wells for model calibration. Few groundwater quality tests were available for irrigation wells; therefore, irrigation well production water was estimated using other groundwater quality data sources. For model calibration, wells with construction information (top and bottom perforated interval), a precise well location, and several water quality tests (greater than 10 tests) from 1991 to 2000 were used to calibrate the model by comparing known water quality with modeled water quality. While wells with these criteria were available for most of the modeled area, there are data gaps in the west and south that do not have wells for model calibration.

It is recommended that groups developing local/regional SNMPs or MZs consider the following:

1. Assess the distribution of groundwater quality data in the context of the physical conceptual model recommended above, i.e., distribution of wells with available data, precision of well location information, construction information for the monitored wells, historical record for the monitored wells, types of monitored wells, etc.
2. The stakeholders involved in the development of a SNMP/MZ should obtain construction data for drinking water wells and other monitored wells as early as possible (this process can take three to six months or more to complete) in order to improve the efficiency of the data analysis and characterization effort.
3. Identify data gaps and develop a plan to address data gaps as needed relative to the goals, objectives, and management strategies for the SNMP/MZ.

Additionally, the AID ambient groundwater quality and assimilative capacity analyses illustrated the utility of higher resolution detail for the various zones of the groundwater system. The additional groundwater quality detail used for the AID MZ allowed a greater spatial understanding of current groundwater quality conditions, trends, and assimilative capacity based on actual groundwater quality observations. When groundwater quality data are averaged and aggregated over a local or regional area, the details that help inform the SNMP/MZ entity of the effectiveness of management strategies and particularly areas that remain in balance, improve and/or become impaired will be obscured with aggregated types of methodologies and visualizations.

It is recommended that groups developing local/regional SNMPs or MZs consider the following:

1. Develop and utilize higher resolution details at a level appropriate to the data available.
2. Utilize the distribution of available data to determine whether data gaps need to be addressed.
3. Utilize higher resolution details to determine ambient groundwater quality and assimilative capacity.

9.3.2 Land Cover and Soils

Future refinements of water, salt, and nitrate balances should update the representation of recently converted land cover classes, especially when changes are likely to have a strong influence on results.

For the AID archetype, available information was used to characterize land cover and soils characteristics in the MZ area. Real land cover is dynamic, but data related to land cover are less so. The CVHM model employs DWR land cover data to represent most irrigated lands that comprise most of the Central Valley acreage.

It is recommended that groups developing local/regional SNMPs or MZs consider the following:

1. Refine land use classes for mixed or blended classes of crops (e.g., other row crops);
2. Aggregate land use classes with small percentages of total land use and loading where possible;
3. Perform sensitivity analyses for soil classes and parameters and refine soil data from STATSGO, if appropriate, to the more detailed SSURGO mapping and parameters;
4. Refine land use classes for Urban, Commercial, and Industrial related to imperviousness; and
5. Check land use class parameters against actual documented characteristics and practices.

9.4 TOOLS FOR ASSESSING SALT AND NITRATE SOURCE LOADING, SALT AND NITRATE FATE AND TRANSPORT, AND FUTURE ASSIMILATIVE CAPACITY ESTIMATES

9.4.1 Assessing Surface Loading to Groundwater

For the AID archetype, available information was used in conjunction with the SWAT model to estimate hydraulic, salinity, and N loadings from root zones to the groundwater basin under different management scenarios. This information was used as input to the predictive model.

Nitrogen leaching rates responded as expected to more efficient use of fertilizer and irrigation water. This suggests that, in relative terms, ongoing actions to implement N management improvements through the Dairy General Order and Irrigated Lands Regulatory Program, should have the desired effect of reducing N loading from irrigated lands (including dairy land application areas). Some additional reductions in N leaching, as well as TDS loading, should result from anticipated shifts to more efficient irrigation systems. However, it may be important to offset reductions in hydraulic loading on agricultural lands with increases in high-quality recharge at some locations. Otherwise, despite loading reductions, the concentration of recharge could increase.

Salt and nitrate loading are the primary drivers for the AID MZ computations, or any related type of analysis. Therefore, more accurate data regarding this loading will make future analyses more reliable.

It is recommended that groups developing local/regional SNMPs or MZs consider the following:

1. Utilize the best available data for actual applied water quality (surface and groundwater qualities applied to lands, and the proportions of each source employed for irrigation).
2. Use best available data for actual (organic and inorganic) fertilizer and amendments applied to each land cover class. The amount of N is the most critical parameter, but as analyses become more refined, it would become helpful to know field-specific rates, forms, and timing of application and verify through comparing estimated fertilizer application with fertilizer sales/use data.

3. Refine nitrogen loading parameters for dairy solids to include forms of nitrogen.
4. Assess regional variations in gaseous N losses (volatilization, denitrification) in soils and aquifers.
5. Conduct refinements with focus on calibrating and validating crop models for Central Valley agricultural systems to ensure that crop functions, such as ET and N uptake, are accurately predicted. For example, compare modeled plant N update with harvest data and harvest N content data. This will improve the ability to predict loading with greater absolute accuracy.
6. Relatively smaller loading sources, such as urban land uses and septic systems, deserve more detailed development such as building POTW and recharge land uses into the SWAT model to avoid the need for post-processing.

9.4.2 Groundwater Flow and Quality Modeling

During the course of groundwater model development and application there will likely be hydrogeologic factors associated with the structure of existing modeling platforms that will need to be considered when newly defined MZs are created. These may include the addition of model layers to add to the understanding of the subsurface heterogeneity, as well as the addition or movement of groundwater production wells and alteration of pumping amounts for both agricultural and domestic uses to better reflect local conditions. Refining a pre-existing model grid using a smaller scale may also be helpful. Changes may also be necessary to adjust or refine land cover and water application rate differences between a pre-existing model and one used for SNMP/MZ purposes.

The hydrogeologic settings in many parts of the Central Valley, especially the central to southern parts of the Valley including the AID area, are such that a significant amount of recharge occurs in a vertically downward direction – salt and nitrate move down into the lower part of the aquifer system. Other California groundwater basins, such as in the Santa Ana Region, where smaller alluvial river valleys involve more overland recharge and flushing and dilution of salts within a smaller overall groundwater basin are suited to analysis using different tools than those needed for the hydrogeologic settings typical of the San Joaquin Valley Groundwater Basin where some of the more challenging salt and nitrate issues are occurring.

It is recommended that groups developing local/regional SNMPs or MZs consider the following:

1. Modeling tools for SNMP/MZ analyses and assessment of future management actions can be simpler or more complex, i.e., tools might include GIS relational models, spreadsheet mass balance computations, and/or groundwater flow and transport models. The latter is typically useful for more complex basins/subbasins, and or areas where groundwater quality in one or more parts of the aquifer system is already significantly impaired. A simpler model (a spreadsheet) may be appropriate when groundwater quality in the SNMP/MZ area is generally good and planned management strategies and analysis of future conditions is more straightforward. Even simpler modeling tools still benefit from the use of higher resolution details, particularly when predictions are made.
2. The groundwater transport modeling could be refined to better account for local distribution of nitrogen, salt, and recharge inputs and flow field effects due to pumping and other water management scenarios.

3. Existing groundwater model platforms should be evaluated for their utility for application to salt and nitrate planning and management. For areas where no model has been developed, CVHM could be considered for use, or local entities may choose to develop their own local model with another modeling approach.
4. A modeling tool that can simulate very long timeframes and accommodate a wide variety of variables may be needed to effectively assess the potential effectiveness of proposed management strategies.
5. If the groundwater flow and transport model domain encompasses the MZ boundary as well as a buffer of the surrounding area in order to minimize boundary effects, the SNMP/MZ stakeholders should reach out to other key stakeholders in the surrounding areas to ensure that they are involved and understand the analyses that are being conducted as well as the results of such analyses (especially since the surrounding areas could be included in key graphics, maps, etc. summarizing the results).

9.5 IMPACT OF A RANGE OF MANAGEMENT SCENARIOS ON GROUNDWATER QUALITY

An analysis of several management scenarios was performed using the AID MZ model to evaluate the effects of short and long-term strategies for managing salt and nitrate in the AID MZ. This analysis indicated that, even after 100 years, the aggressive management scenario resulted in minimal differences in ambient groundwater quality compared to the baseline.

It is recommended that groups developing local/regional SNMPs or MZs consider the following:

1. Use a predictive modeling tool to evaluate different management scenarios for their planning area to understand the effect of those management practices on the quality of groundwater over time. The development and use of predictive modeling tools provides information that is of high value to answer key questions pertaining to groundwater management plan development, and is otherwise, unavailable.
2. Work with stakeholders (including stakeholders involved with other programs, such as ILRP, Dairy, SGMA GSPs) to identify meaningful management alternatives for their planning area. Consider both planned changes and aggressive future management alternatives to allow an understanding of the ability to achieve groundwater objectives in the future.
3. Ensure that there is an adequate assemblage of data for the development and use of predictive modeling tools.
4. Develop model scenarios that clearly delineate changed conditions between scenarios (i.e., overly complicated scenarios with too many variables may make it more difficult to interpret the results).
5. Focus on management options that deal directly with beneficial use protection, given the difficulty in changing ambient groundwater quality in the short term. Projects to replace impaired drinking water supplies should be prioritized.

9.6 MONITORING AND OTHER CONSIDERATIONS RELATED TO ONGOING SALT AND NITRATE MANAGEMENT

For the AID archetype, readily available monitoring data were used for the data analyses, characterization of existing conditions, and modeling efforts. The AID archetype demonstrated different techniques to extrapolate the available data to address areas that are lacking data. Depending on the level of analysis required, identified data gaps may or may not be important to fill.

It is recommended that groups developing local/regional SNMPs or MZs consider the following:

1. Improve management zone/aquifer-specific monitoring to fill essential data gaps. The existing monitoring network(s) should be assessed to determine whether the network(s) will satisfy longer-term water quality monitoring interests and needs, for example:
    a. Can baseline conditions be adequately described in the vicinity of a planned project that involves recycled water use or other management actions?
    b. Are monitoring wells optimally located relative to key sources of community groundwater supplies in relation to significant recharge areas?
2. Evaluate the historical data record for existing monitoring wells with respect to its suitability to adequately characterize present groundwater quality conditions. This includes the following characteristics:
    a. Construction information for monitored wells such that the groundwater quality data can be appropriately used to represent the corresponding parts of the aquifer system;
    b. Spatial distribution is adequate to establish ambient groundwater quality conditions and preliminarily assess assimilative capacity; and
    c. The historical period provides some indication of whether trends are stable, improving, or degrading.
3. Coordinate with other existing monitoring programs (e.g., GAMA, ILRP, Dairy, IRWMP, SGMA GSP), including emphasis on the design of a network at the basin/subbasin scale that can be used to assess regional trends in salt and nitrate while factoring in data collected under the regulatory purview of site-specific discharges (e.g., POTW, food processor, septic systems, etc.)
4. Local entities (SNMPS/MZs), whenever possible, perform their own monitoring or in coordination with other local/regional programs. Outreach efforts by local managing entities will facilitate the identification of existing monitoring efforts that can be coordinated and datasets can be combined datasets for ambient water quality, trends, and assimilative capacity analyses.
5. SNMP/MZ determines what is appropriate to its area that is representative of relatively shallower and deeper parts of the aquifer system (i.e., upper, lower and production zones).
6. SNMP/MZ monitoring plans and subsequent reports should proactively work to demonstrate sufficient monitoring at the program outset and/or steps that the SNMP/MZ entity will take to dynamically evolve the program (i.e., fill data gaps as they are able).

9.7 CONCLUSION

The work performed under the AID archetype provided valuable information to inform the larger CV-SALTS Central Valley SNMP and Basin Plan amendment effort. The archetype identified issues and demonstrated needs that will confront local/regional groups during the development of SNMPs and MZs.

Importantly, the AID archetype demonstrated that attainment of water quality objectives in ambient groundwater may not always be possible, assimilative capacity may not be available, and management philosophies, and that the regulatory framework must be adapted to this potential legacy condition in some areas of the Central Valley.

Given the diversity of conditions throughout the Central Valley, the findings from the AID archetype will not be indicative of other areas. However, the basic methodology for characterizing conditions, performing data analysis, developing and using predictive management models, and the development of appropriate management plans suited to local realities should be of benefit valley-wide.