10 ATTACHMENT 7 - SCHEDULES

For the "AttachmentName" in the naming convention of BMS, use "SCHED" for this attachment. Provide a detailed realistic schedule showing the timeline for each task shown on the work plan and budget. If awarded LGA grant, assume a realistic start date for your proposed project of no sooner than April 2013, and anticipate maximum 2-year performance period. The work plan, budget, and schedule must be consistent throughout the proposal. Explain how the proposed work will be ready to proceed when funding is secured including time to obtain environment and other permits and complete any CEQA documentation. Explain how obstacles would be resolved to keep on schedule, such as obtaining land owner access. Work must start and progress toward completion during the term of the grant agreement. Explain how the schedule was derived. Show appropriate subtasks.

Pursuant to CWC Section 10753.4(a) the local agency shall prepare a GWMP within two years of the date of the adoption of the resolution of intention. Therefore, for a proposal to complete or update a GWMP the completion date must be within two years of the local agency's governing board adoption of the resolution for initiation of work on the GWMP.

The Gantt chart depicting the 2012 PIXID Groundwater Banking Support Project schedule can be found in **Appendix 5-A of Attachment 5**. The schedule for the 2012 PIXID Groundwater Banking Support Project coheres with the project work plan and the Project Budget in this application. The schedule shows the 2012 PIXID Groundwater Banking Support Project beginning in April 2013 and being completed in approximately 12 months. The longest duration part of the Project is the development of a numeric groundwater well to evaluate a potential groundwater banking project.

The development of the numeric model is anticipated to require approximately 12 months and that this work will begin immediately after funding is secured/made available. The proposal submitted to the District for the development of a numeric groundwater model by the District's groundwater modeling consultant which includes an anticipated schedule can be found in **Appendix 5-B of Attachment 5**. The District has developed water balance information for the development of a numeric groundwater model in the anticipated model area from 1996 – 2009 so that there does not appear to be anything that would delay the beginning of this work. Also, as this effort is to develop a model and there will be no disturbance of any property, this effort will be able to proceed without CEQA documentation. This brief description refers to the efforts described in the application as Task 9.

- Task 9 – Developing a Numeric Groundwater Model
    - Task 9.1 – Scoping Meeting with Project Team
    - Task 9.2 – Compile Gathered Data
    - Task 9.3 – Model Development and Calibration
        - Task 9.3.1 – Hydrogeological Conceptual Model
        - Task 9.3.2 – Numerical Model Setup and Transient Calibration
        - Task 9.3.3 – Sensitivity and Uncertainty Analysis
        - Task 9.3.4 – Numerical Model Verification and Validation
        - Task 9.3.5 – Predictive Simulations
    - Task 9.4 – Model Documentation

The expansion of the District's groundwater monitoring network will take four to six months to work with landowners to find willing parties and review candidate wells for inclusion. The effort will not require any disturbance of any property and therefore will be able to proceed without CEQA documentation. The District's goal will be to have the 20 additional ag wells included in the District's groundwater monitoring network before the October 2013 groundwater measurements are collected. The District plans on beginning this effort immediately after funding is secured/made available. It is believed that there will be time to accomplish the GPS survey on the additional monitoring wells prior to the October 2013 groundwater measurements, but if there is not the survey can be accomplished after and the readings set to the new elevation datum after the survey is completed. This brief description refers to the efforts described in the application as Tasks 4 and 10.

- Task 4 – Agreement with Landowners for Use of 20 Ag/Monitor Wells
- Task 10 – GPS Survey of Additional Ag/Monitor Wells
    - Task 10.1 – Selection of Preferred Locations
    - Task 10.2 – Selection of alternative ag/monitor wells if necessary
    - Task 10.3 – GPS Survey of authorized ag/monitor wells
    - Task 10.4 – Update of previous documentation of Monitoring Network wells

The development of two new dedicated groundwater monitoring wells will take approximately 3 months to select the project locations, accomplish the preliminary biological review, design the facilities and produce the construction documents. The District's CEQA documentation will begin at almost the same time and be completed in a similar timeframe. Then there will be approximately a month of public noticing while well drilling contractors learn about the project and develop their bid proposals to the District. It is envisioned that a month after the bids are received the apparent low bidding contractor can be awarded the project and construction could begin within a matter of weeks after that. It is hoped that construction could proceed in the fall of 2013 and require approximately two months. The timeframes depicted for these tasks on the

Gantt chart found in **Appendix 5-A of Attachment 5** were developed by the District's engineering and planning consultant and are viewed as a formal proposal. This brief description refers to the efforts described in the application as Tasks 5 – 8 and 11 – 14.

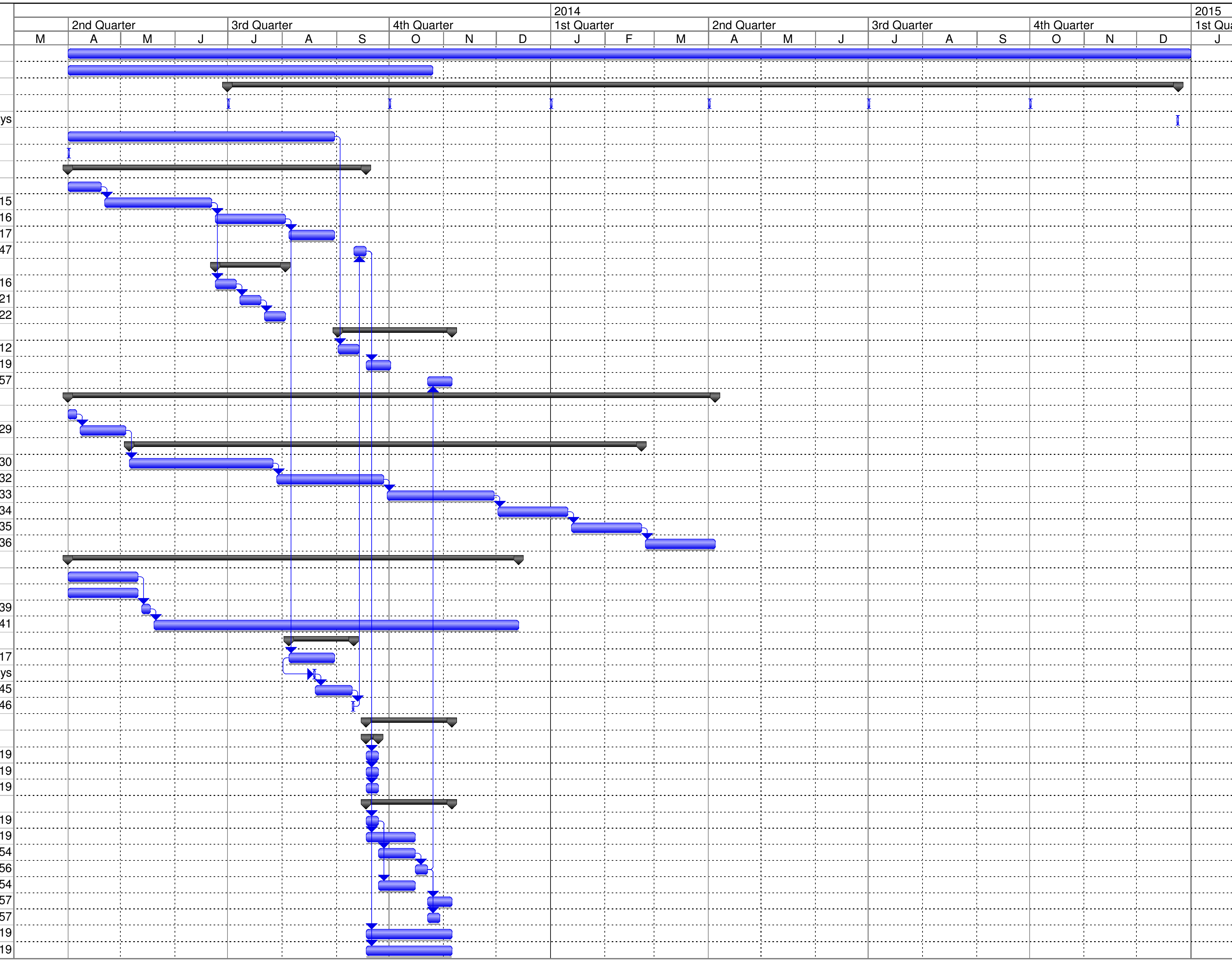
- Task 5 – Preliminary Biological Assessment
- Task 6 – Design of Dedicated Monitor Wells
    - Task 6.1 – Design Memorandum
    - Task 6.2 – Construction Drawings
    - Task 6.3 – Project Specifications
    - Task 6.4 – Solicitation and Competitive Bid Documents
    - Task 6.5 – Contract Documents
- Task 7 – Environmental Documentation
    - Task 7.1 – Environmental Checklist and Biological Assessment
    - Task 7.2 – Development of CEQA Documentation
    - Task 7.3 – Final CEQA Documentation
- Task 8 – Permitting
    - Task 8.1 – Private Property Access and GW Data Use
    - Task 8.2 – Well Driller's Permit
    - Task 8.3 – Well Completion Report
- Task 11 – Construction Contracting and Deliverables
    - Task 11.1 – Publish Notice to Bidders
    - Task 11.2 – Pre-Bid Meeting and Addendum No. 1
    - Task 11.3 – Bid Opening and Bid Evaluation
    - Task 11.4 – Bid Award
- Task 12 - Construction
    - Subtask 12.1 - Mobilization and Site Preparation
        - Subtask 12.1.1 – Mobilization
        - Subtask 12.1.2 – Worker Protection
        - Subtask 12.1.3 – Miscellaneous Facilities and Operations
    - Subtask 12.2 – Project Construction;
        - Subtask 12.2.1 – Construction Staking
        - Subtask 12.2.2 – Miscellaneous Engineering Services
        - Subtask 12.2.3 – Monitor Well Construction
        - Subtask 12.2.4 – E-logs, Geologic and Geophysical Logging
        - Subtask 12.2.5 – Construction Inspection
        - Subtask 12.2.6 – As-Built Drawings
    - Subtask 12.3 –Demobilization
- Task 13 - Environmental Compliance/Mitigation/ Enhancement
- Task 14 - Construction Administration

Project Administration and Project Reporting, as well as conforming to the labor compliance program are projected to start on April 1, 2013 and continue throughout the entire project. This brief description refers to the efforts described in the application as Tasks 1 - 3.

- Task 1 – Administration
- Task 2 – Labor Compliance Program
- Task 3 – Reporting
-

APPENDIX 5-A - DETAILED PROJECT SCHEDULE
PIXID Groundwater Banking Support Project

ID	Task Name	Duration	Start	Finish	Predecessors
1	**Task 1 - Project Administration**	458 days	Mon 4/1/13	Wed 12/31/14	
2	**Task 2 - Labor Compliance Program**	150 days	Mon 4/1/13	Fri 10/25/13	
3	**Task 3 - Reporting**	**388 days**	**Mon 7/1/13**	**Wed 12/24/14**	
4	**3.1 Quarterly Progress Reports**	**328 days**	**Mon 7/1/13**	**Wed 10/1/14**	
11	3.2 Final Report	1 day	Wed 12/24/14	Wed 12/24/14	10SS+60 days
12	**Task 4 - Agreement w/ Landowners for Use of 20 Ag/Monitoring Wells**	110 days	Mon 4/1/13	Fri 8/30/13	
13	**Task 5 - Preliminary Biological Assessment**	1 day	Mon 4/1/13	Mon 4/1/13	
14	**Task 6 - Dedicated Monitor Wells**	**122 days**	**Mon 4/1/13**	**Tue 9/17/13**	
15	6.1 Design Memorandum	15 days	Mon 4/1/13	Fri 4/19/13	
16	6.2 Construction Drawings	45 days	Mon 4/22/13	Fri 6/21/13	15
17	6.3 Project Specifications	30 days	Mon 6/24/13	Fri 8/2/13	16
18	6.4 Solicitation and Competitive Bid Documents	20 days	Mon 8/5/13	Fri 8/30/13	17
19	6.5Contract Documents	5 days	Wed 9/11/13	Tue 9/17/13	47
20	**Task 7 - Environmental Documentation**	**30 days**	**Mon 6/24/13**	**Fri 8/2/13**	
21	7.1 Environmental Checklist and Biological Assessment	10 days	Mon 6/24/13	Fri 7/5/13	16
22	7.2 Development of CEQA Documentation	10 days	Mon 7/8/13	Fri 7/19/13	21
23	7.3 Final CEQA Documentation	10 days	Mon 7/22/13	Fri 8/2/13	22
24	**Task 8 - Permitting**	**47 days**	**Mon 9/2/13**	**Tue 11/5/13**	
25	8.1 Private Property Access and GW Data Use	10 days	Mon 9/2/13	Fri 9/13/13	12
26	8.2 Well Driller's Permit	10 days	Wed 9/18/13	Tue 10/1/13	19
27	8.3 Well Completion Report	10 days	Wed 10/23/13	Tue 11/5/13	57
28	**Task 9 - Developing a Numeric Groundwater Model**	**265 days**	**Mon 4/1/13**	**Fri 4/4/14**	
29	9.1 Scoping Meeting w/ Project Team	5 days	Mon 4/1/13	Fri 4/5/13	
30	9.2 Compile Gathered Data	20 days	Mon 4/8/13	Fri 5/3/13	29
31	**9.3 Model Development and Calibration**	**210 days**	**Mon 5/6/13**	**Fri 2/21/14**	
32	9.3.1 Hydrogeological Conceptual Model	60 days	Mon 5/6/13	Fri 7/26/13	30
33	9.3.2 Numerical Model Setup and Transient Calibration	45 days	Mon 7/29/13	Fri 9/27/13	32
34	9.3.3 Sensitivity and Uncertainty Analysis	45 days	Mon 9/30/13	Fri 11/29/13	33
35	9.3.4 Numerical Model Verification and Validation	30 days	Mon 12/2/13	Fri 1/10/14	34
36	9.3.5 Predictive Simulations	30 days	Mon 1/13/14	Fri 2/21/14	35
37	9.4 Model Documentation	30 days	Mon 2/24/14	Fri 4/4/14	36
38	**Task 10 - GPS Survey of Additional Ag/Monitor Wells**	**185 days**	**Mon 4/1/13**	**Fri 12/13/13**	
39	10.1 Selection of Preferred Locations	30 days	Mon 4/1/13	Fri 5/10/13	
40	10.2 Selection of alternative ag/monitor wells if necessary	30 days	Mon 4/1/13	Fri 5/10/13	
41	10.3 GPS Survey of authorized ag/monitor wells	5 days	Mon 5/13/13	Fri 5/17/13	39
42	10.4 Update of previous documentation of Monitoring Network Wells	150 days	Mon 5/20/13	Fri 12/13/13	41
43	**Task 11 - Construction Contracting and Deliverables**	**27 days**	**Mon 8/5/13**	**Tue 9/10/13**	
44	11.1 Publish Notice to Bidders	20 days	Mon 8/5/13	Fri 8/30/13	17
45	11.2 Pre-Bid meeting and Addendum No. 1	1 day	Mon 8/19/13	Mon 8/19/13	44SS+10 days
46	11.3 Bid Opening and Bid Evaluation	15 days	Tue 8/20/13	Mon 9/9/13	45
47	11.4 Bid Award	1 day	Tue 9/10/13	Tue 9/10/13	46
48	**Task 12 - Construction**	**35 days**	**Wed 9/18/13**	**Tue 11/5/13**	
49	**12.1 Mobilization and Site Preparation**	**5 days**	**Wed 9/18/13**	**Tue 9/24/13**	
50	12.1.1 Mobilization	5 days	Wed 9/18/13	Tue 9/24/13	19
51	12.1.2 Worker Protection	5 days	Wed 9/18/13	Tue 9/24/13	19
52	12.1.3 Miscellaneous Facilities and Operations	5 days	Wed 9/18/13	Tue 9/24/13	19
53	**12.2 Project Construction**	**35 days**	**Wed 9/18/13**	**Tue 11/5/13**	
54	12.2.1 Construction Staking	5 days	Wed 9/18/13	Tue 9/24/13	19
55	12.2.2 Miscellaneous Engineering Services	20 days	Wed 9/18/13	Tue 10/15/13	19
56	12.2.3 Monitor Well Construction	15 days	Wed 9/25/13	Tue 10/15/13	54
57	12.2.4 E-logs, Geologic and Geophysical Logging	5 days	Wed 10/16/13	Tue 10/22/13	56
58	12.2.5 Construction Inspection	15 days	Wed 9/25/13	Tue 10/15/13	54
59	12.2.6 As-Built Drawings	10 days	Wed 10/23/13	Tue 11/5/13	57
60	12.3 Demobilization	5 days	Wed 10/23/13	Tue 10/29/13	57
61	**Task 13 - Environmental Compliance/Mitigation/Enhancement**	35 days	Wed 9/18/13	Tue 11/5/13	19
62	**Task 14 - Construction Administration**	35 days	Wed 9/18/13	Tue 11/5/13	19



Task | Progress | Summary | External Tasks | Deadline
Split | Milestone | Project Summary | External Milestone

PROPOSAL FOR GROUNDWATER MODELING IN SUPPORT OF WATER BANKING ALTERNATIVES

Pixley Irrigation District & Delano-Earlimart Irrigation District
Tulare County, California

Submitted to:
Provost & Pritchard Consulting Group, Visalia, CA

Submitted by:
AMEC Environment & Infrastructure, Inc., Fresno, CA

July 13, 2013

Proposal 2012-025

TABLE OF CONTENTS

FIGURES

PROPOSAL FOR GROUNDWATER MODELING IN SUPPORT OF GROUNDWATER BANKING ALTERNATIVES

Delanio-Earlimart Irrigation District and Pixley Irrigation District
Tulare County, California

1.0 INTRODUCTION

This proposed modeling effort is designed to simulate groundwater flow beneath and in the vicinity of a proposed groundwater banking facility located along Deer Creek in southern Tulare County (Figure 1). The proposed water banking facility would be jointly operated by the Delano-Earlimart Irrigation District (DEID) and Pixley Irrigation District (PIXID). The proposed extraction facilities would recover up to 30,000 acre feet (af) of groundwater per year.

The objectives of the proposed modeling effort are to:

- prepare a groundwater numerical flow model of the proposed DEID-PIXID groundwater banking facility and vicinity;
- calibrate the groundwater flow model to historical groundwater elevation data for the period 1996 through 2009;
- validate model calibration using a sub-set of the historical groundwater elevation data; and
- estimate the potential impacts of groundwater banking and recovery operations on groundwater resources beneath and in the vicinity of the banking facilities assuming three proposed operational scenarios, including:
  - ❖ recharge and recovery of 10,000 af/y,
  - ❖ recharge and recovery of 20,000 af/y, and
  - ❖ recharge and recovery of 30,000 af/y.

  - ❖ Additional or alternative operational scenarios may be run based on initial predictive simulation results

2.0 PROJECT TEAM AND EXPERIENCE

The proposed AMEC Environment & Infrastructure, Inc. (AMEC) project team members for this project have extensive experience in hydrogeologic investigations and preparing numerical groundwater models throughout the Central Valley. The project team members and their experience are described in the following subsection.

2.1 PROJECT TEAM AND QUALIFICATIONS

The key proposed project team personnel consists of David Bean, PG, CHg; Philip Ross, PG; Gary Kramer, PG; and Diana Babshoff. The project team roles are as follows:

David Bean, PG, CHg, will be the Principal in Charge and lead modeler for the project. He will assure that the necessary AMEC resources are provided to complete this project in a timely and cost effective manner. Mr. Bean has 28 years of experience evaluating groundwater resources on a local, regional, and basin scale throughout California and North America. He has utilized field data to develop conceptual hydrogeologic models, prepared detailed water budgets, and estimated yields of wells and aquifers. Many of the studies used analytical and numerical 3-dimensional groundwater flow and contaminant transport models (GWFLOW, MODFLOW, MT3DMS, etc.) to evaluate the fate and transport of chemicals in groundwater. He has also used particle tracking models (MODPATH, Path3D) to optimize the zone-of-capture of remediation wells and evaluate the influence of extraction wells, municipal well fields, and agricultural supply wells on the migration of contaminants in groundwater. Mr. Bean has experience in aquifer testing and data analysis, database design and management, statistical data analysis, report preparation, and regulatory agency interaction.

Philip Ross, PG, will be the Technical Reviewer for the project. He will assure that the project is conducted in a technically sound and defensible manner. Mr. Ross has served in senior technical and management capacities on a multitude of groundwater and surface water projects. His 37 years of professional experience provide substantial expertise in surface and groundwater hydrology, water resources evaluation and development, groundwater modeling, hydrogeochemical evaluation, waste discharge permitting, and groundwater monitoring system design and installation. His duties have included project management, client consultation, regulatory agency interaction, report preparation, supervision of drilling, well installation, groundwater sampling, aquifer testing, surface water measurement and sampling, and data interpretation.

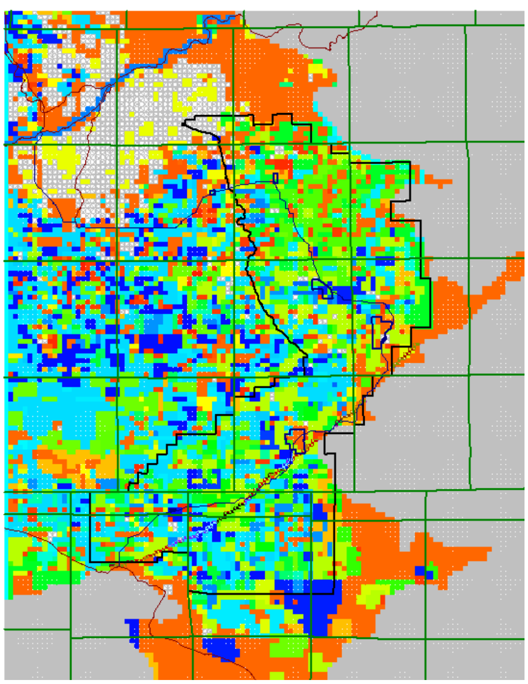
Gary Kramer, PG, will be the assistant modeler for the project. Mr. Kramer has more than 20 years of experience in engineering projects that involve soil and groundwater assessment and remediation and the characterization and development of groundwater resources. He has conducted investigation and remediation projects in California, Nevada, and Utah. He has coordinated investigative site activities that involved drilling soil borings; monitoring well installation, development, and sampling; statistical analysis; and geophysical investigations. Mr. Kramer is experienced in soil logging, hydrogeology, evaluation of groundwater geochemistry, and statistical analysis of groundwater data.

Diana Babshoff will provide geographic information systems (GIS) and database services for the project. Ms. Babshoff's experience includes creating maps, figures, and visualizations for geotechnical and environmental projects. She has successfully applied her GIS knowledge to the production of deliverables for projects including environmental sampling and water resources using ESRI's ArcView GIS. Her GIS experience includes: data acquisition, georeferencing of maps and images, projections, data queries, and data posting. She most recently has added computer aided drafting (CAD) to her work experience, applying CAD knowledge to the production of environmental engineering drawings. Her database skills include: data entry, query development, data import/export, data formatting and data quality assurance/quality control using Microsoft Access. She has 7 years of experience in data compilation and management, project administration, and reporting for projects involving surface water, groundwater, and geotechnical data.

Additional administrative personnel will be utilized as necessary.

2.2 RELEVANT EXPERIENCE

The AMEC team members have worked together on several projects relevant to the proposed modeling effort for DEID-PIXID. All of these projects involved developing and calibrating numerical groundwater flow models at a local, regional, or basin scale, and several involved evaluating the groundwater banking operations throughout the Central Valley. A brief description of these projects is provided in the following paragraphs.

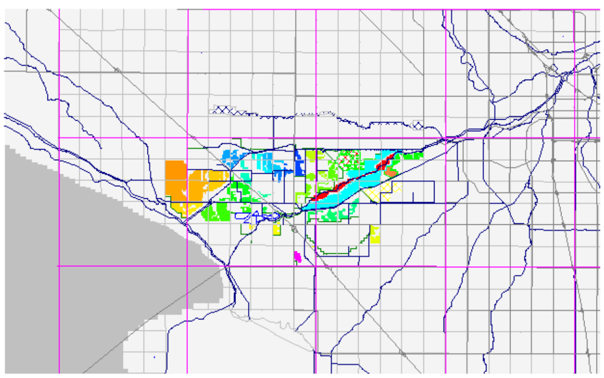


Distribution of Agricultural Demand 1992

Arvin-Edison WSD Model

Arvin-Edison Water Storage District
Arvin, California

The Arvin-Edison Water Storage District (AEWSD) retained AMEC to prepare a water budget and calibrate a MODFLOW2000 numerical groundwater flow model of the AEWSD and surrounding area in Kern County, California. The AEWSD model covers an area of approximately 945 square miles in the southern San Joaquin Valley in California. The model encompasses the AEWSD (~206 square miles) and portions of the adjacent Kern Delta WD, Wheeler- Ridge-Maricopa WSD, and the City of Bakersfield. The San Joaquin Valley is a large structural trough filled with several thousand feet of alluvium derived primarily from the Sierra Nevada to the east and Tehachapi Mountains to the south. The basin dips steeply to the north and west away from the mountain fronts and towards the Buena Vista Lake bed. Structural controls include the Edison Fault in the north and the White Wolf Fault in the south. The model simulates the period from 1992 through 2008 using 68 quarterly stress periods. Inflow to the model was primarily via mountain front recharge, recharge from the Kern River and streams, leakage from surface water irrigation canals, artificial recharge, over application of irrigation water, and precipitation. Outflow was primarily via 72 recovery wells and 475 agricultural supply wells. Inflows and outflows were balanced in an Excel spread sheet on a quarterly basis and the resulting recharge or discharge arrays were imported into the MODFLOW2000 data set. The model was calibrated to approximately 5,200 water level observations in 246 monitoring and water supply wells within the basin. The model is being utilized to evaluate the potential impact(s) of different recharge and recovery scenarios on groundwater levels beneath the AEWSD and to assist the AEWSD in optimizing future agricultural demand, water supply, and water banking operations.



Surface Water Conveyances and Recharge Basins

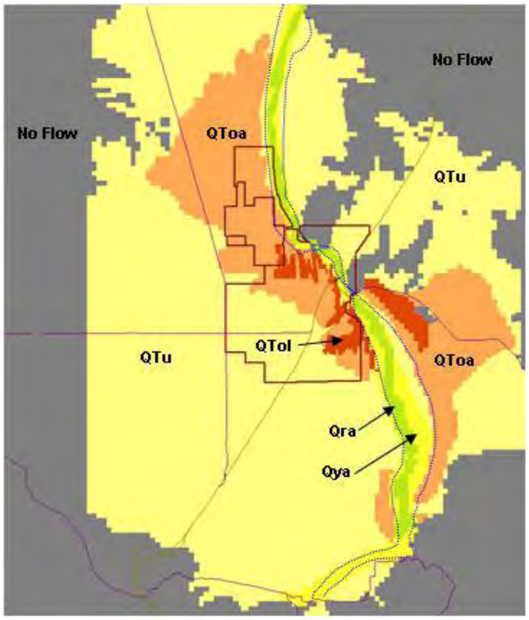
Kern River Alluvial Fan Model

Kern Water Bank Authority
Bakersfield, California

KWBA has retained AMEC to develop a regional scale groundwater flow model to evaluate artificial recharge and recovery pumping operations on the Kern River Alluvial Fan. The model utilizes MODFLOW2000 and MODPATH to evaluate the impacts of the infiltration of over 900,000 acre-ft of applied water on groundwater levels beneath 75 recharge basins spread over a 13 square mile area. The model is an update of a 1995 modeling effort by the DWR. The model domain has been expanded to encompass nearby and adjacent recharge operations by others and the model grid was refined from 1-mile spacing to 2.5 acre spacing in the water bank area. Over 260 geophysical logs were utilized to develop a 3-dimensional model of hydraulic conductivity distribution in the upper 1,000 feet of the alluvial aquifer. The model simulates the period from October 1988 through December 2011 using 217 semi-annual and quarterly stress periods. Inflow to the model was primarily via intentional recharge in over 70 basins and regional precipitation. Outflow was primarily via 678 recovery wells and water supply wells. The model was calibrated to over 21,000 water level observations in 165 monitoring and water supply wells within the model domain. In addition, the model was verified against a target data set not used in the calibration process which consists of 5,700 observations of heads in 56 groundwater supply wells randomly distributed through the model domain. The model has been used to evaluate the benefits of the water banking projects on the Kern River Alluvial Fan.

Upper Mojave River Basin Model

Victor Valley Water District
Victorville, California



Surficial Geology and Mojave River

The Victor Valley Water District (VVWD) retained AMEC to prepare a water budget and calibrate a numerical groundwater flow model of the Upper Mojave River Basin, San Bernardino County, California. The Upper Mojave River Basin model covers an area of approximately 800 square miles and encompasses most of the Alto subarea and Alto Transition Zone groundwater subbasins within the Mojave River Basin. The model encompasses the Victor Valley Water District (~55 square miles) and portions of the adjacent Apple Valley Ranchos Water District, Baldy Mesa Water District, and the Cites of Adeanto and Hesperia. The Alto subarea and Alto Transition Zone form a large (~500,000 acres) basin filled with alluvium and debris flows derived from the San Gabriel and San Bernardino Mountains to the south, the Shadow Mountains to the west, and the Silver Mountains to the East. The basin dips steeply to the North and towards the Mojave River Channel with over 5,000 feet of relief from the San Bernardino Mountains to the outlet of the Mojave River at the northern edge of the model domain. The model simulates the period from 1980 through 2004 using 100 quarterly stress periods. Inflow to the model was primarily via mountain front recharge reaches, the Mojave River (intermittent stream), and deep percolation of irrigation water, septic systems, and waster water treatment plants. Outflow was primarily via 376 wells including 42 municipal water supply wells and stream discharge from to Mojave River. The model was calibrated to over 5,300 water level observations in 47 monitoring and water supply wells within the basin. The purpose of the model is to simulate groundwater flow in the vicinity of the VVWD under various production and recharge scenarios, to evaluate groundwater in storage, and to evaluate the impact of artificial recharge to local groundwater. Specifically, modeled scenarios included 3 percent (%) and 7% growth in groundwater demand (pumping) with and without artificial recharge. The model was used to estimate: (1) the "safe yield" of the aquifer system beneath the VVWD service area, (2) the time remaining to depletion of existing supply wells (with and without artificial recharge), (3) useful storage capacity available in the aquifer system, (4) flow into the VVWD service area from the south, (5) travel times for recharged surface water to reach the nearest pumping wells, and (6) groundwater mounding effects resulting from artificial recharge. As part of the study, the estimated percentage of VVWD delivered water that goes back into the ground as return flow was also calculated.

3.0 PROJECT UNDERSTANDING

The *Reconnaissance Study on Joint Groundwater Bank within Pixley Irrigation District* report (Reconnaissance Study, P&P, March, 2008) provided: 1) a comprehensive overview of existing in-lieu and direct recharge capabilities within Pixley Irrigation District (PIXID); 2) identified areas that could be used for potential direct recharge and in-lieu recharge; and 3) means to allow recovery of banked groundwater without adversely affecting PIXID water users. The Reconnaissance Study identified a potential groundwater bank location (Figure 1) and provided preliminary geologic assessments, engineering evaluations and cost analyses for three potential projects including the recharge and recovery of 10,000, 20,000, and 30,000 af/y.

The conceptual groundwater banking project (Project) includes in-lieu recharge, construction of new direct recharge ponds, recharge along Deer Creek, recharge from seepage losses along the existing canal system, construction of new recovery wells and construction of new conveyance facilities from the recovery wells to the existing distribution system for return to DEID for use or exchange.

The Reconnaissance Study noted that water management opportunities increase when entities share their resources and cooperate to achieve a goal greater than would be possible for the individuals. The benefits derived from these new opportunities cannot be obtained at the expense of others and the Project includes measures to preclude impacts to others in the area, with the guiding principal being that the groundwater bank and recovery wells not adversely impact local groundwater users. In order to protect local groundwater users, the Project has been structured to only recover water that has been recharged. In wet years, the newly proposed direct recharge facility will store banked volumes of water in the aquifer beneath the recharge facility.

This proposal describes a proposed numerical groundwater flow model for the Project area that will quantify groundwater inflows and outflows, consider seepage, precipitation and available surface water supplies, and also consider existing groundwater pumping in the area. This numerical groundwater flow model will be calibrated to historical groundwater elevation data in an effort to create a tool that accurately considers and anticipates responses to changes in available supplies and impacts to groundwater levels.

Once this modeling tool has been developed, then it can be utilized to evaluate potential impacts of the proposed Project so that Project partners and local growers have a reasonable idea of how Project operations may impact groundwater resources in the Project area. The groundwater model will assess groundwater flow directions and rates and provide estimates of the capture zone of the recovery wells. The changing shape of the groundwater table over time will be simulated as the recharge facilities are operated and recovery wells pumped. Hydrographs of simulated monitoring well locations will provide a history of water levels in the areas affected by the groundwater bank. The extent to which local farming operations benefit from a raised water table will be assessed. Such benefits would include lower pumping costs, increased well yields and improved water quality.

In years when banked water is requested for return, the recovery facilities would recover recharged water. The groundwater model will assist in drawing up restrictions on the amount that can be recovered in any one year and a schedule of recovery limits for successive dry years will protect local groundwater users from potential negative impacts from the Project. This modeling effort will also provide a basis for any environmental permitting or CEQA compliance that is undertaken prior to Project construction.

4.0 PROJECT APPROACH

AMEC proposes to prepare a 3-dimensional numerical groundwater flow model of the proposed DEID & PIXID groundwater bank and vicinity to simulate the response of groundwater to various operational alternatives. The following subsections describe the proposed modeling effort in general terms. Specific operational scenarios will be delineated as the model is developed.

4.1 PROPOSED MODEL CODES

In order to meet the model objectives discussed in Section 1.0, the groundwater flow model code must meet the following criteria:

- be able to simulate 3-dimensional groundwater flow and multi-species solute transport within the model domain,
- be well documented and verified against analytical solutions for specific flow scenarios,
- be accepted by regulatory agencies,
- be readily understandable and usable by others for simulation of future groundwater conditions, and
- have a readily available technical support structure.

The model codes MODFLOW-NWT (Niswonger et al., 2011) meets these criteria and are recommended to develop the site model.

MODFLOW-NWT is the latest version of MODFLOW2005, a modular, finite-difference computer code developed by the USGS to simulate three-dimensional groundwater flow (Harbaugh, 2005). The MODFLOW family of codes is well documented in technical literature and is the de facto standard for groundwater flow modeling worldwide. MODFLOW-NWT is a stand-alone version of MODFLOW-2005, including a new Upstream-Weighting Package that treats nonlinearities of a model cell drying and rewetting by use of a continuous function of groundwater head. This allows for the use of the Newton method for unconfined groundwater flow problems. The Newton method is a commonly used method in the earth sciences to solve nonlinear equations, such as for variably-saturated flow equations in an unconfined aquifer. MODFLOW-NWT solves the partial-differential equations that describe three-dimensional groundwater flow by approximating the solution through the finite-difference method, wherein the continuous groundwater flow system is replaced by a finite set of discrete points in time and space. This process leads to a system of linear algebraic equations, which are solved by the computer program to yield values of potentiometric head and groundwater flow velocity at specific locations and at specific points in time (Harbaugh, 2005).

The proposed model codes will be implemented on a Windows® based platform. To facilitate the preparation and evaluation of each model simulation, AMEC will utilize the graphics pre/post processor GWVistas™ Version 6.xx (GWV) by Environmental Simulations, Inc. (ESI). GWV is a Windows® program that utilizes a graphic user interface (GUI) to build and modify a database of model parameters. The model grid, hydraulic properties, and boundary conditions are input using the GUI and then GWV creates the necessary MODFLOW data input files. The input files generated by GWV are generic (standard) MODFLOW files compatible with USGS MODFLOW-88/96 and/or MODFLOW2000/2005. AMEC also utilized some in-house utilities and Microsoft EXCEL spreadsheets to generate standard MODFLOW data input files for selected simulations and for post-processing simulation results.

GWV comes supplied with MFNWTWin32, a Windows® based version of MODFLOW2005, compiled by ESI. MFNWTWin32 is a standard versions of MODFLOW2005 optimized to run under the Windows® environment. This version will be utilized for the modeling effort.

GWV will also be utilized to post-process the model simulations. GWV can display the simulated head and concentration results as plan views and cross sections. In plan view, the contour intervals and labels specified by the user and dry cells are denoted by a different color. In cross-section view, the water table surface is also plotted. Most outputs to the screen can be saved in a number of formats (DXF, WMF, PCX, SURFER, etc.) for utilization in other graphics programs.

4.2 PROPOSED MODEL DOMAIN

The lateral boundaries of the model domain must be placed far enough away from the area of interest so that the specified boundary conditions do not unduly influence the simulation results within the area of interest. In this case, the model boundaries should extend away from the recharge basins and recovery wells a distance to where there are little or no impacts from the Project operations. The model grid will be set up as a variable spacing network with two zones of grid spacing initially established. The inner grid area will consist of an approximately 7 by 7mile area centered on the proposed water bank lands (Figure 1). This area will be simulated using an approximately 330 by 330 foot grid spacing (about 2.5 acre spacing) to provide high resolution simulation and evaluation of potential impacts from water banking operations. The outer grid will extend an additional 3 miles around the perimeter of the inner grid and will be simulated using an approximately 1320 by 1320 foot grid spacing (about 40-acre spacing). The outer grid is designed to provide a buffer zone between the boundary conditions and the inner grid area of interest.

Based on a review of available site stratigraphy, six hydrogeologic units have been identified from the surface to a depth of approximately 1,600 feet. These consist of: younger alluvium surficial soils; an older alluvium upper water-bearing zone which generally overlies the Corcoran Clay; the Corcoran Clay (a laterally extensive confining clay); an older alluvium intermediate depth water-bearing zone generally located beneath the Corcoran Clay; the Schenley Sand, a major aquifer; and a lower water-bearing zone. The sediments dip to the west at 50 to 150 feet per mile, with the deeper sediments dipping at a greater angle than the shallower sediments. With the exception of the surface soils, the sedimentary zones important to the Project are shown on the conceptual block model. These hydrogeologic units will be simulated using no less than five model layers and as many as 11 model layers. The number of model layers will depend on the vertical resolution required to represent wells within the project area of interest.

The model grid will be aligned with the primary direction of groundwater flow and decrease from 1,320 by 1,320 feet around the edges of the model to 330 by 330 feet in the vicinity of the DEID-PIXED Water bank facilities as described above. The proposed model grid consists of 136 rows, 136 columns, and between 5 and 11 layers.

4.3 PROPOSED MODEL STRESS PERIODS

Review of the available data indicates that groundwater elevations have been measured in monitoring wells and production wells within the model domain on approximately a monthly basis since 1996. Based on these measurements, the proposed model will utilize 168 monthly stress periods to simulate the period from January 1996 through December 2009.

4.4 PROPOSED AQUIFER PARAMETERS

The hydrostratigraphic heterogeneity of the aquifer system will be simulated in the numerical model at a scale appropriate for the modeling objectives. AMEC proposes to initially populate the model with the aquifer parameters (horizontal hydraulic conductivity, vertical hydraulic conductivity, specific yield, specific storage, porosity) utilized by the USGS for the Central Valley Hydrologic model (USGS, PP 1766). Site-specific data collected various investigation (soil boring logs, geophysical logs, grain-size analysis, aquifer pumping tests, etc.) will be utilized to update the initial parameters estimates. The model parameters estimates will be further refined (within pre-set limits) during the model calibration process to achieve an acceptable level of fit to groundwater levels observed during the period January 1996 through December 2009. The aquifer parameters will only be modified as necessary to improve the calibration of the model to field observations. As such, the model will contain no more complexity than is justified by the available field data and the model objectives.

5.0 SCOPE OF WORK

The proposed scope of work is discussed in the following subsections.

5.1 TASK 1 – SCOPING MEETING WITH DEID-PIXID AND PROVOST & PRITCHARD TEAM

AMEC will meet with representatives of DEID-PIXID and the Provost & Pritchard (P&P) teams to refine the scope of the modeling effort, determine what the data needs are, and establish a schedule of deliverables. We anticipate that the meeting can be conducted at the Pixley ID offices within 1 week of authorization to proceed.

5.2 TASK 2 – COMPILE AVAILABLE DATA

AMEC will compile the available data for the study area into a database. The database will include: historical precipitation, groundwater elevations, pumping by well, surface water deliveries, cropping patterns, ETo, crop coefficients, etc. These data will be used to develop a water balance for the model domain on a monthly basis for use in the numerical model.

5.3 TASK 3 – MODEL DEVELOPMENT AND CALIBRATION

AMEC will develop and calibrate the proposed groundwater flow model in accordance with ASTM Standards and other modeling guidelines. Model development and calibration is a multi-step process as described in the following paragraphs.

5.3.1 Hydrogeologic Conceptual Model

AMEC will meet with DEID-PIXID and P&P to discuss the existing hydrogeologic conceptual model and to determine where refinements of the conceptual model may benefit the proposed groundwater flow model. The purpose of the hydrogeologic conceptual model will be to simplify field conditions and organize the associated field data so that the system can be analyzed more readily.

There are four steps in developing a hydrogeologic conceptual model: (1) define the model domain, (2) define the hydrostratigraphic units, (3) prepare a water budget, and (4) define the groundwater flow system. We assume that boring logs, geophysical logs, and well construction details (from both older and new wells) are available in some electronic format. The use of electronic data sets will simplify preparation of the hydrogeologic conceptual model and numerical model.

5.3.2 Numerical Model Setup and Transient Calibration

AMEC will prepare a numerical groundwater flow model of the proposed DEID-PIXID water banking facility and vicinity using MODFLOWNWT. AMEC will utilize GWVistas™, a pre- and post-processor for MODFLOW, to discretize the hydrogeologic conceptual model data and prepare input files for the numerical model.

As described in Section 4.2, we anticipate that the model domain will be larger than the water banking facility in order to push the numerical model boundaries sufficiently away from the area of interest. We anticipate using a relatively fine grid area of about 2.5-acres in the vicinity of the water bank recharge basins, expanding the grid size outward towards the model boundaries. We anticipate using five to eleven model layers to represent the sub surface stratigraphy. Vertical discretization into model layers will be dependent on the quality of the available data and the level of vertical resolution required by the project. The model will also incorporate significant hydrogeologic features which may fall within the model domain such as water delivery canals, streams, etc.

The numerical groundwater flow model will be calibrated in transient mode to historical groundwater levels, recharge, and pumping beneath the proposed water bank and vicinity. We anticipate calibrating the groundwater flow model over a 13-year period from 1996 through 2009 using monthly stress periods. The accuracy of the transient calibration will be dependent on the number and length of model stress periods, the accuracy of the discharge to land and pumping data, and the availability sufficient observation data. The calibration process will involve iterative modification of aquifer parameters and boundary conditions (within reasonable limits) in order to minimize the residual (difference) between observed and simulated heads at selected observation points. The model aquifer parameters may be further refined utilizing an automated parameter estimate program (PEST) to further reduce the model residuals.

5.3.3 Sensitivity and Uncertainty Analysis

Following calibration of the groundwater flow model, AMEC will conduct a sensitivity and uncertainty analysis. The purpose of this analysis is to quantify the reliability of the calibrated model in light of uncertainty in the estimates of aquifer parameters, discharge to land, pumping stresses, and boundary conditions used in the model. The analysis will help identify existing "data gaps" and suggest areas where additional information may be useful in improving model accuracy. The sensitivity and uncertainly analysis involves running the calibrated model numerous times, varying single aquifer hydraulic parameters over the likely range of values for each parameter. Model parameters that can be changed over a large range that do not significantly change the model calibration results are insensitive parameters. Model parameters that can be changed over a small range that significantly change the model calibration results are sensitive parameters. Sensitive model parameters that are poorly constrained by field data may require additional investigation.

5.3.4 Numerical Model Verification and Validation

Model verification and validation (V&V) are the primary processes for quantifying and building credibility in numerical models. Verification is the process of determining that a model implementation accurately represents the developer's conceptual description of the model and its solution. Validation is the process of determining the degree to which a model is an accurate representation of the real world from the perspective of the intended uses of the model. Both verification and validation are processes that accumulate evidence of a model's correctness or accuracy for a specific scenario; thus, V&V cannot prove that a model is correct and accurate for all possible scenarios, but, rather, it can provide evidence that the model is sufficiently accurate for its intended use.

Prior to model calibration, approximately 20 to 25 percent of the groundwater elevation data available for calibration will be reserved for model V&V (i.e. the model will be calibrated using only 75 to 80 percent of the available data). After model calibration has been completed, the model will be verified and validated by comparing the reserved V&V data set to the calibrated model simulation results. If the model is well calibrated, the residual between the reserved V&V data set observations and the simulated heads will be approximately the same as for the calibration observation data set, thus validating the model calibration.

5.3.5 Predictive Simulations

Following model calibration, AMEC will conduct up to three predictive simulations to evaluate the potential impact(s) of proposed water banking operations on groundwater levels beneath and in the vicinity of the DEID-PIXID facilities. These predictive simulations will include: (1) 10,000 af/y recharge and recovery, (2) 20,000 af/y recharge and recovery, and 3) 30,000 af/y recharge and recovery. Additional or alternative operations scenarios may be developed in consultation with DEID-PIXID and P&P.

Each predictive simulation will be run by adding the proposed recharge and recovery to the calibrated model and re-running the simulation. The difference between the predictive simulation heads and the calibrated model heads will be a measure of the impacts of the proposed recharge and recovery on the aquifer system. The impacts will be visualized using simulated hydrogaphs at selected observation wells and map views of the differences in groundwater elevations.

5.4 MODEL DOCUMENTATION

AMEC will maintain a journal of the model setup and simulation runs during this task in accordance with ASTM International (ASTM) standards. The journal will document the purpose of each simulation, the results of the simulation, and recommended modifications for the subsequent simulation. The purpose of the journal is to facilitate reconstruction of each simulation (should that become necessary), reduce calibration time, and facilitate report preparation.

Subsequently, following completion of the modeling, a model report will be prepared in accordance with ASTM standards and other guidance. Descriptions of the model and the modeling results will be presented in a report submitted to DEID-PIXID and P&P. The model report will include a summary of the conceptual hydrogeologic model, the calibrated groundwater flow model parameters, the groundwater flow model sensitivity and uncertainty analysis, the groundwater flow model validation analysis, and a summary of predictive simulation results.

6.0 SCHEDULE

AMEC can begin as soon as we receive a signed authorization to proceed (ATP). The schedule will depend in large part on the amount of information available and what form the information is in (e.g., paper or electronic). We have the qualified personnel available to move expeditiously on this project. We would suggest a timeline that includes the following:

1. Kickoff Meeting, 1 week after ATP – Attended by key personnel from DEID-PIXID and P&P, and AMEC to determine scope of the modeling effort and what data are available and in what formats.

2. Exchange of Data, during 2 weeks following Kickoff Meeting – DEID-PIXID, P&P and AMEC exchange data and review how much time/effort will be required to upload data and to locate additional outside data (USGS, DWR, TID, etc.).

3. Conceptual Model Review Meeting, approximately 3 months from ATP – A review meeting is suggested to present the findings of the water balance and conceptual hydrogeologic model. We would also present the framework and timeline for the numerical model at this time. Generally, we would expect a numerical model could be done in about 3 months, assuming that the necessary data are readily available.

4. Presentation of Numerical Model Calibration Results, approximately 6 months from ATP – It is anticipated that the results of the numerical model calibration and sensitivity analysis can be presented in a meeting (or via Live Meeting) approximately 3 months following the conceptual model review meeting. If the results are acceptable, AMEC will conduct up to three predictive simulations, which will take approximately 1 month to complete.

5. Presentation of Numerical Model Predictive Simulations, approximately 7 months from ATP – It is anticipated that the predictive simulations results can be presented in a meeting (or via Live Meeting) approximately 1 month following the model calibration review meeting. If the results are acceptable, AMEC will begin drafting model documentation, which will take approximately 2 months to complete.

6. Draft Numerical Model Results Report, approximately 9 months after ATP – A draft model report conforming to ASTM standards and other guidance will be submitted to DEID-PIXID and P&P for review. The draft model report will describe the conceptual hydrogeologic model, model calibration to groundwater flow, sensitivity analysis, and predictive simulation results.

7. Submit Final Numerical Model Results Report – It is anticipated that approximately 2 weeks after receiving comments from DEID-PIXID and P&P (about 10 months after ATP), the final numerical model results report can be submitted to the DEID-PIXID and P&P.

7.0 COST ESTIMATE

AMEC will provide the proposed scope of work to the DEID-PIXID and P&P on a time-and-materials basis in accordance with the 2012 Schedule of Charges (Appendix A), with labor rates discounted 10 percent. Final costs will be dependent upon the agreed scope of work and the amount and format of available data. Based on the level of effort of work proposed and our understanding of DEID-PIXID and P&P needs at this time, we estimate that the project will cost approximately $100,000. These estimates will be refined after the scope of work is finalized and the data availability is better understood.

8.0 REFERENCES

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