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# List of Abbreviations

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<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASTM</td>
<td>American Society for Testing and Materials</td>
</tr>
<tr>
<td>BC</td>
<td>Brown and Caldwell</td>
</tr>
<tr>
<td>BCDWRC</td>
<td>Butte County Department of Water and Resource Conservation</td>
</tr>
<tr>
<td>CEQA</td>
<td>California Environmental Quality Act</td>
</tr>
<tr>
<td>CSU</td>
<td>California State University</td>
</tr>
<tr>
<td>DWR</td>
<td>California Department of Water Resources</td>
</tr>
<tr>
<td>GIS</td>
<td>Geographic Information System</td>
</tr>
<tr>
<td>IRWM</td>
<td>Integrated Regional Water Management</td>
</tr>
<tr>
<td>IS/MND</td>
<td>Initial Study/Proposed Mitigated Negative Declaration</td>
</tr>
<tr>
<td>LTA Project</td>
<td>Lower Tuscan Aquifer Monitoring, Recharge, and Data Management Project</td>
</tr>
<tr>
<td>MND</td>
<td>Mitigated Negative Declaration</td>
</tr>
<tr>
<td>TSC</td>
<td>Technical Steering Committee</td>
</tr>
</tbody>
</table>
Section 1

Introduction

This report is being submitted as the Fourth Quarter 2012 Quarterly Report concerning activities completed for the Lower Tuscan Aquifer Monitoring, Recharge, and Data Management Project (LTA Project). This Quarterly Report is intended to meet the requirements of Attachment Two Section A2.3 of the County of Butte Contract Number 18050 dated January 31, 2010 between Butte County and Brown and Caldwell (BC). The purpose of the Quarterly Reports are to provide the Butte County Department of Water and Resource Conservation (BCDWRC) and the public progress reports on activities completed during the quarter, a summary of initial findings, and an estimate of activities that will be completed during the next quarter. The LTA Project consists of seven tasks as follows:

Task 1 – California Environmental Quality Act (CEQA) Initial Study
Task 2 – Technical Steering Committee
Task 3 – Development of Geographic Information System (GIS) Geodatabase
Task 4 – Aquifer Recharge Assessment
Task 5 – Installation of Groundwater Monitoring Wells
Task 6 – Aquifer Performance Testing
Task 7 – Public Outreach

The Tuscan Aquifer system, a regional aquifer of the Sacramento Valley Groundwater Basin, is among the principal water bearing units in Butte County. For this project, the Tuscan Formation has been divided into four units, labeled A through D, as defined by Helly and Hardwood (1985). Units A and B define the LTA, the subject of this study, and units C and D define the Upper Tuscan Aquifer. The approximate extent of the LTA within the project boundaries is shown on Figure 1-1.

1.1 LTA Project Purpose

Butte County has been awarded grant funds from the California Department of Water Resources (DWR) through Proposition 50 (Water Security, Clean Drinking Water, Coastal and Beach Protection Act of 2002) for implementation of the LTA Project. Included as part of Proposition 50, is the Integrated Regional Water Management (IRWM) Grant Program. Butte County is administering the LTA Project in partnership with the Northern Sacramento Valley Integrated Regional Water Management Group, previously the Four County Group.
The LTA Project grant application included a scientific investigation that is to develop data and analytical tools to improve the understanding of the aquifer. Specifically, the LTA Project is a scientific field investigation that seeks to improve the scientific understanding of the properties of the LTA system including:

- The physical parameters affecting percolation of surface water to the LTA.
- The interaction between surface water and the LTA.
- Recharge contributions from other aquifers to the LTA.
- Measurements of standard aquifer properties and their variability.
- Identification of natural recharge areas under current hydrologic conditions.
- Identification of recharge areas under increased utilization.
- How additional pumping may impact the aquifer and surface water.

In addition, the project included development of a comprehensive GIS Geodatabase to store data collected during the duration of the project. As part of the GIS Geodatabase, the project also included development of a field data collection tool that improved the quality of data collected in the field to be incorporated into the Geodatabase. Finally, the project includes a public outreach program that heightens the public awareness and understanding of the aquifer.

### 1.2 Report Format

As stated above, the purpose of the Quarterly Reports is to provide the BCDWRC and the public progress reports on activities completed during the quarter, a summary of initial findings, and an estimate of activities that will be completed during the next quarter. As such, the format of this report has been developed based on activities completed during the Quarter. For the Fourth Quarter 2012, activities have been conducted for Tasks 2, 3, 4, 6 and 7 stated in the introduction. The activities discussed in this report cover the period from October 1, 2012 to December 31, 2012. An updated schedule showing the progress of the project is provided on Figure 1-2.
Figure 1-2 LTA Project Schedule
Section 2

CEQA Initial Study

BCDWRC, acting as the CEQA Lead Agency, has determined that the proposed LTA Project would not have a significant effect on the environment pursuant to CEQA. Because the Lead Agency finds no substantial evidence that the project or any of its aspects may cause a significant impact on the environment with mitigation, a Proposed Mitigated Negative Declaration (MND) was prepared. BC with teaming partner Galloway Consulting were responsible for preparation of the CEQA Initial Study/Proposed Mitigated Negative Declaration (IS/MND). The IS/MND was approved by the Butte County Board of Supervisors on July 13, 2010. A copy of the IS/MND and response to comments can be found at the project website listed below.


As discussed in the Third Quarter 2011 Quarterly Report, submission of the September 7, 2011 mitigation measures letter report completed the CEQA task for this project.
Section 3

Technical Steering Committee

A Technical Steering Committee (TSC) has been formed to provide input and recommendations to help guide the progress of the project and the quality of the data. The TSC is comprised of qualified scientists selected from within the Four County area and includes representatives from State and local agencies, the academic community and various special districts throughout the Northern Sacramento Valley. The TSC meets on an as needed basis throughout the duration of the project and will act solely in an advisory capacity to Butte County and the BC Project Team. A list of the TSC members and the organization they represent are in the Table 3-1.

<table>
<thead>
<tr>
<th>TSC Member</th>
<th>Organization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vickie Newlin</td>
<td>BCDWRC</td>
</tr>
<tr>
<td>Allan Fulton</td>
<td>Tehama County</td>
</tr>
<tr>
<td>Lester Messina</td>
<td>Glenn County, Department of Agriculture</td>
</tr>
<tr>
<td>Steve Hackney</td>
<td>Colusa County, Planning and Building Department</td>
</tr>
<tr>
<td>Dan Peterson</td>
<td>Water Resources, Sutter County Department of Public Works</td>
</tr>
<tr>
<td>Joe Connell</td>
<td>University of California Cooperative Extension</td>
</tr>
<tr>
<td>Brendon Flynn</td>
<td>Pacific Farms &amp; Orchards</td>
</tr>
<tr>
<td>Dr. Steffen Mehl</td>
<td>California State University (CSU) Chico</td>
</tr>
<tr>
<td>Dr. Todd Greene</td>
<td>CSU Chico</td>
</tr>
<tr>
<td>Benn Pennock</td>
<td>Glenn Colusa Irrigation District</td>
</tr>
<tr>
<td>Ted Trimble</td>
<td>Western Canal Water District</td>
</tr>
<tr>
<td>Kelly Stanton</td>
<td>DWR, Northern District</td>
</tr>
<tr>
<td>Tracy McReynolds</td>
<td>Department of Fish and Game</td>
</tr>
<tr>
<td>John Lane</td>
<td>Chico Environmental Science and Planning</td>
</tr>
<tr>
<td>Mark Kimmelshue</td>
<td>Armco</td>
</tr>
<tr>
<td>Dr. Lev Kavvas</td>
<td>Hydraulic Research Laboratory, California Hydrologic Research Laboratory</td>
</tr>
<tr>
<td>Carol Perkins</td>
<td>Butte Environmental Council</td>
</tr>
</tbody>
</table>
3.1  Activities Completed - Fourth Quarter 2012
A TSC meeting was conducted on November 8, 2012 to present the results of the overall LTA project. A copy of the presentation prepared for this meeting is provided in Appendix A.

3.2  Planned Activities - First Quarter 2013
A TSC meeting will be conducted after preparation of the draft Final Report for project anticipated to be completed in March 2013.
Section 4

GIS Geodatabase

As stated in Section 1, the project includes development of a comprehensive GIS Geodatabase to store data collected during the duration of the project. This system is an important tool for the BCDWRC to monitor conditions in the groundwater basin and promote education regarding the local water resources and will allow qualification and quantification of surface water and groundwater properties from the LTA Project area including:

- Aquifer transmissivity and hydraulic conductivity;
- Aquifer storage values (storativity or specific yield);
- Surface water and groundwater temperature;
- Streambed and soil infiltration capacities;
- Monitoring well location and construction;
- Extraction well location, construction, yield, drawdown and specific capacity.

As part of this task, the BC Project Team also developed a field data collection tool that will improve the quality of the data collected in the field to be incorporated into the geodatabase.

4.1 Activities Completed - Fourth Quarter 2012

No data was collected for the project during the Fourth Quarter 2012

4.2 Planned Activities - First Quarter 2013

During the First Quarter 2013, remaining data from the field programs will be collected using the field tool that includes stream gauge data from the five monitored streams (Section 5). The geodatabase will be updated with this data. After completion of this input, the geodatabase will be finalized and the Draft Technical Memoranda documenting geodatabase development and implementation will be prepared and submitted to BCDWRC for review and approval.
Section 5

Aquifer Recharge Assessment

The aquifer recharge assessment is intended to gain a better understanding of the flow pathways by which surface water enters the subsurface and recharges the LTA. Three subtasks have been identified to assess the potential for recharge from surface water sources: Subtask 1 – Soil Infiltration Testing; Subtask 2 – Stream Gauging; and Subtask 3 – Stream-Aquifer Temperature Gradient Evaluation.

The soil infiltration testing (Subtask 1) will be performed at 10 locations (Figure 1-1). Each test location will include the performance of basic geologic outcrop mapping in the immediate vicinity of the test location. One double-ring infiltrometer test will be performed at each of the ten proposed sites following American Society for Testing and Materials (ASTM) Standard D-3385-03. The stream gauging task (Subtask 2) was intended to provide estimates of discharge, and potential recharge to the LTA, from 6 primary streams within the drainage basin overlying and intersecting the LTA. These streams included: Antelope Creek, Mill Creek, Deer Creek, Big Chico Creek, Butte Creek, and Little Dry Creek (Figure 1-1). However, due to access issues, the stream gauging task will only be conducted from five streams: Mill Creek, Big Chico Creek, Butte Creek, Deer Creek, and Little Dry Creek. As indicated below, access to Deer Creek was granted in June 2011. Access to Antelope Creek was not granted for the project.

The stream-aquifer interaction task (Subtask 3) included three components which relate to the ability for the stream channels to act as primary recharge conduit to the LTA. The three tasks to be implemented here include a temperature gradient evaluation, slug testing of shallow piezometers, and seepage meter evaluation. Details of each of these tasks are presented in the Draft IS/MND. To assess the viability of these tests for future use, these tests were only conducted at Mill Creek and Big Chico Creek.

5.1 Completed Activities Fourth Quarter 2012

With the exception of downloading the final data from pressure transducers located at each of the stream gauges and temperature probes and Mill Creek, all activities for this task have been completed.

5.2 Planned Activities – First Quarter 2013

During the First Quarter 2013, as weather conditions permit, the BC team will download data from each of the transducers at each stream gauge station and the temperature probes installed at Mill Creek. The Technical Memorandum discussing the activities and results of this task will also be prepared during this quarter.
Section 6

Installation of Groundwater Monitoring Wells

Over the past few years, dedicated groundwater monitoring infrastructure (monitoring wells) have been installed in the Northern Sacramento Valley, which has contributed to a better understanding and quantification of the region. The LTA Project includes the installation of additional monitoring wells to further contribute to groundwater monitoring databases. The purpose of this task is to:

- Establish a reliable baseline of hydrogeologic data,
- Fill data gaps,
- Measure drawdown during aquifer performance tests,
- Monitor groundwater recharge, and
- Evaluate well performance and pumping impacts.

Dedicated groundwater monitoring wells provide data regarding the depths of different aquifers. Small diameter PVC pipes with perforations at varying depths were placed near existing production well and measurements of groundwater depth and quantity will be made at different times to assess local groundwater recharge and recovery. The newly installed monitoring wells cannot be used for or retrofitted for groundwater extraction or production of water. Once the monitoring project is complete, the monitoring wells will be integrated into the cooperative DWR-BCDWRC groundwater monitoring network.

All planned field activities for this task have been completed. The Field Investigation Report that includes a summary of the procedures used and results for the installation of the groundwater monitoring wells was issued on October 15, 2012.
Section 7
Aquifer Performance Testing

This task consists of two subtasks, a review of existing aquifer performance testing and the performance of up to three aquifer performance tests. Up to six detailed reviews of existing aquifer performance tests will be conducted. The review will include the evaluation of test design, test implementation, the data collected during the test, and the analysis of the test data. If the analysis of the data is found to be inconsistent with industry standards the data will be re-analyzed to verify results.

Aquifer performance testing was conducted on three existing production wells. The locations of these wells are shown on Figure 1-1. Newly installed groundwater monitoring wells MW-MT-1 and MW-HKT-1 were used as observation wells during two of these tests. An existing groundwater monitoring well installed by the DWR (see Figure 1-1) was used as an observation well during the third aquifer test. The production wells utilized are existing groundwater pumping wells and are connected to irrigation distribution systems. The water extracted was used as part of existing irrigation practices and distributed according to normal operating conditions at each location. These tests were compliant with the Regional Water Quality Control Board General Discharge Permit, where applicable and no additional permitting was required.

7.1 Activities Completed - Fourth Quarter 2012

During Fourth Quarter 2012, the BC Team reviewed existing aquifer tests conducted by others throughout the area.

7.2 Planned Activities - First Quarter 2013

During the First Quarter 2013, the BC Team will complete the assessment of existing aquifer test results conducted by others and prepare the Aquifer Test Technical Memorandum.
Section 8

Public Outreach

The purpose of the public outreach task is to educate regional and county decision makers and the public about the aquifer investigation’s objectives, progress, and results. Public outreach as part of the LTA Project will primarily consist of stakeholder and public meetings, with support in the form of quarterly reports, a website, and newsletters. This website would provide a means of sharing the project schedule, status, and outreach materials with the public and stakeholders. The website will be updated monthly and can contain content such as: project schedule, CEQA documentation, quarterly reports, meeting minutes, outreach meeting schedules, project data, newsletters, and links to other related websites.

8.1 Activities Completed - Fourth Quarter 2012

Two public meetings were conducted during Fourth Quarter 2012, a presentation to the Butte County Water Commission on December 5, 2012, and a Public Workshop conducted on December 11, 2012. Both of the presentations summarized the result of the LTA field investigation. Copies of the slide presentations for each meeting are provided in Appendix A. The BC team also prepared and issued a newsletter for the project. A copy of this newsletter is provided in Appendix B.

8.2 Planned Activities - First Quarter 2013

No public outreach programs are planned for First Quarter 2013. A public meeting to discuss the results and conclusions of the overall LTA project as presented in the Final Report will be conducted during the Second Quarter 2013.
Appendix A: Meeting Presentations
Lower Tuscan Aquifer/Technical Steering Committee
November 8, 2012
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Presentation Overview

- Introductions
- Project Summary and Results
- Initial Conclusions
- Possible Next Steps
- Discussion

Project Purpose

- Field Investigation that seeks to improve the scientific understanding of the properties of the Lower Tuscan Aquifer system (LTA).
  - Physical parameters affecting percolation of surface water to the LTA
  - Interaction between surface water and groundwater
  - Recharge contribution from other aquifers to the LTA
  - Measure standard aquifer properties and their variability
  - Identify natural recharge areas under current hydrologic conditions
  - Identify recharge areas under increased utilization
  - How additional pumping may impact the aquifer and surface water
Project Purpose

- Things this study provided:
  - Improved understanding of infiltration in regions near foothill streams
  - Evaluation of surface water and groundwater interaction
  - Improved understanding of groundwater recharge to the LTA from streams, foothill areas, and other aquifers
  - Increased knowledge of hydrogeologic characteristics of the LTA
  - Enhanced groundwater monitoring well network

- Developed a sound scientific foundation for understanding of the hydrology of the LTA

Project Purpose

- Things this study was not intended to do:
  - Determine the safe yield of the LTA, locally or regionally
  - Determine the storage capacity of the N. Sacramento Valley
  - Study recharge from the Sacramento and Feather Rivers
  - Update the Butte Basin IWFM model
  - Identify the subsurface extent of the Tuscan Formation

- New production wells were NOT installed

- Project is not connected to any water transfer programs

Activities Performed

- Constructed and Maintained GIS/Geodatabase
- Installed 3 Monitoring Well Nests
- Conducted 11 Dual Ring Infiltrometer Tests
- Performed and Analyzed 3 Aquifer Tests
- Collected two rounds of Groundwater Sampling and One Round of Surface Water Sampling
- Installed and Monitored Stream Gauges at 5 Creeks
- Installed and Monitored Temperature Gradient Wells at Mill Creek
- Reassessed Results of Previous Aquifer Tests
- Compared Results of Project to Input Parameters of IWFM Butte Basin Model
Aquifer Testing

- Collect basic aquifer data regarding transmissivity and storage properties
- Gain better understanding of the vertical interformational leakage between the LTA and other hydraulic units.

Locations include:
- Hackett Property (North)
- M&T Ranch (Central)
- Esquon Ranch (South)
Hackett Property – Northern Area

Analysis Indicates

- Intermediate and deep aquifers are not hydraulically connected
- Intermediate aquifer interacts with shallow aquifer through a leaky aquitard
- Diagnostic plot analysis indicates constant-head boundary or significant recharge occurs to intermediate aquifer through recharge from overlying aquitard.

Aquifer Model

Leaky Solution

Moench (Case 3)

Parameters

\[
\begin{align*}
T & = 2321.9 \text{ ft}^2/\text{day} \\
S & = 3.606 \times 10^{-5} \\
r/B' & = 0.1139 \\
\beta' & = 0.1081 \\
r/B'' & = 0. \\
\beta'' & = 0. \\
S_w & = 0. \\
r(w) & = 0.5833 \text{ ft} \\
r(c) & = 0.3333 \text{ ft}
\end{align*}
\]
M&T Ranch – Central Area

Analysis Indicates
- Intermediate, deep and possible shallow aquifers are hydraulically connected.
- Intermediate aquifer interacts with shallow and deep aquifers through leaky aquitards.
- Diagnostic plot analysis indicates constant-head boundary or significant recharge occurs to intermediate aquifer through recharge from aquitards.
- Hydrographs suggest hydraulic connection between Sacramento River and LTA somewhere north of M&T Ranch area.
  - Response is pressure response consistent with confined aquifer.

M&T Ranch – Central Area
Curve Matching

<table>
<thead>
<tr>
<th>Obs. Wells</th>
<th>Aquifer Model</th>
<th>Leaky Solution</th>
<th>Parameters</th>
</tr>
</thead>
</table>
| MW-MT-1-Shallow     | Moench (Case 1) |                | T = 1.155E+4 ft²/da
|                     |               |                | S = 0.0004537
|                     |               |                | r/B' = 0.07976
|                     |               |                | ß' = 0.0638
|                     |               |                | r/B" = 0.
|                     |               |                | ß" = 0.
|                     |               |                | Sw = 0.
|                     |               |                | r(w) = 1.167 ft
|                     |               |                | r(c) = 0.6667 ft

Esquon Ranch – South Area
Analysis Indicates
- Primary LTA Aquifer is hydraulically interconnected with the aquifer within the upper Ione Formation but water from these two zones follow indirect pathways.
- The shallow aquifer zone of the LTA in this area is not hydraulically connected with the lower zone of the LTA.

Reassessment of Other Aquifer Tests

Tests Reviewed
- July 1993 Off-Property Koppers Company Groundwater Extraction System Test
- December 1996 DWR M&T Chico Ranch Conjunctive Use Investigation
- March 2009 Glenn-Colusa Irrigation District Test Production Well
- October 5, 2009 Aquifer Test Report: Orland Site for Crystal Geyser
Reassessment of Other Aquifer Tests

Summary of Assessment

- Primary purpose of tests to calculate T and S values and specific capacities of production wells
- Calculated values of T & S are consistent with LTA Project Results
- Other than DWR M&T Test, did not evaluate shapes of curves
- GCID Test did evaluate interaction with other aquifers
- Conducted 28-day Constant Rate Test – Pumping Rate 5,000 GPM
- No apparent response to pumping starting at wells located approximately 4.8 miles from test.
- Only one well screened shallower than test well (800 to 1300 feet BGS) showed response to pumping

LTA Recharge Assessment

- Conducted to gain a better understanding of the flow pathways by which surface water enters the subsurface and recharges the LTF aquifer.
- Included:
  - Performance of 11 dual ring infiltrometer tests on a variety of soils directly mapped as Lower Tuscan Outcrop.
  - Differential Stream Gaging on 5 creeks
  - Temperature Gradient observations along Mill Creek
Dual Ring Infiltrometer Tests
- Provided assessment of the passive and active water infiltration capacity of the LTA
- Included
  - Dual Ring Soil Infiltration Test
  - Sieve Analyses
  - Soils confirmation Log

Soil Infiltration Sites

Stream Monitoring Slides
- Provided estimates of discharge and potential recharge to the LTA
- Included monitoring along 5 Creeks:
  - Mill Creek
  - Deer Creek
  - Big Chico Creek
  - Butte Creek
  - Little Dry Creek
Relationship of heat as a tracer can provide insight to the stream-aquifer interactions throughout the water year.
Temperature Profile Analysis

- Pilot Conducted at Mill Creek
  - Two Borings Perpendicular to Stream Flow
  - Low Permeability
  - Stagnation of standing water
  - Method not developed for hard rock settings.

Seasonal Variation in Temperature Profile Wells

Start of IWFM Inputs/Observations

- Developed to address regional scale management alternatives analyses and provide a resource management tool
- Not intended to evaluate potential yields or impacts of operation of individual wells or recharge facilities
- Model Evaluations include
  - Soil Properties
  - Aquifer Properties
  - Stream-aquifer interactions
  - Hydrogeologic Parameters
  - General Aquifer System Conceptualization
Take Home Message

1. Creeks provide little recharge to LTA where they cross outcrops.
2. Recharge waters appear to indicate a lower elevation precipitation source.
3. Recharge is likely occurring over broad areas where saturated alluvial materials overlie the LTA.
4. The Lower Tuscan Formation is composed of fluvial and reworked lahar material forming channelized deposits preferentially controlling the movement of groundwater.
5. Observations during normal agricultural pumping provide valuable insights to groundwater flow, aquifer interactions, and recharge sources.
6. Data suggest a direct connection of LTA with Sacramento River.
7. Depositional environment of the Tuscan Formation, and thus LTA, changes from north to south.
8. LTA exhibits confined or semi-confined aquifer response.
9. Significant leakage occurs through aquitards separating LTA from other aquifer zones.
10. Results of project indicate that localized management of resources such as the LTA should not be conducted under broad assumed aquifer characteristics.

Next Steps

1. Expand isotopic analysis to further assess spatial and seasonal relationships.
2. Assess interaction between Sacramento and other river stage response to changes in groundwater levels.
3. Assess recharge potential of shallow alluvial aquifer to LTA.
4. Conduct focused recharge and aquifer interaction assessments in vicinity of Esquon Ranch towards development of management tools such as groundwater model.

Discussion

- Questions and general discussion
- Approach for public workshop and information dissemination
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Lower Tuscan Aquifer/Public Workshop
December 11, 2012
Presentation Overview

- Project Purpose
- Activities Performed
- What We Learned
  - Creeks
  - Recharge source
  - Aquifer testing
- Possible Future Studies
- Discussion and Meeting Layout

Project Purpose

- Things this study provided:
  - Improved understanding of infiltration in regions near foothill streams
  - Evaluation of surface water and groundwater interaction
  - Improved understanding of groundwater recharge to the LTA from streams, foothill areas, and other aquifers
  - Increased knowledge of hydrogeologic characteristics of the LTA
  - Enhanced groundwater monitoring well network
- Developed a sound scientific foundation advancing the understanding of the LTA hydrology
Project Purpose

Things this study was not intended to do:
- Determine the safe yield of the LTA, locally or regionally
- Determine the storage capacity of the N. Sacramento Valley
- Study recharge from the Sacramento and Feather Rivers
- Update the Butte Basin IWFM model
- Identify the subsurface extent of the Tuscan Formation

New production wells were NOT installed
Project is not connected to any water transfer programs

Activities Performed

- Constructed and maintained GIS/Geodatabase
- Installed 3 monitoring well nests
- Conducted 11 dual ring infiltrometer tests
- Performed and analyzed 3 aquifer tests
- Collected two rounds of groundwater sampling and one round of surface water sampling

Activities Performed

- Installed and monitored stream gauges at 5 creeks
- Installed and monitored temperature gradient wells at Mill Creek
- Reassessed results of previous aquifer tests
- Compared results of project to input parameters of IWFM Butte Basin Model
What We Learned

1. Creeks provide little recharge to LTA where they cross outcrops
2. Recharge waters appear to indicate a lower elevation precipitation source
3. Recharge is likely occurring over broad areas where saturated alluvial materials overlie the LTA
4. The Lower Tuscan Formation is composed of fluvial and reworked lahar material forming channelized deposits preferentially controlling the movement of groundwater
5. Observations during normal agricultural pumping provide valuable insights to groundwater flow, aquifer interactions, and recharge sources

What We Learned (continued)

6. Data suggest a direct connection through confined response of LTA with rise in river stage of Sacramento River
7. Depositional environment of the Tuscan Formation, and thus LTA, changes from north to south.
8. LTA exhibits confined or semi-confined aquifer response
9. Significant leakage occurs through aquitards separating LTA from other aquifer zones
10. Results of project indicate that localized management of resources such as the LTA should not be conducted under broad assumed aquifer characteristics

Study Indicates Creeks Provide Little Recharge
Recharge Appears to Be From Lower Elevation Precipitation Source

Isotope Data - Surface Water

Isotope Data - Groundwater

(continued)
Data Suggests Direct Connection of LTA to Sacramento River within Northern Basin Area

Confined Aquifer Response

North to South Changes in Geologic Environment

- North – Classic "Lahar" Units
- South – Reworked Lahar Units forming Fluvial Deposits

North to South Changes in Geologic Environment

North Central South
Aquifer Tests Conducted During Normal Agricultural Practices to Irrigate Fields

North – Spray Irrigation for Walnut Orchard
Central – Drip Irrigation for Almond Orchard
South – Flood Irrigation for Rice Fields

Observations During Agricultural Pumping Provide Valuable Insights to Groundwater Flow, Aquifer Interactions, and Recharge Sources

Observations During Agricultural Pumping Provide Valuable Insights to Groundwater Flow, Aquifer Interactions, and Recharge Sources (Continued)
Reassessment of Other Aquifer Tests

- Four Tests Reviewed
- Primary purpose of tests to calculate T and S values and specific capacities of production wells
- Calculated values of T & S are consistent with LTA Project Results
- Other than DWR M&T Test, did not evaluate shapes of curves
- GCID Test did evaluate interaction with other aquifers
  - Conducted 28-day Constant Rate Test – Pumping Rate 5,000 GPM
  - No apparent response to pumping starting at wells located approximately 4.8 miles from test.
  - Only one well screened shallower than test well (800 to 1300 feet BGS) showed response to pumping

Possible Future Studies

1. Expand isotopic analysis to further assess spatial and seasonal relationships
2. Assess interaction between Sacramento and other river stage response to changes in groundwater levels
3. Assess recharge potential of shallow alluvial aquifer to LTA
4. Conduct focused recharge and aquifer interaction assessments in vicinity of Esquin Ranch towards development of management tools such as groundwater model.

Discussion

- Questions and general discussion
- Poster session
Lower Tuscan Aquifer/Butte County Water Commission
December 5, 2012
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Project Purpose

- Things this study provided:
  - Improved understanding of infiltration in regions near foothill streams
  - Evaluation of surface water and groundwater interaction
  - Improved understanding of groundwater recharge to the LTA from streams, foothill areas, and other aquifers
  - Increased knowledge of hydrogeologic characteristics of the LTA
  - Enhanced groundwater monitoring well network
- Developed a sound scientific foundation for understanding the hydrology of the LTA
Project Purpose

- Things this study was not intended to do:
  - Determine the safe yield of the LTA, locally or regionally
  - Determine the storage capacity of the N. Sacramento Valley
  - Study recharge from the Sacramento and Feather Rivers
  - Update the Butte Basin IWFM model
  - Identify the subsurface extent of the Tuscan Formation
- New production wells were NOT installed
- Project is not connected to any water transfer programs

Activities Performed

- Constructed and Maintained GIS/Geodatabase
- Installed 3 Monitoring Well Nests
- Conducted 11 Dual Ring Infiltrometer Tests
- Performed and Analyzed 3 Aquifer Tests
- Collected two rounds of Groundwater Sampling and One Round of Surface Water Sampling
- Installed and Monitored Stream Gauges at 5 Creeks
- Installed and Monitored Temperature Gradient Wells at Mill Creek
- Reassessed Results of Previous Aquifer Tests
- Compared Results of Project to Input Parameters of IWFM Butte Basin Model

Aquifer Testing

- Collect basic aquifer data regarding transmissivity and storage properties
- Gain better understanding of the vertical interformational leakage between the LTA and other hydraulic units.
- Locations include
  - Hackett Property (North)
  - M&T Ranch (Central)
  - Esquin Ranch (South)
North to South Changes in Geologic Environment

- North – Classic "Lahar" Units
- South – Reworked Lahar Units forming Fluvial Deposits

Changing Irrigation Practices

- North – Spray Irrigation for Walnut Orchard
- Central – Drip Irrigation for Almond Orchard
- South – Flood Irrigation for Rice Fields

Conceptual Models

- North
- Central
- South
Aquifer Response and Interactions

North Central South

Reassessment of Other Aquifer Tests

- Four Tests Reviewed
- Primary purpose of tests to calculate T and S values and specific capacities of production wells
- Calculated values of T & S are consistent with LTA Project Results
- Other than DWR M&T Test, did not evaluate shapes of curves
- GCID Test did evaluate interaction with other aquifers
  - Conducted 28-day Constant Rate Test – Pumping Rate 5,000 GPM
  - No apparent response to pumping starting at wells located approximately 4.8 miles from test.
  - Only one well screened shallower than test well (800 to 1300 feet BGS) showed response to pumping
LTA Recharge Assessment

- Conducted to gain a better understanding of the flow pathways by which surface water enters the subsurface and recharges the LTF aquifer.
- Included:
  - Performance of 11 dual ring infiltrometer tests on a variety of soils directly mapped as Lower Tuscan Outcrop.
  - Differential Stream Gaging on 5 creeks
  - Temperature Gradient observations along Mill Creek

Soil Infiltration Sites

Stream Gauging
Temperature Profile Analysis

Start of IWFM Inputs/Observations

- Developed to address regional scale management alternatives analyses and provide a resource management tool
- Not intended to evaluate potential yields or impacts of operation of individual wells or recharge facilities
- Model Evaluations include
  - Soil Properties
  - Aquifer Properties
  - Stream/aquifer interactions
  - Hydrogeologic Parameters
  - General Aquifer System Conceptualization

Isotope Analysis – Surface Waters
Take Home Message

1. Creeks provide little recharge to LTA where they cross outcrops.
2. Recharge waters appear to indicate a lower elevation precipitation source.
3. Recharge is likely occurring over broad areas where saturated alluvial materials overlie the LTA.
4. The Lower Tuscan Formation is composed of fluvial and reworked laharc material forming channelized deposits preferentially controlling the movement of groundwater.
5. Observations during normal agricultural pumping provide valuable insights to groundwater flow, aquifer interactions, and recharge sources.
6. Data suggest a direct connection through confined response of LTA with rise in river stage of Sacramento River.
7. Depositional environment of the Tuscan Formation, and thus LTA, changes from north to south.
8. LTA exhibits confining or semi-confined aquifer response.
9. Significant leakage occurs through aquitards separating LTA from other aquifer zones.
10. Results of project indicate that localized management of resources such as the LTA should not be conducted under broad assumed aquifer characteristics.

Next Steps

1. Expand isotopic analysis to further assess spatial and seasonal relationships.
2. Assess interaction between Sacramento and other river stage response to changes in groundwater levels.
3. Assess recharge potential of shallow alluvial aquifer to LTA.
4. Conduct focused recharge and aquifer interaction assessments in vicinity of Esquon Ranch towards development of management tools such as groundwater model.

Discussion

- Questions and general discussion.
- Approach for public workshop and information dissemination.
Appendix B: Project Newsletter
Dual Ring Infiltrometers Testing Performed

Dual ring infiltrometer tests were performed at nine locations throughout the study area. Permeability tests help the study better understand how fast water can move through the ground immediately below the infiltrometer. The infiltrometer must seal against the ground to prevent water from leaking during the test, and was set on bentonite clay chips in areas with hard ground to prevent leaking. Initial results show variability in infiltration, and will be further analyzed during the study.
Aquifer Performance Testing

The aquifer performance testing has been conducted on Esquon Ranch and the Hackett property, however the test has not been performed at the M&T ranch at this time. Testing at the M&T Ranch may occur later this year or next summer depending on weather conditions and operations at the ranch. Aquifer performance testing at these operating ranches has been made possible by using temperature sensors on nearby pumping wells, which identify when production wells in the test area are on or off. Groundwater level information collected during the test is analyzed in conjunction with pumping well information to calculate aquifer parameters.

Stream Gauging

Stream gauges have been installed on Mill, Deer, Big Chico, Butte, and Little Dry Creeks. Each stream gauge includes a staff gauge, stilling well, and pressure transducer. The pressure transducer measures the pressure of water above it, and converts that reading into a water level measurement, which is stored in memory. Depth of water measurements are converted into stream flow measurements by determining the stream’s cross-sectional profile. Profiles must be taken at multiple flow levels to accurately reflect the stream bed at different flows. Profiles are still being collected for the streams listed above, using an RDI—Stream Pro Acoustic Doppler Current Profiler, called “The Boat” by the project team. The Boat uses sound waves to detect the stream bed to provide an accurate stream bed profile.

Monitoring Well Photos

Completed multicompletion monitoring wells are comprised of a lockable outer steel casing, and 2 inch diameter plastic pipes. The plastic pipe makes up the monitoring wells. There are three monitoring wells at each multicompletion monitoring well location. The extra space inside the outer casing is used to house cabling that is connected to pressure transducers, which measure groundwater levels.

Additional information is available at the project web site at www.buttecounty.net/WaterandResourceConservation/TuscanAquiferInvestigation/