

## **Attachment 5: Work Plan**

### **Identification and Evaluation of Groundwater Recharge in Butte County**

#### **A. Purpose, Goals and Objectives**

To provide a more comprehensive, defensible characterization of groundwater, the County of Butte is proposing a project that will produce an updated countywide map of groundwater recharge areas, identify locations for potential recharge projects and evaluate hydrologic and geologic characteristics in one or more groundwater recharge locations. Groundwater resources have long played an important role in the development, growth, and sustainability of Butte County and its residents. Local groundwater management continues to increase in complexity and scope, driven by evolving demands for groundwater resources both within and adjacent to Butte County. Nearly one-third of Butte County's water demand is directly met from groundwater. The county's streams, creeks and ecosystem depend on a healthy and connected groundwater basin. Butte County has recognized the importance of protecting groundwater and groundwater recharge to ensure a healthy water resource system. Through policies and programs, Butte County has incorporated groundwater recharge considerations into its water resource planning efforts. Butte County formalized the linkage between land use and water resource planning through its General Plan process. The proposed project will fulfill objectives of the Butte County Groundwater Management Plan, the Butte County Integrated Water Resource Management Plan and the Butte County General Plan 2030. The proposed project will provide land use planners, water managers and stakeholders with practical information on groundwater recharge areas.

The first task involves preparing a countywide map identifying areas of natural groundwater recharge, for both the shallow unconfined aquifer and the confined Lower Tuscan aquifer system. A comprehensive identification of recharge areas will allow for improved characterization of groundwater conditions and ultimately protection of the basin. A map identifying areas that significantly contribute to groundwater recharge is included in the Butte County Groundwater Management Plan. However, the map does not provide the specificity needed by land and water resource managers. A methodology to refine the existing groundwater recharge map was developed as part of the Butte County General Plan 2030 update process but was not completed. Additionally, in 2012 Butte County will complete a three year study characterizing areas that specifically recharge the Lower Tuscan Formation. Other regional efforts have produced viable approaches to represent areas based on their potential to contribute to groundwater recharge. The proposal will build upon existing and most current datasets to refine and improve the map identifying groundwater recharge areas in Butte County.

A second task will further identify specific areas in the county where groundwater recharge projects (e.g., flood detention basins, storm water or similar facilities) can provide benefits. The scope of this task will consist of developing criteria to identify areas where groundwater recharge could be effective and feasible and then identifying those areas that could benefit from managed groundwater recharge. The results from Task 1 and 2 may be used for future groundwater recharge planning efforts and will be a basis for identifying suitable sites for Task 3.

A third task will select and instrument a representative study area (smaller than a sub-basin but larger than a parcel) to explore and observe natural recharge processes during the recharge period. Better characterization of natural recharge mechanisms, source and flow paths of recharged water, and interconnectedness of the valley's aquifer systems will aid groundwater management efforts, guide

land use decisions, and provide valuable information for managed recharge projects that may occur in the future. The results of the investigation will be used to modify, if necessary, the products of Tasks 1 and 2 and will also outline a methodology for evaluating potential future sites for managed recharge projects.

The fourth task will involve project administration and management. The budgetary, contractual and fiscal aspects will be addressed through this task.

## **B. Project Tasks**

To achieve the goals of the project, four tasks are necessary. The County will oversee the project and conduct specific project tasks. Given the scientific complexity of specific tasks, Butte County will request proposals from interested consultants and select a consultant (Consultant) who has adequate knowledge and experience in the field of GIS development/implementation, groundwater recharge, local regional hydrology/hydrogeology and geophysical methodologies related to aquifer investigations.

### **Task 1 – Countywide Map of Groundwater Recharge Areas**

A map of natural groundwater recharge areas will be developed from a literature search and file review focused on collecting key datasets including geology, soil permeability, topography, and land use that will be critical for identifying areas based on their potential to contribute to groundwater recharge to both the shallow aquifer system and confined Tuscan aquifer. These data sets will include GIS and non-GIS based datasets. GIS data to be collected will include:

- Geology
- Soil permeability data
- Remote sensing data
- Land ownership parcel map (Provided by the County)
- Creeks, canals and other water bodies
- Roads and highways
- High resolution aerial photos
- Land use and irrigation source
- DWR monitoring wells
- Butte County CASGEM wells
- Topography/digital elevation map
- Change in groundwater storage (2005-2012) contours

GIS data obtained for the project will be stored within the Butte County GIS database system for use by County land use planners and the public.

#### Subtasks:

1. Methodology – A written methodology to develop the countywide groundwater recharge map will be produced. The subtask will include the compilation of existing datasets.
2. First initial draft – A draft countywide groundwater recharge map will be produced. The draft will be reviewed by the Technical Advisory Committee and other experts (e.g., NRCS, Department of Development Services, USGS). The draft will be presented for review and comment to the Butte County Water Commission. The finalization of the map will take into account comments received and possibly additional insights gained from Task 3.

3. Finalize the Countywide Groundwater Recharge Map – The final Countywide Groundwater Recharge Map will be prepared taking into consideration results from Task 3 and other pertinent data. The final map will be presented to the Butte County Water Commission for a potential recommendation to the Butte County Board of Supervisors.
4. Approval by the Butte County Board of Supervisors to accept the updated Groundwater Recharge Map and to authorize the Department of Water and Resource Conservation to amend the GWMP. The new map will become part of Butte County’s GIS land use data layers.
5. Amend the GWMP – The Department of Water and Resource Conservation will amend its GWMP by incorporating the revised groundwater recharge map. The groundwater recharge map will be formally transmitted to the Butte County Department of Development Services.

Evaluating Progress: 1) Compilation of datasets according to the project schedule; 2) Development of the draft recharge map according to the project schedule; 3) Ability to address technical issues from the Technical Advisory Committee, Water Commission and the public; 4) Acceptance of the final map by the Water Commission and Board of Supervisors; 5) Amendment of the Groundwater Management Plan to incorporate the updated groundwater recharge map.

Deliverables: 1) Technical Memorandum will include data collected and evaluated, and a summary of the evaluation criteria; 2) Countywide map depicting areas based on their potential contribution to groundwater recharge, and 3) An amended Butte County Groundwater Management Plan that includes the countywide groundwater recharge map.

## Task 2 – Groundwater Recharge Study Locations

The Countywide Map of Groundwater Recharge Areas (Task 1) will provide a base for subsequent analysis to identify areas that may benefit from managed groundwater recharge activities. Areas will be evaluated based on change in storage, groundwater contours, monitoring well levels, and other indicators to identify the portions of the County that have drawdown problems and would benefit from groundwater recharge activities. Using the information developed above, criteria will be developed that identifies areas where it would be feasible and beneficial to enhance groundwater recharge.

Areas of Butte County that could benefit from enhanced groundwater recharge will be identified and mapped. Areas may vary in number and size, depending on local conditions.

### Subtasks:

1. Development of Initial Criteria – Compiled data will be collected and evaluated. Based on the compiled data, criteria will be developed to determine potential managed groundwater recharge locations and options for recharging (flooded fields, spreading basins, canals, enhanced stream recharge, gravel pits).
2. Draft Maps – Based on the criteria, map of groundwater recharge study areas that could benefit from managed groundwater recharge and areas where recharge is feasible will be prepared.
3. Review of the draft maps and initial criteria – The draft work products will be reviewed by the Technical Advisory Committee, other technical experts and agencies, the Butte County

Water Commission and the public. The final work product will take into account comments received and other pertinent data.

4. Final Report on Potential Groundwater Recharge Areas – The final report on the Groundwater Recharge Study Locations will be presented to the Butte County Water Commission.

Evaluation of Progress: 1) Compilation of datasets according to the project schedule; 2) Development of the draft locations according to the project schedule; 3) Ability to address technical issues from the Technical Advisory Committee, Water Commission and the public; 4) Acceptance of the final map depicting locations that may benefit from managed groundwater recharge.

Deliverables: 1) A Technical Memorandum will include a summary of the criteria used to collect and evaluate data and a summary of the evaluation criteria. 2) Maps indicating areas that could potentially benefit from managed groundwater recharge. Maps will include: areas that will benefit from additional recharge and areas where managed recharge is feasible. 3) A summary of applicable groundwater recharge techniques (flooded fields, spreading basins, canals, enhanced stream recharge, detention basins, gravel pits, injection wells).

### Task 3 – Groundwater Recharge Investigation (GRI)

Effective groundwater management requires understanding recharge processes in order to make informed decisions. This task will lead to a better understanding of natural recharge processes, groundwater source and pathways, and interconnectedness of the valley's aquifer systems through data collection and analysis. The GRI will select and instrument a representative study area (smaller than a sub-basin but larger than a parcel) to explore and observe natural recharge mechanisms during the recharge period, October-April. Additional monitoring may occur during the irrigation season to assess recharge characteristics of applied water, if appropriate for the site.

This task has four main objectives and outcomes:

1. To evaluate how conducive to recharge a particular representative area/site is and help overcome uncertainties in characterizing groundwater recharge potential.
2. To identify, and possibly quantify, the source and destination of naturally recharged water at the site. What aquifer system responds to the recharge? Is there storage space in the aquifer for managed supplemental recharge?
  - a. Dependent on site location, the GRI will seek to better understand and potentially provide parameters describing the interconnectedness of the shallower alluvial aquifer and the Lower Tuscan. To what extent is the Lower Tuscan confined in the chosen area?
3. To identify possible sources of water for supplemental recharge in the study area.
4. To explore and employ a suite of tools and data types that may be of use for future investigation of a managed recharge site for recharging flood flows or another surface water source. Especially valuable techniques and data will be identified. This project will provide lessons learned and background information useful for such a future effort.

The map and analysis from Task 2 will be used to identify potential study areas. Authorization from the landowner(s) will be necessary to conduct the evaluation at the particular site. Receiving authorization may be a limiting factor in determining the study location(s). However, access to

some of the prospective sites is likely since many of them have been willing participants in previous studies.

The existing data available on the study areas(s) will be compiled and evaluated. The existing data may include well logs, soil borings, groundwater elevation measurements, aquifer performance tests, and other appropriate data. The compilation and review of existing data will be critical to correlate the geophysical data and to conduct the field data collection.

The field data collection activities in the study area(s) may begin with a geophysical survey. Based on initial survey results, a site specific field investigation will be conducted during the recharge period. The field investigation will involve collection and analysis of a variety of types of data to provide a clearer understanding of recharge sources, groundwater flow paths, deep percolation, stream-aquifer interactions, vertical interconnection of aquifer systems, and overall evaluation of the study area's conduciveness to groundwater recharge. This will include a combination of geophysical survey methods, water level monitoring, soil moisture monitoring, weather data collection, and/or water sampling chemical constituents. The primary recharge period typically occurs in the first and second quarter of the year. Therefore field data collection will likely occur between October and June.

To the extent practical, a geophysical survey (ground penetrating radar (GPR), frequency domain electromagnetic profiling, direct current (DC) resistivity profiling, magnetic profiling, and metal detector profiling) will be conducted at the site. The geophysical survey will provide an initial detailed assessment of the underlying stratigraphy for use in selecting the final locations for monitoring wells and/or piezometers. Geophysical measurements provide a means of mapping lateral and vertical variations of one or more physical properties or monitoring temporal changes in conditions, or both. ASTM International has established a number of standards relevant to the geophysical investigation of groundwater. The ASTM Standard Guide for Selecting Surface Geophysical Methods (D6429) provides a source for describing the usefulness of geophysical methods and provides a set of standard methodologies. Given the specialized nature of conducting a geophysical investigation, a successful approach would require the development of well-developed objectives for the particular site chosen.

The geophysical survey will provide data from which a preliminary interpretation can be made through the production of a geological features contour map. The results will be correlated with other information, such as soil borings, well logs or outcrops. The geophysical survey results and the site will determine the specific methods and procedures to install new monitoring/piezometer wells. The first step will include drilling soil borings to install piezometers/monitoring wells based on the results of the geophysical survey discussed above. During drilling, continuous cores will be collected for preparation of detailed lithologic logs. After completing these wells, additional wells will be installed at appropriate depths to assess the potential for recharge and to monitor infiltration rates during periods of groundwater recharge.

During the drilling of these borings, downhole permeability tests will be collected at major lithologic boundaries identified during the coring of the soil borings in the first step of the field investigation. This method will allow estimates of infiltration rates for subsurface units and will provide valuable input parameters for subsequent efforts such as modeling. Using this information in conjunction with the detailed lithologic logs, selected borings will be used to install moisture/electrical conductivity sensors. Placed at various depths, these sensors will be used to observe the progression

of the wetting front as moisture infiltrates through the subsurface during periods of groundwater recharge.

Existing monitoring wells and new piezometers will be instrumented with transducers to continuously monitor water level throughout the study period. Since this investigation will measure and observe natural recharge processes, precipitation data will be needed to be able to analyze changes in water levels/soil moisture with respect to rainfall events and cumulative seasonal rainfall. A CIMIS station located in the Durham area may be sufficient in providing accurate and representative weather data, depending on the chosen study area. Alternatively, a weather station measuring rainfall, solar radiation, temperature, relative humidity, and wind speed and direction could be purchased and set up within the study area. Relevant surface water features (river, irrigation canal, etc) within or related to the study area may also be instrumented with flow gauges to assess gains or losses to/from the aquifer.

Collection and analysis of water samples for isotopes and other chemical constituents from both surface and groundwater sources within and potentially influencing the study area will likely be part of the suite of collected data. Laboratory analysis for general chemistry would likely include Na, Ca, Mg, K, Fe, Cl, HCO<sub>3</sub>, CO<sub>3</sub>, SO<sub>4</sub>, F, B, NO<sub>3</sub>, As, hardness, alkalinity, conductivity and total dissolved solids. Field parameters of conductivity, pH, and temperature will be monitored for all new and existing wells in the study area. Select stable isotope measurements may include carbon, hydrogen, oxygen, sulfur, and/or boron. Water chemistry and isotope data can be helpful for addressing uncertainties in the conceptual model of groundwater recharge and flow paths. This type of data can often identify recharge sources to better understand groundwater pathways and aquifer dynamics. The primary objective of this testing will be to assess recharge source and interactions between surface water and groundwater. With the choice of study area, the procedures and methods to collect and analyze surface water and groundwater samples will be further developed to include specifications on the frequency, choice of analytes, and QA/QC procedures.

Since the investigative methodologies are not overly intrusive, permit requirements are not expected to be required. However, a specific study design may include the installation of temporary piezometer wells, other monitoring structures or soil borings. Certain approaches may require permits from the Butte County Department of Environmental Health.

Given the variety of approaches and data sources, it is the interpretation and integration of all site data that results in useful information for site characterization. The conversion of raw data to useful information is a value-added process that experienced professionals achieve by careful analysis. Such analysis must be conducted by a competent professional to ensure that the interpretation is consistent with geologic and hydrologic conditions. A Technical Memorandum will be produced describing the study area, reviewed baseline data and data from previous studies, estimated groundwater recharge properties, and a description of the geophysical survey method and results. A discussion of the subsequent investigation detailing its components and methods will be presented. After completing the field investigation and data analysis, a draft and final report will be prepared that summarizes the study's findings. The report, at a minimum, will include a summary of site selection, data collected, recharge processes, flow mechanisms, and problems encountered during the study and how they were resolved. A methodology for future recharge assessments could be outlined based on lessons learned from this investigation.

### Subtasks:

1. Study Design – The study area will be chosen based on Task 2 results and other considerations. The final study design will be determined.
2. Authorization
  - a. Secure authorization from landowners
  - b. Obtain applicable permits
3. Review and evaluate existing data
4. Field Investigation
  - a. Conduct geophysical survey of the study location(s)
    - i. The survey will be conducted according to survey protocol consistent with ASTM standards.
    - ii. A Technical Memorandum will describe the study location, geophysical survey method description survey results, estimated groundwater recharge properties, and geological contours. A discussion of the subsequent investigation will be presented.
  - b. Groundwater Recharge Monitoring Data Collection
    - i. Conduct soil borings for piezometers/monitoring wells, prepare detailed lithologic logs and collect down hole permeability tests
    - ii. Install transducers to continuously monitor water levels
    - iii. Install moisture/electrical conductivity sensors.
    - iv. Identify or install suitable weather station
    - v. Identify wells and surface water features for water chemistry and isotope sampling
    - vi. Data collection
5. Technical Memorandum and maps (Final Report) - After completing the field investigation and data analysis, a draft and final Technical Memorandum will be prepared summarizing the study's findings. The report, at a minimum will include:
  - a. A summary of the data collected
  - b. The recharge process, flow mechanisms, factors influencing the recharge efficiency, problems encountered during the study and how they were resolved
  - c. The areas that may be influenced by recharge
  - d. An estimate of the amount of water rechargeable and aquifer characteristics
  - e. Issues and concerns that need further resolutions

Performance Evaluation: 1) Timely contracting for professional services to conduct the field investigation; 2) Establishment of investigation methodology and site selection in time for the recharge season; 3) collection and evaluation of recharge data, and; 4) completion of the final Technical Memorandum.

Deliverable: A Technical Memorandum that will include a summary of data collected, a description of recharge processes, areas conducive to recharge, an estimate of the amount of water rechargeable, aquifer characteristics, and issues and concerns that need further resolutions.

## Task 4 – Administration and Project Management

The purpose of this task is to provide program supervision and coordination of the project team for the duration of the work to ensure timely and successful project completion. The work in this task includes developing and maintaining schedules, project status meetings, and compliance with quality assurance/quality control procedures. Develop and release a request for proposals (RFP) for professional services to conduct the groundwater recharge investigation and other aspects of the project and administer the contract.

Performance Evaluation: 1) Compliance with grant obligations; 2) Anticipating barriers to achieving project deliverables and making appropriate adjustments, 3) Subcontract for professional services.

Deliverables: 1) Selection of a consultant that will carry out technical aspects of the project; 2) Production of quarterly reports; 3) Oversee the development and submission of the final report.