June 14, 2008

2008 TECHNICAL MEMORANDUM I
BUTTE COUNTY WATER SUPPLIES AND DEMANDS
COMPARISON OF 2000 AND 2005 BASE YEARS

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Section 1
Water Supply and Use Analysis

An analysis of water supply sources and demands within the county was performed by Camp Dresser and McKee (CDM) in the Butte County Water Inventory and Analysis (March, 2001). CDM was to provide baseline water balance information and a methodological tool for future projections of supply and demand. The results of this analysis provided both a basis for planning and evaluating Butte County's water supplies.

The general methodology of the inventory paralleled that used by the California Department of Water Resources (DWR) to produce updates of the California Water Plan in the Bulletin 160 series. However, Bulletin 160 covers the entire State of California at a relatively large scale, whereas the original analysis focused on Butte County with a greater level of detail. The supply/demand analysis process creates a baseline water balance to support the county's efforts in developing sound monitoring and management of its water resources.

This cursory update of the initial inventory is to evaluate the methodology, suggest updates of the methodology and prepare for more detailed work in the future. A guiding principle of this update is to identify how a more detailed update could be prepared at minimum cost to the county. Finally, the limitations to the accuracy of water use estimates and forecasts will be noted.

1.1 Methodology

In the original Inventory and Analysis, agricultural, environmental, and urban water use data were combined with water supply information to determine the overall water budget for individual inventory units and for the county as a whole. These budgets cover only the managed and measurable "applied" component of the water cycle. DWR adopted the applied water method in the mid-1990's because applied water data are generally analogous to agency water delivery data, making it easier for water agencies to review. Use of consistent, statewide terminology allowed Butte County to compute its water demands and supplies on the basis of available information and to compare the county's water resource data with that from other areas.

The original inventory and analysis used the inflows from dedicated water to produce an inflow-outflow analysis for sub-areas of the county in the year 2000. For each sub-area, the inflows were compared to all outflows, including depletion, percolation, or outflow from the area.

For this technical memorandum only the data for the entire county will be discussed at the 2005 level of development. In this update, countywide information will be relied on with some data from individual water agencies for comparing 2000 and 2005 data.

1.1.1 Water Use Methodology

For the 2000 base year losses were estimated by type of water use. Agricultural, urban, and environmental water demands were compiled separately and then combined to understand the complete demands within an area. In this update, a new 2005 base year will be suggested, and the water supplies and use be compared for certain agencies. This update will replace the word demand with use, since use does not imply meeting a demand in the economic sense.

Agricultural Water Use

2000 agricultural water use was originally estimated by multiplying the irrigation season crop water requirements by the associated irrigated acreages. The unit irrigation water requirements and irrigated acreages were determined for each crop, and then all crop water needs were totaled by inventory unit to produce the final agricultural water use.

For this update a new base acreage for 2005 was established using the 2005 Agricultural Commissioners Report and compared to 2000. The results were then discussed with DWR Land and Water Use Scientists to ensure that only irrigated acres were included.

In order to estimate the agricultural water use, the evapotranspiration (ET) for each crop must be determined. However, irrigated crops receive some rainfall to support their growth and the evapotranspiration of applied irrigation water (ETAW) represents the amount of ET applied by irrigation. ETAW assumes a soil that has been recharged completely from either precipitation or pre-irrigation.

The ETAW defines the amount of applied water for each crop that must be included in the agricultural water use. However, the amount of applied water required to meet the ETAW is generally greater than the ETAW due to losses associated with irrigation system application and soil variability. To account for these losses, seasonal application efficiencies have been developed by the Department of Water Resources (DWR) that are specific to the type of irrigation system for each crop. Seasonal application efficiencies indicate a percentage of the applied water that contributes to the ETAW.

Seasonal application efficiency is sometimes confused with irrigation efficiency. Irrigation efficiency represents the efficiency of a single irrigation, whereas seasonal application efficiency represents the average irrigation efficiency for all events over a season. The applied water necessary for each crop can be calculated by dividing the ETAW by the seasonal application efficiency, and represents the amount of water delivered to a farmer’s headgate. The applied water values are combined with land use information to produce the amount of water required by each field.

This technical update is based on countywide data for 2005 from Butte County Agricultural Commissioner and DWR. 2000 and 2005 water diversions were also collected from Western Canal Water District.

Environmental Water Use

Applied water for managed wetlands was included in the 2000 assessment of environmental water use. These wetlands include state and federal wildlife refuges, publicly or privately managed wetland habitat, and agricultural lands flooded for rice straw decomposition or duck habitat. 2005 data was compared with the year 2000 estimates for Western Canal Water District as an example for this report.

Within Butte County, much of the rice acreage is flooded following harvest for the purpose of decomposing the remaining rice straw, which provides some habitat value to migratory birds. In addition, some rice fields are managed specifically to provide duck habitat. Water suppliers were interviewed to determine trends in rice decomposition activities and to estimate the volume of applied water used for rice decomposition.

Various factors were combined in the 20000 base-year to develop a rough ETAW for each wetland area that was included in the regional demand projections. As for agricultural lands, the ETAW for these areas was estimated using the habitat types within each wetlands area. However, this analysis provided limited information on environmental water use, since precipitation provides water supply for habitat that is not supported by agricultural irrigation water.

The county's proposal to gain more accurate information on environmental water use resulted in a board of supervisor's Resolution to pursue funding. Funding was obtained to develop a plan within the Butte County Integrated Regional Water Management Plan. Funding to implement the environmental water use element of the Integrated Plan has not yet been secured.

Urban Water Use

Water delivered to meet urban use was assessed through a review of local urban water management plans (AB 797) completed in 2000. Interviews with water managers, and annual summaries of urban water production data submitted by urban suppliers to DWR were also carried out. The water use data from 2005 urban water management plans was reviewed and checked for this report. Data from the California Water Service Company-Chico was compared with the 2000 information.

The urban water production data submitted to DWR were compared to area populations to determine per capita water needs. Several areas with urban development are not served by an urban water supplier, so these data are not available. Per capita estimates of urban areas with similar characteristics were applied to these areas to produce urban demands for all areas. In addition, rural per capita use was estimated to establish domestic well extractions throughout the county.

Water managers were interviewed to evaluate changes in urban per capita water use during periods of drought and patterns of water use following drought. Water rationing procedures, short-term restrictions, and other demand management tools implemented during droughts were also discussed.

After urban applied water was determined by per capita water needs, additional analysis was performed to determine the amounts of this water that are returned to the system. The amount of water that was used for indoor or outdoor uses was calculated by assuming that during the winter, the only uses are indoors. These indoor uses are constant throughout the year, so any use above these numbers could be considered outdoor use. Approximately 65% of the outdoor use was considered ETAW for landscapes, and the remaining water percolated into the ground. However no seasonal application efficiency data for landscapes is available. Indoor use was returned to the system as treated wastewater (usually discharged into a waterway) or as groundwater percolation through a septic tank.

Urban water use in 2000 and 2005 was compared in this update.   Population information for 2005 found in the "2008 Economic and Demographic Profile of Butte, Glenn and Tehama Counties" was used.   The urban water use information from Paradise Irrigation District, South Feather Water and Power Agency and California Water Service Company were reviewed. Only the data from California Water Service Company was analyzed in this brief report.

Water Supply Methodology

The 2001 water inventory and analysis included managed water supplies designated for agricultural, environmental, and urban use. The supplied water was classified by origin into two categories, surface water and groundwater. The source water (groundwater, surface water, or a combination of both) available to water users within the county, was determined as part of the DWR's 1994 land use survey. Surface water includes natural and developed supplies from the CVP, the SWP, and local water supply projects. Surface-water supplies include those supplies available for reapplication downstream, such as urban wastewater discharges and agricultural return flows. Groundwater includes developed well supplies and includes deep percolation water recovered for use.

1.2 Definition of Hydrologic Scenarios

Historical records of hydrologic conditions were reviewed to identify appropriate periods of record that could be used to represent typical water supply and use within Butte County. The scenario for a typical year was compared to the "normal year" scenario from the original inventory and analysis for this update.   Typical was used in this update as normalization implies some statistical manipulation which is not used in this update.

1.2.1 Definition of the Typical Hydrologic Scenario

Agricultural, environmental, and urban water supply patterns were reviewed to establish typical water use patterns for water, and select a year that best represented a typical pattern. The following activities were pursued:

- For agricultural water use and supply, the following data was reviewed:
  - DWR land use survey information and Butte County Agricultural Commissioner's data, which provided cropping data to determine a year that had a full cropping pattern;
  - Long-term rainfall and pan-evaporation records, which established a year that had a growing season climate that best represents typical hydrologic conditions and growing conditions;
  - Crop ET records (established through crop coefficients and pan evaporation data) to examine patterns of ET values; and
  - Precipitation, snow-pack, runoff and reservoir storage that represented a full water supply from the DWR Bulletin 120 Series.
- For environmental water use, required surface water deliveries associated with environmental water use were gathered and compiled. Areas for which environmental supplies were evaluated included the following:
  - Private and government-managed lands administered for wildlife or riparian habitat; and
  - Rice land acreage associated with rice straw decomposition;
- For urban water use, per capita and total water use and related losses were compared historically. These values were compared to the latest used in the DWR Bulletin 160 series to determine how the calculated local values compared to the previous values. This information was compiled to identify periods of record with typical per capita use.

2000 "Normal" Year Scenario

1997 cropping pattern

1997 precipitation

1997 ET values

Following the review of urban, environmental, and agricultural water demand, a period of record consistent with normal water demand was selected. For this analysis, the year 1997 was chosen to represent a normal year. During 1997, the Chico University Farm precipitation station recorded 26.5" of precipitation, and the historical average at this location is 26.09". Out of all recent years, this year was one of the few with long growing seasons. Many people remember the flooding that occurred during 1997, however, the precipitation throughout the entire year was very close to average. Extensive flooding resulted because nearly all of the rainfall occurred during January. There was minimal rainfall after January, which meant that January's flooding did not result in wet soil conditions when the growing season started. The combination of a long growing season, full water supplies, and complete cropping patterns made 1997 a good option to represent a normal year.

Suggested 2005 Typical Year Scenario

2005 cropping pattern

2003 precipitation

2005 ET values

2005 water deliveries

Following the review of precipitation etc. from DWR a year of normal water deliveries was selected. As was stated above, the year 1997 was chosen to represent a normal year. For this update 2003 was chosen. Out of all recent years, 2003 was one for this update as representing water supplies close to average. Precipitation at the Western Canal weather station was about 23 inches which is slightly above average. The combination of typical growing season, full water supplies and complete cropping patterns make 2003 a useful update of 1997 and a good option to represent a typical year for 2005.

1.3 Definition of the Drought Scenario

In the original inventory, drought was represented by a selected period of record with increased applied water use due to reduced rainfall and reduced flows in the Butte Creek, and delivery cutbacks defined in water contract, water right stipulations. Agricultural cropping patterns were assumed to remain the same as in a normal year, which may not adequately represent a drought scenario. The drought scenario was developed using a similar data review of the agricultural, environmental, and urban components as was used for normal conditions.

Following the review of agricultural, environmental, and urban water use, conditions consistent with low water availability and high water use were selected as the representative conditions for the drought scenario. The drought period therefore was represented by the following conditions:

Drought Year Scenario

1976-77 cropping pattern

1976-77 precipitation

1997 ET values

1987 urban per capita data

- High evaporative demand in 1997;
- Low effective precipitation in 1976-77;
- Drought cropping patterns cropping pattern;
- Water transfers;
- High urban water use (generally associated with exterior water uses such as landscape irrigation); and

- Restricted water supply based on flow records and delivery contract stipulations (which may reduce the benefits of carryover storage in surface-water facilities).

The drought scenario proved to be more difficult to select than the typical year because all the conditions did not exist in a single year. Therefore, several years were used to illustrate the worst recent examples of drought-year impacts. In this study, the purpose of the drought-year water budget is to examine an extreme scenario to draw conclusions about maximum demand and reduced available supplies. Using information from several years produced results that combine the most severe situations in recent years.

Suggested Multi-Drought Year Scenario
1987-1993 cropping patterns
1987-1993 precipitation
1987-1993 ET values
1987-1993 water delivery data

While it is useful to evaluate a single-year drought such as 1997, the more recent drought of the late 1980s and early 1990s had a much greater impact in California. The original inventory and analysis noted that fact in its conclusions and recommendations. The primary limitation of using one year is that most of California has sufficient water supply to carry over sufficient water to avoid significant impacts in one year. Therefore, this update calls for a more detailed analysis of a multi-year drought. 1987-1993 had 6 drought years and one year about average, which is more indicative of a major drought with significant impacts. While there is no attempt to develop this drought scenario in this technical memorandum such a scenario should be evaluated in a more detailed update in the future.

1.4 Water Use

1.4.1 Water Use in 2000

Each sector (agricultural, municipal and industrial, and environmental) was separately delineated, with an additional section for conveyance losses. The conveyance losses represented the amount of water required to conveyed supplies to their destination, and include free water surface evaporation, evapotranspiration by canal riparian areas, percolation into the groundwater, and spillage from the system. Some of these losses (evaporation and evapotranspiration) are lost from the system for future use, but deep percolation and spillage are available for future use.

The original inventory and analysis illustrated the composition of water use in various parts of the county.

- The majority of use occurred in the valley area, due to increased urban population and extensive farming areas.

- Agriculture produced the majority of county water use, with 71% of the total demand. The remaining use was composed of conveyance losses (15%), environmental use (10%), and urban use (4%).

1.4.2 Water Use in 2005

The following indicates the comparative changes since 2000 in 2005 were largely due to variations in cropping patterns, urban growth and the vagaries of climate. The information below indicates the cropping changes, agricultural diversions and urban water production between those two periods.

- The cropping pattern for Butte County was reduced from over 203,000 harvested acres in 2000 to 198,000 acres in 2005. This small amount of acreage reductions can most likely be accounted for because of climate variations, agronomic needs or market conditions that are not indicative of any trend.

- Water diversions in Western Canal Water District also decreased by 5,600 acre feet between 2000 and 2005.

- Population increased in Butte County by 11,150 persons between 2000 and 2005 of which almost all of the growth was in Chico.

- Data from California Water Service Company-Chico showed increased water production of approximately 2,400 acre feet over the same period.

- Water diverted for rice straw decomposition and waterfowl habitat increased by almost 4,000 acre feet acre feet over the same time.

In summary, there was little change in water use or supply during 2000 to 2005 other than that related to the population growth in Chico. This can lead to a concern for the water supply in the future, because Chico relies solely on groundwater.

1.4.3 Supplies

The water supplies indicated the amount of developed water necessary to meet uses. Therefore, the supplies were equal to or less than the uses in the original report. The applied water balance does not include the water supply necessary to meet all environmental demands.

The various surface water supply sources were separated, including local surface water, Feather River water, and deliveries from the SWP or CVP. The total amount of groundwater pumped by each sub-unit was presented. Surface-water reuse illustrates the amount of water that is used more than once after it is diverted from the original surface-water body.

- The eastern portion of Butte Basin and the foothill Inventory primarily use surface-water, and the remainder of the county primarily uses groundwater.
- The primary water source within the county was surface water (55%), followed by groundwater (31%) and surface water reuse (14%).
- Supplies are distributed throughout the county in the same pattern as use with the most water going to the eastern Butte Basin (64%), followed by the western Butte Basin(18%), the Vina area (10%), north Yuba (5%), foothills (2%) and mountainous areas (1%).
- Butte County's supply of 1.4 million acre-feet is approximately 1.8 percent of the total California water supply of 79.5 million acre-feet.
- The difference in surface water supplies in 2005 remained similar to 2000, as surface water rights and water delivered under contract did not change.

1.4.4 Net Groundwater Extraction

The total amount of groundwater pumped for consumptive use within the county, did not provide a complete picture of the groundwater use because it does not include water that is concurrently percolating into the ground. The amounts of deep percolation from surface water supplies and groundwater supplies should be subtracted from the total groundwater extraction to result in net groundwater pumping. The net pumping in the original analysis illustrated areas that are pumping more groundwater than is percolating into the ground from applied water in that area. However, the net groundwater pumping did not consider the amount of recharge that enters the groundwater through natural processes. Areas with no net pumping include the areas where an equivalent amount or more applied water percolates into the ground than is pumped out.

It appears that some areas of the county had a net groundwater extraction in typical years. However, the data does not include the effects of natural recharge, which generally occurs during the winter months. Although local pumping may seasonally depress groundwater levels, pumping generally does not result in a long-term decrease of storage. Use of a comprehensive groundwater modeling tool is necessary to rigorously evaluate groundwater level changes due to pumping.

Butte County has upgraded groundwater monitoring, and the groundwater model to provide tools to address data gaps that will be applied in the next detailed update. The current watershed model soon to begin development should also give the county further information on groundwater recharge. One note of caution should be exercised however. Models are tools that can provide useful information, but they too are constrained by limitations of existing data.

1.4.5 Impacts on Groundwater

In a groundwater basin, groundwater levels fluctuate as a result of changes in the amount of groundwater in aquifer storage. Factors that affect the amount of groundwater in storage include the seasonal and annual amount of groundwater extraction and aquifer recharge. The aquifer system is recharged from subsurface inflow to the basin and percolation of precipitation, streams, and irrigation water. Aquifer discharge occurs when groundwater is extracted by wells, discharges to streams, or flows out of the groundwater basin in the subsurface. Seasonally, the majority of the aquifer discharge happens during the summer because of groundwater extraction for beneficial uses, but the aquifer recharge occurs during the winter. The most extreme impacts to groundwater take place seasonally, and have the potential to decrease groundwater levels to the point that some wells may not function without lowering the pump impeller.

The average depth-to-groundwater was estimated from monitoring sites around Butte County. The estimated change in depth during the growing season illustrated the groundwater changes during the time of year where the groundwater will change the most dramatically because there is the most pumping and very little natural recharge. To determine the groundwater changes during the growing season, the volume of groundwater extracted for all uses during this period must be estimated. The volume of groundwater extracted represents the sum of agricultural demands during the growing season plus seventy percent of the yearly M&I demand less thirty percent of yearly deep percolation. The seasonal change in groundwater level can be calculated by dividing the volume of extracted groundwater by the product of the surface area and specific yield of the aquifer. The estimated change in depth does not consider the details of local groundwater formations, but is purely based on aquifer storage characteristics and the volume of groundwater pumped.

The total depth-to-groundwater (average depth plus the maximum depth change) was then compared to the well depths in each sub-unit. The results indicated that most wells in the county will not be affected by the seasonal change in groundwater during the course of a normal year. The foothills and mountains were not included because their groundwater is more difficult to predict and have fewer wells. The table indicates the wells that would be dewatered to their total depth, and does not include wells that would be partially dewatered. However, local groundwater conditions are not included, so the results may not be indicative of actual performance. To fully understand the groundwater impacts, the groundwater modeling tool should be used.

1.4.6 Groundwater Status 2000-2005

The summaries of the annual groundwater status reports for 2000 and 2005 were examined and compared for this report. In essence, the groundwater levels taken in 2000 provided an optimistic outlook for groundwater levels. No depletion in groundwater storage was occurring after the wet period that followed the 1987-1993 drought. However, the 2005 groundwater monitoring indicates that groundwater levels had steadily declined since then, but that there was some stabilization. The report called for closer evaluation during future groundwater status reports. Both annual reports noted there was no subsidence as identified by the five extensometers in the County. Butte County has also implemented a limited agricultural groundwater quality measurement program, with data reported in the annual groundwater report.

1.5 Summary of Drought Year Inventory

The drought year inventory was created to understand the changes that could occur within Butte County in a year with little precipitation. A multi-year drought also needs to be examined to more adequately discuss the impact of drought.

1.5.1 Demands in a Single Year of Drought

Water use increased from the typical year, although the changes were not dramatic. The increase is caused because there is less effective precipitation and therefore less moisture left in the ground after the wet season. The changes can impact agriculture which uses the greatest amount of water, but there is normally sufficient agricultural water supply to make up deficiencies in soil moisture for a year. Non-irrigated rangeland is the first agricultural commodity to be impacted by drought in the first year.

The drought year scenario assumed that the cropping patterns do not change from typical years in a single year of reduced precipitation. However, it is likely that farmers would fallow land or plant less water-intensive crops when they realize that the winter had not been wet enough to provide them with adequate water storage in a second year of drought. This analysis assumed that all areas are fully planted in the same manner as an average year during the drought year to illustrate the full amount of shortage.

The composition of agricultural, municipal and industrial, and environmental demands does not appear to change substantially. In a single drought year, the majority of the demand is agricultural, at 74%, followed by conveyance losses (11%), environmental demand (10%) and urban demand (5%). Two reasons that demand composition remains the same is the assumption that cropping patterns do not change, and that the water demands of the environment are not well understood.

1.5.2 Supplies

Many areas with surface water had their supplies reduced during droughts.

Surface-water deliveries for the drought-year scenario were determined according to the maximum cutbacks that could occur to the water right or contract. For areas along Butte Creek or the tributaries, the surface-water deliveries reflecting 1977 hydrologic conditions were used to provide a realistic estimate of drought supplies.

After surface-water deliveries were calculated, groundwater was assumed to provide the remaining water to meet demand if the infrastructure is available. DWR land use surveys delineate the available water sources as a part of the survey, and thus indicate if each field has groundwater access. Any fields that do not receive surface water were assumed to pump groundwater if they have the infrastructure. However, the most recent DWR survey was performed in 1994, and some landowners could have installed wells since that time. Drilling new wells would increase supplies in the appropriate area.

Several noteworthy changes occurred during a single year of drought include:

- Increased groundwater pumping and less surface water use. Surface water decreases from 55% of supply in normal years to 41% during a drought, and groundwater increases from 31% to 44%. Surface water reuse stays essentially the same, going from 14% in a normal year to 15% during a drought.

- In several service areas, surface-water reuse increases in drought years because these water suppliers are more careful with the water that can leave their system. By reducing outflows, the water remains in the system for a longer time and is often reused. However, increased surface water reuse has the potential to degrade water quality.

- Distribution of supplies in various areas of the county is roughly similar to typical years demands.

1.5.3 Shortages

In most areas, drought water use was greater than normal year demands because of less precipitation and increased evapotranspiration.

Shortages occurred primarily in the southwest portion of the county. Shortages are defined by lack of supply, which is limited by the groundwater infrastructure available in the southwest, not by total water supply.

The water shortage in the Paradise Ridge is somewhat different than the other sub-units, and is caused by a lack of surface water infrastructure. The shortage in Cohasset is due to a lack of groundwater depth and infrastructure.

Richvale, Biggs-West Gridley, and Butte are all part of the Joint Water District, which has adequate surface water supplies during typical years. There are insufficient wells in these areas to provide groundwater during droughts. During typical years, it is not economical for farmers to pump groundwater; so many farmers do not have the necessary infrastructure. Shortages only occur in areas that do not receive surface water and do not have the infrastructure to pump groundwater.

1.5.5 Impacts on Groundwater

Most wells remained below the estimated groundwater level during a single year of drought. Estimated additional drawdown was calculated to assess the potential change in groundwater levels for areas with projected water shortages under the single year drought scenario. Shortages result from a lack of wells to extract groundwater from the aquifer and/or a lack of conveyance; adequate supplies of groundwater exist to meet all shortages. Additional drawdown calculations include the total projected shortage volume without consideration of deep percolation recharge of the additional waters. Estimates of additional drawdown to meet shortages would result in the lowering of groundwater levels from three feet in the Cherokee area to 18 feet in the Biggs West Gridley area.

1.6 Limitations

The supply and demand inventory was designed to be a tool for decision making and looked simply at a snapshot in time. There are limitations on how accurate the results can be, based on the inputs and the style of analysis. Even though a severe, single-year drought analysis is useful, it is obvious from past history that multi-year drought can have a major impact. Groundwater levels dropped and increased pressure to transfer water occurred during the 1987-1993 drought.

1.6.1 Data Collection

Collecting additional data could further refine the analysis. The following information would be important next steps to continue to improve the understanding of Butte County's water resources:

- Additional groundwater-level data;
- Return flows;
- Deep percolation for groundwater recharge;
- Multiple drought year impacts; and
- Improved understanding of total environmental demands

The original inventory and this update also are affected by how the data is collected. To make inferences from the data they must be collected according to a rigorous sampling scheme. For example, random or systematic sampling is necessary for good science, but most samples in the real world must be taken where they are feasible. This is particularly true of field information, much of which must be collected on private property where access may be or not be allowed. Another limitation is the cost of sampling. Rarely are there funds available to employ rigorous sampling techniques.

1.6.2 Analysis

The greatest limitation to the inventory was the analysis method. The inventory created a snapshot of 1 normal year and 1 very dry year. However, it cannot display links between years. Most droughts in California include multiple years, so looking at 1 drought year does not completely illustrate a drought scenario. Historical evidence also indicates that there were more severe droughts in California in the past (Butte county Drought Plan, 2004).

The groundwater analysis in the original report was a simple analysis performed to illustrate potential impacts of how supply and demand are distributed. Butte County, the Butte Basin Water Users Association and Camp Dresser & McKee have upgraded the groundwater modeling that will be a better tool to understand the groundwater within the county. The information in the original inventory and further updates can be used as input to improve the understanding of Butte County's water supplies and demands. In addition, the development of Basin Management Objectives, under Butte County's Integrated Water Resources Plan (and under Butte County Ordinance) should assist with greater knowledge of local groundwater conditions.

Originally, the process employed was similar to the DWR approach. The primary objective of this update was to identify a simpler method to acquire data and analyze it at lower cost. For example, much useful information has already been compiled by the Center for Economic Development in their "Economic and Demographic Profile of Butte County". The annual groundwater status reports are also extremely helpful in providing useful information for groundwater levels, subsidence, precipitation and water year type. Finally, the good cooperation the county receives from DWR's Northern District Office provides a wealth of information and input.

One note of caution, however, is to remember that the estimates discussed are just that…estimates. Such estimates are very useful in planning for Butte County's future. Nevertheless, all estimates entail some error requiring professional judgment and common sense. It is very difficult to obtain enough data to directly employ the scientific method over such a large area as a county.

Section 2 – Forecasting Methods

2.1 Urban Water Use Project Description

The original technical memorandum, described the urban water use forecast for the Butte County Integrated Watershed and Resource Conservation Plan (IWRCP). *The IWRCP was intended to improve water management in the County and to maintain agricultural viability, meet urban and environmental needs, ensure a future groundwater supply to overlying users, enhance the economy, and protect the citizens and natural resources of Butte County.* For the purposes of this update changes are suggested and the original forecasts analyzed.

2.1.2 Purpose and Scope

The purpose of the forecasts described in the original technical memorandum was to provide data useful for the formulation of recommended actions. Describing the existing and forecasted settings for which the plan was developed was an early step in the integrated planning process. These forecasts helped to predict the County's situation in the future. Using these forecasts, the IWRCP can be updated to describe the County's future urban water needs and, through the planning process, develop and evaluate potential actions that can address the planning objectives, which include meeting the County's water needs.

These forecasts were prepared for Butte County specifically, and include water demand estimates for 2000, 2010, 2020, and 2030. The forecast was intended for use at the countywide level. This update will only look at the trends identified to 2005 and compares them to 2005 actual data. A new, simpler approach for arriving at the forecasts will also be suggested.

2.1.3Document Overview

The model selection and forecasting method; the input sources and development; and the findings of the forecasts were describes in the 2003 document. A separate analysis described forecasts made for countywide agricultural water demand will be described later in this updated document.

Definiions:

Study area = defined geographic unit (e.g., a city or watershed)
Sector = a class of water users (e.g., residential housing units)
Subsector = subclass of water users (e.g., single family housing units)

This section introduced a method selected for the original analysis and presented the basic information required. The results of the model were tested against the regression analysis employed by the California Water Service Company for Chico. The results were similar.

2.1.4 Model Selection

The IWR-MAIN Water Demand Management Suite© was selected to perform the urban water demand forecast. This software is a state-of-the-art, relatively easy to use, flexible, and powerful suite of tools for forecasting water demand and is a standard in the industry. The selected forecasting method is IWR-MAIN's *adjusted rate of use* method. This method is consistent with those used by the DWR for development of the *California Water Plan Update* (Bulletin 160-03), a statewide planning effort. However, DWR finally opted for a simpler, more straightforward spread-sheet approach.

2.1.5 Study Areas

In the original Technical memorandum, water purveyors and the DWR public water system statistics database were the sources for study area water use data. Table 2-1 lists the population and major water purveyors for each study area. In general, the boundaries of the water purveyors match the boundaries of the study areas that they serve except in Oroville and the unincorporated areas. Oroville receives water from three water purveyors whose service area borders are partially inside and partially outside of the incorporated area boundary. The unincorporated areas of the county are served by several urban water purveyors (not listed) and by a significant number of private wells.

Table 2-1
Water Purveyors of Forecast Model Study Areas

Study Area	2,000 Census Population	Water Purveyor
Biggs	1,799	City of Biggs
Chico	59,444	California Water Service Company, Chico
Gridley	5,450	City of Gridley

Oroville	12,969	California Water Service Company, Oroville
		Oroville Wyandotte Irrigation District
		Thermalito Irrigation District
Paradise	26,451	Paradise Irrigation District
Unincorporated Areas	97,058[1]	Several Water Purveyors *(not listed)*
		Private Wells

[1]Estimated as population of incorporated areas subtracted from population of the entire county.

For this update, only data from the California Water Service Company –Chico, Paradise Irrigation District and South Feather Water and Power Agency (formerly Oroville Wyandotte were evaluated. The water information for Chico was solely relied on as the preponderance of urban growth occurred there between 2000 and 2005.

2.1.6 Sectors and Sub-sectors

A sector is a group of water users with similar water use characteristics. This analysis estimates water demand independently by two sectors, residential and nonresidential. Similarly, each sector has sub-sectors (Table 2-2). Although not a true sector, the unmetered/unaccounted water use category is also included in the water demand estimate for each study area.

Table 2-2
Model Sectors and Sub-sectors

Sector	Sub-sector
Residential	Single-Family
	Multifamily
Nonresidential	Commercial
	Industrial
	Large Landscape

2.1.7 Forecast Years and Base Year

The original analysis forecasted water demand for the years 2010, 2020, and 2030. To make these forecasts, the *adjusted rate of use* method draws on one year of historical water use data, called the base year, for input. The base year of the forecast was 2000. The forecasts used this base year and the number of base year counting units, as well as a projection of future counting units (see below), to project the water demand for each sub-sector. For future years, this calculated rate of use is adjusted to reflect the difference between the base year and future year values of the explanatory variables.

2.1.8 Counting Units

A counting unit represents a water user, or set of users, for which a per unit water use rate may be calculated. Counting units for this analysis include numbers of people, jobs, and housing units.

Table 2-3

Model Counting Units

Sector	Subsector	Counting Unit
Residential	Single-Family	Single-Family Housing Units
	Multifamily	Multifamily Housing Units
Nonresidential	Commercial	Commercial Jobs
	Industrial	Industrial Jobs
	Large Landscape	Population, in 1000's

2.1.9 Explanatory Variables

An explanatory variable (X in Equation 2.1) is a variable that has an effect on the value of the per unit water use rate, such as the average daily maximum temperature during a month. (As the temperature increases, so typically does the per unit water use rate.) The model used explanatory variables to adjust the base year per unit water use rates. Table 2-4 lists the explanatory variables selected for this analysis.

Table 2-4
Model Explanatory Variables

Sector	Explanatory Variable
Residential	Median Income (Year 2000 Dollars)
	Housing Density (Units per Acre)
	Persons per Household
	Marginal Water Price ($)
	Average Daily Maximum Temperature (°F)
	Precipitation (Inches)
Nonresidential	Marginal Water Price ($)
	Average Daily Maximum Temperature (°F)
	Precipitation (Inches)
	Cooling Degree Days (°F)

2.1.10 Urban Water Use to Forecasted Compared With 2005 Actual

As was illustrated in Table 2.1, the cities of Biggs, Chico, Gridley, Paradise and Oroville were analyzed for the original forecasts. For this update, these communities were analyzed for population growth only. Chico was the only community indicating significant growth over the period between 2000 and 2005. The original forecast indicated there could be an increase of water use of approximately 2.3%/year indicating an 11.5% increase in water use over a five year period. In reality, the increase in water production of California Water Service Co.-Chico of 9.4 %over that period was slightly less that that predicted by the IWR-MAIN model.

2.1.11 Simplified Urban Forecasting Approach

The California Department of Water Resources found that a simplified spreadsheet could be developed that produced results similar to the IWR-MAIN Model. The spreadsheet relied on: single and multi-family housing; commercial and industrial employment; total population; median household income; water price with single and multifamily persons per household. Most of these factors are forecasted in the annual economic and demographic profile mentioned earlier. DWR also worked with the Rand Graduate School that produced a document with DWR entitled, "Quantified Scenarios of 2030 California Water Demand", that discussed the value of various scenarios and not just a single projections of water demand in various sectors.

For this update, it appears that data is available to use a simpler approach for estimating future demands. The Delphi approach to evaluating the results of future projections, as described in the following section, may also be transferable to urban demands.

2.2 Agricultural Forecasting Method

A Butte County forecasting model was a simpler spreadsheet analysis based on the Cal-Ag model developed by U.C. Davis in cooperation with DWR. The output of the model was evaluated by a Delphi Group of agricultural experts familiar with Butte County agriculture.

2.2.1 Average Year

The average year baseline used applied water rates and ETAW values from the average year analysis in the *Butte County Water Inventory and Analysis Report (2001)*.

2.2.2 Data Categories

The model input data reflects the economics of crop production, including crop prices, yields, costs of production, and applied water rates. Major sources of information include:

- County Agricultural Commissioner reports for crop price and yield data;
- University of California Cooperative Extension crop budget analysis for fixed and variable costs data;
- Discussions with water district personnel for water cost data;
- *Butte County Water Inventory and Analysis Report (2001)* for irrigation acreage and irrigation water requirements data;
- Cal-Ag model for acreage elasticities; and
- Delphi group (see Section 2.1).

2.2.3 Conclusions

The agricultural water demand forecast generated several conclusions important for future water resource planning.

- In general, the analysis indicated that most of the reasonably foreseeable changes evaluated would not result in significant long-term changes in agricultural water demand in Butte County.

- Crop idling resulted in the largest decreases to agricultural water demand and provides purveyors with surplus water that could be used by government programs or other water districts.

- Agricultural land conversion resulted in a small reduction in irrigated cropland and agricultural water use in the County. Total agricultural water demand in the County under the agricultural land conversion scenario would decrease 9,600 acre-feet (0.9 percent).

- Water conservation would reduce applied water and provide purveyors with surplus water that could be used by government programs or other water districts; however, costs of conservation could be expensive. Total agricultural water demand in the County under the water conservation scenario would decrease 51,800 acre-feet (5.1 percent).

- The original output of the model was reviewed and compared to a revised 2005 base year. Agricultural Commissioners reports for 2005 show the conservative outlook of the model to remain accurate. There was no attempt of run the model in this cursory update.

2.2.4 Agricultural Water Use Forecasted Changes compared to 2005 Actual.

The model's "Combination Scenario" indicated there could be a relatively small reduction in agricultural water use of approximately 60,000 acre feet forecasted for 2030. The changes according to the model could be 10,000 acre feet over a five year period. The water use in Western Canal Water District did decrease 5,600 acre feet during 2000-2005. However, this amount is variable because of weather, market conditions and agronomic practices.

2.3 Limitations

A scenario approach was developed by DWR in its working paper "Quantified Scenarios of 2030 California Water Demand." A similar approach was used in the agricultural forecasts noted in this update. However, such additional work would be costly for the county. A simpler approach may be to recognize that forecasts are seldom accurate and a range of outcomes are more realistic (+/- some percentage).

For example, DWR did use a spreadsheet approach to simplify forecasting urban water use for the most recent California Water Plan Update. The spreadsheet required less information and included an estimated error of +/- 5%.

Based on guidance from the Delphi group, a reasonable set of scenarios was evaluated using the model, but many other sets of assumptions could have been evaluated. For example, scenarios could have been expanded to include water for rice decomposition or sprinkler irrigation for frost protection. The model, however, provided an appropriate structure for future analyses.

The models are designed to provide planning-level analysis. Use of models for site-specific conditions would be inappropriate without further data collection and model testing. The output of the models need to be evaluated periodically and adjusted if necessary.

Section 3
Conclusions and Recommendations

3.1 Conclusions

- The conclusions of the original Water Inventory and Analysis remain valid for Butte County over the five year period since its inception.
- Forecasts should be included in the further updates of the inventory and analysis.
- The inventory and analysis can be updated adequately, and at less cost, by relying more on existing reports for most of the data.
- It appears that simple, spreadsheet analysis is sufficient to adequately analyze and forecast water use and supply.
- Data acquisition needs improvement, particularly for environmental water use, water quality and groundwater recharge.

3.2 Recommendations

- There were a number of recommendations made in the original Water Inventory and Analysis. The Department should document the status of these recommendations in the near future.
- The Water Inventory and Analysis should be updated in detail after the 2000 census in 2011.
- Use the Economic and Demographic Profile series published by the Chico State Center for Economic Development , the annual groundwater status report, the annual Butte County Agricultural Commissioners report and water use data available via the internet from DWR and Water agencies to minimize costs.

- Continue to use the spreadsheet analysis for agricultural forecasts developed for Butte County, and utilize the spreadsheet developed by DWR for urban forecasts.
- Consider using the Delphi method to gain useful input from urban, environmental and agricultural experts.

3.3 Status of Recommendations from 2001 Report

The original inventory and analysis contained a number of recommendations in the "Additional Water Management Issues" section of the report. The status of these recommendations follows.

- **Water quality data needs improvement**. The Department of Water and Resource Conservation has been involved in water quality improvements. Basic groundwater quality measurements are now taken annually in a number of groundwater wells. The Department was also involved in an urban water quality report with surrounding counties. However, the primary responsibility for water quality in Butte County does not reside in the Department of Water and Resource Conservation, but with the Department of Health and the Agricultural Commissioner.
- **Environmental water use needs to be addressed more comprehensively.** The Department of Water and Resource Conservation has attempted to deal with this issue. A resolution was passed by the Boar of Supervisors to give the Department authority to seek funding for an environmental monitoring program. The plan for such a monitoring program was part of the Integrated Water Resources Plan, and was a component of the original application for Prop. 50 funding. Funding was not approved by the State and needs to be sought from other sources.
- **Flood Control** has not been identified as a primary role for the Department of Water and Resource Conservation. The responsibility lies with Emergency Services Officer and the Department of Public works.
- **Water Use Efficiency** has also not been viewed as a major activity of the Department of Water and Resource Conservation and was better left to local water agencies. The Department has supported the efforts of local agencies when requested.
- **Forecasting trends in water use** has been a major effort by the Department of Water and Resource Conservation. It was a major effort in the development of the County's integrated plan and continues today with recommendations in this memo report.