SONOMA COUNTY WATER AGENCY

CF/42-0.19-9 SWRCB Order Approving Temporary Urgency Change in Permits 12947A, 12949, 12950 & 16596 for 2013 (ID 4707)

April 30, 2015

VIA EMAIL AND FEDEX PRIORITY OVERNIGHT

State Water Resources Control Board
Division of Water Rights
Attn: Barbara Evoy
P.O. Box 2000
Sacramento, CA 95812-2000

Re: Lake Mendocino Water Supply Reliability Evaluation Report

Dear Ms. Evoy:

On April 24, 2013, the Sonoma County Water Agency (Water Agency) filed a Temporary Urgency Change Petition (2013 TUCP) for water right Permits 12947A, 12949, 12950, and 16596 (Applications 12919A, 15736, 15737, and 19351) with the State Water Resources Control Board (State Board). The State Board's Division of Water Rights issued an order approving the 2013 TUCP on May 1, 2013 (Order). Term 17 in the Order requires the Water Agency to work with several Russian River water users with diversions from the Russian River above its confluence with Dry Creek to evaluate the long-term reliability of Lake Mendocino to meet water supply and environmental water demands. It also requires the coordination with land use planners in the region. Term 17 stated that the Water Agency was to file this report with the Deputy Director by December 31, 2014. However, due to addressing ongoing and worsening drought-related issues in 2014, the Water Agency requested in December 2014 that the original submittal date be extended out until April 30, 2015. The State Board approved this request in a letter dated December 30, 2014.

The Water Agency is pleased to submit the enclosed report on the Lake Mendocino Water Supply Reliability Evaluation, which fulfills the requirements of Term 17. Please contact me if you or your staff have any questions or comments regarding the enclosed report.

Sincerely,

Don Seymour

Donald J. Seymour, P.E.
Principal Engineer

Enclosures

c: Katherine Lee - State Water Resources Control Board, Division of Water Rights
G. Davis, J. Jasperse, P. Jeane, D. Seymour - Sonoma County Water Agency
S. Shupe, C. O'Donnell - Sonoma County Counsel
Alan Lilly - Bartkiewicz, Kronick & Shanahan

RW S:\Clerical\Pinks\04-27-15\SCWA_CoverLetter_ltr_30apr15.docx

State Water Resources Control Board
Order 5/1/2013

Lake Mendocino Water Supply Reliability Evaluation Report

Term 17

April 30, 2015

Prepared by

Sonoma County Water Agency

404 Aviation Blvd

Santa Rosa, CA 95403

LAKE MENDOCINO WATER SUPPLY RELIABILITY EVALUATION REPORT

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

EXECUTIVE SUMMARY

This water supply reliability study of Lake Mendocino (Reliability Study) has been completed by the Sonoma County Water Agency (Water Agency) to fulfill a requirement of the May 1, 2013 Order issued by the State Water Resources Control Board (State Water Board). The Reliability Study evaluates the long-term reliability of Lake Mendocino to meet water supply and environmental water demands.

Lake Mendocino is administered by the United States Army Corps of Engineers (Corps) and was formed by the construction of Coyote Valley Dam (CVD) which is located on the East Fork of the Russian River, about 4 miles northeast of the City of Ukiah in Mendocino County. The Corps coordinates releases from CVD during flood management operations. As the local sponsor, the Water Agency controls and coordinates water supply releases from the CVD in accordance with its water rights permits and Decision 1610.

In addition to runoff from within its own watershed, Lake Mendocino also receives water from the Eel River through the Potter Valley Project (PVP), a hydroelectric facility located in the headwaters of the East Fork of the Russian River approximately 11 miles upstream of the reservoir. Due to a recent (2006) implementation of a 2004 Federal Energy Regulatory Commission (FERC) license amendment for the PVP, diversions from the Eel River through the PVP have been cut back significantly, which has resulted in a reduced reliability to annually fill Lake Mendocino to adequate levels to meet downstream minimum instream flow requirements and demands. Since 2006, the Water Agency has had to file five Temporary Urgency Change Petitions with the State Water Board to reduce the minimum instream flow requirements downstream of Lake Mendocino in an effort to conserve lake storage for water supply and fisheries beneficial uses.

To complete the Reliability Study, the Water Agency developed a model of the Upper Russian River from the Potter Valley Project down to the Healdsburg USGS streamflow gaging station. The model was developed to evaluate conditions for both historical hydrology (1911-2013) and future climate change hydrology (2000-2099). Model hydrology was developed under a separate study completed by the U.S. Geologic Survey (Flint et al, 2013). Model scenarios were developed to evaluate reservoir reliability for both current demand conditions and projected (2045) demand conditions. To aid the development of the system demand datasets for the model, the Water Agency worked closely with water users in the Upper Russian River and held several meetings to discuss data availability for the study.

Eight model scenarios were evaluated with the Reliability Study Model. Each scenario represents a unique combination of assumptions and input datasets. Model scenarios were formulated to evaluate system reliability under: current conditions, current system demand with no diversions from the PVP, future (2045) demand with historical hydrology, and future (2045) demand with potential changes to hydrology due to climate change.

In summary, the analysis presented in this report indicates that Lake Mendocino's water supply reliability has decreased in recent years, especially since the PVP operations were changed after 2006. Future growth projections for the areas that rely on Lake Mendocino for their water supply indicate modest growth through 2045. Even with only modest growth, Lake Mendocino's water supply reliability is expected to continue to further decline, both under scenarios that assume historical climate conditions, and also under scenarios that assume potential changes to climate. A scenario evaluating the effect of no PVP diversions (with current demand conditions and historic climate conditions) shows that under that scenario, Lake Mendocino would go dry for some period during a majority of years (over 60 percent). If Lake Mendocino were to go dry with this frequency, there would be severe impacts to downstream water users, ecosystems, and groundwater aquifers.

As with any water supply study, the analysis can be improved by collecting additional data and increasing the sophistication of the analytical tools and models employed in the analysis. Key data gaps and model limitations are identified in this Reliability Study.

Given the significance of these preliminary findings on water supply reliability, the Water Agency plans to further engage the entities with which it has already coordinated and also to engage water users on the Upper Russian River to identify prospective new programs or initiatives that may address the ongoing water supply shortages and improve long-term reliability of Lake Mendocino. There are several programs that are actively being pursued to improve water supply reliability. However, these programs alone will not solve the sever reliability problems that are described in this report, so additional actions need to be undertaken collectively by water users that rely on Lake Mendocino. To that end, the Water Agency intends to prepare a follow-up report, based on input from Upper Russian River water users, that will describe current projects and programs and propose new initiatives that could promote more resilient water resource management.

1.0 INTRODUCTION

1.1 Purpose and Scope

This report presents the results of a water supply reliability study for Lake Mendocino (Reliability Study) conducted by the Sonoma County Water Agency (Water Agency). On April 24, 2013, the Water Agency filed a Temporary Urgency Change Petition (TUCP) with the State Water Resources Control Board (State Water Board) requesting approval of temporary changes to water rights Permits 12947A, 12949, 12950 and 16596 (Applications 12919A, 15736, 15737 and 19351). The TUCP requested temporary reductions to the Russian River instream flow requirements to address low storage conditions in Lake Mendocino. The Water Agency also filed TUCPs in 2007, 2009, December 2013, and 2014, all of which requested temporary reductions to Russian River instream flow requirements to address low storage conditions in Lake Mendocino.

The May 1, 2013 Order (Order) issued by the State Water Board approving the April 2013 TUCP required the Water Agency to evaluate the long-term reliability of Lake Mendocino to meet water supply and environmental water demands, working with Russian River water users above the confluence with Dry Creek. This requirement was included as term 17 in the Order (see Appendix A). Term 17 requires that the water supply reliability evaluation analyze the potential impacts to Lake Mendocino storage due to climate change, future projected land use practices and forecasted water demands, to the extent that such information is available or provided by the water users specified in the Order.

Term 17 requires the Water Agency to contact several listed water providers for coordination to support the Reliability Study and recommends the Water Agency to contact others to seek their cooperation. These water users, as well as other cooperating entities, are identified in Table 1.

This study was conducted using the best information and modeling tools available to the Water Agency to assess current and future reliability of Lake Mendocino to maintain releases to meet downstream minimum instream flow requirements and demands. As with any water supply modeling study, assumptions are required where data does not exist, is not complete, or is not sufficiently detailed to meet the needs of the analysis. This is especially true for evaluation of future scenarios. This study identifies key data gaps and assumptions, so that opportunities to reduce these data gaps can be pursued to improve future versions of this analysis. This study uses available data to provide Upper Russian River water users and stakeholders who utilize or manage water from Lake Mendocino a comprehensive assessment of the reservoir’s reliability. This information provides those water users and stakeholders an opportunity to work together to implement coordinated management actions to improve the region’s current and future water supply resiliency.

1.2 Organization of Report

This report presents the following information: (1) background information regarding Coyote Valley Dam and Lake Mendocino; (2) the Water Agency’s study methodology; (3) results of model simulations and observations; and (4) recommendations.

This report describes Lake Mendocino reliability under future operations to the terms of existing water right permits, including: (a) the hydrologic condition criteria and minimum instream flow requirements as described in the State Water Board's Decision 1610 (SWRCB, 1986); (b) the temporary minimum instream flow recommendations included in the *Biological Opinion for Water Supply, Flood Control Operations, and Channel Maintenance Conducted by the U.S. Army Corps of Engineers, the Sonoma County Water Agency, and the Mendocino County Russian River Flood Control and Water Conservation Improvement District in the Russian River Watershed* (Biological Opinion; NMFS 2008) for the mainstem Russian River; and (c) Pacific Gas and Electric's (PG&E) operation of the Potter Valley Hydroelectric Project since 2006 under its amended Federal Energy Regulatory Commission license.

2.0 BACKGROUND

2.1 Project History and Description

Lake Mendocino is located on the East Fork of the Russian River, about 4 miles northeast of the City of Ukiah in Mendocino County (Figure 1). Lake Mendocino was created with the construction of the Coyote Valley Dam (CVD) Project, which was authorized by the Flood Control Act of 1944 for the purposes of flood control, water supply, recreation and stream flow regulation. Construction was completed by the United States Army Corps of Engineers (Corps) in January 1959 with the Water Agency acting as the local sponsor. CVD is an earth embankment dam approximately 160 feet high with a crest length of 3,500 feet.

Lake Mendocino has a total current storage capacity of 116,500 acre-feet, which includes a water conservation pool of between 68,400 acre-feet and 111,000 acre-feet, depending on the time of year (Figure 2). Based on reservoir bathymetric surveys (original conducted in 1952 and most recently in 2001) the average sedimentation rate in the reservoir is approximately 130 acre-feet per year. The invert of the controlled outlet is at an elevation of 637 feet above mean sea level (USACE, 1986). This level in the reservoir establishes the top of the inactive pool, which was calculated as having a remaining storage of 135 acre-feet in the 2001 survey. Based on the historic rate of sedimentation, it is expected that the inactive pool has reached its capacity to accumulate sediment.

The contributing watershed of the reservoir is approximately 105 square miles which is approximately 7 percent of the total watershed area of the Russian River Basin. Average annual inflow into the reservoir, since it was completed, is approximately 235,000 acre-feet per year, with a peak annual inflow of 443,000 acre-feet in 1983 and a minimum annual inflow of 60,000 acre-feet in 1977. Inflow into the reservoir consists of natural flows from the contributing watershed area and additional water from the Eel River diverted through the Potter Valley Project (PVP), a hydroelectric facility owned and operated by PG&E.

The City of Ukiah operates a hydroelectric facility at the CVD utilizing incidental releases. The powerhouse has two turbine/generator units with capacities of 2,500 and 1,000 kilowatts.

At the base of CVD, the California Department of Fish and Wildlife operates a fish facility, managed in conjunction with the Don Clausen Fish Hatchery at Warm Springs Dam on Dry

Creek in the Russian River watershed northwest of Healdsburg, to support a steelhead population.

2.2 Flood Management Operations

The Corps maintains Lake Mendocino and coordinates releases of water from the reservoir during flood management operations. The coordination of flood control and water supply operations is established in the Water Control Manual, Appendix I to the CVD Master Water Control Manual published by the Corps originally in April 1959 and most recently revised in August 1986.

Storage in the reservoir is controlled by the reservoir guide curve (Guide Curve) in the Water Control Manual. This Guide Curve sets the maximum threshold for storage of conservation water in the reservoir and is seasonally varying. The volume of the conservation pool decreases during the rainy season to maximize flood capacity and increases in the dry season to maximize conservation storage for water supply purposes. The flood control pool is defined by the storage levels above the Guide Curve. Under typical flood operations, water is temporarily detained in the flood control pool until the threat of flooding downstream has diminished. After the threat of downstream flooding diminishes, water is released from the reservoir to bring storage levels back down to the top of the Conservation Pool.

Flood control releases are initiated in accordance with the requirements established in the Water Control Manual. Operations during flood management are guided by release schedules that are set based on the water level in the reservoir flood pool.

2.3 Water Supply Operations

As the local sponsor, the Water Agency makes water supply releases from Lake Mendocino as necessary to comply with its water rights permits. These permits implement the provisions of the State Water Board's Decision 1610. The Water Agency's permits authorize diversions to storage in Lake Mendocino, re-diversions of water released from storage and direct diversions at points downstream. Collection of water into Lake Mendocino's water supply pool is authorized by the Water Agency's water right Permit 12947A.

The Water Agency makes releases from CVD: (1) to meet the downstream water demands from the hundreds of agricultural, commercial and residential water users, the Water Agency, and several public water systems along the Upper Russian River; and (2) to maintain minimum in-stream flows in the Russian River, primarily in the Upper Russian River, which extends down to the confluence with Dry Creek. These minimum flow requirements vary based on the hydrologic condition designations (*Normal, Dry and Critical*) established by the Water Agency's water right permits. Figure 3 shows the minimum instream flow requirements for the different stream reaches and the different hydrologic conditions.

Since the National Marine Fisheries Service (NMFS) issued the Biological Opinion in September 2008, the Water Agency has been required to petition the State Water Board to modify summertime minimum instream flow requirements. From May 1 through October 15, the recommended minimum instream flow on the Upper Russian River for *Normal* water supply conditions is 125 cubic feet per second (cfs). On the Lower Russian River, from the confluence of Dry Creek to the Pacific Ocean, the recommended minimum instream flow for *Normal* and *Dry* water supply conditions is 70 cfs. In addition to these requirements, the Biological Opinion required that the Water Agency initiate a SWRCB process for permanent changes to the minimum instream flows to improve rearing habitat conditions in the Upper Russian River mainstem, Lower Russian River in the vicinity of the estuary, and Dry Creek for steelhead, which are listed species under the federal and state Endangered Species Acts. These changes were based on the NMFS findings that water supply operations resulted in flow rates that were higher than historic summer conditions and too high for optimal rearing habitat for young salmonids. The potential impact of permanent changes to Decision 1610 minimum instream flow requirements to improve habitat conditions for listed salmonids will be analyzed in the Fish Habitat Flows and Water Rights Project (Fish Flow) Environmental Impact Report (EIR). The Fish Flow EIR will evaluate the potential environmental impacts of changes in minimum instream flow requirements, including to Lake Mendocino's reliability. This Reliability Study provides a foundation for understanding the existing conditions that affect Lake Mendocino reliability. This study also considers several additional scenarios for future conditions.

In addition to the Water Agency's water rights to water stored in Lake Mendocino, the Mendocino County Russian River Flood Control and Water Conservation Improvement District (Mendocino RRFC) and Russian River mainstem post-1949 water right holders in Sonoma County under a 10,000-acre-feet per year reservation established by the State Water Board in Decision 1030 also have water rights that authorize the re-diversion and use of water released from Lake Mendocino storage. The 10,000-acre-feet per year reservation is administered by the State Water Board and available to qualifying appropriative water rights in Sonoma County. The Mendocino RRFC holds water-right Permit 12947B, which authorizes re-diversions and use of up to 8,000 acre-feet per year of water released from Lake Mendocino. The Mendocino RRFC manages this water-right permit through water supply contracts with farmers and public water purveyors in the Hopland Valley, Ukiah Valley and Redwood Valley. While Redwood Valley County Water District (CWD)'s water right Permit 17593 does not authorize the re-diversion of water stored in Lake Mendocino, it does authorize Redwood Valley CWD to divert water from Lake Mendocino during times when the reservoir is in its flood control pool.

A significant challenge in the water supply operations of Lake Mendocino is that there has been little-to-no coordination among water diverters below Lake Mendocino and between these water diverters and the Water Agency. These diverters rely, almost exclusively, on the Upper Russian River and the releases of stored water from Lake Mendocino to meet their water supply needs.

Water Agency operational decisions for Lake Mendocino are based on preserving the maximum amount of water in the reservoir's water supply pool while complying with the applicable minimum instream flow requirements. Operationally, during times of sufficient rainfall, the Water Agency limits releases from the water supply pool to the amounts needed to meet the 25 cfs requirement for minimum flows in the East Fork Russian River immediately downstream of the dam, because tributary inflows are sufficient to meet the instream flow criteria in all reaches of the Upper Russian River. During other times, the Water Agency must make higher releases to ensure that the required minimum instream flows are maintained at stream gage locations (compliance points) all along the Upper Russian River. Typically, there is a transition period in the spring and early summer during which the stream gage for which the Water Agency must make CVD releases to maintain the minimum flows shifts from the calculated flow at the Forks (the farthest upstream compliance point) to a more downstream gage and ultimately to the gage at Healdsburg (the farthest downstream gage on the Upper Russian River) as the watershed dries up and tributary inflows decrease. During the dry summer season, due to the lack of appreciable tributary inflows and high water demands, the Water Agency normally must release sufficient water from CVD to maintain the required minimum instream flows at the Healdsburg Gage.

Unlike the water users on the Upper Russian River, water users on the mainstem of the Russian River downstream of Dry Creek have the benefit of releases from the significantly larger Lake Sonoma to supplement streamflows. The authorized uses of reservoir storage releases from Lake Sonoma are, however, limited to re-diversions by the Water Agency and its customers and meeting minimum instream flows.

2.4 Potter Valley Project Operations

Water has been diverted from the Eel River to the upper reach of the East Fork of the Russian River for power generation purposes at the PVP since the early 1900s. The PVP has a maximum diversion capacity of approximately 300 cfs, and maintains flow in the East Fork of the Russian River year-round. The project consists of: an upstream regulating reservoir on the Eel River, Lake Pillsbury; a diversion dam on the Eel River, Cape Horn Dam; a redwood-lined tunnel and penstocks; and the Potter Valley Powerhouse upstream of Lake Mendocino. The powerhouse has a capacity of 9.4 megawatts. The PVP is owned and operated by PG&E under a license issued by the Federal Energy Commission (FERC). The operation of the PVP by PG&E under its FERC license is independent of the operations of Coyote Valley Dam.

PG&E schedules releases from Lake Pillsbury to meet FERC-required minimum instream flow requirements in the Eel River and to provide water for diversions at Cape Horn Dam and through a trans-basin tunnel to the PVP Powerhouse. Eel River flows diverted through the PVP powerhouse are released into the East Fork of the Russian River. A portion of the water released from the PVP Powerhouse is diverted by the Potter Valley Irrigation District (PVID) at two canals located just below the powerhouse. PVID has a contract with PG&E for up to 50 cfs. Additional water is released from the PVP Powerhouse to maintain FERC-required minimum flow requirements in the East Fork of the Russian River from the powerhouse to Lake Mendocino.

Diversions from the Eel River through the PVP averaged over 150,000 acre-feet annually (Figure 4) during the period when: (1) the Coyote Valley Dam Project and Lake Mendocino were designed, (2) the Water Control Manual for Lake Mendocino was developed, and (3) the State Water Board adopted water right Decision 1610. While PG&E does not coordinate its operations of the PVP with the Water Agency’s operations of Lake Mendocino, the historic importance of water from the PVP for Lake Mendocino water supplies is apparent from historical reservoir inflow data and the role of Lake Pillsbury inflows in the Water Agency’s water-right permits. Specifically, the hydrologic index established by the State Water Board in Decision 1610 that is used to set the minimum instream flow requirements in the Water Agency’s water-right permits for the Upper and Lower Russian River and Dry Creek is based on cumulative inflows into Lake Pillsbury.

The Federal Power Act license issued by FERC in 1983 for the PVP required PG&E, in cooperation with the California Department of Fish and Game (CDFG) and U.S. Fish and Wildlife Service (USFWS), to carry out ten years of fish monitoring studies at the PVP. Upon completion of the 10-year fish monitoring studies, PG&E, in consultation with the resource agencies, filed recommendations with FERC for modifications to the required flow schedule. PG&E filed a consensus recommendation, in which the National Marine Fisheries Service (NMFS) joined, with FERC in March 1998. In November 2002, NMFS issued a Biological Opinion in connection with the proposed license amendment. Based on the requirements in this Biological Opinion, FERC amended PG&E's license in January 2004 to require implementation of the Biological Opinion requirements. When FERC did so, it believed that the differences between the Biological Opinion requirements and an earlier flow proposal by NMFS that had been modeled in the PVP Environmental Impact Statement were "modest differences … not likely to result in any material difference in the environmental effects." (FERC Order on Rehearing, 107 FERC ¶ 61,232, Para. 22.) However, when the Biological Opinion requirements were fully understood and implemented in 2006, they resulted in unexpectedly significant decreases in PVP flows into the Russian River Watershed that had not been modeled in the FERC proceeding or evaluated in the EIS.

Since 2006, operation of the PVP under the terms of the Biological Opinion and the amended license has significantly reduced PVP diversions compared to historic levels. Annual PVP diversions now average 72,000 acre-feet. These reduced PVP flows have significantly reduced inflows into Lake Mendocino. Figure 4 shows the average cumulative diversions through PVP by water year for three periods, 1922-1983, 1984-2006 and 2007-2013. The observed reduction in diversions for the most recent period shown in Figure 4 has significantly impacted the water supply reliability of Lake Mendocino.

In addition to the reductions in the annual amounts of PVP diversions, the timing of the PVP diversion reductions also has exacerbated the impacts on Lake Mendocino water supply reliability. Springtime diversions from the PVP diversions have been greatly reduced since 2006. The resulting reduced inflows during the spring are at odds with the design of Lake Mendocino as a relatively small reservoir having a water supply pool that expands as flood risk decreases during the spring, as illustrated in Figure 2. The consequence has been that the Water Agency has had to file a number of Temporary Urgency Change Petitions (TUCP) with the State Water Board to request reductions in the minimum instream flow requirements in the Water Agency's water-right permits to preserve adequate water supply storage in Lake Mendocino.

3.0 METHODOLOGY

The Reliability Study focuses on characterizing the status of the Lake Mendocino reservoir operations under current conditions and assessing the impacts of potential changes over a 30-year planning period. The study considers how future water supply reliability (based on amounts of water stored in Lake Mendocino) may be affected by parameters like watershed demands, land use changes, hydrology, and regulatory operational requirements. Variations of these parameters were combined to develop eight evaluation scenarios that assist in assessing water supply reliability under potential future conditions. The assessment of the evaluation scenarios relies on the simulation of reservoir operations of Lake Mendocino with a water balance model that incorporates the operational rules and parameters that the reservoir operators use to manage both water supply and flood control operations.

3.1 Evaluation Scenarios

For this water supply reliability evaluation, eight scenarios were developed to assess potential future conditions of Lake Mendocino. These scenarios are listed in Table 2. To understand the model results for future conditions, it is essential first to understand how the water balance model characterizes the current condition (Scenario 1). This study does not contemplate all potential future conditions and instead considers reasonable “bookend” scenarios (based on best available information) for future urban and agricultural growth and climate change.

One of the scenarios (Scenario 2) evaluates the impacts on current water supply reliability of Lake Mendocino, assuming no future diversions from the Eel River into the Russian River watershed by the PVP. All of the model scenarios assume implementation of the interim minimum instream flows recommended by the Russian River Biological Opinion.

3.2 Stakeholder Outreach

As described in Section 1.1, the Order directs the Water Agency to coordinate with specific stakeholders in the Upper Russian River (listed in Table 1) in developing datasets for current and future water use. Table 1 also lists other entities that were contacted to develop background and essential datasets for the study. On May 17, 2013, the Water Agency sent notification letters to the stakeholders to provide information about the Order and the outreach component and to solicit participation from stakeholders in the Reliability Study. Following up on these letters, Water Agency staff organized meetings with the stakeholders. Details on these initial introductory meetings are presented in Appendix B.

To support the development of its evaluation, Water Agency staff requested records and documents from the various stakeholders. The request included a list of the pertinent documents and records that may be available. The acquisition of datasets and documents from each of the participating stakeholders is documented in Table 3. The Water Agency engaged with the stakeholders during this data collection and analysis process through email and telephone communications to ensure that the stakeholders understood the Water Agency’s evaluation process and to allow each stakeholder to verify the demand datasets that were developed.

Stakeholders listed in Table 1 participated in subsequent meetings to discuss water management strategies being implemented as a result of the drought conditions that occurred in the Upper Russian River and Lake Mendocino during 2013 and 2014. These meetings convened every six to eight weeks and are referred to as the Upper Russian River Water Managers Meetings. These meetings also served to provide updates and coordinate on this study’s progress. An initial meeting was held on February 3, 2014. Additional meetings were held on:

- April 10, 2014
- June 26, 2014
- August 18, 2014

- October 9, 2014
- January 8, 2015
- March 5, 2015
- April 9, 2015

During the January 8, 2015 meeting in Cloverdale, Water Agency staff presented the draft findings of the Reliability Study. With ongoing dry conditions, these meetings have continued to address water supply reliability issues in the Upper Russian River.

Additional meetings were held with Mendocino RRFC and University of California (UC) Cooperative Extension to develop potential land use changes in the Mendocino County portion of the watershed during the evaluation period. The UC Cooperative Extension provided technical assistance for modeling efforts and updated the agricultural field mapping which serves as the basis for the agricultural demand model.

3.3 Description of Model

The model used to complete the study was developed as a Microsoft Excel spreadsheet and simulates storage conditions in Lake Mendocino under different levels of system demand and varied climatic conditions for both historical hydrology (for 1910 to 2013) and projected hydrology (for 2000 to 2099) resulting from specific downscaled climate future model simulations developed by the U.S. Geological Survey (USGS). The model estimates river water gains and losses and operations necessary to meet minimum instream flows at seven locations on the Russian River. The model simulates reservoir inflows, storage and releases on a monthly time step. Five of the seven modeled locations correspond to existing USGS gage locations. A schematic of the model is provided as Figure 5, with points (nodes) showing the locations for which water balance calculations are completed, and with estimated model system gains and losses shown as arrows. Appendix B provides a detailed description of the model.

3.4 Model Input

The model has numerous input datasets to simulate system hydrology, water loss and operational constraints. Model datasets are described below and in greater detail in Appendix B.

3.4.1 System Water Gains

Systems water gains include water that is added to the system from natural or man-made sources. The gains accounted for in the model include unimpaired flows (often called “natural” flows) from precipitation runoff and groundwater discharges into the river, and diversions from the Eel River through the PVP. Model water system gain locations are shown as solid green arrows in Figure 5.

Unimpaired flows are the “natural flows”, unaffected by man-made influences such as water diversions or reservoir operations. Unimpaired flow datasets were developed by the USGS (Flint et al, 2015) for historical climate from 1910 to 2013, and for potential changes in flows due to climate change from 2000 to 2099 for seven locations in the Upper Russian River. The USGS used the Basin Characterization Model for California (CA-BCM) to integrate high-resolution data of historical and projected climate data to predict watershed-specific hydrologic responses. Two future climate change scenarios were evaluated for this study. These scenarios were developed from global climate change model results that were “downscaled” spatially and temporally for the Russian River watershed. These downscaled climate change scenarios were prepared for incorporation into the CA-BCM from the Global Fluid Dynamic Laboratory (GFDL) model for the A2 (medium-high) and B1 (low) future greenhouse gas emissions scenarios. Downscaling was completed spatially to 270 meters and temporally to a 1-day time step. For the purposes of this study, daily estimated flows were converted to monthly flow rates.

Trans-basin diversions from the Eel River into the Russian River watershed through the PVP were estimated using the Eel River Model version 2.5 developed by Natural Resources Consulting Engineers (Oakland, CA) with recent refinements made by the Water Agency. Due to changes in operations of the PVP, observed historical PVP diversions were not used in the historical period simulated by the model. As described in Section 2.4, in the fall of 2006 operations of the PVP changed significantly due to a 2004 FERC license amendment, and historical diversions therefore do not represent current PVP operations. For this reason, modeled PVP diversions were developed to approximate current, post-2006 operations. Additionally, as described in Section 3.1, a model scenario was developed to simulate conditions with no PVP diversions. System gains from diversions from the PVP are defined at model node 1, as shown in Figure 5.

3.4.2 System Water Losses

System water losses include all water that flows out of or is diverted from the system and include losses due to environmental processes (e.g. riparian vegetation evapotranspiration and surface-groundwater interactions) and losses due to human uses such as diversions for domestic, municipal and agricultural purposes. The model accounts for system losses at five geographic points on the Russian River. System loss locations in the model are shown as hollow red arrows provided in Figure 5. System losses accounted for in the model include municipal diversions, agricultural diversions, water diverted for crop frost protection, and riparian vegetation, lake evaporation and water balance losses. The Reliability Study Model is a surface water hydrologic model, which does not simulate the physics of water exchange between surface water and the underlying groundwater aquifer. While not explicitly simulated as discrete processes, exchanges of water between the surface water and groundwater systems are implicitly accounted for in the Reliability Study Model through the water balance analysis used to derive reach losses, which incorporates observed reach losses and gains. To estimate the relative contributions of discrete processes on surface water losses and gains (e.g. direct surface water diversions, evapotranspiration, and groundwater seepage), a coupled surface water/groundwater flow model is needed. Such a model does not currently exist for the Upper Russian River.

System losses were evaluated for current conditions as described above, and system losses through 2045 were estimated for Scenarios 3 through 8 (see Section 3.1). These scenarios were developed through analyses that incorporated observed water diversions from municipalities, land use planning documents, observed streamflows from USGS discharge gages on the Russian River and spatial mapping layers and remote sensing data. A detailed description of the development of these alternatives is provided in Appendix B.

3.4.3 System Operations

Flood operations of Lake Mendocino are incorporated into the model with the reservoir Guide Curve in the Corps Water Control Manual. As discussed in Section 2.2, the Guide Curve is a seasonally varying storage threshold. When Lake Mendocino storage levels are above this curve, USACE makes flood control releases to bring Lake Mendocino storage levels down to the applicable points on the curve. The model assumes that water may not be stored in Lake Mendocino for water supply purposes at levels above the Guide Curve. If end-of-month storage is above the Guide Curve, then this model assumes that sufficient water will be released from the reservoir to bring the storage level down to the top of the conservation pool.

Water supply operations of the Upper Russian River System are constrained by Decision 1610 and the Russian River Biological Opinion. The model utilizes the hydrologic index defined in Decision 1610. This hydrologic index is a metric that sets the water supply condition and the corresponding minimum instream flow schedule for the Russian River system. For November to April, the model assumes that the minimum instream flow requirements of Decision 1610 are met. For May to October, the model assumes that minimum instream flow requirements are those identified as the interim flow requirements of the Biological Opinion. The hydrologic index and the minimum flow requirements are summarized in Figure 6.

3.4.4 Municipal Water Use

Water demands for municipal and industrial water use were established for the nine public water systems listed in the Order. The evaluation of existing water use and estimates of future water use were developed in collaboration with each of the Russian River stakeholders listed in Table 1. Based on 2012 annual reports submitted to California Department of Water Resources (DWR), the total service population for these systems is approximately 55,000. Table 4 lists each system's service population. The City of Ukiah serves the largest population with 16,000 persons. Overall, the Upper Russian River watershed has an estimated population of 55,706 based on data from the 2010 U.S. Census.

The water supply for these nine systems is primarily composed of surface water diversions and groundwater well pumping from the alluvial aquifer of the Russian River. Other than the City of Healdsburg (which receives a portion of its water from Dry Creek), these systems only use water available along the mainstem corridor in the Upper Russian River watershed.

Existing water demands for these water service providers were established using recent water production records submitted to the DWR in the annual Public Water System Statistics (PWSS) reports. Total annual production calculated for the water systems are listed in Table 5 for the five-year period from 2009-2013. The production records contain monthly production amounts by source category (well, surface water, purchased, recycled, and untreated). For the purposes of this study, only well and surface water sources were considered. For the water balance model, the monthly records for the five-year period from 2009-2013 were the basis for developing a monthly distribution of municipal water use by river reach.

Over this period, the Upper Russian River experienced dry, normal, and wet years. Both 2010 and 2011 were relatively wet years. In 2012, precipitation was about average, while 2009 was dry, and 2013 was extremely dry. Populations in the Upper Russian River municipal service areas did not change significantly during this period. Many of the water providers experienced a lower water usage in 2010 and 2011, reflecting the effects of wet years in reducing irrigation demands. The economic impacts of the Great Recession of 2008-2009 likely reduced the water demands for many of these water systems. In 2013, a stronger economy combined with a record low rainfall in Ukiah contributed to higher overall demands in the region.

Current water production conditions for each of the nine water systems were established as a baseline for the reliability evaluation. The water demands assumed for the evaluation of current conditions (2015) were established considering the average total production over the five-year period as well as considering any extraordinary circumstances that were discussed with the water managers. The current demands established as the evaluation baseline demand for each water system are shown in Table 6.

Water use projections for each water system were established based on a review of published projections found in various planning documents. For the larger water systems, the available documents were often Urban Water Management Plans and water system master plans, which directly address future water demands. For smaller systems, projections were developed based on population growth estimates found in county general plans. In 2010, Mendocino County developed a specific plan, the Ukiah Valley Area Plan (UVAP), which evaluated alternative development strategies for the region. A water supply assessment report was prepared in October 2010 to accompany the UVAP (MCWA, 2010). The report provided projected water use scenarios out to 2030 for Millview CWD, City of Ukiah, Rogina Water Company and Willow CWD. Demand projections for the water systems were reported for high use and reduced use scenarios. A 20 percent reduction in per capita water use was assumed in the UVAP for the reduced use scenario. For the Reliability Study, the projected annual rates of demand change from the UVAP were used.

Similar to the water supply assessment for the UVAP, two projection scenarios—low and high growth—were developed for the water use projections. For this study, projections in five-year increments following the base year of 2015 were estimated out to 2045. Projection estimates for periods beyond a water provider's planning period were extrapolated assuming a continuation of the rate of growth in water demand. The 'Low Growth' water use projections are summarized in Table 7. Under the 'Low Growth' scenario, the total water demand is projected to increase from 10,491 acre-feet per year to 14,241 acre-feet per year by 2045. For the 'High Growth' scenario, municipal water demand for the listed stakeholders is estimated to increase to 17,630 acre-feet per year as shown in Table 8. This corresponds to an increase of 7,139 acre-feet, or an annual average rate of increase of 1.7 percent. Figures 7 and 8 chart the projection data for the 'Low Growth' and 'High Growth' scenarios respectively.

All current condition and projection water demand datasets were reviewed and confirmed by the respective water system stakeholders in a review initiated in September 2014.

Table 9 aggregates the municipal water use projections by river reach. Lake Mendocino is included as a reach because Redwood Valley CWD pumps directly from the reservoir. River reaches are defined by USGS stream gage locations with each named by the corresponding downstream gage (except for Lake Mendocino). The reach with the current highest municipal water use and largest projected increase by 2045 is the Talmage reach.

3.4.5 Agricultural Water Use

Estimates of water use for agricultural lands within the Upper Russian River watershed were developed based on a land use approach methodology. Agricultural demands were estimated for the three primary categories of use: irrigation during the growing season, frost protection during the spring after bud break, and post-harvest application in the fall.

Water use for irrigation was estimated on annual basis using seasonal crop water duties for the various crop types by region. The regional crop water duties were developed based on the agricultural water demand modeling work for the Russian River conducted by Davids Engineering (Davis, CA) for the Water Agency (Davids Engineering, 2013). The annual crop water duties used for this study are listed in Table 10. These annual values are based on monthly crop irrigation requirements established in the Davids Engineering project, which used remote sensing data collected for the 2008 growing season to calculate evapotranspiration (ET). A water balance root zone model was developed to provide soil moisture accounting over time and to estimate the onset of irrigation and its contribution to the observed ET. The annual values in Table 10 are average duties established by runs of this agricultural demand model for the historical period of 2002 through 2008.

An update to the Water Agency's agricultural field mapping was completed to reflect land use changes up to 2012. The updated mapping was completed by Water Agency staff for the Sonoma County portions of the watershed and by UC Hopland Research and Extension Center (under contract with the Mendocino RRFC) for the Mendocino County portions. The Water Agency developed the original agricultural fields GIS layer for the entire Russian River watershed in 2009 by aggregating smaller scale GIS field mapping projects conducted by other organizations and contributing a significant amount of new mapping based on digitizing crop fields identified in orthoimagery. Figure 9 shows the existing agricultural lands. The crop acreages for each subwatershed under current conditions (based on 2012 imagery) are shown in Table 11.

Irrigation water use estimates in the river reaches of the Upper Russian River for the existing agricultural lands are shown in Table 12. These estimates were calculated based on the crop acreages from the agricultural field mapping and the derived regional water duties described above.

Protection of crops from frost damage is practiced in the Upper Russian River watershed primarily using overhead sprinklers. Vineyards and orchards are susceptible to frost damage after bud break. In a given year, the onset and number of frost events that require frost protection water vary, but the season typically runs between March 15 and May 15. Frost protection using overhead sprinklers requires high application rates and therefore pumping rates over a several hour period. Recent additions of storage ponds in the watershed have reduced the instantaneous impacts on the streamflows. However, whether the pumping is from a well, surface water or a storage pond, it is assumed for the purposes of this evaluation that such pumping will impact the monthly river water balance.

The methodology used to estimate frost protection water first calculates the total monthly diversions expected in an average year and then estimates a net water use accounting for return flows. The methodology used for determining associated diversions mimics that used by the UC Cooperative Extension – Ukiah (UCCE-Ukiah) report on irrigated agriculture (MCWA, 2008).

The report provides estimates of the total number of acres that are frost protected. The number of frost events and duration assumed for each region are tabulated in Table 13. These values are based on the parameters published in the report. Overhead sprinkler systems are assumed to operate in frost events with an average application rate of 50 gpm per acre.

Table 14 lists the estimated average water use and net water use for frost protection by subwatersheds. Based on a Water Agency analysis that reviewed historical frost events and observed impacts to Russian River streamflows, estimates of net water use under current conditions were established.

The post-harvest application of water to vineyards was also evaluated for this study using the same methodology as the UCCE–Ukiah report (MCWA, 2008). For the Mendocino County portion of the Upper Russian River watershed, the prevalence of post-harvest applications as a practice was maintained consistent with the report. This evaluation also uses the water application rate of 50 gpm per acre and the duration of 36 hours that were assumed by the UCCE-Ukiah. For the Sonoma County portion of the Upper Russian River watershed, the same post-harvest application operational parameters were assumed for 50 percent of the vineyard acreage. Table 15 lists the estimated average water use for post-harvest application by subwatersheds.

Using the same approach for determining total agricultural water use under current conditions as described above, the water use in the Upper Russian River watershed was projected for future conditions in 2045. Similar to municipal water use projections, ‘Low’ and ‘High’ water demand scenarios were developed. Based on historical trends in crop planting, vineyards are the dominant crop in the watershed and their percentage of the overall agricultural lands has been increasing. For this study, it was assumed that vineyards would comprise all new agricultural fields developed in the study area and that additional vineyards may be planted as a result of crop conversions from orchards and pastures.

Projections of future agricultural land use were completed using different approaches for Mendocino County and Sonoma County. The undeveloped arable lands in the Mendocino County portion of the subwatershed are more confined to a smaller area on the valley floor than in Sonoma County, which led to a more site specific approach. In Mendocino County, a parcel land use approach was used to identify new areas within the watershed that are likely to be developed for agriculture. In Sonoma County, historical trends in the growth of vineyard acreages were reviewed based on the County’s General Plan (Sonoma County, 2010). The average increase in vineyard acreages from the period of 2002 through 2012 was assumed for the future growth rate out to 2045. The overall 10-year change in vineyard acres in the Upper Russian River was calculated at approximately 2,600 acres. In addition to newly developed agricultural fields, the future crop land use projections include assumptions on a certain percentage of crop conversion occurring that increases the number of vineyard acres. Table 16 provides the assumed crop conversion percentages used for the evaluation.

In the ‘Low Demand’ scenario, there are more acres assigned to vineyard than in the ‘High Demand’ scenario since overall water use by vineyards is low compared to other crops. Table 17 lists the projected crop acres for the 2045 ‘Low Demand’ scenario. The ‘High Demand’ scenario for 2045 projected crop acres are listed in Table 18.

Projected irrigation water uses for the two scenarios for 2045 are presented in Tables 19 and 20. Projected frost protection water uses for the two scenarios for 2045 are presented in Tables 21 and 22. Projected post-harvest application water uses for the two scenarios for 2045 are presented in Tables 23 and 24.

The aggregation of all estimated municipal and agricultural water uses is presented in Figure 10. Based on the assumptions described above, total water use in the Upper Russian River watershed is estimated for current conditions at 58,856 acre-feet per year. By 2045, projected total water use is expected to increase to 67,277 acre-feet per year under 'Low Demand' assumptions and to 74,315 acre-feet per year under 'High Demand' assumptions.

3.5 Key Water Balance Model Assumptions

To model an inherently dynamic and complex system certain simplifying assumptions must be made. These assumptions are described in detail in Appendix B and are summarized here:

- When Lake Mendocino storage is within the conservation pool, reservoir releases are made to meet downstream demands along, and the minimum instream flow requirements (including a buffer release) for the Upper Russian River.
  - No additional releases are made to meet demands along, or the minimum instream flow requirements for, the Lower Russian River.
- All system gains and losses are defined with the input datasets for the model.
- The water loss datasets are applied in the model as annually repeating patterns of system losses.
  - Current system loss alternatives incorporate *Normal* and *Dry* year types which are determined through an analysis of springtime precipitation.
  - Projected 2045 system loss alternatives use a single annually-repeating pattern based on average loss.
- To approximate losses in surface water flows for the projected 2045 alternatives, scaling factors were developed correlating observed reach losses to current estimated applied water demands.
- Losses from riparian vegetation water use are the same for all current and future scenarios.
- All estimated current and projected municipal demands directly impact surface water flows in the river.
- No conservation water is stored in Lake Mendocino above the limits of the Corps' Guide Curve.

4.0 MODEL SIMULATION RESULTS AND OBSERVATIONS

The Reliability Study Model was used to simulate Lake Mendocino storage conditions for analyzing the eight scenarios identified in Table 2. Results of the simulations are shown in Figures 11 through 14 as percentile plots of minimum annual lake storage. For comparison purposes, Figures 11 and 12 include historical Lake Mendocino storage levels from water year 1984 to 2006 (Observed Historical Data). These years were selected to represent a time of relative system reliability, after the construction of Lake Sonoma and use of it to meet some municipal demands on the Lower Russian River, and before PG&E began implementing the 2004 FERC PVP license amendment. Observed Historical Data from these years is not directly comparable to the model results due to the limited number of years sampled. Furthermore, this limited time period does not encompass a period of significant drought, such as 1924 or 1976/1977. Additionally, watershed water demands were likely lower for a large portion of this period. However, including the observed storage for the historic period of 1984 to 2006 for comparison to the modeled scenarios does demonstrate the subsequent changes in available water supply due to reductions in PVP transfers of Eel River water. Due to the uncertainty of the minimum reservoir storage level at which water can be released, the model assumes that the reservoir is dry at below 2,000 acre-feet. In addition, the model does not assume that management actions such as reductions in flows or demand curtailments would be implemented. Although water supply managers would take measures to attempt to prevent a dry reservoir condition, there is no way to know now what management measures would actually be implemented, or what the exact impact on water demands of those measures would be.

Results of the model scenarios which incorporate historical hydrology (water years 1911-2013) are provided in Figure 11. These results indicate a reduction in reliability for Scenario 1 (representing current conditions) when compared to the observed historical data (water years 1984-2006). As expected, the results for Scenarios 3 and 4 which simulate Lake Mendocino's water supply reliability to 2045, assuming historical hydrology and low and high projected demands, indicate further reduction in reliability. Scenario 2 which assumes no diversions from the PVP for 2015 estimated water demands, shows a significant reduction in reliability. In more than 60 percent of the modeled years, the reservoir would be dry at some point during the year.

Results of model Scenarios 5 through 8 incorporate future climate change hydrology (water years 2000-2099) and are provided in Figure 12 For comparison, results of Scenario 1 (current conditions) and Scenario 4 (projected 2045 high growth with historic hydrology) are also included in this figure. The Projected 2045 demand scenarios with climate change hydrology all show a significant reduction in reliability for the driest 50 percent of months when compared to the current conditions (Scenario 1) and projected 2045 scenarios with historical hydrology (Scenarios 3 and 4). This reduction in reliability is highlighted with the most optimistic scenario (Scenario 7), which incorporates the wet future climate and the 2045 low growth demand projection. For this scenario, the model predicts Lake Mendocino would go dry in more than eight percent of the years modeled. The results for Scenario 6 (dry future climate and high 2045 growth) indicate that Lake Mendocino would go dry at some point during the year in about 10 percent of the years modeled. All of the future climate change scenarios assume operations of the PVP consistent with current FERC license requirements, but with changed hydrology due to climate change impacts.

In summary, the analysis presented in this report indicates that Lake Mendocino's water supply reliability has decreased in recent years, especially since the PVP operations were changed after 2006. Future growth projections (high and low) for the areas that rely on Lake Mendocino for their water supply indicate modest growth through 2045. Even with modest growth, however, Lake Mendocino's water supply reliability is expected to continue to further decline, both under scenarios that assume historical climate conditions will continue, and also under scenarios that assume future wet and dry climate conditions. A scenario evaluating the effect of having no PVP diversions in the future shows that under that scenario, Lake Mendocino would go dry at some time during a majority of years (over 60 percent). This would have significant impacts to downstream water users, ecosystems, and groundwater aquifers. Without water in Lake Mendocino to release downstream, river reaches could end up with little or no surface water flow. The loss of surface water flow would result in the loss of aquatic habitat for listed and native fish, impacts to riparian and wetland habitats for flora and fauna, as well as loss of recreation opportunities in the reservoir and along the river. Water users dependent on surface water diversions would experience significant impacts to their ability to divert water. In addition, groundwater levels in the alluvial aquifer of the Russian River would decline impacting production from many groundwater wells.

5.0 RECOMMENDATIONS

This section provides recommendations about how to improve and refine the water supply reliability analysis, current and possible future activities to identify ways to improve both the near-term and long-term reliability of Lake Mendocino, and additional measures for demand management.

5.1 Recommended Improvements to Reliability Study

As with any water supply study, the analysis can be improved by collecting and using additional data and by increasing the sophistication of the analytical tools and models employed in the analysis. Key data gaps and model limitations identified in this evaluation of Lake Mendocino's water supply reliability include:

- A lack of a detailed understanding of the surface water - groundwater interactions in the Upper Russian River. There is a general lack of data regarding such interactions. In addition, existing modeling capabilities are not sufficient to evaluate groundwater and surface water conditions in a coupled system.
- Analysis of potential future conditions could benefit from modeling additional future climate scenarios, such as the CMIP5 model results. Furthermore, it is anticipated that there will continue to be improvements in future climate modeling that will enhance ongoing efforts to evaluate the reliability of Lake Mendocino.
- Estimates of agricultural demands are limited to those that can be made using regional and subwatershed characteristics that inform a soil moisture balance model to derive irrigation requirement estimates. Agricultural demand estimates could be improved through further analysis of evapotranspiration of agricultural fields and refinements to the root zone model.
- More improvements and updates of this model could be completed. Alternately, agricultural pumping records combined with source identification and location information would provide a better understanding of agricultural water use.

Although these refinements would improve the accuracy of the predictions of Lake Mendocino water supply reliability under various scenarios, it is unlikely that any of these refinements would change the basic conclusion that Lake Mendocino reliability will continue to decline in the future, with increases in demands and changes in hydrology due to climate change.

5.2 Near-Term and Long-Term Activities

Given the significance of these preliminary findings on Lake Mendocino water supply reliability, the Water Agency plans to further engage the entities with which it has already coordinated and also to engage all Upper Russian River water users to identify prospective new programs or initiatives that may address the ongoing water supply shortages and improve long-term reliability of Lake Mendocino. Ongoing individual programs, which are described below, should be continued, and additional collective actions by all water users that rely on Lake Mendocino should be pursued. Accordingly, the Water Agency intends to prepare a follow-up report, based on stakeholder input, documenting both existing efforts and proposing new initiatives to promote more sustainable water supply conditions for Lake Mendocino and the Upper Russian River.

In the following sections, ongoing activities intended to improve both near- and long-term reliability of Lake Mendocino water supplies are described. Although implementations of these initiatives are expected to improve the reliability problems described in Section 4.0, they will not be sufficient to reduce water supply reliability risks entirely. Consequently, engagement with the Upper Russian River water users to develop additional solutions and strategies for water supply management is essential.

5.2.1 Initiation and Coordination of Water Conservation Programs

To promote water savings that extend beyond the service area of the Water Agency's water transmission system, the Water Agency implemented the Sonoma-Mendocino Immediate Drought Relief Project, a demand reduction program that includes many entities in the Upper Russian River, in areas that have lacked aggressive water conservation programs in the past. The project has been awarded over $1 million of Prop 84 Drought funding to create long-term water savings.

5.2.2 Recycled Water Projects in Healdsburg and Ukiah

The City of Healdsburg constructed a recycled water system that makes tertiary treated wastewater available for nearby vineyard irrigation and dust suppression/construction water demands. The system is being expanded this year to provide recycled water for wash water at a gravel processing plant. This year the recycled water system is anticipated to offset approximately 600,000 gallons per day of direct diversions from the Russian River.

The City of Ukiah is currently in the design stage for Phases 1 and 2 of a recycled water system that will serve approximately 940 acres of vineyards and orchards with recycled water for irrigation and frost protection uses. It is anticipated that 800 acre-feet will be used annually for these beneficial uses, which will be a direct offset diversions from the Russian River. Construction for the project is anticipated to start in the spring of 2016, once all funding is in place.

5.2.3 Leak Detection and Water Loss Audits

Cloverdale has implemented an aggressive leak detection/leak repair program. To date, Cloverdale has completed surveying approximately 90 percent of its distribution system. Repairs of leaks as a result of the leak detection/leak repair program have reduced system losses by 21 percent.

5.2.4 Initiation of Routine Meetings among Upper Russian River Water Managers

On February 3, 2014, the Water Agency hosted a meeting in Hopland with Upper Russian River municipal water managers to discuss Lake Mendocino water supply conditions. Attendees included representatives of each of the agencies listed in Term 17 of the Order, two members of the Sonoma County Board of Supervisors, two members of the Mendocino County Board of Supervisors, and Water Agency staff. These meetings have continued to occur every six to eight weeks in response to the ongoing drought and interests of cooperation and sharing water resources information.

5.2.5 Improved Frost and Heat Event Forecasting

During frost and high heat events, the total amount of water diverted from the Russian River to protect vineyards can dramatically reduce river flows. More accurate temperature predictions will allow vineyard managers to improve frost and heat mitigation techniques, helping farmers reduce pumping costs while reducing impacts to river flows. Combined with additional lead times, better predictions will also allow for fine-tuning releases from Lakes Sonoma and Mendocino to offset such diversions.

The Enhanced Frost/Heat Forecast Information System developed by the National Oceanic and Atmospheric Administration (NOAA) Hydrometeorology Testbed (HMT), and partially funded by the Water Agency, is a unique automated digital forecast system that combines dynamic and statistical forecast models run by the NOAA, high-resolution digital terrain information, and real-time vineyard surface observations from over 50 vineyards in the Russian River area. The result of this combined prediction method is a model that removes the bias that can appear in statistical forecast models as a result of terrain-induced microclimates. Results of this enhanced modeling are available to stakeholders through websites hosted by NOAA and a private weather information company, Western Weather.

5.2.6 Evaluation of Forecast Informed Reservoir Operations (FIRO)

The Water Agency works with the Corps to operate Lake Mendocino and Coyote Valley Dam. Forecast informed reservoir operation (FIRO) is a developing science which has the potential to provide enhanced weather and hydrologic forecasting, thereby improving water supply reliability and flood control capability. The Water Agency is collaborating members from the University of California San Diego, Scripps Institution of Oceanography, DWR, Corps, NOAA, Bureau of Reclamation, and USGS to conduct a demonstration project using Lake Mendocino as a model for testing FIRO and its potential application at other reservoirs.

5.2.7 Development of a New Hydrologic Index

As discussed in Section 2.3 above, the hydrologic index is a metric which is used to set the water supply condition and the corresponding minimum instream flow schedule for the Russian River under the Water Agency's water right permits. The existing index, which is defined in D-1610 using cumulative inflow into Lake Pillsbury, does not accurately reflect the water supply condition of the Russian River basin. As part of the changes in minimum instream flow requirements, the Water Agency is pursuing to comply with the Russian River Biological

Opinion, the Water Agency will also ask the State Water Board to change the hydrologic index in its water rights permits to create a metric more closely matching the actual hydrologic conditions in the Russian River basin. A detailed discussion and evaluation of the proposed modifications to the Decision 1610 hydrologic index, as well as the changes to the minimum instream flow requirements required by the Biological Opinion, will be included in a draft Environmental Impact Report that is anticipated to be released in fall of 2015.

5.2.8 Evaluation of Raising Coyote Valley Dam

On December 17, 2014, a Corps SMART (Specific, Measurable, Attainable, Risk-Informed and Timely) Planning meeting for the Coyote Valley Dam Raising Feasibility Study was held. The two-day event was attended by Corps staff from the South Pacific Division, the San Francisco District, the Dam Safety Modification Mandatory Center of Expertise, the Planning Center of Expertise for Water Management and Reallocation Studies, the Fort Worth District, the two non-Federal sponsors (the Water Agency and the Mendocino RRFC), and regional stakeholders. Facilitation was provided by a SMART Planning Facilitator from the Sacramento District. The purpose of the meeting was to re-scope the dam raising feasibility study for compliance with the Corps' *SMART Planning 3x3x3* policy and determine what steps are necessary to reach the *Alternatives Milestone*. At the meeting, a preliminary assessment of cost estimates and schedules for post-meeting study activities was made, which indicated that the feasibility study on raising the dam would be completed within three years and for $3 million or less, pending receipt of an optimal funding stream.

5.3 Additional Demand Management Measures

As noted above, although implementation of these measures is expected to improve the reliability of the Lake Mendocino water supply, these measures alone are unlikely to eliminate the water supply reliability risks described in Section 4.0 of this report. Even with implementation of these measures, increasing demands for water from the Upper Russian River and reductions in supplies due to changes in hydrology associated climate change still are likely to result in significant Lake Mendocino water supply reliability risks.

The Water Agency and the Upper Russian River Water users, therefore, need to work together to develop additional measures to reduce demands and diversions during drought conditions. If demands and diversions are not reduced sufficiently during drought conditions, there is a significant risk that Lake Mendocino could drop down to its minimum pool. If this were to occur, then Upper Russian River flows would drop to zero or near-zero levels and there would be significant impacts in fish and wildlife, the aquatic ecosystem, groundwater recharge and the entities that divert water from the river.

6.0 REFERENCES

California Department of Water Resources, 2014. *Public Water System Statistics,* Reports for calendar years 2008 through 2013 for water systems in the Upper Russian River watershed.

City of Cloverdale, 2010. *Water System Master Plan Update,* August 2010. Prepared by Coastland Civil Engineering, Santa Rosa, CA.

City of Healdsburg, 2003. *Water System Master Plan,* October 2003. Prepared by HDR Inc., Folsom, CA.

City of Healdsburg, 2005. *2005 Urban Water Management Plan*. Prepared by Winzler & Kelly Consulting Engineers, Santa Rosa, CA.

City of Healdsburg, 2010. *2030 General Plan*. Prepared by City of Healdsburg Planning & Building Department and Earthcraft Planning Services.

City of Ukiah, 2010. *2010 Urban Water Management Plan,* June 2011. Prepared by Carollo Engineers Inc., Walnut Creek, CA.

County of Sonoma, 2008. *Sonoma County 2020 General Plan,* September 23, 2008. Sonoma County Permits and Resource Management Department, Santa Rosa, CA.

County of Mendocino, 2009. *Mendocino County General Plan*, August 2009. Prepared by PMC Inc., Rancho Cordova, CA.

Davids Engineering, 2013. *Russian River Applied Water Estimates, Development Report*, March 2013. Prepared for Sonoma County Water Agency. Davis, CA.

Flint, L.E. and Flint, A.L., 2012. *Downscaling climate change scenarios for ecologic applications*, Ecological Processes 1:1.

Flint, L.E., Flint, A.L., Thorne, J.H., and Boynton, R., 2013. *Fine-scale hydrological modeling for climate change applications; using watershed calibrations to assess model performance for landscape projections*; Ecological Processes 2:25.

Flint, L.E. Flint, Flint, A.L., Curtis, J.A., Delaney, C., and Mendoza, J., 2015. *Unimpaired Mean Daily Streamflow in the Russian River and Upper Eel River Basins, California under Historical and Projected Future Climates: U.S. Geological Survey Data Release*, doi:10.5066/F71C1TX4.

Local Agency Formation Commission of Mendocino County, 2013. *Ukiah Valley Special Districts Municipal Service Review*, May 6, 2013. Prepared by E. Mulberg & Associates, Elk Grove, CA.

Mendocino County Water Agency, 2008. *Irrigated Agriculture Water Needs and Management in the Mendocino County Portion of the Russian River Watershed*, July 2008. Prepared by University of California Cooperative Extension, Ukiah, CA.

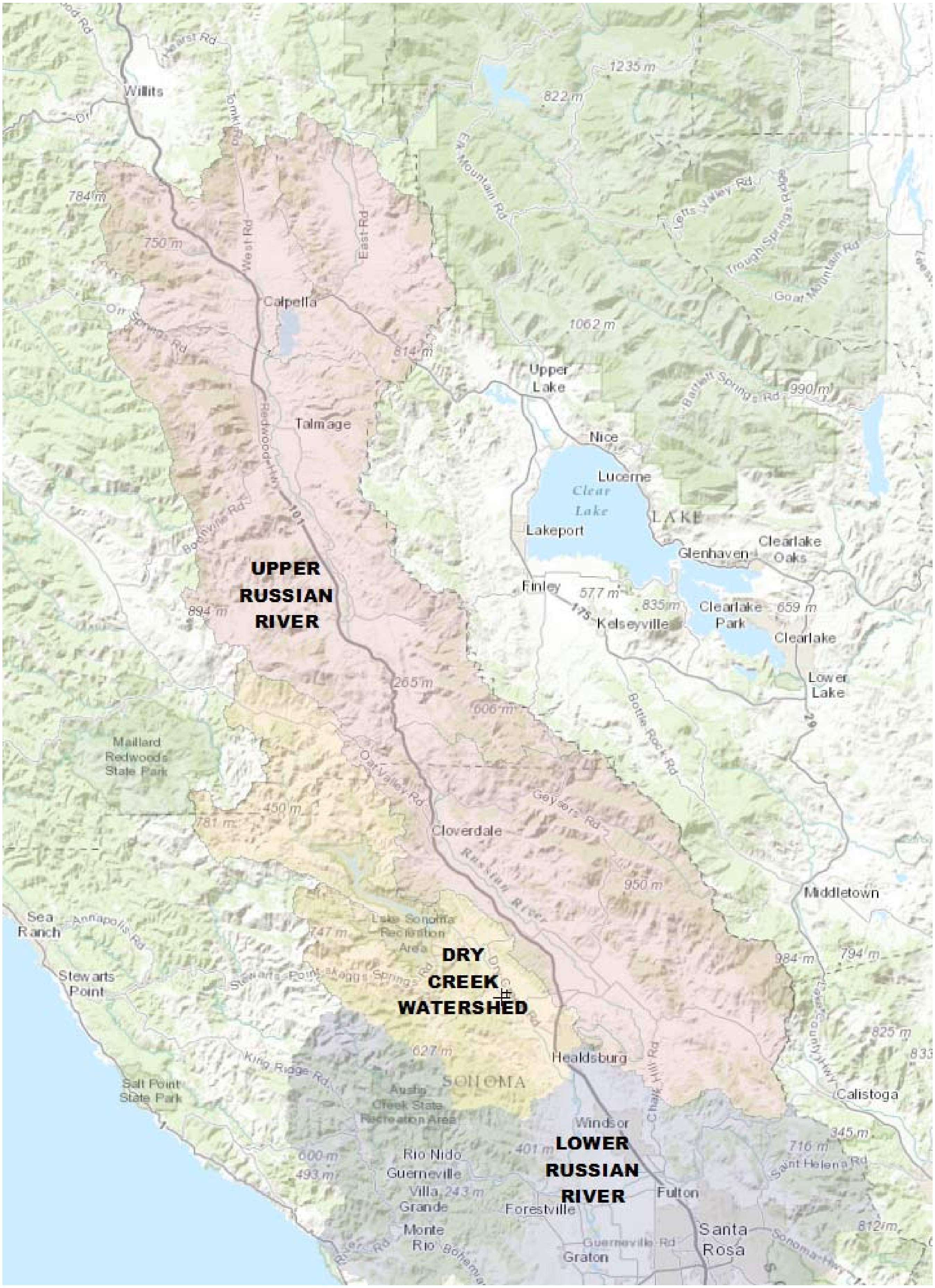
Mendocino County Water Agency, 2010. *Water Supply Assessment for the Ukiah Valley Area Plan*, October 20, 2010. Prepared by Mendocino County Water Agency, Ukiah, CA.

National Marine Fisheries Service (NMFS), 2008. *Biological Opinion for Water Supply, Flood Control Operations, and Channel Maintenance Conducted by the U.S. Army Corps of Engineers, the Sonoma County Water Agency, and the Mendocino County Russian River Flood Control and Water Conservation Improvement District in the Russian River Watershed,* September 24, 2008. Southwest Region, F/SWR/2006/07316.

State Water Resources Control Board (SWRCB), 1986. *Decision 1610, Russian River Project*, April 1986.

State Water Resources Control Board, Division of Water Rights, 2014. Water Rights Licenses, Permits, Reports, and Statements. Retrieved from http://www.waterboards.ca.gov/waterrights/water_issues/programs/ewrims/.

United States Army Corps of Engineers (USACE), 1986. *Coyote Valley Dam and Lake Mendocino, Russian River, California, Water Control Manual, Appendix I to Master Water Control Manual, Russian River Basin, California*, April 1986, Sacramento District.

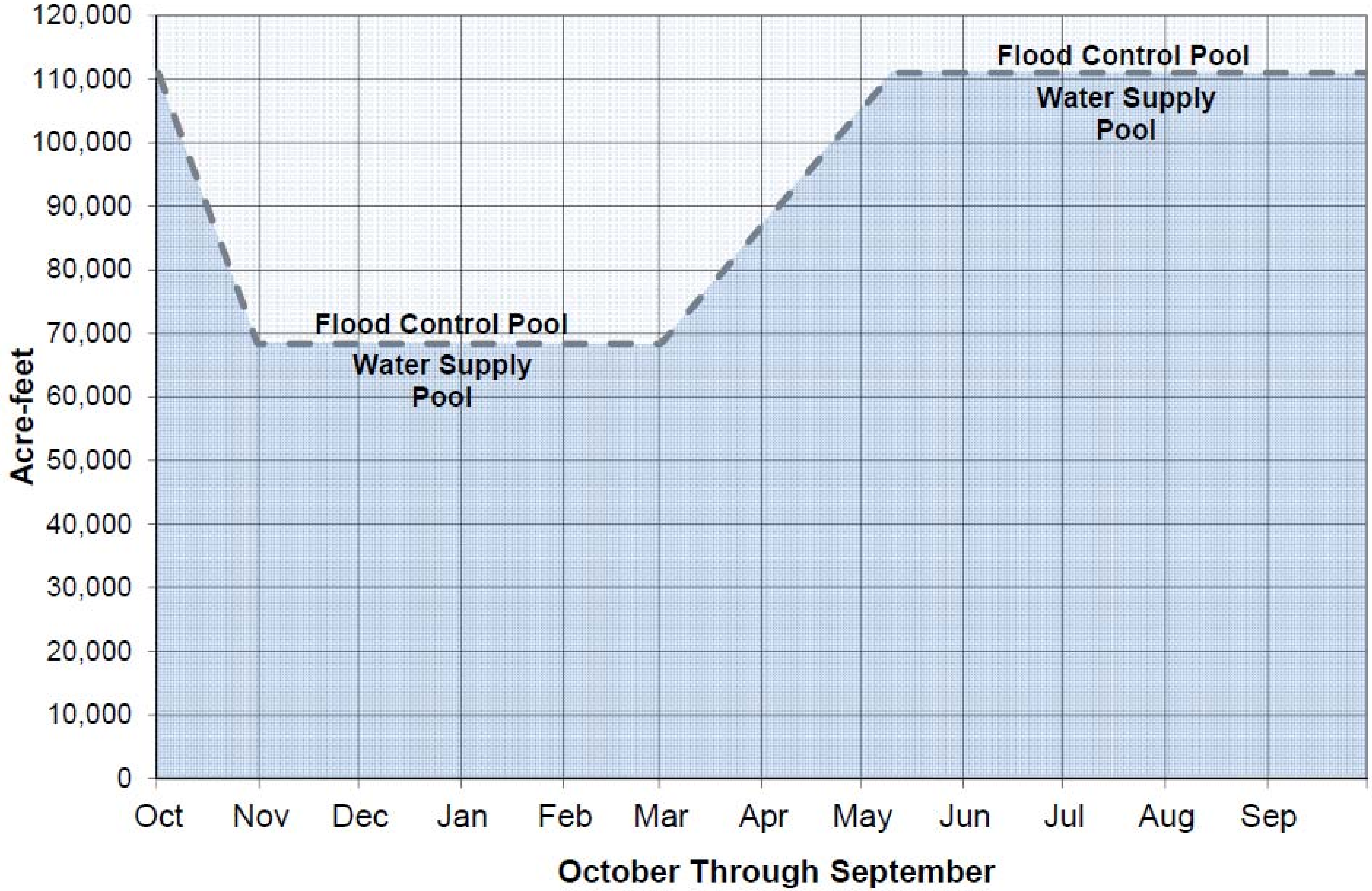


SONOMA COUNTY WATER AGENCY

LAKE MENDOCINO WATER SUPPLY RELIABILITY STUDY
TECHNICAL REPORT
APRIL 2015

Upper Russian River Watershed Map

Figure 1



Lake Mendocino Storage Guide Curve

Figure 2

Cumulative inflow to Lake Pillsbury (acre-feet) from Oct 1 through

	1/1	2/1	3/1	4/1	5/1	6/1	
NORMAL	≥8,000	≥39,200	≥65,700	≥114,500	≥145,600	≥160,000	Water Supply Conditions Prevailing on 6/1 Apply Through 12/31
DRY	<8,000	<39,200	<65,700	<114,500	<145,600	<160,000	
CRITICAL	<4,000	<20,000	<45,000	<50,000	<70,000	<75,000	

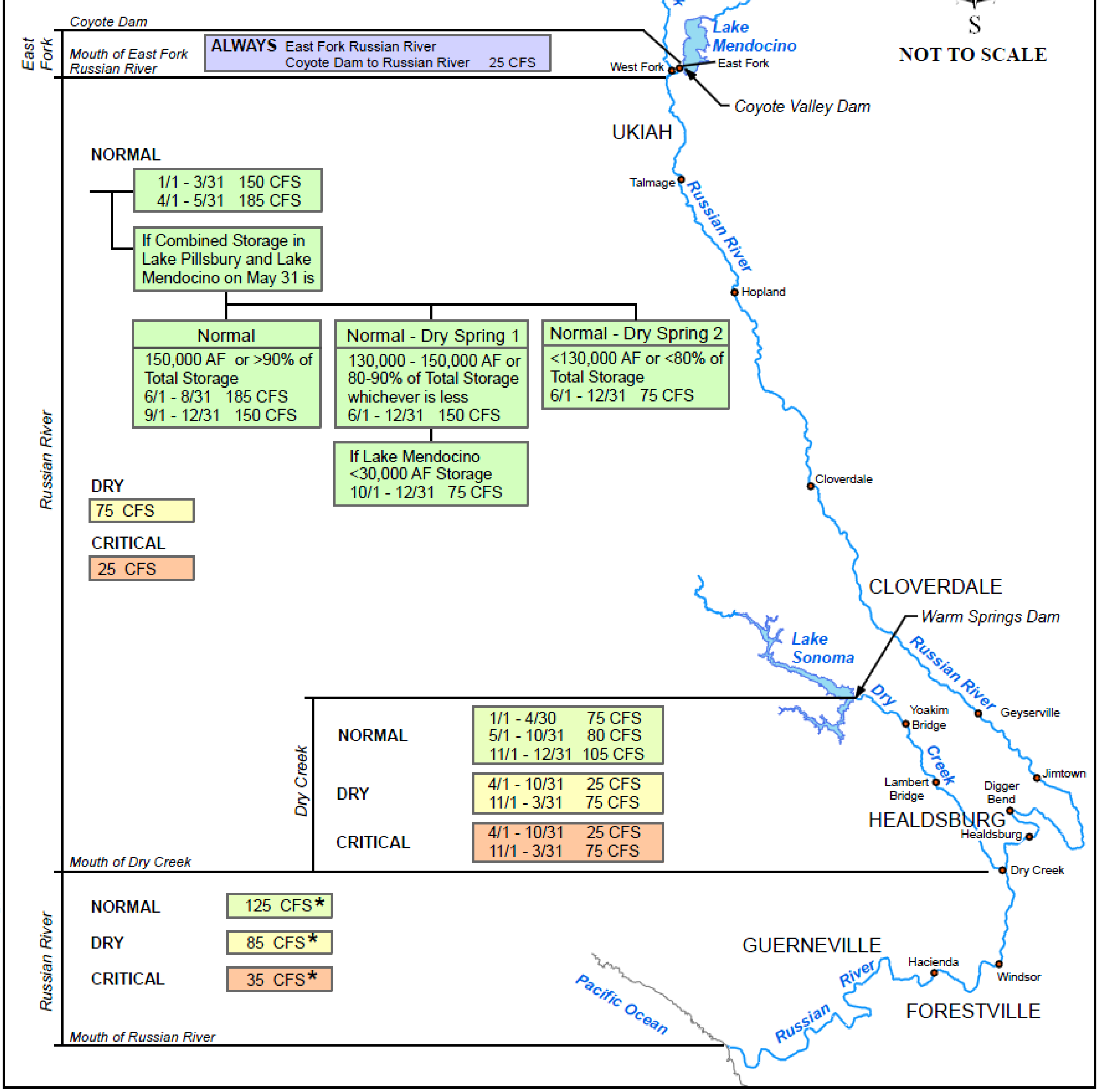
LEGEND

All flows are minimums, expressed in cubic feet per second.

* - Unless Lake Sonoma elevation is below 292.0, or if prohibited by the United States Government.

AF - Acre-Feet

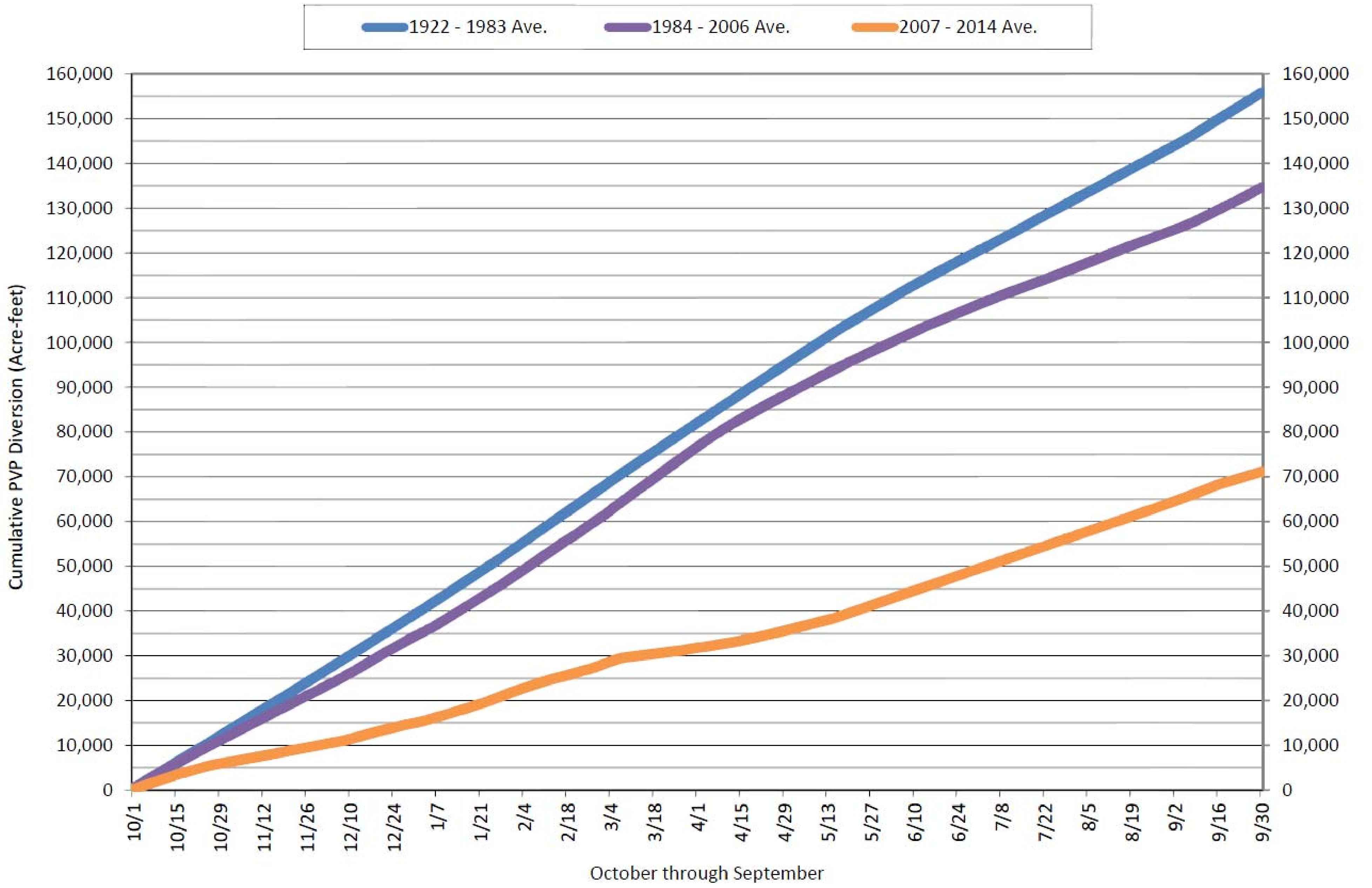
● - USGS Stream Gage Compliance Points



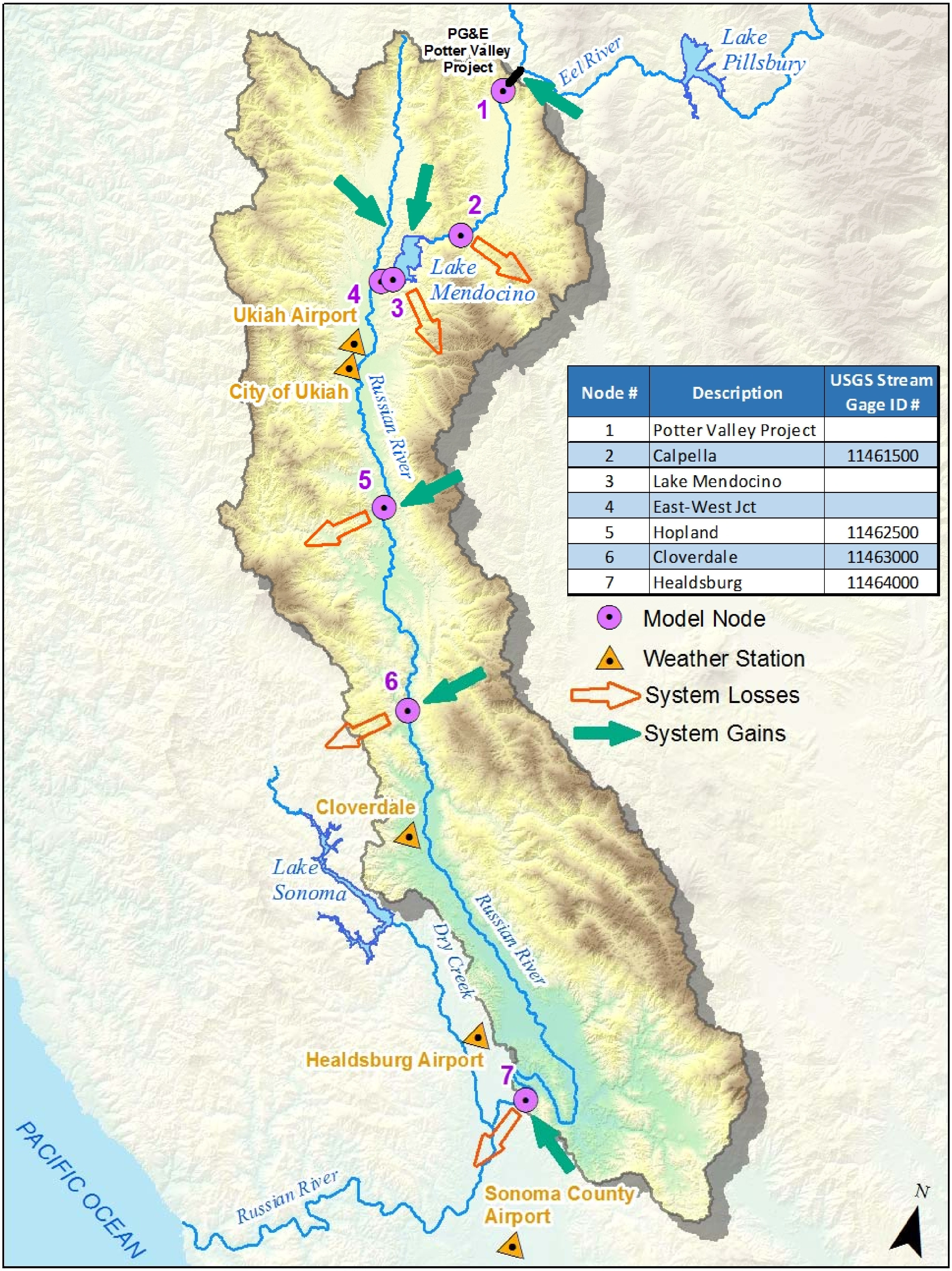
\\FILESERVER\Data\wp\basket\Schram_Projects\2011-USGS-Gage-Streamflow.mxd April 4, 2011 PDF MODIFIED ON 3/30/2015 TO ADD USGS GAGE AT GEYSERVILLE

Minimum Instream Flow Requirements per Decision 1610

Figure 3

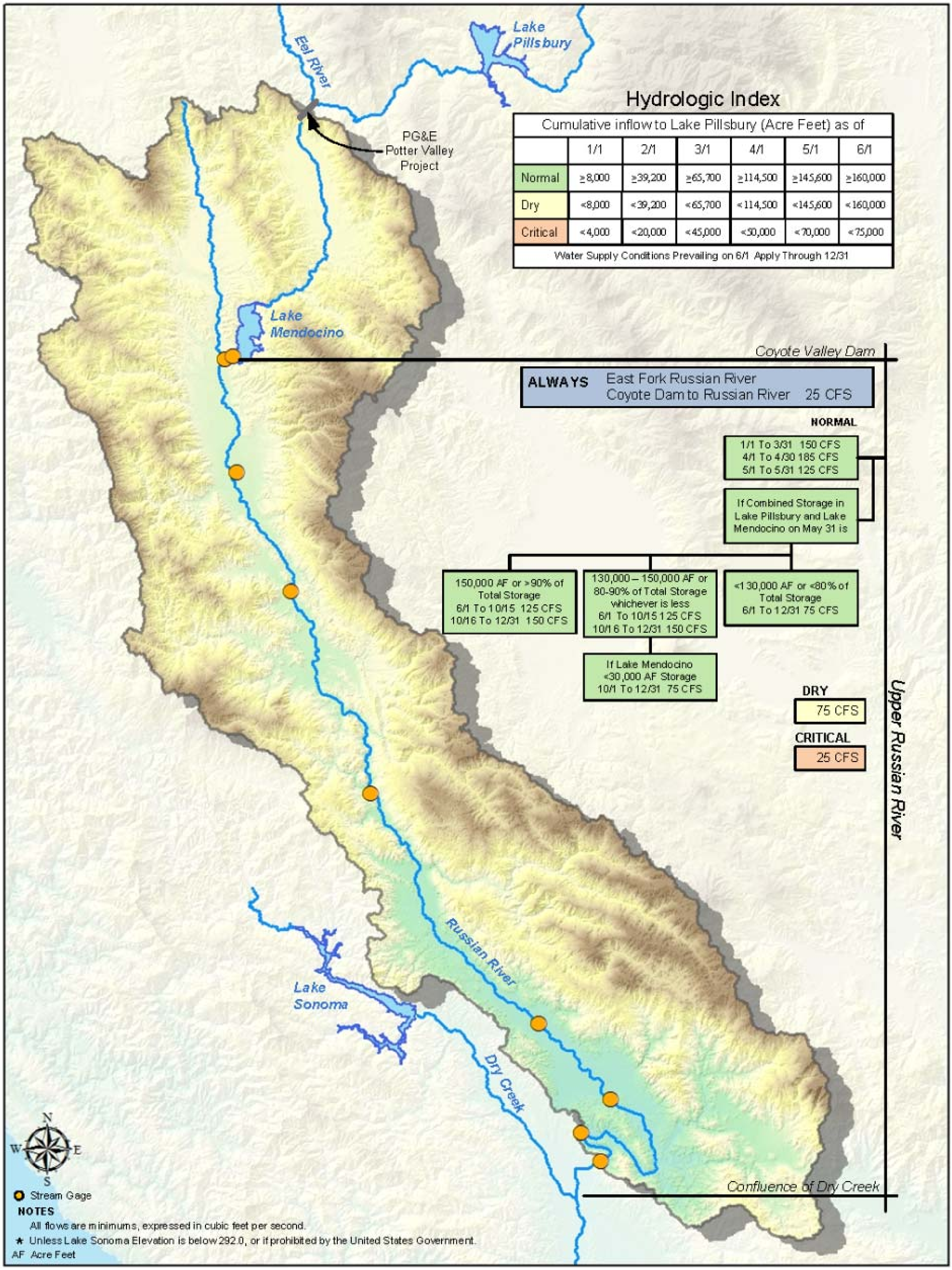


Cumulative Diversions Through Potter Valley Project Figure 4



Node #	Description	USGS Stream Gage ID #
1	Potter Valley Project	
2	Calpella	11461500
3	Lake Mendocino	
4	East-West Jct	
5	Hopland	11462500
6	Cloverdale	11463000
7	Healdsburg	11464000

Water Balance Model Schematic Figure 5

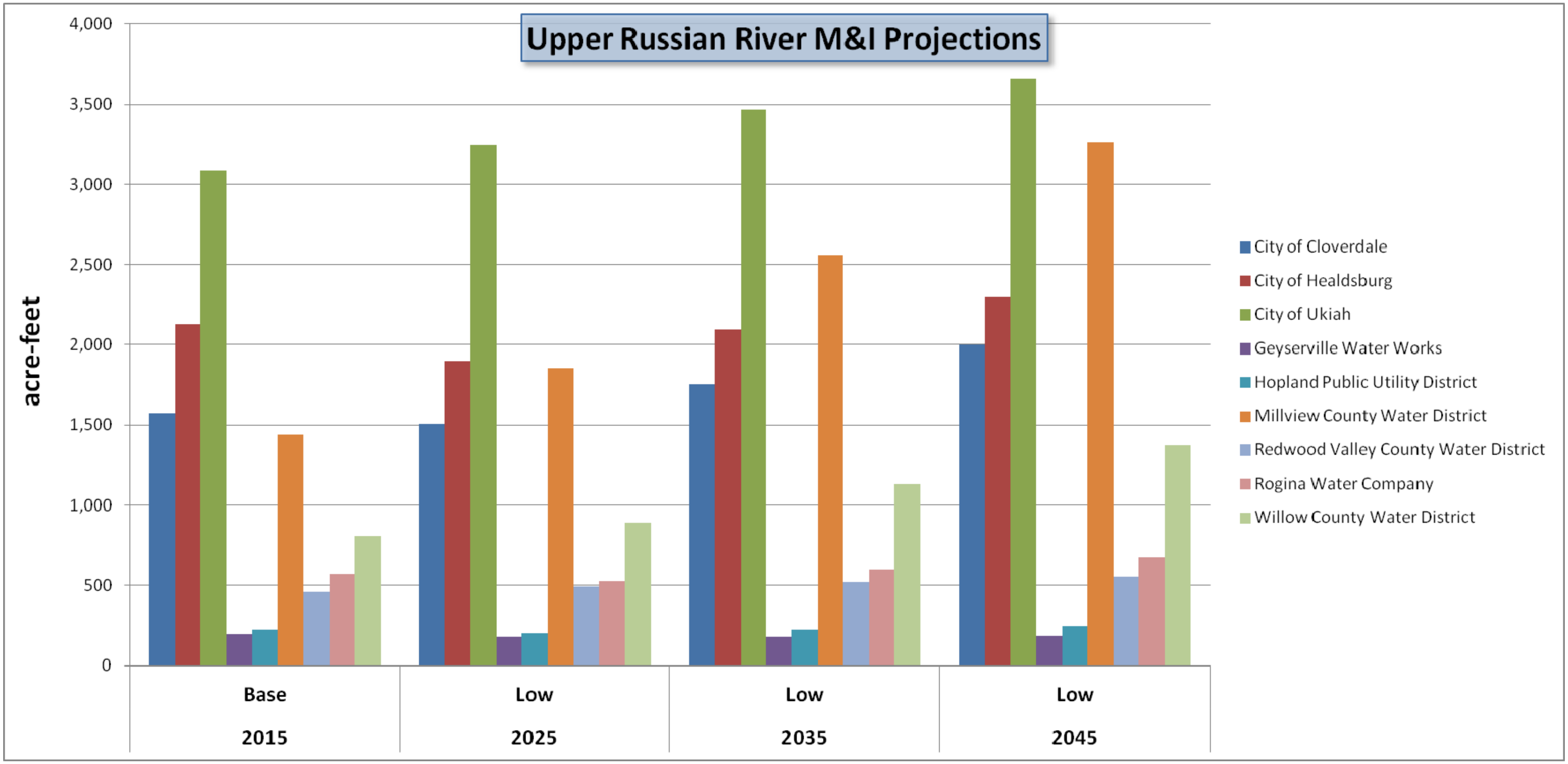


SONOMA COUNTY WATER AGENCY

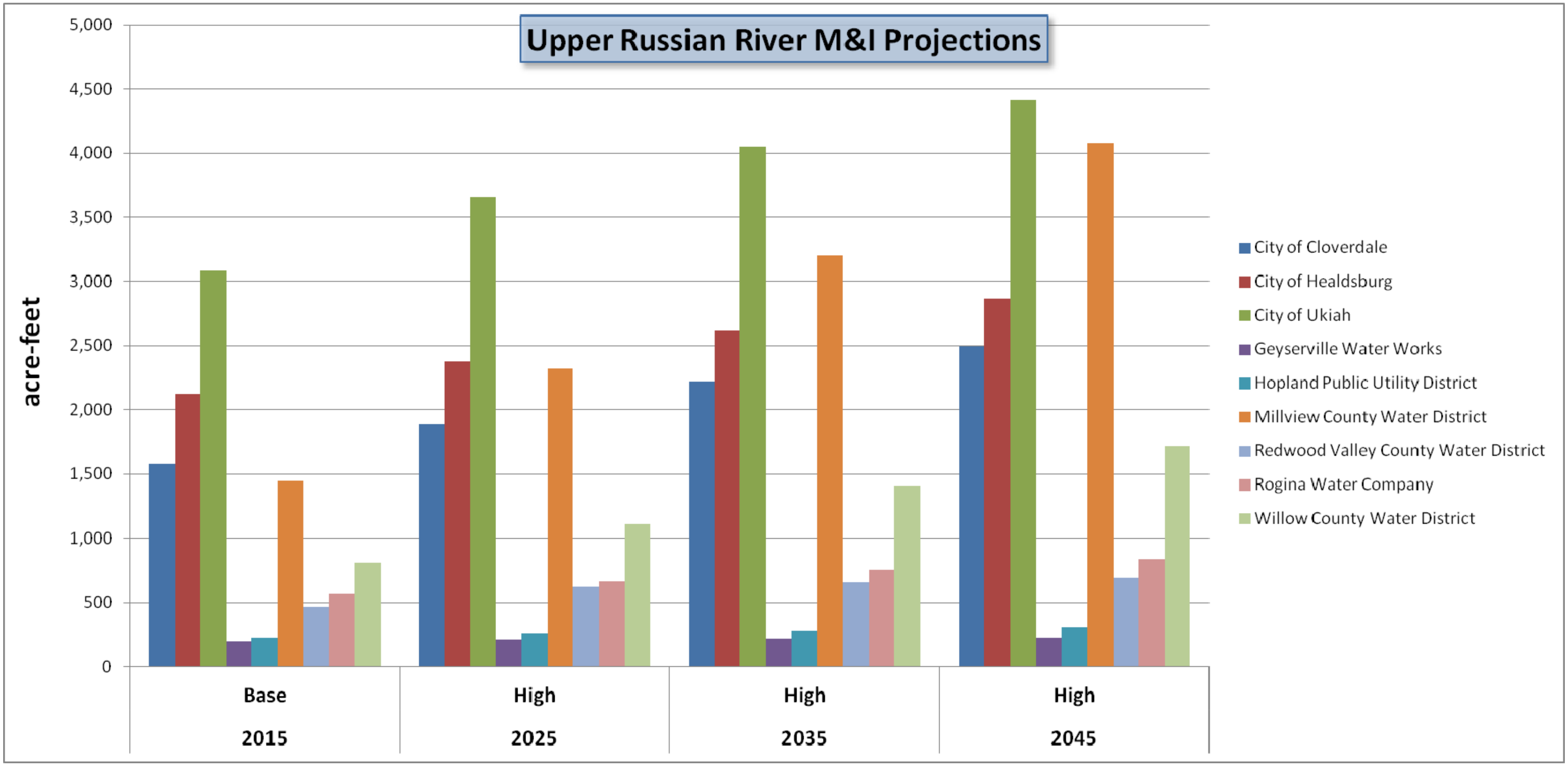
LAKE MENDOCINO WATER SUPPLY RELIABILITY STUDY
TECHNICAL REPORT
APRIL 2015

Minimum Instream Flow Requirements with Biological Opinion Interim Changes

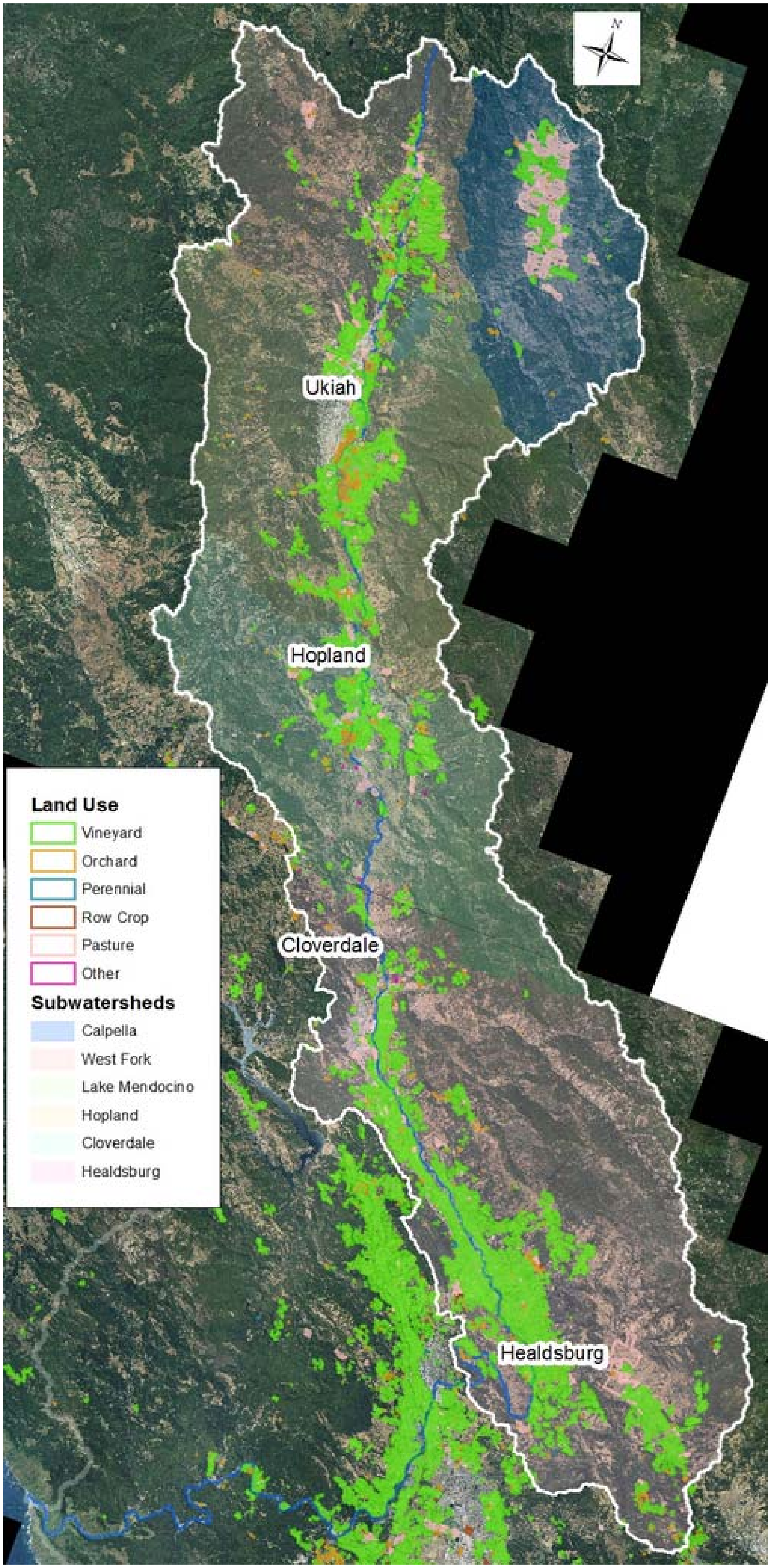
Figure 6



Municipal Water Use Projections Low Growth Scenario Figure 7

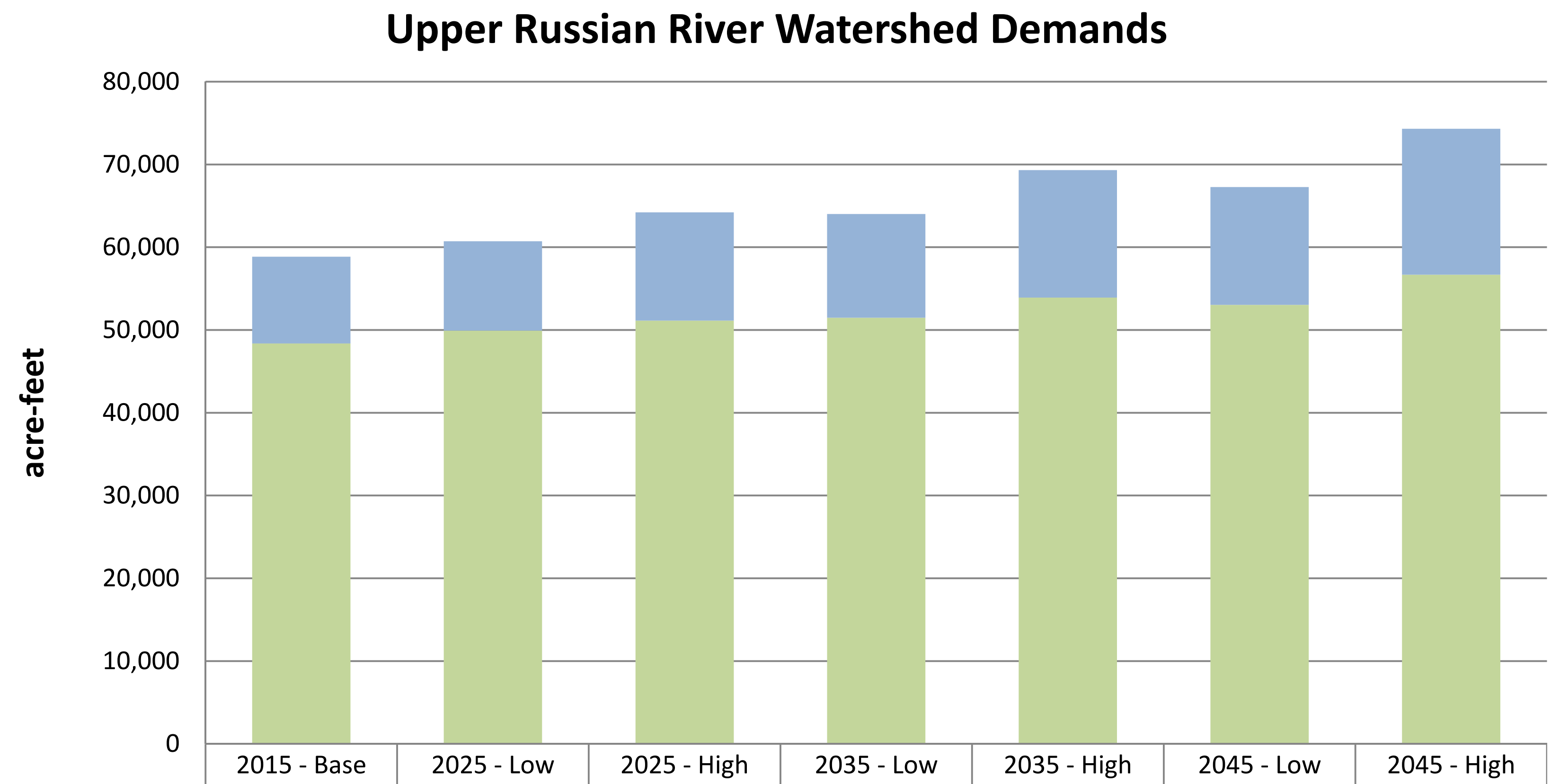


Municipal Water Use Projections High Growth Scenario Figure 8



Upper Russian River Watershed
Agricultural Fields circa 2012

Figure 9

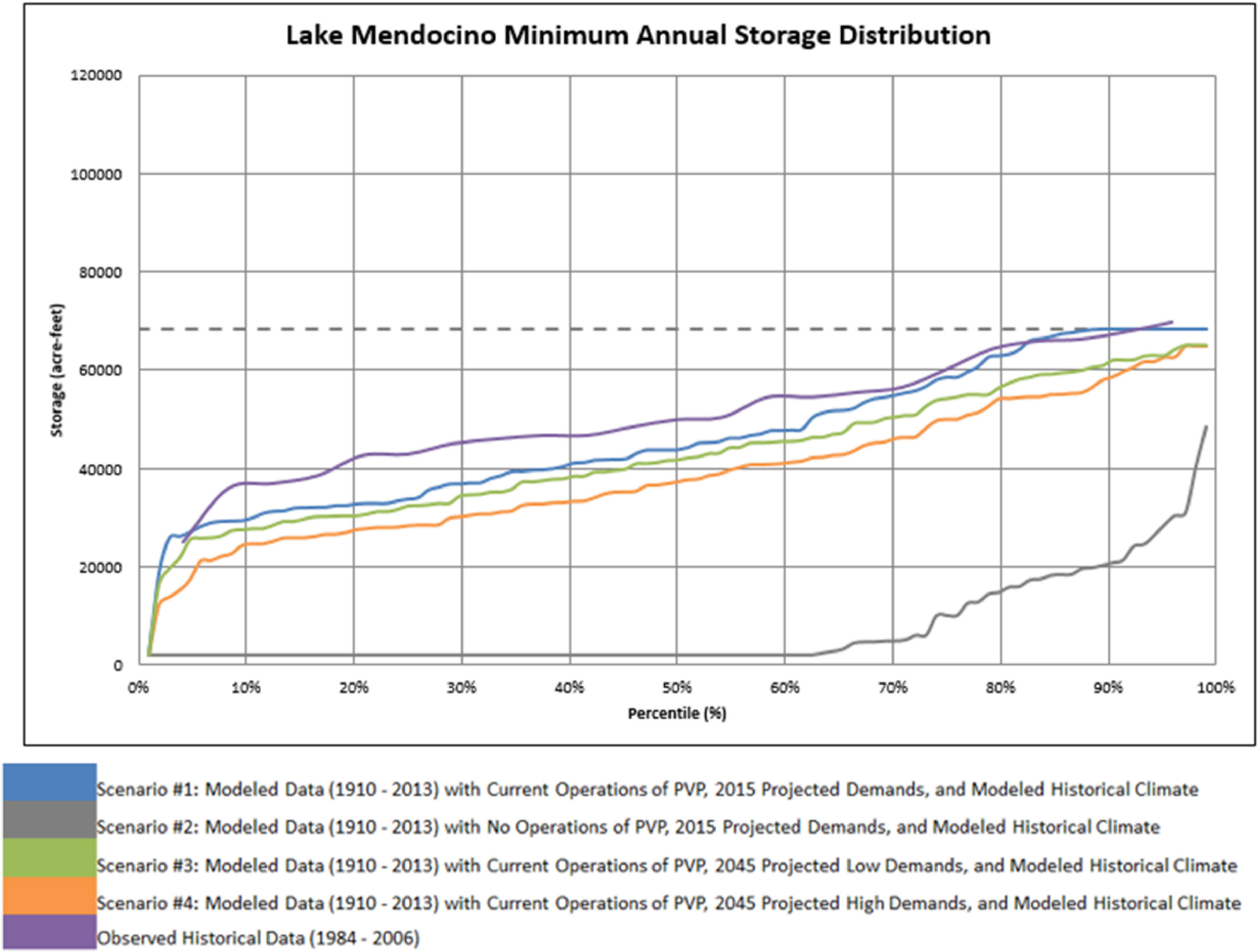


	2015 - Base	2025 - Low	2025 - High	2035 - Low	2035 - High	2045 - Low	2045 - High
Municipal	10,491	10,806	13,080	12,532	15,398	14,241	17,630
Agricultural	48,365	49,922	51,139	51,479	53,912	53,036	56,685

2015	2025	2035	2045	Total (ac-ft)
58,856	64,219	69,310	74,315	High
58,856	60,728	64,011	67,277	Low

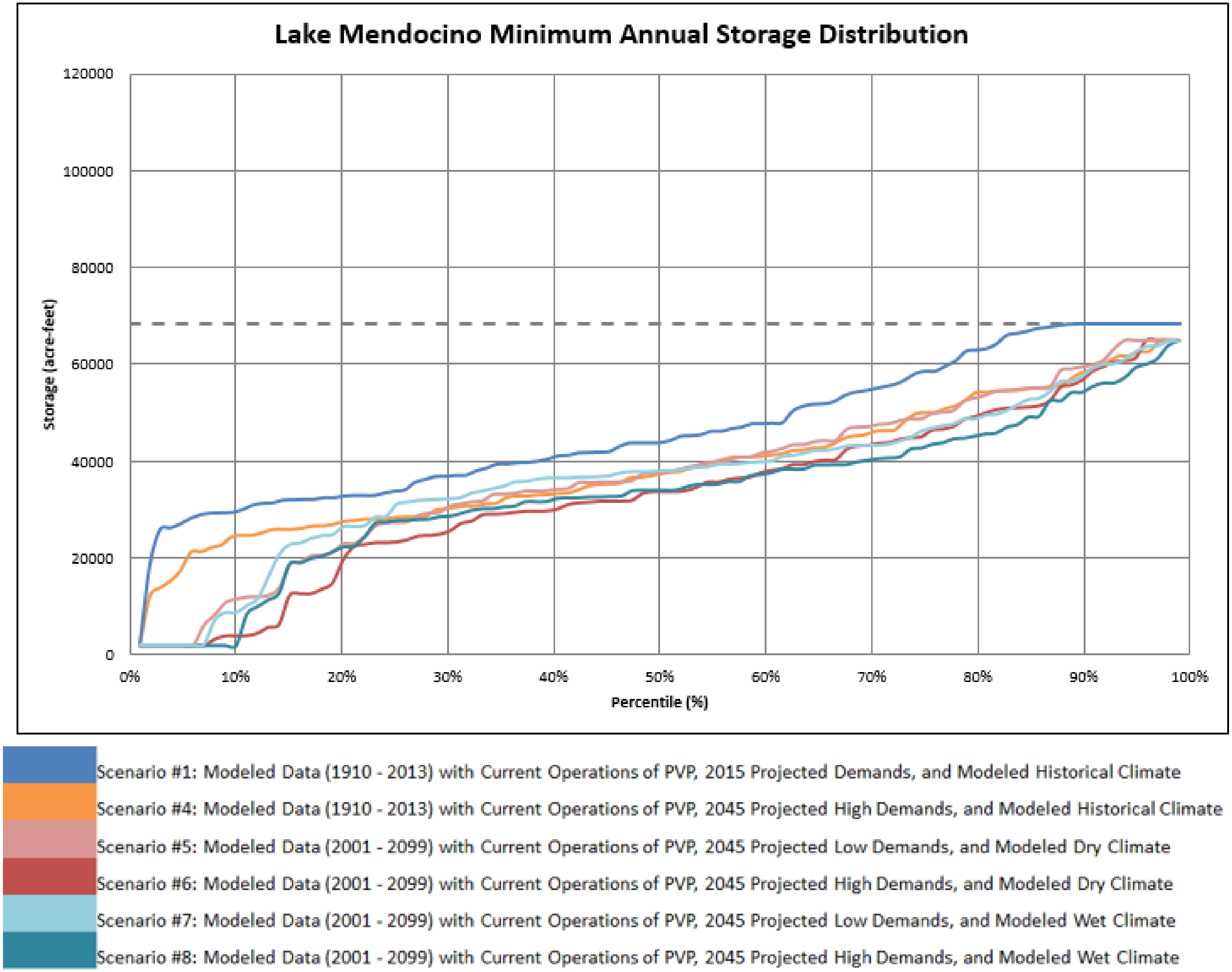
Upper Russian River Watershed Current and Projected Total Annual Water Usage

Figure 10



Modeling Results – Frequency Distribution of Minimum Annual Reservoir Storage Volumes

Figure 11



Modeling Results – Frequency Distribution of Minimum Annual Reservoir Storage Volumes with Climate Change Scenarios

Figure 12

Mendocino County	Sonoma County
City of Ukiah*	City of Cloverdale*
Hopland Public Utility District*	City of Healdsburg*
Local Agency Formation Commission of Mendocino County	Geyserville Waterworks*
Mendocino County* Department of Planning and Building Services	Local Agency Formation Commission of Sonoma County
Mendocino County Russian River Flood Control Water Conservation Improvement District*	Sonoma County* Agricultural Commissioner's Office
Mendocino County Water Agency	Sonoma County* Permit and Resources Management Department
Millview County Water District*	
Redwood Valley County Water District*	
Rogina Water Company*	
Willow County Water District*	

Note: * Denotes entity was specifically identified by State Water Resources Board in May 1, 2013 Order for coordination

List of Collaborating Entities

Table 1

No.	Water Demand	Description
1	Year 2015, Current Conditions	Historic Climate Record (1910 to 2013)
2	Year 2015, Current Conditions	Historic Climate Record (1910 to 2013) without Potter Valley Project in operation
3	Year 2045 Projection with Low Growth Scenario	Historic Climate Record (1910 to 2013)
4	Year 2045 Projection with High Growth Scenario	Historic Climate Record (1910 to 2013)
5	Year 2045 Projection with Low Growth Scenario	Climate Change with Dry Future Climate Scenario
6	Year 2045 Projection with High Growth Scenario	Climate Change with Dry Future Climate Scenario
7	Year 2045 Projection with Low Growth Scenario	Climate Change with Wet Future Climate Scenario
8	Year 2045 Projection with High Growth Scenario	Climate Change with Wet Future Climate Scenario

Notes: 1) All scenarios except No. 2 assume the continuation of current operations at the Potter Valley Project.
2) All scenarios assume minimum instream flows specified in the Russian River Biological Opinion.

System Model Evaluation Scenarios

Table 2

	MCRRFCWCID	Redwood Valley CWD	Cloverdale	Hopland PUD	Millview CWD	Willow CWD	Healdsburg	County of Mendocino / MCWA	Geyserville	Rogina Water Company	Ukiah	County of Sonoma PRMD
Planning Documents and Reports												
General Plan / Specific Area Plan	H	H	H	H	H	H	H	H	H	H	H	H
Urban Water Management Plan (DWR)							H				H	
Water Conservation & Water Shortage Response Plans		H	H		N		H				H	
Recycled Water Plan							H				H	
Water Master Plan			H			N	H					
Municipal Service Review (LAFCO)	H	H	H	H	H	H	H				H	
Water Loss Audit Reports			N	N	N	N	N				H	
Records												
Production Facilities Details		H	H	N	N	N	H		H	N	H	
Monthly Production Records	N	H	P	H	H	H	P		H	H	H	
Monthly Billing Records	N	H	P	H	H	H	P		H	H	H	

Legend

	Not Available
H	Have All Documents
P	Partially Received
N	Not Received

Public Water System	2012 Service Population
City of Cloverdale	8,634
City of Healdsburg	11,442
City of Ukiah	16,075
Geyserville Water Works	1,000
Hopland Public Utility District	1,020
Millview County Water District	5,500
Redwood Valley County Water District	3,969
Rogina Water Company	3,700
Willow County Water District	3,800
Total	**55,140**

Source: CA Department of Water Resources Public Water System Statistics Annual Reports

Current Municipal Water System Service Populations

Table 4

	Annual Total Water Production (ac-ft per year)				
Public Water System	**2009**	**2010**	**2011**	**2012**	**2013**
City of Cloverdale	n/a	1,344.8	n/a	1,643.2	1,741.0
City of Healdsburg	2,139.1	n/a	1,984.1	2,176.6	2,207.2
City of Ukiah	3,064.4	2,952.1	2,918.9	3,173.6	3,316.3
Geyserville Water Works	156.0	137.8	155.4	177.2	213.6
Hopland Public Utility District	225.3	210.5	204.5	226.5	244.5
Millview County Water District	1,018.8	1,122.9	1,142.1	1,327.1	1,354.4
Redwood Valley County Water District	355.6	388.3	392.2	443.0	461.7
Rogina Water Company	565.5	565.5	520.6	629.2	579.7
Willow County Water District	811.4	756.3	752.4	832.0	895.0

Source: CA Department of Water Resources Public Water System Statistics Annual Reports

Historical Municipal Water Use (2009-2013)

Table 5

Public Water System	Current Demand (ac-ft per year)
City of Cloverdale	1,576
City of Healdsburg	2,127
City of Ukiah	3,085
Geyserville Water Works	196
Hopland Public Utility District	222
Millview County Water District	1,442
Redwood Valley County Water District	462
Rogina Water Company	572
Willow County Water District	809
Total	**10,491**

Source: CA Department of Water Resources Public Water System Statistics Annual Reports

Municipal Water Use under Current Conditions (2015)

Table 6

	Water Use Projections (ac-ft per year)			
Public Water System	**2015**	**2025**	**2035**	**2045**
City of Cloverdale	1,576	1,507	1,753	1,999
City of Healdsburg	2,127	1,899	2,097	2,294
City of Ukiah	3,085	3,250	3,465	3,660
Geyserville Water Works	196	179	182	185
Hopland Public Utility District	222	204	223	245
Millview County Water District	1,442	1,857	2,559	3,262
Redwood Valley County Water District	462	492	523	553
Rogina Water Company	572	529	600	671
Willow County Water District	809	889	1,130	1,372
Total	**10,491**	**10,806**	**12,532**	**14,241**

Municipal Water Use Projections - Low Growth Scenario

Table 7

	Water Use Projections (ac-ft per year)			
Public Water System	**2015**	**2025**	**2035**	**2045**
City of Cloverdale	1,576	1,884	2,223	2,498
City of Healdsburg	2,127	2,374	2,621	2,868
City of Ukiah	3,085	3,654	4,048	4,415
Geyserville Water Works	196	204	211	219
Hopland Public Utility District	222	255	279	306
Millview County Water District	1,442	2,321	3,199	4,078
Redwood Valley County Water District	462	616	654	692
Rogina Water Company	572	661	750	839
Willow County Water District	809	1,111	1,413	1,715
Total	**10,491**	**13,080**	**15,398**	**17,630**

	Water Use Projections (ac-ft per year)						
	2015	2025		2035		2045	
River Reach	**Base**	**Low**	**High**	**Low**	**High**	**Low**	**High**
Cloverdale	222	204	255	223	279	245	306
Healdsburg	3,899	3,585	4,462	4,032	5,055	4,478	5,585
Hopland	809	889	1,111	1,130	1,413	1,372	1,715
Lake Mendocino	462	492	616	523	654	553	692
Talmage	5,099	5,636	6,636	6,624	7,997	7,593	9,332
Total	**10,491**	**10,806**	**13,080**	**12,532**	**15,398**	**14,241**	**17,630**

Note: River reaches are defined by USGS stream gage locations and naming is based on the corresponding downstream gage.

Crop Type	Region	Irrigation (ac-ft/ac)
Vineyard	Mendocino County	0.79
	Sonoma County	0.58
Orchard	Mendocino County	2.61
	Sonoma County	1.70
Perennials	All	1.50
Row Crops	All	1.50
Pasture	Mendocino County	2.20
	Sonoma County	1.78
Other	All	1.50

Source: Davids Engineering, 2013

Agricultural Irrigation Water Use Crop Duties

Table 10

	Total Land Area in 2012 (acres)						
River Reach	**Vineyard**	**Orchard**	**Perennials**	**Row Crops**	**Pasture**	**Other**	**Total**
Calpella	2,352	89	4	7	2,821	0	5,272
Cloverdale	3,966	241	1	0	520	14	4,742
Healdsburg	18,530	279	14	59	1,628	8	20,517
Hopland	3,733	512	12	0	120	0	4,377
Lake Mendocino	28	2	0	0	0	0	31
Talmage	2,736	499	0	0	357	0	3,592
West Fork	3,600	155	2	5	464	0	4,226
Total	**34,945**	**1,778**	**34**	**70**	**5,909**	**21**	**42,757**

Note: River reaches are defined by USGS stream gage locations and naming is based on the corresponding downstream gage.

Agricultural Field Acreages by River Reach – Current Conditions

Table 11

	Estimated Seasonal Irrigation Use (ac-ft)						
River Reach	**Vineyard**	**Orchard**	**Perennials**	**Row Crops**	**Pasture**	**Other**	**Total**
Calpella	1,856	233	6	10	6,197	0	8,302
Cloverdale	3,129	629	2	0	1,142	20	4,923
Healdsburg	12,109	475	22	88	2,902	11	15,607
Hopland	2,946	1,337	18	0	263	0	4,564
Lake Mendocino	22	6	0	0	0	0	29
Talmage	2,158	1,303	0	0	784	0	4,245
West Fork	2,841	405	3	7	1,019	0	4,275
Total	**25,061**	**4,388**	**51**	**105**	**12,308**	**32**	**41,946**

Note: River reaches are defined by USGS stream gage locations and naming is based on the corresponding downstream gage.

Agricultural Irrigation Water Use by River Reach – Current Conditions

Table 12

River Reach	West Fork	Calpella / Lake Mendocino	Talmage	Cloverdale	Healdsburg
Duration of Frost Protection Events (hrs)	10	11	6	6	6
		No. of Frost Protection Events for Vineyards			
March 15 - 30	2	2	1	2	1
April	4	6	3	3	3
May 1 - 15	2	2	1	1	1
		No. of Frost Protection Events for Orchards			
March 15 - 30	3	5	3	3	3
April	8	9	5	5	5
May 1 - 15	3	4	2	2	2

Frost Protection Water Use Assumptions

Table 13

	Estimated Water Use (ac-ft)				Estimated Net Water Use (ac-ft)			
River Reach	**Mar 15 - 30**	**Apr**	**May 1 - 15**	**Total**	**Mar 15 - 30**	**Apr**	**May 1 - 15**	**Total**
Calpella	355.5	1,028.6	349.2	1,733.4	195.5	565.8	192.1	953.3
Cloverdale	116.6	296.6	103.3	516.5	93.3	237.3	82.6	413.2
Healdsburg	534.9	1,573.9	527.2	2,636.1	107.0	314.8	105.4	527.2
Hopland	157.1	358.0	128.8	643.8	86.4	196.9	70.8	354.1
Lake Mendocino	3.0	7.9	2.8	13.7	1.6	4.4	1.5	7.5
Talmage	135.6	296.5	108.0	540.1	74.6	163.1	59.4	297.1
West Fork	60.4	167.0	56.9	284.3	33.2	91.9	31.3	156.4
Total	**1,363.1**	**3,728.6**	**1,276.2**	**6,367.9**	**591.6**	**1,574.0**	**543.2**	**2,708.9**

Note: River reaches are defined by USGS stream gage locations and naming is based on the corresponding downstream gage.

Frost Protection Water Use by River Reach – Current Conditions

Table 14

River Reach	Vineyard Acres Applying Post-Harvest	Water Use (ac-ft)
Calpella	1,058.4	350.8
Cloverdale	198.3	65.7
Healdsburg	9,265.1	3,070.8
Hopland	112.0	37.1
Lake Mendocino	12.8	4.2
Talmage	82.1	27.2
West Fork	468.0	155.1
Total	**11,196.6**	**3,711.0**

	% of Existing Crop Field Acres Converted by 2045	
	Low Demand	**High Demand**
	Sonoma County	
Orchard Conversion	50%	0%
Pasture Conversion	10%	0%
	Mendocino County	
Orchard Conversion	80%	0%
Pasture Conversion	15%	0%

Projection Assumptions for Crop Land Conversion

Table 16

	Total Estimated Cultivated Land Area in 2045 (acres)						
River Reach	**Vineyard**	**Orchard**	**Perennials**	**Row Crops**	**Pasture**	**Other**	**Total**
Calpella	2,851	18	4	7	2,397	0	5,277
Cloverdale	4,355	48	1	0	442	14	4,860
Healdsburg	26,402	139	14	59	1,465	8	28,087
Hopland	4,347	102	12	0	102	0	4,564
Lake Mendocino	37	0	0	0	0	0	37
Talmage	3,425	100	0	0	303	0	3,828
West Fork	4,183	31	2	5	394	0	4,615
Total	**45,601**	**439**	**34**	**70**	**5,104**	**21**	**51,269**

Note: River reaches are defined by USGS stream gage locations and naming is based on the corresponding downstream gage.

Agricultural Field Acreages by River Reach – Projected 2045 Low Demand Scenario

Table 17

	Total Estimated Cultivated Land Area in 2045 (acres)						
River Reach	**Vineyard**	**Orchard**	**Perennials**	**Row Crops**	**Pasture**	**Other**	**Total**
Calpella	2,357	89	4	7	2,821	0	5,277
Cloverdale	4,084	241	1	0	520	14	4,860
Healdsburg	26,402	279	14	59	1,628	8	28,389
Hopland	3,920	512	12	0	120	0	4,564
Lake Mendocino	35	2	0	0	0	0	37
Talmage	2,972	499	0	0	357	0	3,828
West Fork	3,989	155	2	5	464	0	4,615
Total	**43,760**	**1,778**	**34**	**70**	**5,909**	**21**	**51,572**

Note: River reaches are defined by USGS stream gage locations and naming is based on the corresponding downstream gage.

Agricultural Field Acreages by River Reach – Projected 2045 High Demand Scenario

Table 18

	Estimated Seasonal Irrigation Use (ac-ft)						
River Reach	**Vineyard**	**Orchard**	**Perennials**	**Row Crops**	**Pasture**	**Other**	**Total**
Calpella	2,250	47	6	10	5,267	0	7,580
Cloverdale	3,436	126	2	0	971	20	4,555
Healdsburg	17,776	238	22	88	2,612	11	20,746
Hopland	3,430	267	18	0	224	0	3,940
Lake Mendocino	29	1	0	0	0	0	30
Talmage	2,702	261	0	0	666	0	3,629
West Fork	3,301	81	3	7	866	0	4,259
Total	**32,924**	**1,020**	**51**	**105**	**10,607**	**32**	**44,740**

Note: River reaches are defined by USGS stream gage locations and naming is based on the corresponding downstream gage.

Agricultural Irrigation Water Use by River Reach – Projected 2045 Low Demand Scenario

Table 19

	Estimated Seasonal Irrigation Use (ac-ft)						
River Reach	**Vineyard**	**Orchard**	**Perennials**	**Row Crops**	**Pasture**	**Other**	**Total**
Calpella	1,860	233	6	10	6,197	0	8,306
Cloverdale	3,223	629	2	0	1,142	20	5,016
Healdsburg	17,776	475	22	88	2,902	11	21,274
Hopland	3,093	1,337	18	0	263	0	4,711
Lake Mendocino	27	6	0	0	0	0	34
Talmage	2,345	1,303	0	0	784	0	4,432
West Fork	3,148	405	3	7	1,019	0	4,583
Total	**31,471**	**4,388**	**51**	**105**	**12,308**	**32**	**48,356**

Note: River reaches are defined by USGS stream gage locations and naming is based on the corresponding downstream gage.

Agricultural Irrigation Water Use by River Reach – Projected 2045 High Demand Scenario

Table 20

	Estimated Water Use (ac-ft)				Estimated Net Water Use (ac-ft)			
River Reach	**Mar 15 - 30**	**Apr**	**May 1 - 15**	**Total**	**Mar 15 - 30**	**Apr**	**May 1 - 15**	**Total**
Calpella	399.0	1,189.5	397.8	1,986.3	219.5	654.2	218.8	1,092.5
Cloverdale	176.4	265.9	89.5	531.8	141.1	212.7	71.6	425.5
Healdsburg	1,470.0	2,207.0	736.9	4,413.9	294.0	441.4	147.4	882.8
Hopland	185.1	280.5	95.4	560.9	101.8	154.2	52.5	308.5
Lake Mendocino	2.9	8.5	2.9	14.3	1.6	4.7	1.6	7.9
Talmage	149.0	226.2	77.2	452.4	81.9	124.4	42.5	248.8
West Fork	117.7	176.9	59.2	353.8	64.7	97.3	32.6	194.6
Total	**2,500.1**	**4,354.5**	**1,458.9**	**8,313.5**	**904.6**	**1,689.0**	**566.9**	**3,160.5**

Note: River reaches are defined by USGS stream gage locations and naming is based on the corresponding downstream gage.

Frost Protection Water Use by River Reach – Projected 2045 Low Demand Scenario

Table 21

River Reach	Estimated Water Use (ac-ft)				Estimated Net Water Use (ac-ft)			
	Mar 15 - 30	Apr	May 1 - 15	Total	Mar 15 - 30	Apr	May 1 - 15	Total
Calpella	356.2	1,030.7	349.9	1,736.8	195.9	566.9	192.4	955.2
Cloverdale	197.9	303.5	105.6	607.0	158.3	242.8	84.5	485.6
Healdsburg	1,481.6	2,226.2	744.6	4,452.4	296.3	445.2	148.9	890.5
Hopland	236.4	368.8	132.4	737.6	130.0	202.8	72.8	405.7
Lake Mendocino	3.4	9.3	3.3	16.1	1.9	5.1	1.8	8.8
Talmage	197.6	310.2	112.6	620.5	108.7	170.6	61.9	341.3
West Fork	120.9	183.1	62.2	366.3	66.5	100.7	34.2	201.5
Total	**2,594.1**	**4,431.9**	**1,510.6**	**8,536.7**	**957.7**	**1,734.3**	**596.6**	**3,288.5**

Note: River reaches are defined by USGS stream gage locations and naming is based on the corresponding downstream gage.

Frost Protection Water Use by River Reach – Projected 2045 High Demand Scenario

Table 22

River Reach	Vineyard Acres Applying Post-Harvest	Water Use (ac-ft)
Calpella	1,283.1	425.3
Cloverdale	217.8	72.2
Healdsburg	13,201.2	4,375.4
Hopland	130.4	43.2
Lake Mendocino	16.4	5.4
Talmage	102.7	34.1
West Fork	543.8	180.2
Total	**15,495.5**	**5,135.8**

Post-Harvest Water Use by River Reach – Projected 2045 Low Demand Scenario

Table 23

River Reach	Vineyard Acres Applying Post-Harvest	Water Use (ac-ft)
Calpella	1,060.6	351.5
Cloverdale	204.2	67.7
Healdsburg	13,201.2	4,375.4
Hopland	117.6	39.0
Lake Mendocino	15.6	5.2
Talmage	89.2	29.6
West Fork	518.6	171.9
Total	**15,207.0**	**5,040.2**

Post-Harvest Water Use by River Reach – Projected 2045 High Demand Scenario

Table 24

APPENDIX A

STATE OF CALIFORNIA
CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY
STATE WATER RESOURCES CONTROL BOARD

DIVISION OF WATER RIGHTS

In the Matter of Permits 12947A, 12949, 12950, and 16596
(Applications 12919A, 15736, 15737, 19351)

Sonoma County Water Agency

ORDER APPROVING TEMPORARY URGENCY CHANGE

SOURCES: Dry Creek and Russian River

COUNTIES: Sonoma and Mendocino Counties

BY THE DEPUTY DIRECTOR FOR WATER RIGHTS:

1.0 SUBSTANCE OF TEMPORARY URGENCY CHANGE PETITION

On April 25, 2013, Sonoma County Water Agency (SCWA) filed a Temporary Urgency Change Petition (TUCP) with the State Water Resources Control Board (State Water Board) requesting approval of a change to the subject permits pursuant to California Water Code section 1435. The TUCP requests the following temporary reductions to the Russian River instream flow requirements to address low storage conditions in Lake Mendocino:

(1) From May 1 through June 30, 2013, reduce instream flow requirements for the upper Russian River (from its confluence with the East Fork of the Russian River to its confluence with Dry Creek) from 185 cubic feet per second (cfs) to 75 cfs, and reduce the requirements for the lower Russian River (downstream of its confluence with Dry Creek) from 125 cfs to 85 cfs; and

(2) From July 1 through October 28, 2013, reduce instream flow requirements for the upper Russian River from 185 cfs to 75 cfs, and reduce the requirements for the lower Russian River from 125 cfs to 85 cfs, if during the period from July 1 through October 28 storage in Lake Mendocino remains above SCWA's calculated critical storage curve (Figure 5 in SCWA's Instream Flow Analysis for 2013 Temporary Urgency Change Petition and attached as Exhibit A); or

(3) From July 1 through October 28, 2013, further reduce instream flow requirements to 25 cfs for upper Russian River and 35 cfs for the lower Russian River, if during the period from July 1 through October 28 storage in Lake Mendocino drops below SCWA's calculated critical storage curve for more than three consecutive days.

The TUCP, in effect, requests that minimum flows for the Russian River be established based on State Water Board Decision 1610 (Decision 1610) *Dry* water supply criteria for the period from May 1 to October 28, 2013. In addition, the TUCP requests that minimum flows be based on *Critical* water supply criteria for the period from July 1 to October 28, 2013 in the event that storage in Lake Mendocino drops below SCWA's calculated critical storage curve for more than three consecutive days. This curve is shown in the attached Exhibit A.

The TUCP requests that compliance with minimum instream flow requirements as they pertain to *Dry* water supply conditions be measured based on a 5-day running average of average daily stream flow measurements, with the condition that instantaneous flows on the upper Russian River shall be no less than 65 cfs and on the lower Russian River shall be no less than 70 cfs. This measurement of compliance with minimum instream flow requirements will allow SCWA to manage stream flows with smaller operational buffers, thereby conserving water supply in Lake Mendocino. If after July 1 the water supply condition changes to *Critical*, the TUCP requests that compliance with minimum instream flow requirements be measured on an instantaneous basis.

No changes to the instream flow requirements for Dry Creek are requested.

The request is made to prevent severe depletion of storage in Lake Mendocino, which would gravely impact threatened or endangered Russian River fish species, create serious water supply impacts in Mendocino County and in Sonoma County's Alexander Valley, and harm Lake Mendocino and Russian River recreation.

2.0 BACKGROUND

SCWA's TUCP involves the following permits:

- Permit 12947A is for direct diversion of 92 cubic feet per second (cfs) from the East Fork Russian River and storage of 122,500 acre-feet per annum (afa) in Lake Mendocino from January 1 through December 31 of each year.

- Permit 12949 is for year-round direct diversion of 20 cfs from the Russian River at the Wohler and Mirabel Park Intakes near Forestville.

- Permit 12950 is for direct diversion of 60 cfs from the Russian River at the Wohler and Mirabel Park Intakes from April 1 through September 30 of each year.

- Permit 16596 is for year-round direct diversion of 180 cfs from the Russian River and storage of 245,000 afa in Lake Sonoma from October 1 of each year to May 1 of the succeeding year.

SCWA submitted with the TUCP a document prepared by its staff titled, "Instream Flow Analysis for 2013 Temporary Urgency Change Petition" (Analysis) dated April 2013. The Analysis indicates that since mid-February, Lake Mendocino storage levels have declined by approximately 10,000 acre-feet. This rapid decline in storage from mid February to date is similar to higher rates of decline that normally occur in the late summer. The rate of decline and low storage levels are the result of the unusually low rainfall in the region this winter. Precipitation records for Ukiah indicate 4.75 inches of rainfall in the area since January 1, which is just 22.8% of the average for this period based on records going back to 1952. Without the requested reductions in minimum instream flow requirements, the storage levels in Lake Mendocino are projected to decline to below 20,000 AF by October 1 due to releases to meet downstream water demands and the anticipated minimum instream flow requirements on the Russian River. The extremely low projected storage level in Lake Mendocino could severely impact listed and threatened Russian River fish species, create serious water-supply impacts in Mendocino County and the Alexander Valley in Sonoma County, and harm Lake Mendocino and Russian River recreation.

As of April 16, 2013, the water supply storage level in Lake Sonoma was 96 percent of the available conservation pool. Consequently, no changes to the instream flow requirements for Dry Creek are requested in the TUCP. However, SCWA is requesting changes to the minimum instream flow requirements on the lower Russian River, downstream of its confluence with Dry Creek to the Pacific Ocean. These changes are requested because the reduced minimum instream flows being requested on the upper Russian River will provide significantly less contribution to meet minimum instream flow requirements in the lower river. Consequently, increased releases from Lake Sonoma into Dry Creek would be necessary to maintain Decision 1610 minimum instream flow requirements on the lower Russian River. However, such increased releases into Dry Creek would result in SCWA violating the Incidental Take Statement contained in the September 24, 2008, National Marine Fisheries Service (NMFS) Biological Opinion for Water Supply, Flood Control Operations, and Channel Maintenance conducted by the U.S. Army Corps of Engineers, SCWA, and the Mendocino County Russian River Flood Control and Water Conservation Improvement District in the Russian River watershed (Biological Opinion). The Incidental Take Statement restricts releases from Lake Sonoma into Dry Creek because they can result in flows that are too high for optimal habitat for juvenile salmonids.

Following is the language contained in SCWA's permits regarding minimum instream flow requirements:

Term 20 of SCWA’s Permit 12947A states:

For the protection of fish and wildlife, and for the maintenance of recreation in the Russian River, permittee shall pass through or release from storage at Lake Mendocino sufficient water to maintain:

(A) A continuous streamflow in the East Fork Russian River from Coyote Dam to its confluence with the Russian River of 25 cfs at all times.

(B) The following minimum flows in the Russian River between the East Fork Russian River and Dry Creek:

(1) During normal water supply conditions when the combined water in storage, including dead storage, in Lake Pillsbury and Lake Mendocino on May 31 of any year exceeds 150,000 af or 90 percent of the estimated water supply storage capacity of the reservoirs, whichever is less:

From June 1 through August 31	185 cfs
From September 1 through March 31	150 cfs
From April 1 through May 31	185 cfs

(2) During normal water supply conditions and when the combined water in storage, including dead storage, in Lake Pillsbury and Lake Mendocino on May 31 of any year is between 150,000 af or 90 percent of the estimated water supply storage capacity of the reservoirs, whichever is less, and 130,000 af or 80 percent of the estimated water supply storage capacity of the reservoirs, whichever is less:

From June 1 through March 31	150 cfs
From April 1 through May 31	185 cfs
If from October 1 through December 31, storage in Lake Mendocino is less than 30,000 acre-feet	75 cfs

(3) During normal water supply conditions and when the combined water in storage, including dead storage, in Lake Pillsbury and Lake Mendocino on May 31 of any year is less than 130,000 af or 80 percent of the estimated water supply storage capacity of the reservoirs, whichever is less:

From June 1 through December 31	75 cfs
From January 1 through March 31	150 cfs
From April 1 through May 31	185 cfs

(4) During dry water supply conditions 75 cfs

(5) During critical water supply conditions 25 cfs

(C) The following minimum flows in the Russian River between its confluence with Dry Creek and the Pacific Ocean to the extent that such flows cannot be met by releases from storage at Lake Sonoma under Permit 16596 issued on Application 19351:

(1) During normal water supply conditions 125 cfs
(2) During dry water supply conditions 85 cfs
(3) During critical water supply conditions 35 cfs

For the purposes of the requirements in this term, the following definitions shall apply:

(1) Dry water supply conditions exist when cumulative inflow to Lake Pillsbury beginning on October 1 of each year is less than:

8,000 acre-feet as of January 1
39,200 acre-feet as of February 1
65,700 acre-feet as of March 1
114,500 acre-feet as of April 1
145,600 acre-feet as of May 1
160,000 acre-feet as of June 1

(2) Critical water supply conditions exist when cumulative inflow to Lake Pillsbury beginning on October 1 of each year is less than:

4,000 acre-feet as of January 1
20,000 acre-feet as of February 1
45,000 acre-feet as of March 1
50,000 acre-feet as of April 1
70,000 acre-feet as of May 1
75,000 acre-feet as of June 1

(3) Normal water supply conditions exist in the absence of defined dry or critical water supply conditions.

(4) The water supply condition designation for the months of July through December shall be the same as the designation for the previous June. Water supply conditions for January through June shall be predetermined monthly.

(5) Cumulative inflow to Lake Pillsbury is the calculated algebraic sum of releases from Lake Pillsbury, increases in storage in Lake Pillsbury, and evaporation from Lake Pillsbury.

(6) Estimated water supply storage space is the calculated reservoir volume below elevation 1,828.3 feet in Lake Pillsbury and below elevation 749.0 feet in Lake Mendocino. Both elevations refer to the National Geodetic Vertical Datum of 1929. The calculation shall use the most recent two reservoir volume surveys made by the U. S. Geological Survey, U. S. Army Corps of Engineers, or other responsible agency to determine the rate of sedimentation to be assumed from the date of the most recent reservoir volume survey.

Term 17 of both Permit 12949 and Permit 12950 requires SCWA to allow sufficient water to bypass the points of diversion at the Wohler and Mirabel Park Intakes on the Russian River to maintain the following minimum flows to the Pacific Ocean:

(1)	During normal water supply conditions	125 cfs
(2)	During dry water supply conditions	85 cfs
(3)	During critical water supply conditions	35 cfs

Term 13 of Permit 16596 sets forth the following minimum flows for Dry Creek and the Russian River:

(A) The following minimum flows in Dry Creek between Warm Springs Dam and its confluence with the Russian River:

(1) During normal water supply conditions:

75 cfs from January 1 through April 30
80 cfs from May 1 through October 31
105 cfs from November 1 through December 30

(2) During dry or critical water supply conditions:

25 cfs from April 1 through October 31
75 cfs from November 1 through March 31

(B) The following minimum flows in the Russian River between its confluence with Dry Creek and the Pacific Ocean, unless the water level in Lake Sonoma is below elevation 292.0 feet with reference to the National Geodetic Vertical Datum of 1929, or unless prohibited by the United States Government:

(1)	During normal water supply conditions	125 cfs
(2)	During dry water supply conditions	85 cfs
(3)	During critical water supply conditions	35 cfs

Note: Permits 12949, 12950, and 16596 use the same water-year classification definitions as those listed in Permit 12947A. The water year classifications (Normal, Dry or Critically Dry) were established in Decision 1610 and are based on cumulative inflow into Lake Pillsbury beginning October 1. Although Lake Mendocino storage is unusually low, cumulative inflow into Lake Pillsbury during this water year has been sufficiently high that, under Decision 1610, 2013 is currently classified as a *Normal* year and, based on current hydrologic trends, SCWA anticipates *Normal-Dry Spring 2* water supply conditions starting June 1.

3.0 COMPLIANCE WITH CALIFORNIA ENVIRONMENTAL QUALITY ACT

SCWA has determined that the requested temporary urgency change is statutorily and categorically exempt under the California Environmental Quality Act (CEQA). SCWA found that the change is consistent with the statutory exemption criteria for an emergency project as well as the Class 1, 7, and 8 categorical exemption criteria. The State Water Board has reviewed the information submitted by SCWA and has made its own independent finding that the temporary urgency change is statutorily and categorically exempt under CEQA for the following reasons:

- As of April 16, 2013, the storage level in Lake Mendocino was 62 percent of the available water conservation pool and rapidly declining. Information provided by SCWA demonstrates that continued releases of water under *Normal-Dry Spring 2* year operating rules would prematurely drain the remaining storage. If storage in Lake Mendocino is depleted, water will not be available to support threatened and endangered species, agriculture, and domestic/municipal water service. Approval of the TUCP is therefore necessary to prevent and mitigate loss of or damage to the environment, fishery resources, property, public health, and essential public services. Accordingly the project is statutorily exempt from CEQA because it is necessary to prevent or mitigate an emergency (Pub. Resources Code, § 21080, subd. (b)(4), Cal. Code Regs., tit. 14, § 15269, subd. (c).)

- The proposed action consists of the operation of existing facilities involving negligible or no expansion of use beyond that existing, and accordingly is categorically exempt from CEQA under a Class 1 exemption. (Cal. Code Regs., tit. 14, § 15301.) The proposed action will be within the existing operational parameters established by Decision 1610. The proposed action does not request and will not expand the water supply available to SCWA for consumptive purposes.

- The proposed action will assure the maintenance of a natural resource, i.e., the instream resources of the Russian River, by reserving water in Lake Mendocino to benefit adult Chinook salmon migrating upstream in the fall, and accordingly is categorically exempt from CEQA pursuant to a Class 7 exemption. A Class 7 exemption "consists of actions taken by regulatory agencies as authorized by state law or local ordinance to assure the maintenance, restoration, or enhancement of a natural resource where the regulatory process involves procedures for protection of the environment." (Cal. Code Regs, tit. 14, § 15307.)

- A Class 8 exemption "consists of actions taken by regulatory agencies, as authorized by state or local ordinance, to assure the maintenance, restoration, enhancement, or protection of the environment where the regulatory process involves procedures for protection of the environment." (Cal. Code Regs., tit. 14, § 15308.) The proposed action will assure the maintenance of the environment, i.e., the instream environment of the Russian River, in the same way as stated for the Class 7 exemption.

4.0 PUBLIC NOTICE OF THE TEMPORARY URGENCY CHANGE PETITION

The State Water Board will issue and deliver to SCWA as soon as practicable, a notice of the temporary urgency change order pursuant to Water Code section 1438(a). Pursuant to Water Code section 1438(b)(1), SCWA is required to publish the notice in a newspaper having a general circulation, and that is published within the counties where the points of diversion lie. The State Water Board will post the notice of the temporary urgency change and the TUCP (and accompanying materials) on its website. The State Water Board also will distribute the notice through an electronic notification system. Pursuant to Water Code section 1438, the State Water Board may issue a temporary change order in advance of the required notice.

5.0 CRITERIA FOR APPROVING THE PROPOSED TEMPORARY URGENCY CHANGE

Water Code section 1435 provides that a permittee or licensee who has an urgent need to change the point of diversion, place of use, or purpose of use from that specified in the permit or license may petition for a conditional temporary change order. The State Water Board's regulations set forth the filing and other procedural requirements applicable to TUCPs. (Cal. Code Regs., tit. 23, §§ 805, 806.) The State Water Board’s regulations also clarify that requests for changes to permits or licenses other than changes in point of diversion, place of use, or purpose of use may be filed, subject to the same filing and procedural requirements that apply to changes in point of diversion, place of use, or purpose of use. (*Id*., § 791, subd. (e).)

Before approving a temporary urgency change, the State Water Board must make the following findings:

1. the permittee or licensee has an urgent need to make the proposed change;
2. the proposed change may be made without injury to any other lawful user of water;
3. the proposed change may be made without unreasonable effect upon fish, wildlife, or other instream beneficial uses; and
4. the proposed change is in the public interest.

(Wat. Code, § 1435, subd. (b)(1-4).)

5.1 Urgency of the Proposed Change

Under Water Code section 1435, subdivision (c), an "urgent need" means "the existence of circumstances from which the board may in its judgment conclude that the proposed temporary change is necessary to further the constitutional policy that the water resources of the state be put to beneficial use to the fullest extent of which they are capable and that waste of water be prevented . . . ." However, the State Water Board shall not find the need urgent if it concludes that the petitioner has failed to exercise due diligence in petitioning for a change pursuant to other appropriate provisions of the Water Code.

In this case, an urgent need exists for the proposed flow changes on the upper Russian River because SCWA predicts near depletion of water supply storage in Lake Mendocino by October 1, 2013 unless the requested TUCP is approved. Water supplies sufficient to support survival of listed Russian River salmonid fisheries, agricultural and municipal use, and recreation are at risk. Without the proposed changes, SCWA would need to release additional stored water from Lake Mendocino, which would result in the significant depletion of storage during the summer and reduce water supplies needed for fishery protection and stable flows in the upper Russian River during the fall when spawning state and federally listed fish species are most sensitive to flow and water temperatures. An urgent need exists for the proposed changes on the lower Russian River because SCWA will violate the Incidental Take Statement contained in the Biological Opinion unless the requested temporary urgency change is approved.

The depletion of storage in Lake Mendocino that would occur if the TUCP is not approved also would result in the potential elimination of water supplies for water users in Mendocino County and northern Sonoma County (above the confluence with Dry Creek) during the fall, which would cause serious impacts to human health and welfare. SCWA predicts that without the proposed change, Lake Mendocino will be drawn down to storage levels that would jeopardize SCWA's ability to release water to the Russian River. In this event, water supplies for domestic and municipal uses of Russian River water would be severely impaired. Moreover, as discussed in Decision 1610, Section 10.2, with less than 30,000 acre feet of carry-over storage, Lake Mendocino's reliability as a storage facility is impaired. SCWA's permits include terms requiring a 50 percent reduction in deliveries to Redwood Valley County Water District when Lake Mendocino storage drops below 30,000 acre feet in order to preserve Lake Mendocino water supply reliability. The purpose of this order is, in part, to prevent Lake Mendocino storage from dropping below 30,000 acre feet. The SCWA's forecasts indicate that Lake Mendocino storage will drop below 30,000 acre feet during August 2013 unless the TUCP is approved. Furthermore, if the upcoming Water Year 2014 is a dry or critical year, carryover storage in Lake Mendocino from 2013 will be crucial for the continued recovery of the Russian River salmonid fishery and water supply reliability during 2014. For the reasons stated above, an urgent need for the proposed change exists.

5.2 No Injury to Any Other Lawful User of Water

Under this Order, SCWA will be required to maintain specific flows in the Russian River from its most upstream point of diversion to the river's confluence with the ocean. Therefore, because these minimum flows will be present, it is anticipated that all other lawful users of water will still be able to divert and use the amounts of water to which they are legally entitled during the period of reduced minimum flows specified in this Order. Moreover, failure to implement the reduced instream flow could result in severe depletion of Lake Mendocino, which in turn could result in serious impacts to entitled users of water downstream of Lake Mendocino later in the year. Accordingly, granting this TUCP will not result in any injury to any other lawful user of water. Pursuant to Water Code section 1439, the State Water Board shall supervise diversion and use of water under this temporary change order for the protection of all other lawful users of water and instream beneficial uses.

5.3 No Unreasonable Effect upon Fish, Wildlife, or Other Instream Beneficial Uses

Although flows in the main stem Russian River will be reduced upon approval of this TUCP, prevention of the depletion of storage in Lake Mendocino is crucial for fishery resources. Conservation of water in Lake

Mendocino will insure water is available to support Chinook salmon migration and spawning in early fall. Also, minimum instream flows lower than those required by Decision 1610 could encourage formation of a closed or perched lagoon at the mouth of the Russian River and therefore noticeably enhance the salmonid estuarine rearing habitat while preventing flooding of adjacent properties.

SCWA's TUCP under *Critical* water supply conditions seeks a minimum instream flow requirement in the lower Russian River of 35 cfs, from July 1 through October 28, 2013, if during that period Lake Mendocino drops below SCWA's calculated critical storage curve for more than three consecutive days. Previous TUCP orders required SCWA to implement temporary reductions of diversions from the Russian River to ensure beneficial use of water resources to the fullest extent possible and to prevent waste of water. SCWA identified that past reductions in diversions resulted in increased groundwater pumping by the cities and special districts that purchase wholesale water from SCWA. This response has the unintended consequence of stressing local groundwater resources even though adequate surface water is available from Lake Sonoma.

Notwithstanding the potential impact to groundwater resources, to minimize impacts to water quality, recreation, and other water users along the lower Russian River, to the extent feasible, this Order requires a minimum instream flow in the lower Russian River of 50 cfs instead of 35 cfs if *Critical* water supply conditions are required. This will be accomplished through a combination of SCWA reducing its diversions by as much as 25 percent and releasing additional water from Lake Sonoma. Compliance with the *Critical* water supply condition in the lower Russian River shall be measured based on a 5-day running average of average daily stream flow measurements, with the condition that instantaneous flows on the lower Russian River shall be no less than 35 cfs. In the event that SCWA can demonstrate that there is an urgent need for a further reduction in this minimum flow requirement to the originally requested 35 cfs, this Order may be amended to make such change.

It is possible that reduced flows in the Russian River may impair some instream beneficial uses, principally recreation uses. However, since 2004, Russian River flows have frequently been managed at decreased levels, both under Decision 1610 and under other temporary urgency change orders. Notwithstanding lower flows, Russian River recreation has continued. Accordingly, although recreation uses may be affected, considering the potential grave impacts to fisheries, water supply, and recreation in Lake Mendocino that could occur if the TUCP were not approved, any impact on recreation for this summer is reasonable under the circumstances.

SCWA has been required to collect water quality and fishery information and data during periods when reduced minimum flow requirements are in effect. These monitoring activities are summarized in annual reports intended to evaluate whether and to what extent the reduced flows caused any impacts to water quality and availability of aquatic habitat for salmonids. This information serves to inform the review and approval of the TUCP and the State Water Board's continuing supervision of the diversion and use of water under this temporary change order pursuant to Water Code section 1439. Under this order, similar monitoring and reporting criteria will be required.

SCWA also strives to make water available for reasonable beneficial use and to preserve instream values by continuing to work on water use efficiency. As part of this goal, SCWA continues to work with its Water Contractors to achieve SBx7-7's goal of reducing per capita water use 20 percent by the year 2020. Additionally, the majority of SCWA's Water Contractors require their dedicated irrigation customers be assigned a water budget designed to achieve a maximum applied water allowance of 60 percent ETo, which exceeds the State's Water Efficient Landscape Ordinance requirements.

5.4 The Proposed Change is in the Public Interest

Approval of this TUCP will help conserve stored water in Lake Mendocino so that it can be released for listed Russian River salmonid fisheries present in the Russian River during the fall Chinook salmon migration season. In addition, approval of this TUCP will help preserve storage in Lake Mendocino as a precaution in case 2014 also is a dry water year. It is in the public interest to preserve water supplies for these beneficial uses when hydrologic circumstances cause severe reductions to water supplies. To further ensure preservation of water supplies in the public interest, this order includes requirements for conservation planning.

SCWA reported that requirements to meet specific conservation goals in Sonoma and Mendocino County that were imposed as conditions of approval of a TUCP filed by SCWA in 2009 were not effective outside of SCWA's service district, with the exception of water users who voluntarily cooperated. Therefore, there is a need to evaluate other long term solutions. As such, this order retains previous requirements to coordinate regarding conservation actions, and includes a new requirement to develop a water supply reliability evaluation and report, including recommendations for future water management practices to improve Lake Mendocino water supply reliability. Taking steps to improve the reliability of Lake Mendocino's water supplies will minimize potential future impacts to threatened and endangered fish species, water users, water quality, recreation, and other beneficial uses along the upper and lower Russian River in future years of water scarcity.

6.0 CONCLUSIONS

The State Water Board has adequate information in its files to make the evaluation required by Water Code section 1435.

I conclude that, based on the available evidence:

1. The permittee has an urgent need to make the proposed change;

2. The petitioned change will not operate to the injury of any other lawful user of water;

3. The petitioned change will not have an unreasonable effect upon fish, wildlife, or other instream beneficial uses; and,

4. The petitioned change, with the modifications described above, is in the public interest.

ORDER

NOW, THEREFORE, IT IS ORDERED THAT: the Petition filed by Sonoma County Water Agency (SCWA) for temporary urgency change in Permits 12947A, 12949, 12950, AND 16596 is approved, in part.

All existing terms and conditions of the subject permits remain in effect, except as temporarily amended by the following provisions:

1. From the date of this Order until October 28, 2013, minimum flows in the Russian River, as specified in Term 20 of Permit 12947A, Term 17 of Permits 12949 and 12950, and Term 13 of Permit 16596, shall be modified as follows:

   A. Minimum instream flow in the **upper Russian River (from its confluence with the East Fork of the Russian River to its confluence with Dry Creek)** shall be as follows:

      (1) From May 1, 2013 through June 30, 2013, minimum instream flow shall remain at or above 75 cubic feet per second (cfs);

(2) From July 1 through October 28, 2013, minimum instream flow shall remain at or above 75 cfs, if during the period from July 1 through October 28 storage in Lake Mendocino remains above SCWA's calculated critical storage curve (shown in attached Exhibit A);

(3) From July 1 through October 28, 2013, minimum instream flow shall remain at or above 25 cfs, if during the period from July 1 through October 28 storage in Lake Mendocino drops below SCWA's calculated critical storage curve for more than three consecutive days;

(4) After a cumulative seasonal total of 200 adult Chinook salmon move upstream past the SCWA Mirabel inflatable dam, SCWA shall consult with the National Marine Fisheries Service (NMFS) and the California Department of Fish and Wildlife (CDFW) regarding the possibility of increasing instream flow at the USGS gages at both Hopland (No.11462500) and Healdsburg (No. 11464000) to a level not exceeding 125 cfs.

B. Minimum instream flow in the **lower Russian River (from its confluence with Dry Creek to the Pacific Ocean)** shall be as follows unless the water level in Lake Sonoma is below 292.0 feet with reference to the National Geodetic Vertical Datum of 1929, or unless prohibited by the United States Government:

(1) From May 1, 2013 through June 30, 2013, minimum instream flow shall remain at or above 85 cubic feet per second (cfs).

(2) From July 1 through October 28, 2013, minimum instream flow shall remain at or above 85 cfs, if during the period from July 1 through October 28 storage in Lake Mendocino remains above SCWA's calculated critical storage curve;

(3) From July 1 through October 28, 2013, minimum instream flow shall remain at or above 50 cfs, if during the period from July 1 through October 28 storage in Lake Mendocino drops below SCWA's critical storage curve for more than three consecutive days.

C. For purposes of compliance with this term, the minimum instream flow requirement between May 1, 2013 and June 30, 2013, and the minimum instream flow requirement in place when storage in Lake Mendocino is above SCWA's calculated critical storage curve *(Dry* water supply conditions*)* shall be measured based on a 5-day running average of average daily stream flow measurements, with the condition that instantaneous flows on the upper Russian River shall be no less than 65 cfs and on the lower Russian River shall be no less than 70 cfs. The minimum instream flow requirement in place when storage is below SCWA's calculated critical storage curve for more than three consecutive days (*Critical* water supply conditions) shall be measured based on an instantaneous basis in the upper Russian River and based on a 5-day running average of average daily stream flow measurements in the lower Russian River, with the condition that the instantaneous flows shall be no less than 35 cfs.

2. The Deputy Director for Water Rights (Deputy Director) reserves authority to approve the 35 cfs requirement that was sought initially under Critical water supply conditions in the lower Russian River upon a request from SCWA supported by an updated instream flow and hydrologic analysis demonstrating the urgent need for the requested change and supporting the findings that the change (1) will not result in injury to any lawful user, (2) will not unreasonably affect fish, wildlife, or other instream beneficial uses, and (3) will be in the public interest. If authorized by the Deputy Director, compliance with the 35 cfs minimum instream flow requirement shall be measured on an instantaneous flow basis.

3. To protect against stranding of fish when releases from Lake Mendocino are converted from *normal*-year to *Dry* water supply conditions, or from *Dry* water supply conditions to *Critical* water supply conditions, flow in the East Fork Russian River immediately below Coyote Dam shall not

be reduced by more than 25 cfs per hour. Ramping rates specified in this term may be revised at the direction of the NMFS and the CDFW.

4. SCWA shall monitor and record daily numbers of adult Chinook salmon moving upstream past the Mirabel inflatable dam beginning no later than September 1, 2013, and continuing through at least November 15, 2013.

5. If adult Chinook salmon can enter the Russian River estuary, SCWA shall monitor numbers of adult Chinook salmon in representative deep pools in the Lower Russian River downstream of the Mirabel inflatable dam on a weekly basis beginning September 15, 2013, and ending when 200 fish have passed Mirabel Dam, when sustained flows in the Russian River at Hacienda Bridge are greater than 125 cfs, or on November 15, 2013, whichever is earliest.

6. SCWA shall monitor numbers of adult Chinook salmon at known spawning sites and in representative deep pools in the Upper Russian River (Lake Mendocino to Healdsburg) on a weekly basis after the number of adult Chinook salmon counted at Mirabel Dam exceeds 200 fish. Weekly surveys shall continue until November 15, 2013, or when sustained flow at Healdsburg is above 185 cfs, whichever is earlier.

7. If after July 1 the water supply condition changes to *Critical* water supply conditions, then SCWA shall measure water depth and velocity to conduct an assessment of adult Chinook salmon passage at a total of 9 riffles; 3 each in the lower, middle, and upper reaches of the Russian River.

8. SCWA shall monitor juvenile salmonids and other native fishes by snorkel survey at six sites in the Upper main stem Russian River (upstream of Mirabel) between August 2013 and September 15, 2013, when suitable visibility conditions exist.

9. Consistent with the requirements of the Biological Opinion, SCWA shall monitor downstream movement of juvenile salmonids in Dry Creek and the main stem Russian River at Mirabel Dam and monitor and record juvenile salmonid population and life history data at the Russian River Estuary (when river conditions permit safe monitoring).

10. SCWA shall report to NMFS and CDFW every two weeks regarding the applicable fisheries monitoring activities specified in Terms 3 through 9 of this Order. If water supply conditions adjust to Critical water supply conditions after July 1, then SCWA will report on a weekly basis ending when sustained flows are above Decision 1610 flows or when this Order expires whichever is first. Consistent with the Biological Opinion, SCWA shall consult with NMFS and CDFW regarding any necessary adaptations to the monitoring program including revisions to Terms 3 through 9. Upon consultation with NMFS and CDFW, any necessary revisions to Terms 3 through 9 shall be made upon approval by the Deputy Director. Reporting of fisheries monitoring tasks described in Terms 3 through 9 shall be submitted to the Deputy Director by April 1, 2014 in accordance with NMFS and CDFW annual reporting requirements as more fully described in the Biological Opinion.

11. SCWA shall prepare a Water Quality Monitoring Plan (Monitoring Plan) for the Russian River in consultation with: (1) the North Coast Regional Water Quality Control Board; (2) the United States Geological Survey; (3) NMFS; and (4) the Division of Water Rights. The purpose of the Plan shall be to determine the water quality effects and effects to the availability of aquatic habitat for salmonids resulting from the temporary urgency change approved herein. At a minimum, the following water quality parameters in the Monitoring Plan shall be evaluated: water temperature, pH, dissolved oxygen, specific conductivity, bacteria, nutrients, and algae. Furthermore, the Monitoring Plan should build upon previous water quality studies that have been conducted in the Russian River and the estuary water quality monitoring required by the Biological Opinion and include a Quality Assurance Project Plan or description of an existing quality assurance protocol

to be followed. The Monitoring Plan may provide information to support the development of a CEQA document required for permanent changes to Decision 1610. The Plan shall be submitted to the Deputy Director for approval within 28 days of the date of this Order, and SCWA shall immediately implement the Monitoring Plan upon submittal.

12. SCWA shall summarize all data collected during the 2013 water quality monitoring program. The summary report shall include an evaluation of whether, and to what extent, the reduced flows authorized by the Order caused any impacts to water quality, including any water quality impacts affecting the availability of aquatic habitat for salmonids and recreation. The report shall be submitted to the Deputy Director by March 31, 2014.

13. This Order does not authorize any act that results in the taking of a candidate, threatened or endangered species, or any act that is now prohibited, or becomes prohibited in the future, under either the California Endangered Species Act (Fish and Game Code sections 2050 to 2097) or the federal Endangered Species Act (16 U.S.C.A. sections 1531 to 1544). If a "take" will result from any act authorized under this Order, the permittee shall obtain authorization for an incidental take permit prior to construction or operation of the project. Permittee shall be responsible for meeting all requirements of the applicable Endangered Species Act for the temporary urgency change authorized under this Order.

14. The State Water Board reserves jurisdiction to supervise the temporary urgency change under this Order, and to coordinate or modify terms and conditions, for the protection of vested rights, fish, wildlife, instream beneficial uses and the public interest as future conditions may warrant.

15. The SCWA shall immediately notify the State Water Board if any significant change in storage conditions in Lake Mendocino occurs that warrants reconsideration of this Order.

16. SCWA shall provide a written update to the Deputy Director by March 31, 2014, regarding activities and programs being implemented by SCWA and its water contractors to assess and reduce water loss, promote increasing water use efficiency and conservation, and improve regional water supply reliability. The written update shall include a report regarding the actual maximum applied water allowance (MAWA) achieved by each of SCWA's contractors during May through November 2013.

17. SCWA shall work with the Russian River water users above the confluence with Dry Creek that are specified in this term to evaluate the long-term reliability of Lake Mendocino to meet water supply and environmental water demands and shall prepare a report of its findings. SCWA shall contact the specified Russian River water users listed below and request that they participate and support SCWA's evaluation by providing information regarding their current water demands, potential future land use changes and forecasts of water demands. For purposes of this Order, the specified Russian River water users are: Mendocino County, Sonoma County, Mendocino County Russian River Flood Control and Water Conservation District, Millview County Water District, Rogina Water Company, Willow County Water District, Redwood Valley County Water District, City of Ukiah, Hopland Public Utility District, City of Healdsburg, City of Cloverdale and Geyserville Water Works Public Utility District. SCWA may also contact other water users and seek their cooperation in its evaluation. The water supply reliability evaluation and report shall analyze the potential impacts to Lake Mendocino storage due to climate change, future potential land use practices and forecasted water demands to the extent existing information is available or provided by the entities. The evaluation and report shall also include recommendations for future water management practices to improve Lake Mendocino water supply reliability. SCWA shall provide a status report to the Deputy Director by December 31, 2013 identifying the entities that have been contacted and the responses of those entities to SCWA's request that they participate in the reliability evaluation. SCWA shall submit the final water supply reliability evaluation and report to the Deputy Director by December 31, 2014.

18. SCWA shall provide a written update to the Deputy Director regarding the progress of the Santa Rosa Plain Groundwater Management Planning Program by March 31, 2014. The update shall include a discussion of: (1) progress being made toward implementation of groundwater recharge in the Santa Rosa basin; and (2) efforts by SCWA and its water contractors to conjunctively manage surface water and groundwater resources within SCWA's service area. Such management should emphasize the conservation and replenishment of groundwater resources and utilization of available surface water supplies to the extent feasible.

STATE WATER RESOURCES CONTROL BOARD

ORIGINAL SIGNED BY:

Barbara Evoy, Deputy Director
Division of Water Rights

Dated: May 1, 2013

Attachment: Exhibit A

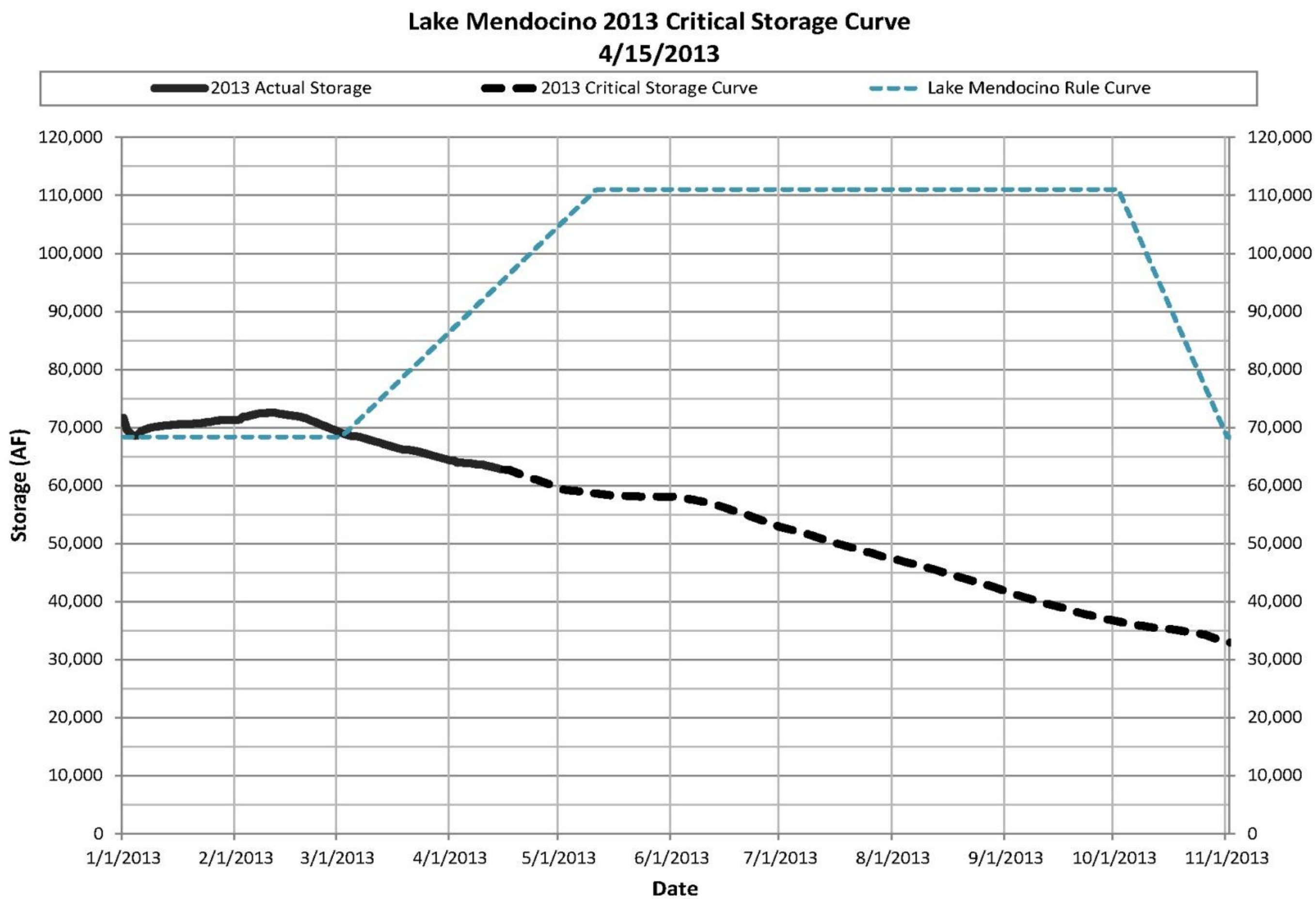


Exhibit A - SCWA Calculated Critical Storage Curve for Lake Mendocino

APPENDIX B

TECHNICAL MEMORANDUM

DATE: April 30, 2015

PREPARED FOR: Jay Jasperse, P.E., Chief Engineer, Sonoma County Water Agency

CC: Donald Seymour, P.E., Principal Engineer, Sonoma County Water Agency

PREPARED BY: Todd J. Schram, P.E., John Mendoza, P.E and Chris Delaney, P.E., Sonoma County Water Agency

SUBJECT: **UPPER RUSSIAN RIVER WATER ACCOUNTING MODEL**

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1.0 INTRODUCTION

This technical memorandum describes the development of the Upper Russian River Water Accounting Model (Model) by the Sonoma County Water Agency (Water Agency). The model simulates conditions in the Upper Russian River from the Potter Valley Project down to the United States Geologic Survey (USGS) Healdsburg streamflow gaging station. The Model was developed to support the technical analysis of the Lake Mendocino Reliability Study (Reliability Study), which is a requirement of Term 17 of the May 2013 Temporary Urgency Change Order (Order) issued by the California State Water Resources Control Board.

1.1 Model Overview

The model used to complete the study was developed as a Microsoft Excel spreadsheet and simulates storage conditions in Lake Mendocino under different levels of demand and varied climatic conditions for both historical hydrology from 1911 to 2013 and projected climate change hydrology from 2000 to 2099. The model has seven locations in the Upper Russian River at which estimated water gains, water losses and operational compliance are taken into account to simulate reservoir inflow, storage and release on a monthly time step. Five of the calculation points correspond with existing USGS discharge gage locations. A schematic of the model is provided as Figure 1 with points showing locations at which water balance calculations are completed and estimated river system gains and losses are shown as arrows. The datasets used in the model to quantify system water gains include diversions from the Eel River through the Potter Valley Project (PVP), unimpaired flows or natural flows from rainfall and groundwater. System water losses include lake evaporation, river diversions, and losses due to riparian vegetation and aquifer recharge. Model reaches referenced in this report are defined by their downstream node. For instance, the Cloverdale reach extends from the Hopland model node to the Cloverdale model node.

Model scenarios were developed to approximate "Current" (2015) and "Projected 2045" conditions for the Upper Russian River System. The Current scenario was developed to approximate both current levels of system water demand and current operations of the system. The Projected 2045 scenarios were developed to evaluate potential impacts of future water demand over a 30-year planning period. Two future scenarios were developed to approximate water demand for both "High Growth" and "Low Growth" conditions. An additional scenario was developed to evaluate change in reliability with no diversions from the Eel River through the PVP. Due to uncertainty of future operations, model operational assumptions were not modified for any of the future conditions scenarios, although projections were made to account for loss of storage in Lake Pillsbury and Lake Mendocino due to sedimentation.

2.0 SYSTEM WATER GAINS

System water gains include water that is added to the system, which may be from unimpaired or man-made sources. The gains accounted for in the model include unimpaired flows (often called "natural" flows) from precipitation runoff or groundwater and diversions from the Eel River through the PVP. Model system gain locations are shown as green solid arrows in Figure 1.

2.1 Unimpaired Flows

Unimpaired flows are the "natural flows," unaffected by man-made influences such as water demands or reservoir operations. The model accounts for system gains from unimpaired flows at five geographic points in the Upper Russian River as indicated with the solid green arrows in Figure 1. Unimpaired flow datasets were developed by the USGS (Flint et al., 2015) for historical climate from 1911 to 2013 and potential changes in climate due to climate change from 2000 to 2099. The USGS used the Basin Characterization Model for California (CA-BCM) to integrate high-resolution data of historical and projected climate data to predict watershed-specific hydrologic responses. Two future climate scenarios were evaluated in this study. A Gonzales plot of 18 climate change scenarios from the Intergovernmental Panel on Climate Change (IPCC) 4th Assessment and 5th Assessment Reports is provided in Figure 2. The scenarios incorporated in this study are circled for reference. Downscaled climate was prepared for incorporation into the CA-BCM from the Global Fluid Dynamic Laboratory (GFDL) model for the A2 (medium-high) and B1 (low) future greenhouse gas emissions scenarios. Downscaling of the climate scenarios was completed spatially to 270 meters and temporally to a 1 day time step. Unimpaired flows were estimated as daily average flows, but for the purposes of this study monthly flow rates were calculated from the daily flows.

2.2 Potter Valley Project Diversions

Trans-basin diversions from the Eel River into the Russian River through the PVP were estimated using the Eel River Model version 2.5. Due to changes in operations of the PVP throughout the historical period simulated by the model, observed historical diversions were not used. In the fall of 2006 operations of the PVP changed significantly due to a 2004 Federal Energy Regulatory Commission (FERC) license amendment, therefore, historical diversions would not be representative of current operations of the PVP. Modeled PVP diversions were developed to approximate current, post-fall 2006 operational constraints and practices. Additionally the modeling completed for the reliability study also includes analysis of impacts due to climate change and projected change in storage due to sedimentation, therefore, model scenarios had to be developed to incorporate these changed conditions. System gains from diversions from the PVP are defined at model node 1 as shown in Figure 1.

The Eel River Model version 2.3 developed by Natural Resources Consulting Engineers (Oakland, CA) was used for the alternatives analysis of the 2004 FERC license amendment. In 2007, version 2.4 was developed by Water Agency and the model was modified to better account for the E5 Condition of the license amendment. The Water Agency further modified the model and developed the Eel River Model version 2.5 (ER2.5) for the purposes of the Reliability Study. Version 2.5 was developed through further refinements to the model code and input datasets to better simulate current operations of the PVP under: (a) the 2004 FERC license amendment (FERC 2004) operational requirements as detailed in the "NOAA Fisheries' Reasonable and Prudent Alternative" (RPA); and (b) the "Flow Regulation and Verification Plan" (FRVP; PG&E, 2006). ER2.5 was used to provide estimated diversions under current management practices of the PVP for historical hydrology for water years 1910 to 2006 and for climate change hydrology for water years 2000 to 2099. Because water years 2007 to 2013 are consistent with current management, actual diversions were used for those years for the historical hydrology dataset used in the Reliability Study. Modifications made to the model are summarized in the following sections.

2.2.1 E5 Condition

The E5 condition of the 2004 RPA stipulates that diversions through the PVP tunnel in excess of the minimum flow in the East Branch Russian River (E16) and the release to the Potter Valley Irrigation district can only be made when Lake Pillsbury storage is above the Target Storage Curve (TSC). The model code was modified to conform to this condition with an additional minimum release buffer of 5 cfs as required in the FRVP. The previous version of the code would allow diversions in excess of the minimum flow requirements of E16 if Lake Pillsbury storage was below the TSC and Scott Dam was in a spill condition. The previous version also did not include the minimum release buffer.

2.2.2 E6 Condition

Model input datasets were modified to use the TSCs finalized in Condition E6 of the 2004 RPA, which includes three curve types (A, B and C). Different TSCs are used depending on the water year classification of the PVP, which is based on the water year cumulative Lake Pillsbury inflow as of May 15. Based on the water year classification as of May 15, the appropriate TSC is used for the following 12 months beginning on August 1 of that year. The previous version of the model only incorporated 2 TSCs, a wet and a dry curve, with different thresholds than those finalized in the 2004 RPA.

2.2.3 Maximum Diversion through the PVP Tunnel

Maximum diversion through the PVP tunnel based on the physical capacity is approximately 305 cfs. An analysis of historical operations from water year 2007 to 2014 shows that when storage is above the TSC, operators of the PVP rarely divert this maximum flow through the tunnel and on average divert approximately 150 cfs. The chart included as Figure 3 shows historical Lake Pillsbury storage and diversions through the PVP tunnel with power production diversion highlighted in red. It can be seen in Figure 3 that power production diversions only occur when Lake Pillsbury storage is above the TSC and that historical power production diversions are quite variable. The amount diverted for power production diversions is likely a function of a number of factors including energy demand, energy market prices and current operational constraints due to project maintenance and repair.

The Eel River model uses the maximum diversion parameter to set tunnel releases any time storage in Lake Pillsbury exceeds the TSC. The previous version of the model set the maximum diversion parameter to 305 cfs, which, when compared to historical operations, overestimates annual diversions. Therefore, in effort to develop a model that best approximates current operations of the PVP, the maximum diversion parameter in ER2.5 was constrained to 150 cfs, the average power production diversion post implementation of the 2004 license amendment.

2.2.4 Minimum Instream Flows at E11

Based on analysis of historical operations from water year 2007 to 2014, when Scott Dam is not in a spill condition and all releases are being made through the needle valve, releases from Scott Dam are made according to the current minimum instream flow requirements below Cape Horn Dam (E11) including a minimum flow buffer and releases through the PVP tunnel. Accretion flows between Scott Dam and Cape Horn Dam are not taken into consideration when determining Scott Dam releases. The previous version of the model assumes that accretion flows are included in the water balance calculation to set Scott Dam releases when managing for minimum flows at E11. Therefore, the ER2.5 code was modified to better reflect actual operations by not including these accretion flows to help meet minimum flows at E11 and tunnel releases. By not incorporating these accretion flows to set modeled release from Scott Dam, ER2.5 more closely matches observed releases from Scott Dam than previous versions of the model.

2.2.5 Minimum Instream Flow Buffer at E11

The FRVP requires a release buffer of approximately 15 cfs from Cape Horn Dam when minimum flows at E11 exceed 115 cfs. Review of historical operations from water 2007 to 2014 show that a buffer of approximately 15 cfs is released from Cape Horn Dam at all minimum flows at E11. The ER2.5 model was modified to add a 15 cfs buffer to all minimum flows at E11 consistent with observed operations. The previous version of the model does not include any buffer to minimum flows at E11.

2.2.6 No Potter Valley Project Diversions

A scenario was developed in which no diversions from the Eel River to the East Branch of Russian River are made through the PVP tunnel. For this scenario, the code for ER2.5 was modified to not allow any diversions through the tunnel while still making releases from Scott Dam to meet the minimum instream flow requirements below Cape Horn Dam at E11.

2.2.7 Potter Valley Project Diversions with Climate Change

To assess the impacts of climate change on Lake Mendocino, PVP diversions were estimated for the changes in hydrology due to climate change. Daily climate change unimpaired flows were developed by the USGS for the Scott Dam and Cape Horn Dam sub-basins for the GFDL A2 and B1 scenarios for the water years 2000 to 2099. These flows were incorporated into ER2.5 to simulate PVP diversions with this modified hydrology.

2.2.8 Projected Lake Pillsbury Storage Capacity

For the Projected 2045 PVP scenarios for both historical climate and climate change hydrology, Lake Pillsbury hypsometry was projected to 2045 conditions with reduced storage capacity due to sedimentation of the reservoir. To account for reduced storage capacity, projections of lake storage, lake surface area, and flow capacity of the needle valve were made using the observed sedimentation rates from the 1959 to 1984 bathymetric surveys.

2.2.9 Eel River Model Results

Results of the updated ER2.5 were compared to observed PVP diversions from water year 2007 to 2013. A scatter plot of modeled monthly diversions versus observed monthly diversions is provided as Figure 4. Model results show very good agreement with observed diversions. As provided in Figure 4, a least-squares linear regression fit shows a coefficient of determination (R^2) of 0.71 and also approximately 1 to 1 correlation. Model results correlate best for values below 8,000 acre-feet per month, which captures the range of operations for compliance (non-power production) diversions. Actual power production diversions are a function of numerous factors not accounted for in the model, such as operational constraints due to facility maintenance, energy demand, and energy market prices. Therefore, the increase in scatter for diversions above 8,000 acre-feet per month is expected. When comparing water year cumulative diversions as provided in Figure 5, model results compare very well with observed diversions. It should be noted that while modeled diversions for water years 2007 to 2013 were compared here to actual diversions to assess model performance, modeled diversions for these years were not actually used in the Reliability Study. Instead actual diversions were used for water years 2007 to 2013 to provide the most accurate information for those years.

3.0 SYSTEM LOSSES

System water losses includes all water that is removed from the system and include natural processes and human uses. The model accounts for system losses at five geographic points in the Upper Russian River. System loss locations in the model are shown as hollow red arrows provided in Figure 1. System losses accounted for in the model include municipal diversions, agricultural diversions, riparian vegetation, lake evaporation and water balance losses.

System water loss scenarios were developed for Current (2015 conditions) and Projected 2045 watershed conditions. The Projected 2045 scenarios were developed to evaluate potential impacts of future water demand over a 30-year planning period. Two future scenarios were developed to approximate water demand for both High Growth and Low Growth conditions. Losses in the model are accounted for as annually repeating patterns of monthly demand. For the Current loss scenario, there are two loss year types: a dry and a wet year type. These year types are determined based on springtime rainfall. For the Projected 2045 scenarios, a singular yearly loss pattern was developed. Two 2045 loss scenarios were developed to capture potential future high growth and low growth scenarios. Development of the water loss datasets are described in further detail below.

3.1 Municipal Water Demands

Water demands for municipal and industrial water use were established for the nine public water systems listed in the Order. Table 1 provides a listing of the each of the public water system's service population. Based on 2012 annual Public Water System Statistics (PWSS) reports submitted to California Department of Water Resources (DWR), the total service population for these systems is approximately 55,000 (CDWR, 2014). The City of Ukiah serves the largest population with 16,000 persons. Overall, the Upper Russian River watershed has an estimated population of 55,706 based on data from the 2010 U.S. Census.

Among these water systems, their water supply is primarily composed of surface water and groundwater wells located in the alluvial aquifer. Other than the City of Healdsburg, which receives a portion of its water from Dry Creek, the systems use water available along the mainstem corridor in the Upper Russian River watershed.

3.1.1 Current (2015)

Existing water demands for these water service providers was established using recent water production records submitted to the DWR in the annual PWSS reports (CDWR, 2014). Total annual production for the water systems are listed in Table 2 for the five-year period from 2009-2013. Over this period, the Upper Russian River experienced dry, normal, and wet years. Both 2010 and 2011 were relatively wet years. Precipitation was about average in 2012, while 2009 was dry and 2013 was extremely dry. Population trends over this period showed little change. Many of the water providers experienced lower water usage in 2010 and 2011, reflecting the impact of the wet years depressing irrigation demands. The impact of the Great Recession of 2008-2009 likely reduced the water demands for many of these water systems. In 2013, a stronger economy combined with only 8 inches of rainfall for the year in Ukiah contributed to higher demands overall for the region.

Current conditions of water production for each of the water systems were established as a baseline for the Reliability Study. The water demands assumed for the evaluation base year of 2015 were established considering the average total production over the five-year period as well as considering any extraordinary circumstances that were discussed with the water managers of each public water system. The Current demands established as the evaluation baseline demand for each water system are shown in Table 3.

3.1.2 Projected (2045)

Water use projections for each water system were established based on a review of published projections found in various planning documents. Table 4 lists the relevant planning projections from 2010 through 2050 for each system. For the larger water systems, the available documents were often Urban Water Management Plans and water system master plans, which directly address future water demands. For smaller systems, projections were developed based on population growth estimates found in county general plans. In 2010, Mendocino County developed a specific plan, the Ukiah Valley Area Plan (UVAP), which evaluated alternative development strategies for the region. A water supply assessment report was prepared in October 2010 to accompany the UVAP. The report provided projected water use scenarios out to 2030 for the following Ukiah Valley water systems: Millview County Water District (CWD), City of Ukiah, Rogina Water Company and Willow CWD. Demand projections for the water systems were prepared for high use and reduced use scenarios. A 20 percent reduction in per capita water use was assumed in the UVAP for the reduced use scenario. For the Reliability Study, the projected annual rates of demand change from the various planning documents were used.

Similar to the water supply assessment for the UVAP, two projection scenarios—low and high growth—were developed for the water use projections. For this study, projections in five-year increments following the base year of 2015 were estimated out to 2045. Projection estimates for periods beyond a given water provider's planning period were extrapolated assuming a continuation of the rate of growth in water demand. The 'Low Growth' projections are detailed on Table 5. Under the 'Low Growth' scenario, the total water demand is projected to increase from 10,491 acre-feet (ac-ft) per year to 14,241 ac-ft per year by 2045. For the 'High Growth' scenario, municipal water demand for the listed stakeholders is estimated to increase to 17,630 ac-ft per year as detailed in Table 6. This corresponds to an increase of 7,139 ac-ft, or an annual average rate of increase of 1.7%. Figures 6 and 7 chart the projection data for the 'Low Growth' and 'High Growth' scenarios, respectively.

All current condition and projected water demand datasets were vetted by the respective water system stakeholders in a review initiated in September 2014.

Table 7 aggregates the municipal water use projections by river reach, including Lake Mendocino as a reach since Redwood Valley CWD pumps directly from the reservoir. River reaches are defined by USGS stream gage locations with the naming convention based on the corresponding downstream gage (except for Lake Mendocino). The reach with the current highest municipal water use and largest projected increase by 2045 is the Talmage reach.

The monthly distribution of municipal water demands was developed based on the monthly production datasets in DWR's PWWS reports. First, the average monthly production volumes for each water provider were aggregated by river reach. Second, the monthly average daily production rates for each reach was calculated and divided by the annual average daily production rate to develop a normalized monthly demand factor. These monthly factors for each reach are applied to the current conditions and projection datasets to distribute the annual demands. The monthly demand factors for each reach are listed in Table 8.

3.2 Agricultural Demands

Reach sub-watershed estimates of monthly agricultural demand were made using land use data and applied water estimates by crop type developed by Davids Engineering (Davids, 2013) for the Current and Projected 2045 High Growth and Low Growth scenarios. These total sub-watershed estimates of agricultural demand exceed observed reach losses in the river. Therefore, these estimates were further broken out by Davids Engineering to areas along the Russian River, Applied Water Analysis Zone (AWAZ), within which diversions or consumption of water is either known or presumed to have immediate effects on Russian River flows. Steve Grinnell completed an analysis of observed flows and estimated reach gains to estimate water balance losses not accounted for with observed municipal diversions or estimated AWAZ diversions. To estimate expected surface water losses, Current scenario agricultural losses were estimated by summing AWAZ diversions estimates and water balance losses estimated by Grinnell. Agricultural losses for the Projected 2045 scenarios were estimated by developing monthly scaling factors of Current agricultural losses to Current land use estimates of total agricultural demand for each model reach. The scaling factors represent the fraction of total watershed demand that impacts surface water flows. These scaling factors were then applied to the total land use estimates for the Projected 2045 scenario to estimate the expected loss to surface water flows for these projected land use changes.

3.2.1 Current (2015)

Monthly agricultural demands for the Current scenario were developed combining applied water estimates (Davids Engineering, 2013) and reach loss estimates through water balance analysis (Grinnell, 2015) for each river reach. Both methods are described in the sections below and resulting model inputs are shown in Tables 9-12.

3.2.1.1 Agricultural Applied Water Estimates

Limited agricultural diversion data is available for the study area therefore these diversions were estimated in an analysis completed for the Water Agency in 2013 by Davids Engineering (Davids Engineering, 2013). In this study estimates of historical irrigation diversions were developed using an agricultural irrigation demand model and a soil moisture accounting model.

Estimates of daily applied water and riparian vegetation water losses were developed by estimating total daily crop evapotranspiration (ET). Daily total crop ET was calculated for different crop types using unique crop coefficients derived from a 2008 analysis of actual ET (ETa), based on the Surface Energy Balance Algorithm for Land (SEBAL®) model, coupled with quality-controlled reference ET (ETo) data from the California Irrigation Management Information System (CIMIS).

The Soil-Water-Atmosphere-Plant (SWAP) model was used to calculate a daily root zone water balance and estimate applied water volumes from 2002 to 2008 for agricultural fields and within the Applied Water Analysis Zone (AWAZ). The AWAZ represents the area within which diversion or consumption of water is either known or presumed to have immediate effects on Russian River flows. Monthly AWAZ applied water volumes were estimated for wet and dry year types as discussed in further detail in Section 3.5.

3.2.1.2 Water Balance Losses

Water balance losses were quantified as part of an analysis completed by Steve Grinnell in March 2015 (Grinnell, 2015). A water balance analysis was completed from 2002 to 2013 for the months May through October to estimate the total observed loss for each reach in the system. This analysis incorporated multiple datasets including observed upstream and downstream flows, estimated reach gains as quantified by the unimpaired flows developed by the USGS, known reach losses for municipal diversions, estimated diversions from agriculture as estimated by Davids Engineering, and estimated losses from riparian vegetation. The water balance loss is the excess observed loss that cannot be accounted for from observed municipal diversions, estimated agricultural diversions and estimated losses to riparian vegetation. Although water balance losses cannot be directly accounted for by observed direct diversions from the river, for this study it is assumed that this water balance loss is the result of the cumulative impact of water being pumped from groundwater wells or diverted from tributaries. Monthly water balance loss patterns were estimated for wet and dry year types as discussed in further detail in Section 3.5.

3.2.2 Projected (2045)

Agricultural demands for the two Projected 2045 scenarios were estimated using Current and Projected 2045 land use datasets as described in the section below. These land based estimates of agricultural water demand in the Upper Russian River watershed were not applied directly as model inputs because they exceed observed reach losses estimated by Grinnell (Grinnell, 2015) for current conditions. This is likely due to the fact that that much of the water used for agriculture is not directly diverted from the river, but instead from groundwater wells at varying distances from the mainstem of the river. The impact that these groundwater diversions have on surface water flows is a function of a number of factors such as distance of the well from the river channel, the surrounding geology to the well, the depth of the well, and whether the well is diverting from a confined or semi-confined aquifer.

To project expected river losses due to the increased agricultural demands from Current 2015 to Projected 2045, as discussed in Section 3.2.2.1, monthly scaling factors were developed that correlate observed non-municipal river reach losses (estimated reach losses excluding diversions made by municipalities, the sum of water balance loss and Davids Engineering estimates of agricultural diversions) to Current annual land use derived water demand within the watershed. These scaling factors were then applied to the Projected 2045 annual land use derived water demands for the High and Low Scenarios, resulting in monthly projected demands. Upper Russian River monthly losses for the Projected 2045 high and low growth loss scenarios are provided in Figure 8. Also included in Figure 8 for comparison is monthly average demand for the Current loss scenario (average of wet and dry).

Scaling factors were not developed for municipal diversions because it was assumed that all current and projected municipal diversions have a direct impact on surface water flows. Additionally, scaling factors were not developed for riparian losses because it was assumed that riparian losses will not change in the 30-year planning horizon. Therefore, the same riparian losses used for the Current scenario were used for the Projected 2045 scenarios.

3.2.2.1 Agricultural Land Use Derived Demands

Estimates of water use for agricultural lands within the Upper Russian River watershed were developed based on a land use approach methodology. Agricultural demands were estimated for the three primary categories of use: irrigation during the growing season, frost protection during the spring after bud break, and post-harvest application in the fall.

Water use for irrigation was estimated on annual basis using seasonal crop water duties for the various crop types by region. The regional crop water duties were developed based on the agricultural water demand modeling work for the Russian River conducted by Davids Engineering (Davis, CA) for the Water Agency in 2009 (Davids Engineering, 2013). The annual crop water duties used for this study are found in Table 13. These annual values are based on monthly crop irrigation requirements established in the Davids Engineering project using remote sensing data collected for the 2008 growing season to calculate evapotranspiration (ET). A water balance root zone model was developed to provide soil moisture accounting over time and estimate the onset of irrigation and its contribution to the observed ET. The annual values in Table 13 are average duties established by runs of this agricultural demand model for the historical period of 2002 through 2008.

An update to the Water Agency's agricultural field mapping was completed to reflect land use changes current up to 2012. The Water Agency developed the original agricultural fields GIS layer for the entire Russian River watershed in 2009 by aggregating smaller scale GIS field mapping projects conducted by other organizations and contributing a significant amount of new mapping based on digitizing crop fields identified in orthoimagery. Figure 9 shows the existing agricultural lands. The crop acreages for each subwatershed under current conditions (based on 2012 imagery) are shown in Table 14.

Irrigation water use estimates in the river reaches of the Upper Russian River for the existing agricultural lands are shown in Table 15. These estimates were calculated based on the crop acreages from the agricultural field mapping and the derived regional water duties described above.

Protection of crops from frost damage is practiced in the Upper Russian River watershed primarily using overhead sprinklers. Vineyards and orchards are susceptible to frost damage after bud break. In a given year, the onset and number of frost events that require frost protection water vary, but the season typically runs between March 15 and May 15. Frost protection using overhead sprinklers requires high application rates and therefore pumping rates over a several hour period. Recent additions of storage ponds in the watershed have reduced the instantaneous impacts on the streamflows. However, whether the pumping is from a well, surface water or a storage pond, for the purposes of this evaluation, it is assumed to partially impact the monthly river water balance. A net water use for frost protection was calculated to account for significant return flows that result from this practice.

The methodology to estimate frost protection water first calculates the total monthly diversions expected in an average year and then estimates a net water use accounting for return flows. The methodology used for determining associated diversions mimics that used by the UC Cooperative Extension – Ukiah (UCCE-Ukiah) report on irrigated agriculture (MCWA, 2008). The report provides estimates of the total number of acres that are frost protected. The number of frost events and duration assumed for each region is tabulated in Table 16. Overhead sprinkler systems are assumed to operate in frost events with an average application rate of 50 gallons per minute (gpm) per acre.

Table 17 lists the estimated average water use and net water use for frost protection by subwatershed. The Water Agency reviewed historical frost events and observed impacts to Russian River streamflows to establish an estimate of net water use under current conditions.

The post-harvest application of water to vineyards was also evaluated for this study using the same methodology as the UCCE–Ukiah report (MCWA, 2008). For the Mendocino County portion of the Upper Russian River watershed, the prevalence of post-harvest applications as a practice was maintained consistent with the report. This evaluation also uses the water application rate of 50 gpm per acre and the duration of 36 hours that were assumed by the UCCE-Ukiah (MCWA 2008).

For the Sonoma County portion of the Upper Russian River watershed, the same post-harvest application operational parameters were assumed for 50% of the vineyard acreage. Table 18 lists the estimated average water use for post-harvest application by subwatersheds.

Using the same approach for determining total agricultural water use under current conditions as described above, the water use in the Upper Russian River watershed was projected for future conditions in 2045. Similar to municipal water use projections, a ‘Low’ and ‘High’ water demand scenario were developed. Based on historical trends in crop planting, vineyards are the dominant crop in the watershed and their percentage of the overall agricultural lands has been increasing. For this study, it was assumed that vineyards would comprise all new agricultural fields developed in the study area and that additional vineyards may be planted as a result of crop conversion from orchards and pastures.

Projections of future agricultural fields were completed using different approaches for the Mendocino County and Sonoma County. In Mendocino County, a parcel land use approach was taken to identify new areas within the watershed that are likely to be developed for agriculture. In Sonoma County, historical trends in the growth of vineyard acreages were reviewed based on the County’s General Plan (Sonoma County, 2010). The average increase in vineyard acreages from the period of 2002 through 2012 was assumed for the future growth rate out to 2045. The overall 10-year change in vineyard acres in the Upper Russian River was calculated at approximately 2,600 acres. In addition to newly developed agricultural fields, the future crop land use projections include assumptions on a certain percentage of crop conversion occurring, which increases the number of vineyard acres. Table 19 provides the assumed crop conversion percentages used for the evaluation.

In the ‘Low Demand’ scenario, there are more acres assigned to vineyard than in the ‘High Demand’ scenario since overall water use by vineyards is low compared to other crops. Table 20 lists the projected crop acres for the 2045 ‘Low Demand’ scenario. The ‘High Demand’ scenario for 2045 projected crop acres are listed in Table 21.

Projected irrigation water use for the two scenarios for 2045 are presented in Tables 22 and 23. Projected frost protection water use for the two scenarios for 2045 are presented in Tables 24 and 25. Projected post-harvest application water use for the two scenarios for 2045 are presented in Tables 26 and 27.

3.3 Water Loss from Riparian Vegetation

3.3.1 Current (2015)

Monthly water losses to riparian vegetation were estimated for the months of May through October. Riparian vegetation zones were delineated with the Normalized Difference Vegetation Index (NDVI) developed using May 2013 USGS Landsat 8 imagery data (USGS, 2013). The 2013 Sonoma County LiDAR program (NASA Grant NNX13AP69G, the University of Maryland, and the Sonoma Vegetation Mapping and LiDAR Program 2013) was also used for further refinement for the portions of the study area within Sonoma County. ETa for the delineated riparian zones was estimated for 2008 using the results of the SEBAL analysis completed by Davids Engineering.

An example of the delineation of the riparian vegetation boundaries for the Alexander Valley is provided in Figure 10.

To estimate riparian water loss for other years, a monthly scaling factor was calculated for May through October correlating 2008 riparian ETa to 2008 non-municipal water loss (the sum of water balance loss and Davids Engineering estimates of agricultural diversions) for each model reach. This scaling factor was applied for the years 2002-2013 to estimate riparian water usage for those years. Monthly riparian loss patterns were developed for wet and dry year types for the Current scenario as discussed in further detail in Section 3.5.

3.3.2 Projected (2045)

The same riparian losses used for the Current scenario were used for the Projected 2045 scenario assuming there will not be a considerable change in the amount of riparian vegetation in the 30-year planning horizon.

3.4 Water Loss Due to Frost Protection

3.4.1 Current (2015)

Flow losses due to diversions made by agricultural producers for the protection of crops from frost damage were estimated through an analysis of observed flow depletions at USGS discharge gages during the periods March 15 to May 15 for the years 2004, 2007, and 2008. A number of frost events were analyzed using 15-minute interval flow data from the Calpella, Hopland, Cloverdale, and Healdsburg gaging stations. The impacts to river flows from frost events typically lasts 12-16 hours. For each frost event, flows were estimated if no diversions were made by linearly interpolating from the beginning of the event to the end of the event. The volume of water lost due to frost protection diversions was calculated by taking the difference between the estimated no diversion flows and the observed flows. An example of the loss estimates for a March 2008 frost is event is provided in Figure 11. This volume was calculated for a number of events at each discharge gage to estimate an average event for each gage. Table 28 provides the frost events analyzed for each gage with the resultant volumes of water lost from surface flows for each event. The estimated average frost loss is provided at the bottom of Table 28.

To develop datasets of loss due to frost protection practices for the historical climate scenarios, an analysis of daily minimum temperatures was completed for observed historical climate. Minimum daily temperature data was analyzed from the Ukiah, Ukiah Airport, Cloverdale, Healdsburg, and the Santa Rosa Airport National Weather Service weather stations in the Russian River basin. The locations of these weather stations used for this analysis are shown as orange triangles on Figure 1. Collectively, these stations provide a continuous record of minimum daily temperature for the entire historical simulation period (1910-2013) for the study area, although, there are data gaps at each station due to equipment failure, station maintenance, and lapses in funding. For each model reach, minimum daily temperature data was sampled from the closest station where it was available for each daily time step.

Observed minimum daily temperatures were analyzed yearly during the frost season from March 15 to May 15 for 1910 to 2013 to identify days where minimum temperatures fell below 34° Fahrenheit (F), the assumed temperature threshold at which diversions would be made from the river for frost protection. Figure 12 shows minimum daily temperatures for the Hopland reach with temperatures falling below the 34° F within the frost protection season highlighted. It was assumed that for the identified frost protection days the average estimated frost protection flow loss (described above) for each reach would be applied. An example of the daily frost protection loss for the Hopland reach from 1965 to 1967 has been provided as Figure 13 showing the average frost loss applied each day temperatures fall below 34° F within the frost protection season. For the model scenarios that incorporate historical hydrology, these datasets were developed for each reach for the entire historical model domain (1910-2013). Daily frost protection estimates were calculated as monthly losses.

3.4.2 Projected (2045)

Current (2015) and Projected 2045 (2045 High Demand and 2045 Low Demand) land use datasets developed by Water Agency and Mendocino County Russian River Flood Control and Water Conservation Improvement District of the Upper Russian River were used to project frost protection diversions to the year 2045. Acreages of each identified crop type were broken out and summed by river reach. Vineyard and orchard were the only crops assumed to be frost protected. Each river reach was assigned a percentage of vineyard and orchard acreage that was frost protected (UCCE, 2008; Greenspan, 2008). The percentage values and acreages have been provided in Table 29. An average rate of 50 gpm per acre was assumed to be applied to the crops during a frost event. The average durations of water application for each frost event were assumed to vary by agricultural valley (UCCE, 2008) and are shown in Table 16. An average percent return flow per frost event was calculated for each river reach using observed gage to gage losses during frost events from 2004 to 2008 and rounding to the nearest 5%. Return flow percentages are provided in Table 30. Using these assumptions, the net frost protection diversion for each river reach was estimated for both the Current and Projected 2045 land use datasets.

The expected reach losses in surface water flows due to frost protection diversions were further refined for Projected 2045 High Growth and Low Growth scenarios through the calculation of scaling factors. These scaling factors were determined by dividing the Projected 2045 diversions by the Current diversions for both the 2045 High Growth and 2045 Low Growth datasets. These factors were applied to the average frost event estimates calculated from the observed flows as discussed above, resulting in Projected 2045 frost protection diversions for each river reach as shown in Table 31. The projected frost diversions were multiplied by the average number of frost events per month, shown in Table 32, with the assumption that the number of frost events do not change significantly in the next 30 years. The final monthly Projected 2045 frost demands per river reach are shown in Table 33 and 34.

3.5 Water Loss Year Types

A historical analysis of observed system loss from 1990 to 2013 was completed by Grinnell (Grinnell, 2015). Results of this analysis indicate that springtime precipitation (April to June) for the Upper Russian river correlates with total basin dry season loss (June to October) where dry season losses decrease with increasing springtime precipitation. Additionally this analysis indicates that there are envelopes of demand consistent with wet and dry year types. Figure 14 provides a summary of this analysis with scatter plot of springtime precipitations versus dry season losses with a linearly interpolated trend line and boxed areas showing the envelopes of system loss representing wet and dry year types. Building off the results of this analysis, a threshold of 9 inches of springtime rainfall was used to analyze historical precipitation from 1910 to 2013 to determine the loss year type. Applying this threshold results with 70 dry and 35 wet years. Results of this analysis are shown in Figure 15 indicating the wet and dry loss years.

Wet and dry year patterns of system loss due to non-municipal system demands were developed for each reach for the Current scenario. These losses include estimated applied water from the Davids Engineering study (discussed in Section 3.2.1.1), losses due to riparian vegetation (discussed in Section 3.3.1) and water balance losses quantified by Grinnell (discussing in Section 3.2.1.2). Average monthly losses were calculated for the months March to December for wet and dry year types using data from 2002 to 2013 based on the loss year type determination discussed above. The water balance losses were only calculated for the months of May through October, as unimpaired flows masked any water balance losses for the remaining months of the year. A summary of these calculations is provided for each reach in Tables 9 through 12. Wet and dry monthly losses are provided in Figures 16 and 17 for the entire System. The wet and dry monthly losses were applied in the model for the historical hydrology analysis (1910-2013) based on the loss year type.

3.6 Lake Evaporation

Losses due to evaporation from Lake Mendocino were accounted for in the model using an annually repeating pattern of monthly evaporation rates. The monthly evaporation rates were calculated using observed pan evaporation for Lake Mendocino from 1995 to 2008. The evaporation rates used in the model for all scenarios are provided in Figure 18. Evaporation is calculated in the model by multiplying the previous end of month lake surface area multiplied by the appropriate evaporation depth for that month.

4.0 SYSTEM OPERATIONS

4.1 Lake Storage Capacity

The Current scenario incorporates the hypsometry developed from a 2001 bathymetric survey, which is currently used by the United States Army Corps of Engineers (USACE) to define the reservoir guide curve thresholds. For the Projected 2045 scenarios, reservoir hypsometry was projected to account for change in storage and change in surface area due to sediment inflow. Reservoir hypsometry from historical 1952 and 2001 surveys was projected using linear interpolation to estimate 2045 elevation, storage and surface area relationships. Storage-Elevation plots are provided in Figure 19 for both the Current and Projected 2045 conditions.

4.2 Flood Operations

Flood operations of Lake Mendocino are incorporated into the model with the Conservation Pool Guide Curve defined in the USACE Water Control Manual (USACE, 1986). The reservoir guide curve is a seasonally varying storage threshold above which the USACE makes flood control releases from the reservoir. The model interpretation of the guide curve is quite simple; in that, if end of month storage is above the guide curve then this water is released down to the top of the conservation pool. The model assumes no encroachment of stored water above the guide curve for water supply purposes.

For the Current conditions scenarios, the reservoir guide curve is based on hypsometry from the 2001 bathymetric survey. For the Projected 2045 scenarios, the reservoir guide curve was projected based on the estimated 2045 hypsometry described in Section 2.3.2. The guide curves used in the model for both the Current and Projected 2045 conditions are provided in Figure 20.

4.3 Water Supply Operations

4.3.1 Hydrologic Index

The hydrologic index is a metric that sets the water supply condition and the corresponding minimum instream flow schedule for the Russian River system. The model uses the hydrologic index established by State Water Resources Control Board Decision 1610. The thresholds of the Decision 1610 hydrologic index are provided in Figure 21. The water supply condition was estimated using observed Lake Pillsbury inflow from 1910 to 2013 for the historical hydrology scenarios and the USGS estimated climate change Lake Pillsbury inflows from 2000 to 2099 for the climate change scenarios.

4.3.2 Minimum Instream Flow Requirements

The minimum instream flow requirements set the flow floor for the Russian River for the reach downstream of CVD to the confluence of Dry Creek. In practice the furthest downstream compliance point for maintaining the minimum flows in the Upper Russian River is the USGS gage at Healdsburg therefore the furthest downstream point of the model is this gage. The minimum flow requirements in the model are consistent with the requirements described in the Russian River Biological Opinion for temporary minimum instream flow changes (NMFS, 2008). The minimum flow requirements used in the model are the requirements established under Decision 1610, with the exception of the period May through October, where the minimum instream flow recommendations in the Biological Opinion are used. The minimum flow requirements used in the model are summarized in Figure 22.

4.3.3 Minimum Instream Flow Compliance Buffer

In the operation of Lake Mendocino extra releases are typically made in order to provide a buffer above minimum flows. This buffer release is made by reservoir operators to account for the dynamic variability of flows downstream of the reservoir to help prevent flows from falling below the minimum instream flow requirements. The dynamic nature of flows for this reach is typically caused by direct diversions from the river, groundwater diversions made from wells in close proximity to the river, use of water by riparian vegetation and potential error in discharge measurements. In effort to estimate a reasonable minimum flow compliance buffer to be used in the model, an analysis of observed flow variability was completed for the reaches downstream of CVD for the years 2000 to 2012. To analyze the impact of downstream flow variability on reservoir operations, the analysis looked at daily increases in net reach loss for the period each year that a particular discharge gage was a compliance point for maintaining minimum instream flows. Net reach loss was estimated by calculating the difference between observed total flows at the Forks (by calculating the sum of flows from the East Fork and the West Fork of the Russian River) and the gage under analysis while also accounting for travel time of flows. Data from five USGS gages was incorporated in this analysis: the East Fork of the Russian River at Ukiah, Russian River at Ukiah, Russian River at Hopland, Russian River at Cloverdale, and the Russian River at Healdsburg. The required buffer was then determined as the 1% exceedance of daily increase in net loss of approximately 20 cfs. This statistic was used in place of the maximum because it is believed that the maximum was likely an outlier in the analysis. An exceedance plot of daily net loss in river flows during minimum flow compliance operations from 2000 to 2012 is provided as Figure 23. For this study the instant flow rate buffer was converted to a monthly flow rate.

5.0 OVERVIEW OF MODEL CALCULATIONS

The model uses basic water balance accounting methods to calculate end of month storage and releases. Model simulation can be broken down into the following basic calculation steps:

1. Compute the beginning of month minimum instream flow requirement for compliance points downstream of Lake Mendocino.
   a. January-May: determined based on water supply condition.
   b. June-December: if water supply condition is normal then minimum flow is determined based on combined storage of Lake Pillsbury and Lake Mendocino.
      i. November-December: If Lake Mendocino storage falls below 30,000 acre-feet then reduce minimum flow to 75 cfs.
2. Calculate the flow compliance release at each compliance point downstream of Lake Mendocino.
   a. Minimum release: 25 cfs minimum + buffer (converted to a monthly flow rate).
   b. Minimum instream flow compliance release is calculated for each downstream compliance point by the following equation:
      i. Required monthly flow to meet minimum flows + Minimum flow compliance buffer + Reach losses - Reach flow gains.
   c. The required compliance release is then determined by the maximum needed release for all downstream points.
3. Calculate end of month lake storage:
   a. Estimate lake evaporation based on previous end of month storage
   b. Estimate lake storage taking into account:

i. Lake water balance: Previous end of month storage + Lake inflow - Downstream compliance release - Lake evaporation
ii. If storage exceeds the conservation pool rule curve
   1. Storage is set to the maximum conservation pool rule curve
   2. Release is adjusted to account for flood operations release

6.0 RELIABILITY STUDY SCENARIOS

Eight model scenarios were analyzed with the model for the Reliability Study. Each scenario represents a unique combination of assumptions and input datasets. A summary of the model scenarios including the primary assumptions evaluated is provided in Table 35. Results of these scenarios are presented and discussed in the Water Agency's *Lake Mendocino Water Supply Reliability Evaluation Report*.

7.0 MODEL RESULTS

7.1 Verification Model

In effort to assess model accuracy a historical verification model scenario was developed. The period of analysis for the historical simulation is from water year 2000 to 2013. Results of this scenario compare well with observed historical storage levels in Lake Mendocino. Development of the datasets for the historical simulation scenario are described below.

7.1.1 Verification Model Input

The modeled PVP diversions described above in Section 2.1.2 are designed to simulate current, post 2007 operations of the PVP, therefore this dataset would not accurately simulate water year 2000 to 2006 operations. For this reason, observed diversions were used in place of the modeled PVP diversions.

For system gains, the verification scenario used the historical unimpaired flows from 2000 to 2013 developed by the USGS as discussed in Section 2.1. For system losses, the Current datasets were used applying wet and dry years where appropriate as discussed in Section 3.0.

Review of historical storage of the lake for the historical simulation period shows that periodically the USACE allowed for water to be stored in Lake Mendocino beyond the guide curve to improve water supply capture. To account for this in the verification model, the rule curve was modified to allow for conservation storage above the guide curve consistent with historical operations.

Historical operations of the Russian River System from 2000 to 2013 have varied due to changes in regulatory compliance and necessary emergency actions for conservation of water supply. The minimum instream flow schedule used for the analysis of the Reliability Study is consistent with current operations of the Upper Russian River by using the minimum flows required by Decision

1610 for November to April and the temporary minimum instream flows required in the Biological Opinion from May to October. The Biological Opinion was issued in 2008 and prior to this the Water Agency operated Lake Mendocino consistent with the requirements of Decision 1610. Additionally, for a number of years within the historical simulation period Temporary Urgency Change Orders were issued by the State Water Resources Control Board to reduce minimum instream flows in effort to conserve storage in Lake Mendocino in response to drought conditions. For these reasons, actual historical minimum instream flow requirements were used for the verification model in place of the Biological Opinion temporary minimum instream flows as used in Reliability Study analysis.

The operations used for the analysis of the Reliability Study assumes a constant minimum instream flow compliance buffer as discussed in Section 2.3.3.3. This assumption is consistent with current operations where operators frequently make changes to releases from Lake Mendocino in an effort to minimize the buffer. Review of historical operations shows that the compliance buffer has varied considerably especially prior to water year 2007, before implementation of the 2004 PVP license amendment. In certain years, such as 2004, flows were managed well above the minimum instream flow requirements likely due to healthy storage levels in the lake and high levels of inflow from the PVP. To account for this variability in historic operations, buffer releases were adjusted to better approximate observed historic buffers for the verification model.

7.1.2 Verification Model Results

Results of the simulated Lake Mendocino storage from the verification model were compared to observed storage from water year 2000 to 2013 as shown in Figure 24. Simulated storage correlates very well with observed storage, however, water years 2009 and 2012 showed higher modeled storages than observed storages. The higher storages in these years result from an overestimation of modeled unimpaired flows into Lake Mendocino. The unimpaired flows developed by the USGS were calibrated to observed USGS gage data which is may be inaccurate for high flows for those years. This can potentially lead to incorrect unimpaired flows and result in minor differences between modeled and observed storage. A scatter plot of modeled storage versus observed storage is provided as Figure 25 with a least-squares linear regression fit trend line showing linear interpolation of approximately 1 to 1 correlation and a coefficient of determination (R^2) of 0.95.

7.2 Comparison to Russian River ResSim Model

In addition to the Model discussed in this memo, the Water Agency has another water supply planning model, Russian River ResSim (RR ResSim), which was developed using the HEC-ResSim code from the USACE. In contrast to the Model used for the Reliability Study, RR ResSim runs on a daily time step and simulates conditions in the entire Russian River System which in includes, in addition to the Upper Russian River System, Lake Sonoma, Dry Creek and the Lower Russian River down to the Hacienda Bridge. RR ResSim was developed primarily to support analysis of hydrologic index and minimum instream flow alternatives of the Fish Habitat Flows and Water Rights Project Environmental Impact Report, currently being prepared by Water Agency in order to meet the requirements of the Biological Opinion. In addition to supporting analysis of water supply reliability of the Russian River System, this model is used to assess flow and fish habitat conditions in the river. Results of RR ResSim model are used for water quality modeling and analysis of temperature and dissolved oxygen. RR ResSim runs on a daily time step in order to support these additional activities. Although the Model used for the Reliability Study and RR ResSim contrast in simulation time step and scope of the Russian River System that they simulate, the input datasets for the Model used for the Reliability Study were developed under very similar assumptions as those used to develop the RR ResSim model.

The Model developed for the Reliability Study focuses on simulating storage in Lake Mendocino. It was determined that a monthly time step model that just focused on conditions in the Upper Russian River is adequate to analyze the current and future reliability of Lake Mendocino. Analysis of flow and water quality conditions in the river was not a component of the Reliability Study therefore a daily time step model was not necessary.

Results of the Model developed for the Reliability Study were compared to the RR ResSim model for the Current scenario. A scatter plot of storage results for the Model versus the RR ResSim model is provided as Figure 26. These results show that simulated Lake Mendocino storage from the Reliability Study model compares very well with the results of the RR ResSim model with a least-squares linear regression fit of approximately 1 to 1 correlation and a coefficient of determination (R^2) squared of 0.96. These results support the decision that the monthly time step is adequate to analyze the reliability of the lake. The monthly time step also has the added benefit of having significantly less time steps for analysis reducing the computer memory requirements and therefore making it much more feasible to develop in a simpler format such as a Microsoft Excel spreadsheet.

8.0 REFERENCES

California Department of Water Resources (CDWR), 2014. *Public Water System Statistics* Reports for Calendar Years 2008 through 2013 for water systems in the Upper Russian River watershed.

City of Cloverdale, 2010. *Water System Master Plan Update,* August 2010. Prepared by Coastland Civil Engineering, Santa Rosa, CA.

City of Healdsburg, 2003. *Water System Master Plan,* October 2003. Prepared by HDR Inc., Folsom, CA.

City of Healdsburg, 2005. *2005 Urban Water Management Plan*. Prepared by Winzler & Kelly Consulting Engineers, Santa Rosa, CA.

City of Healdsburg, 2010. *2030 General Plan*. Prepared by City of Healdsburg Planning & Building Department and Earthcraft Planning Services.

City of Ukiah, 2010. *2010 Urban Water Management Plan,* June 2011. Prepared by Carollo Engineers Inc., Walnut Creek, CA.

County of Sonoma, 2008. *Sonoma County 2020 General Plan,* September 23, 2008. Sonoma County Permits and Resource Management Department, Santa Rosa, CA.

County of Mendocino, 2009. *Mendocino County General Plan*, August 2009. Prepared by PMC Inc., Rancho Cordova, CA.

Davids Engineering, 2013. *Russian River Applied Water Estimates, Development Report*, March 2013. Prepared for Sonoma County Water Agency. Davis, CA.

Flint, L.E. and Flint, A.L., 2012. *Downscaling climate change scenarios for ecologic applications*, Ecological Processes, 1:1.

Flint, L.E., Flint, A.L., Thorne, J.H., and Boynton, R., 2013. *Fine-scale hydrological modeling for climate change applications; using watershed calibrations to assess model performance for landscape projections*; Ecological Processes 2:25

Flint, L.E. Flint, Flint, A.L., Curtis, J.A., Delaney, C., and Mendoza, J. 2015. *Unimpaired Mean Daily Streamflow in the Russian River and Upper Eel River Basins, California under Historical and Projected Future Climates: U.S. Geological Survey Data Release*, doi:10.5066/F71C1TX4.

Local Agency Formation Commission of Mendocino County, 2013. *Ukiah Valley Special Districts Municipal Service Review*, May 6, 2013. Prepared by E. Mulberg & Associates, Elk Grove, CA.

Mendocino County Water Agency, 2008. *Irrigated Agriculture Water Needs and Management in the Mendocino County Portion of the Russian River Watershed*, July 2008. Prepared by University of California Cooperative Extension, Ukiah, CA.

Mendocino County Water Agency, 2010. *Water Supply Assessment for the Ukiah Valley Area Plan*, October 20, 2010. Prepared by Mendocino County Water Agency, Ukiah, CA.

National Marine Fisheries Service (NMFS), 2008. *Biological Opinion for Water Supply, Flood Control Operations, and Channel Maintenance Conducted by the U.S. Army Corps of Engineers, the Sonoma County Water Agency, and the Mendocino County Russian River Flood Control and Water Conservation Improvement District in the Russian River Watershed,* September 24, 2008. Southwest Region, F/SWR/2006/07316.

Pacific Gas and Electric Company, *Potter Valley (FERC No. 77), NMFS Fisheries Reasonable and Prudent Measures 3 and 5 (License Article 52(a)), Flow Regulation and Verification Plan*, February 16, 2006.

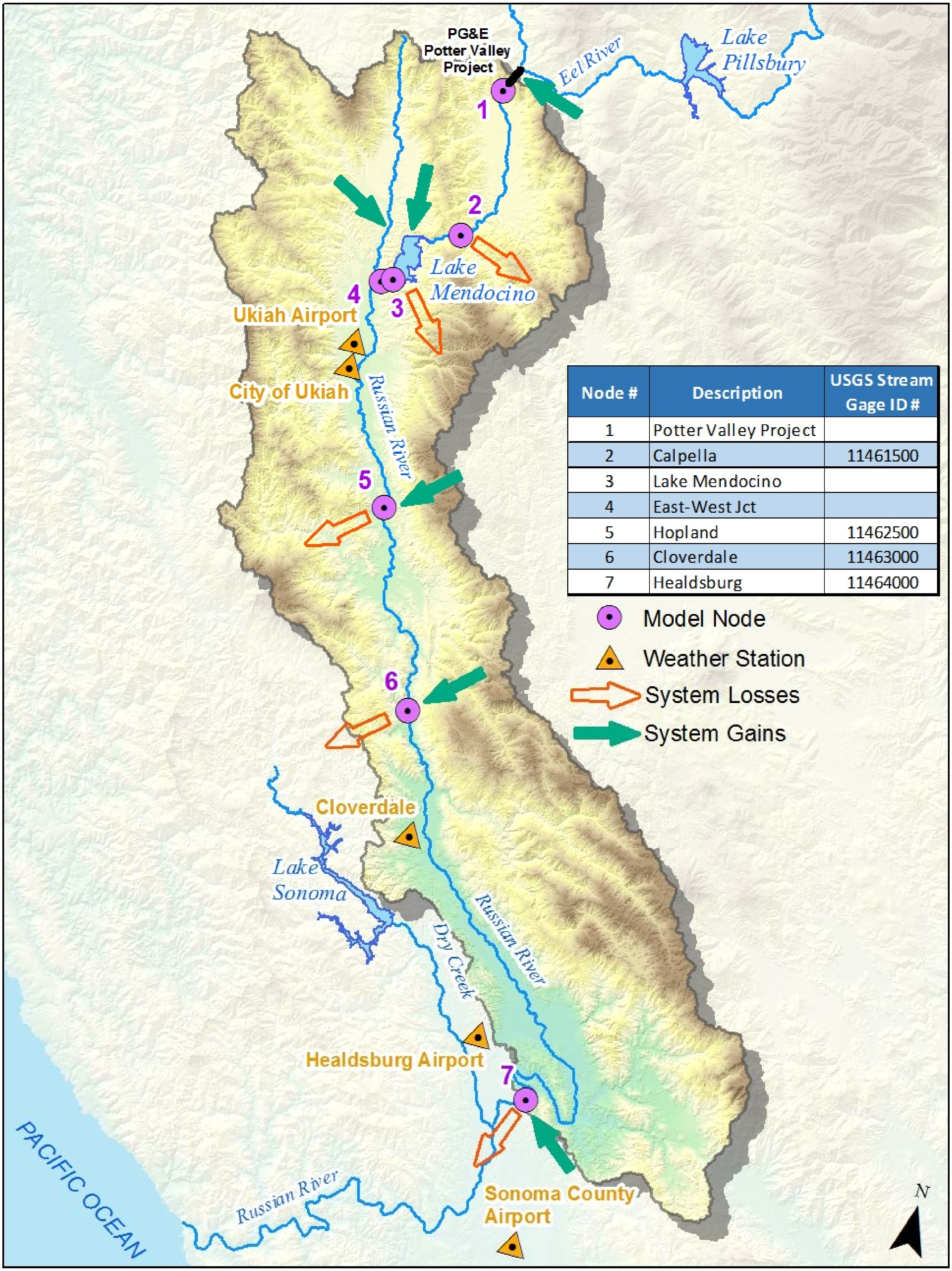
State Water Resources Control Board (SWRCB), 1986. *Decision 1610, Russian River Project*, April 1986.

State Water Resources Control Board, Division of Water Rights, 2014. Water Rights Licenses, Permits, Reports, and Statements. Retrieved from http://www.waterboards.ca.gov/waterrights/water_issues/programs/ewrims/.

United States Army Corps of Engineers (USACE), 1986. *Coyote Valley Dam and Lake Mendocino, Russian River, California, Water Control Manual, Appendix I to Master Water Control Manual, Russian River Basin, California*, April 1986, Sacramento District.

United States Federal Energy Regulatory Commission, *Order Amending License 77-110*, January 28, 2004.

United States Geological Survey (USGS), 2013. *May 2013 Landsat 8 Imagery*, December 2013.



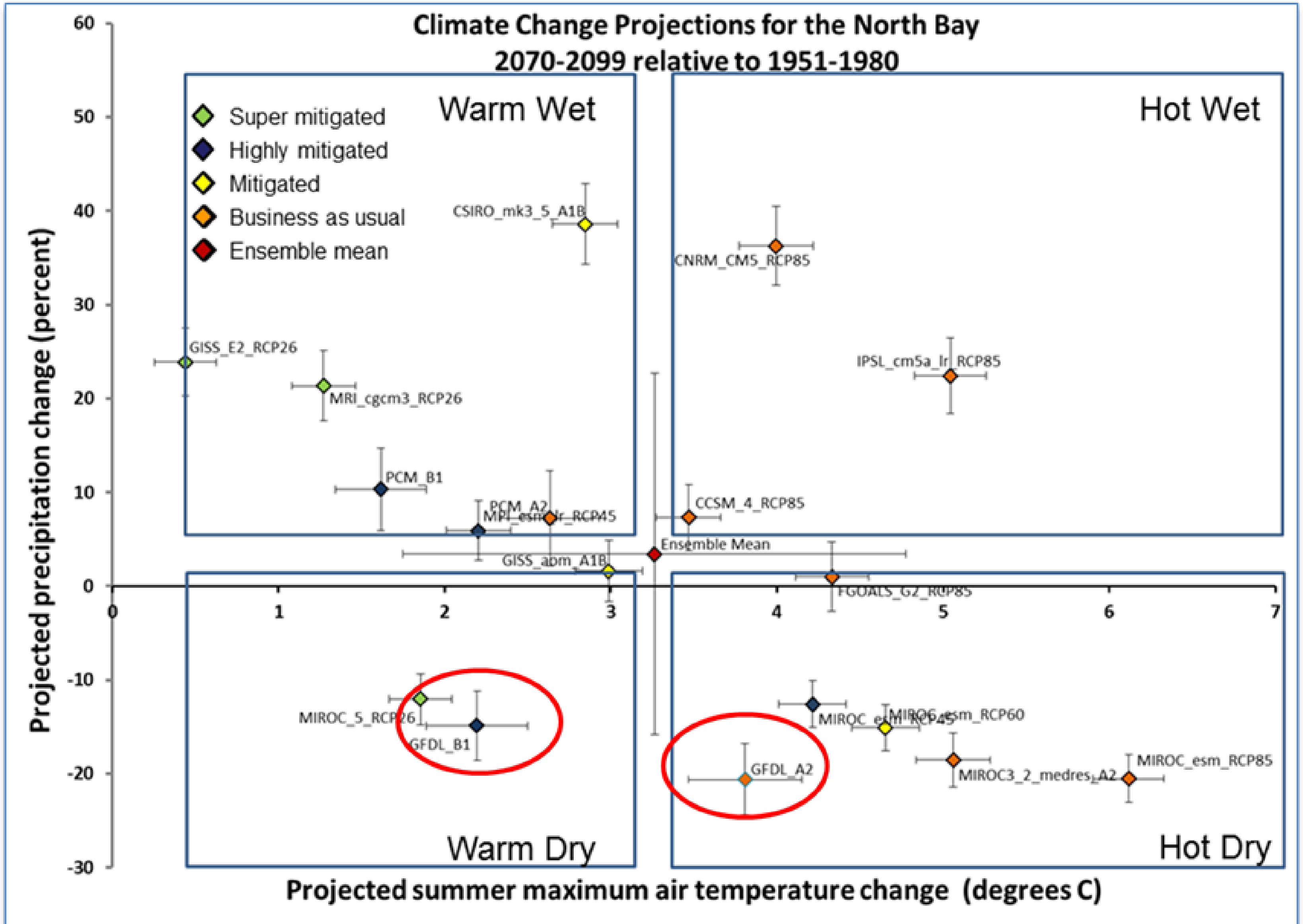
Node #	Description	USGS Stream Gage ID #
1	Potter Valley Project	
2	Calpella	11461500
3	Lake Mendocino	
4	East-West Jct	
5	Hopland	11462500
6	Cloverdale	11463000
7	Healdsburg	11464000

SONOMA COUNTY WATER AGENCY

LAKE MENDOCINO WATER SUPPLY RELIABILITY STUDY
TECHNICAL REPORT
APRIL 2015

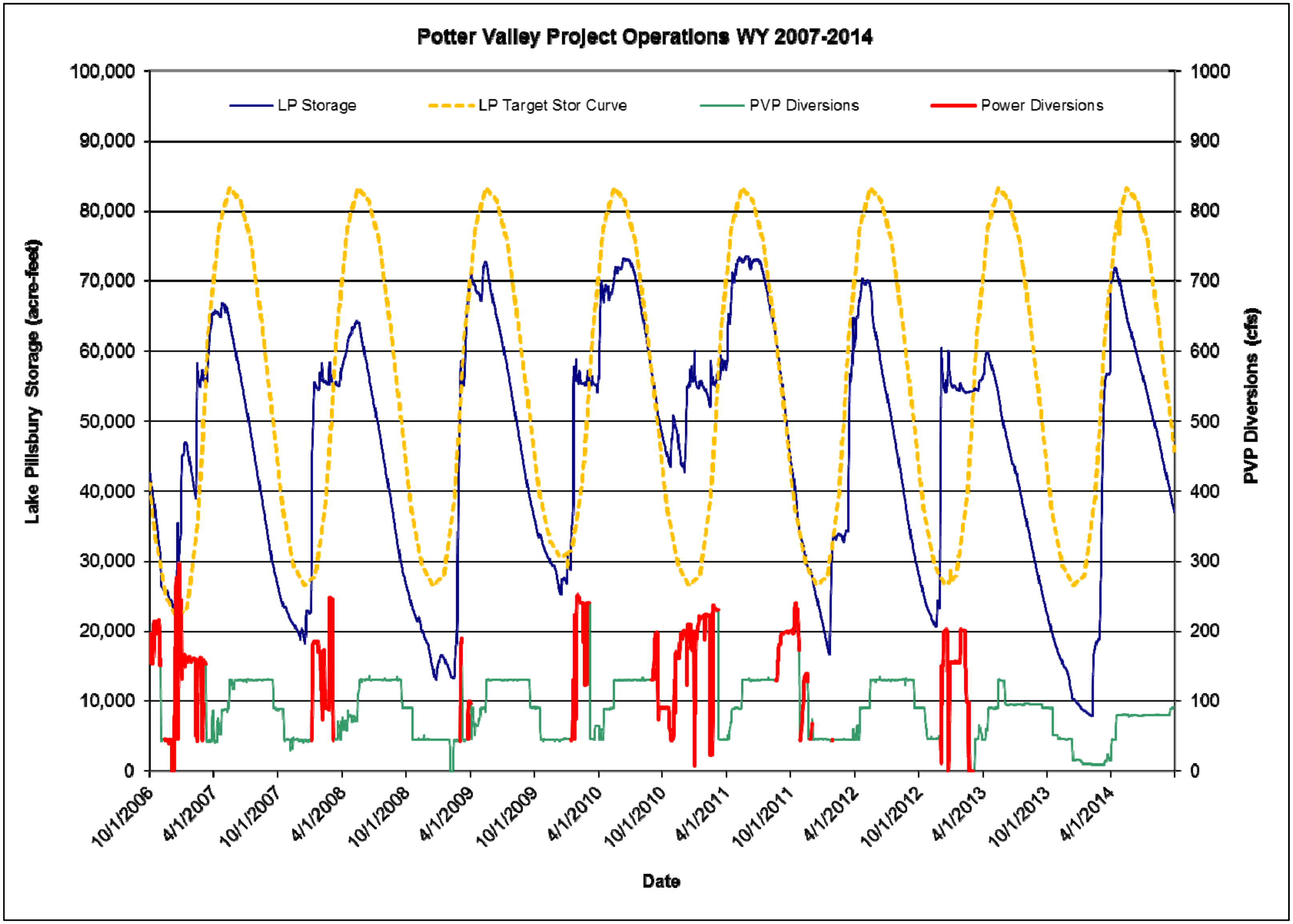
Water Balance Model Schematic

Figure 1



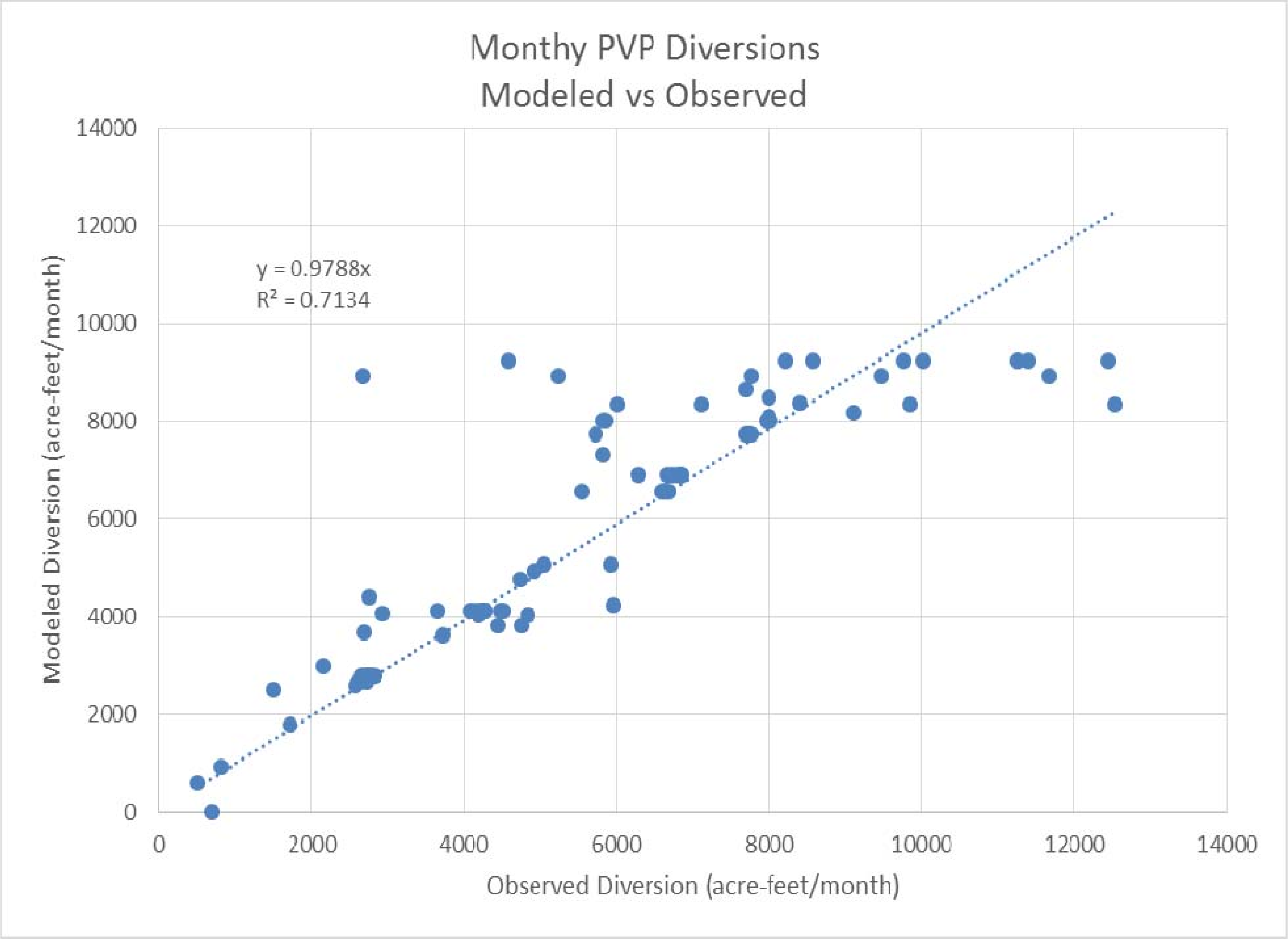
IPCC Climate Projections

Figure 2



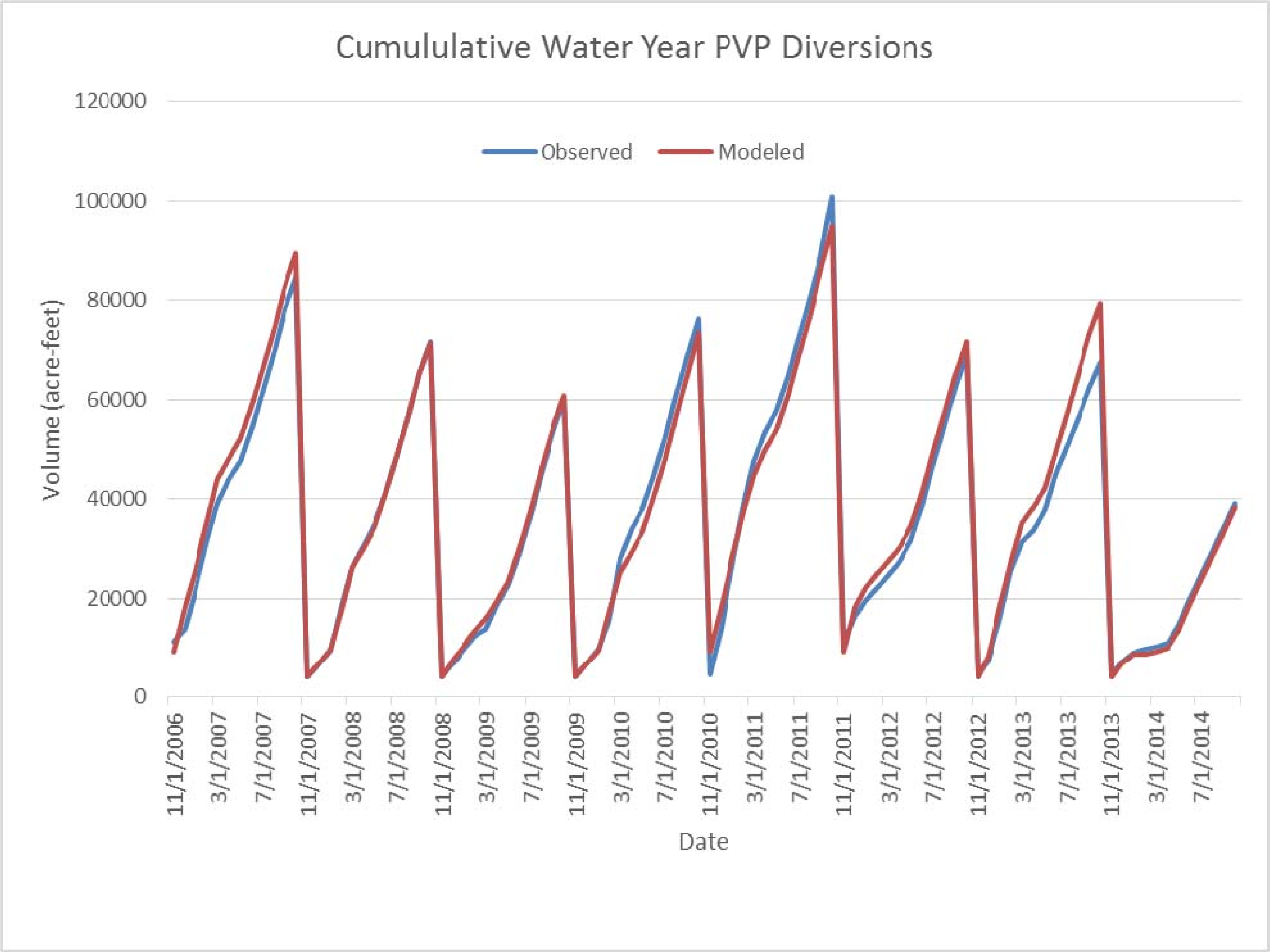
Potter Valley Project Operations 2007-2014

Figure 3



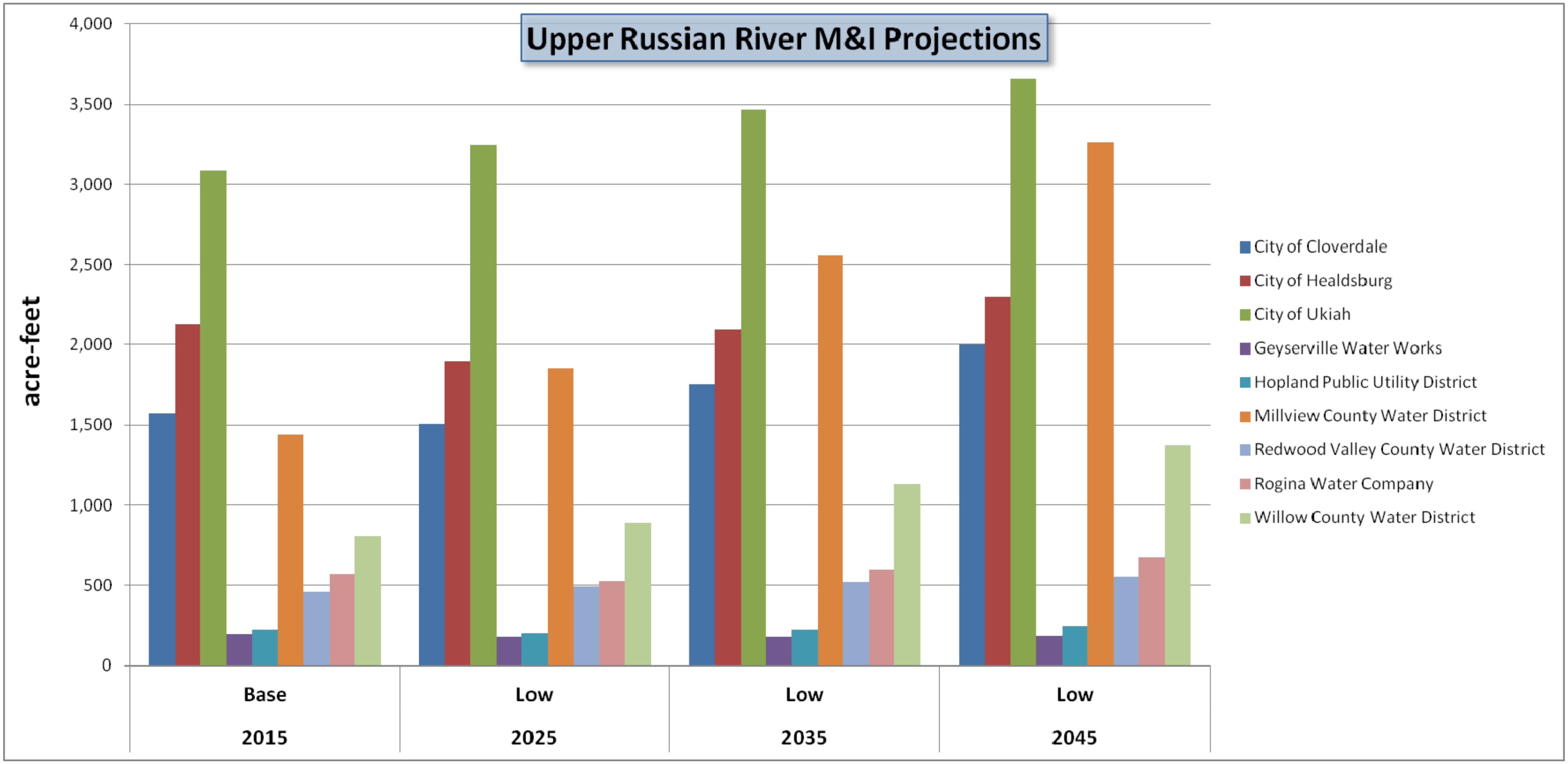
Eel River Model v2.5 Results –
Potter Valley Project Diversions

Figure 4

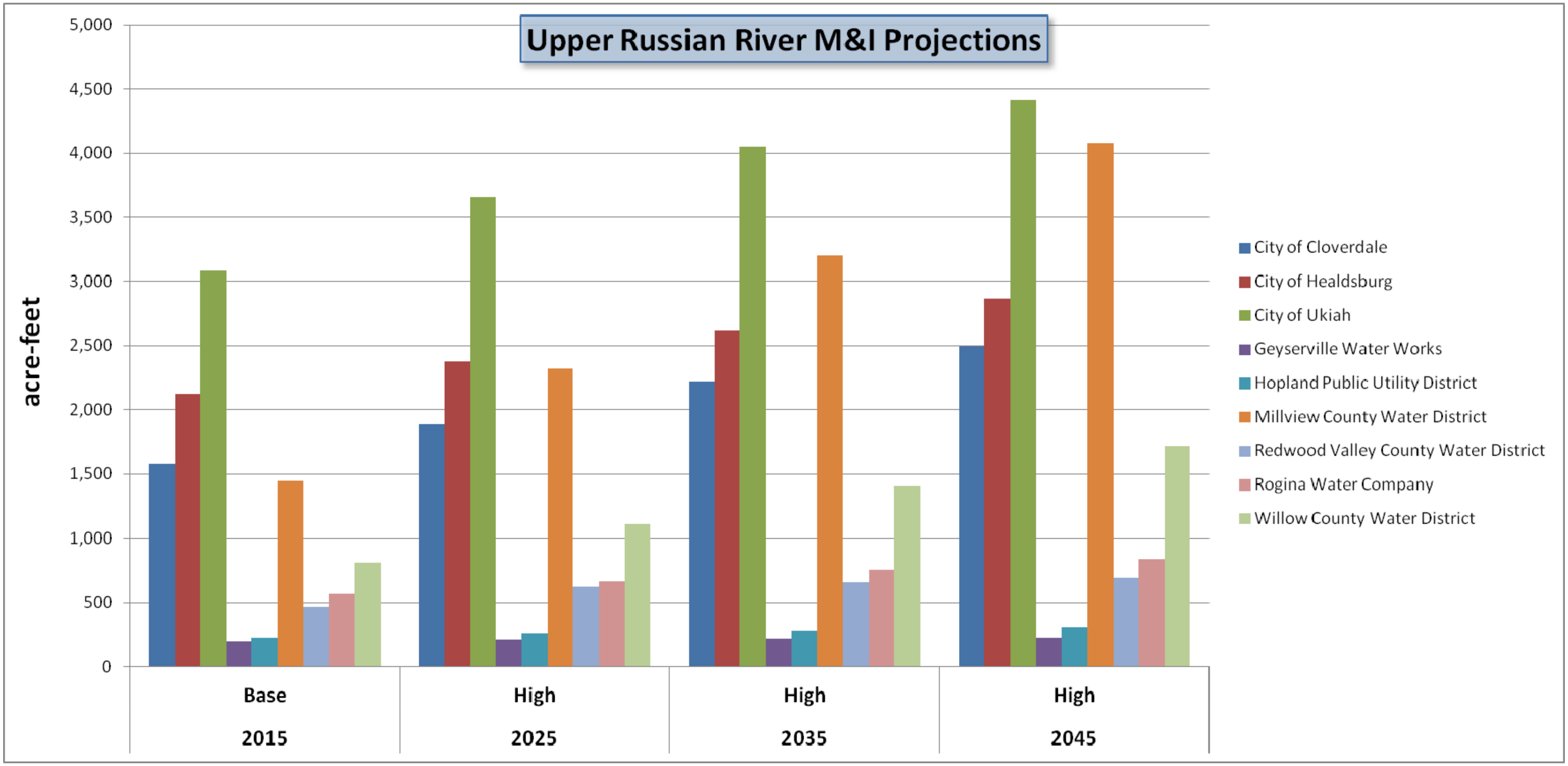


Eel River Model v2.5 Results – Cumulative Water Year Diversions

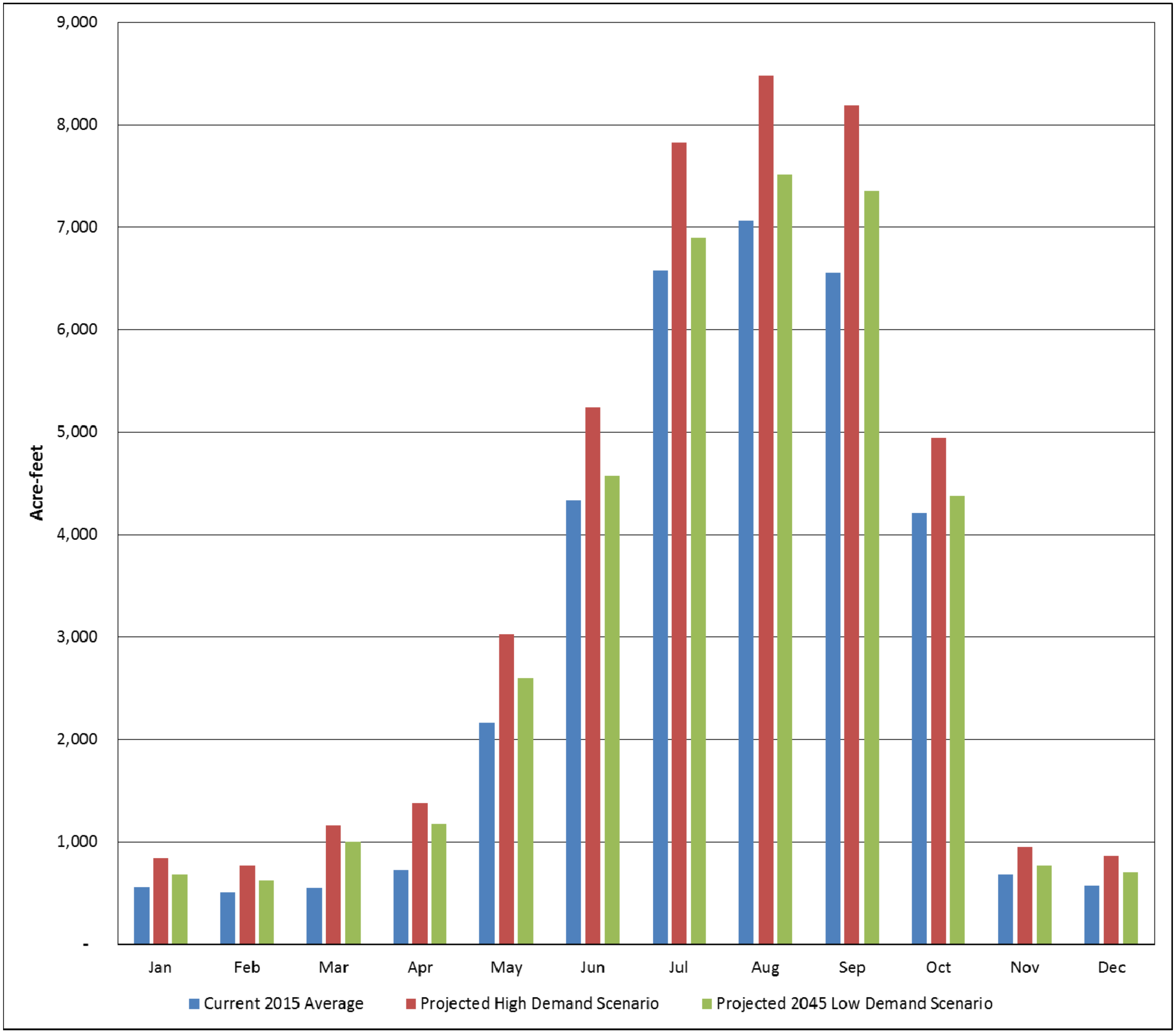
Figure 5



Municipal Water Use Projections Low Growth Scenario Figure 6

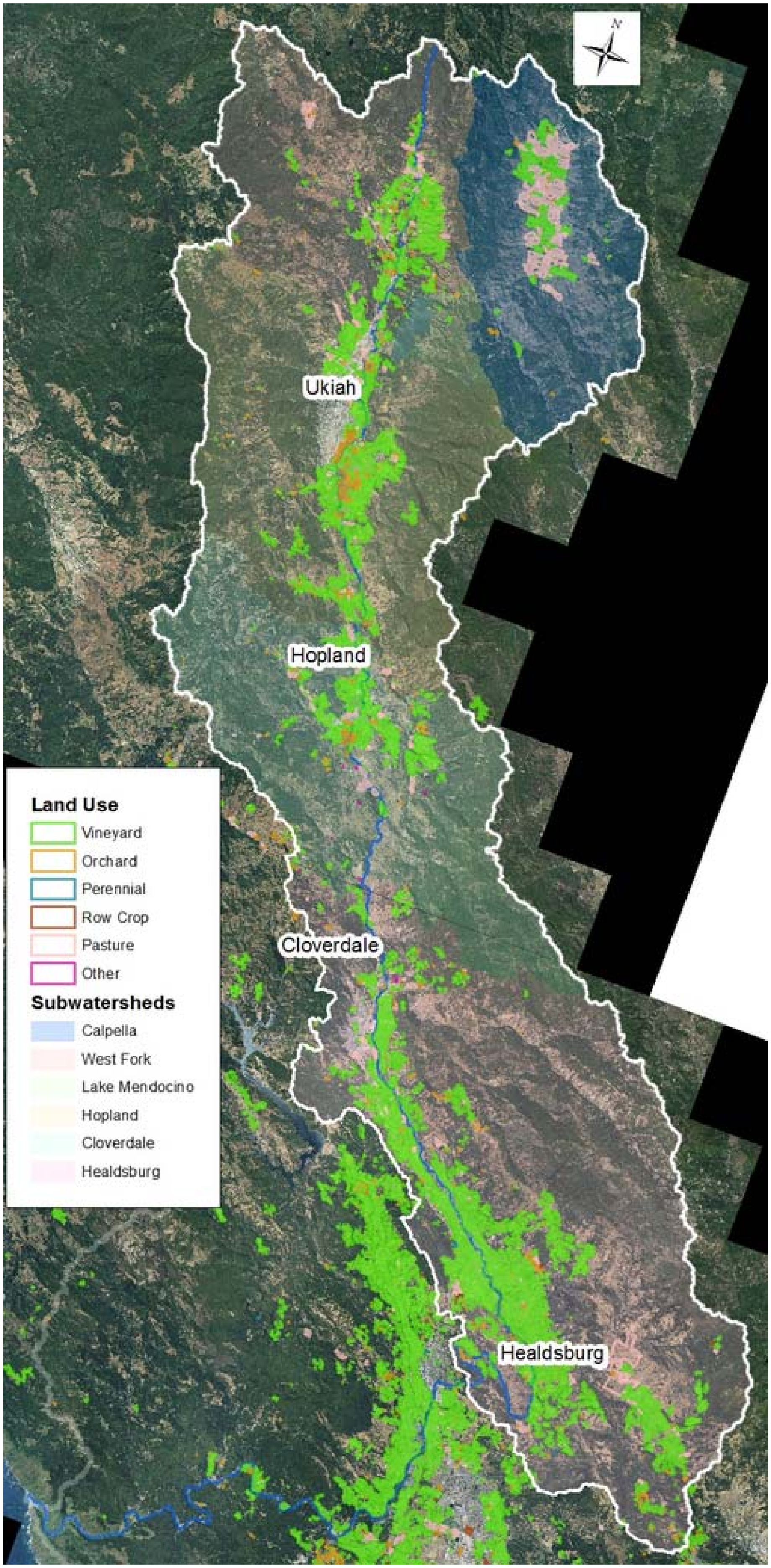


Municipal Water Use Projections High Growth Scenario Figure 7



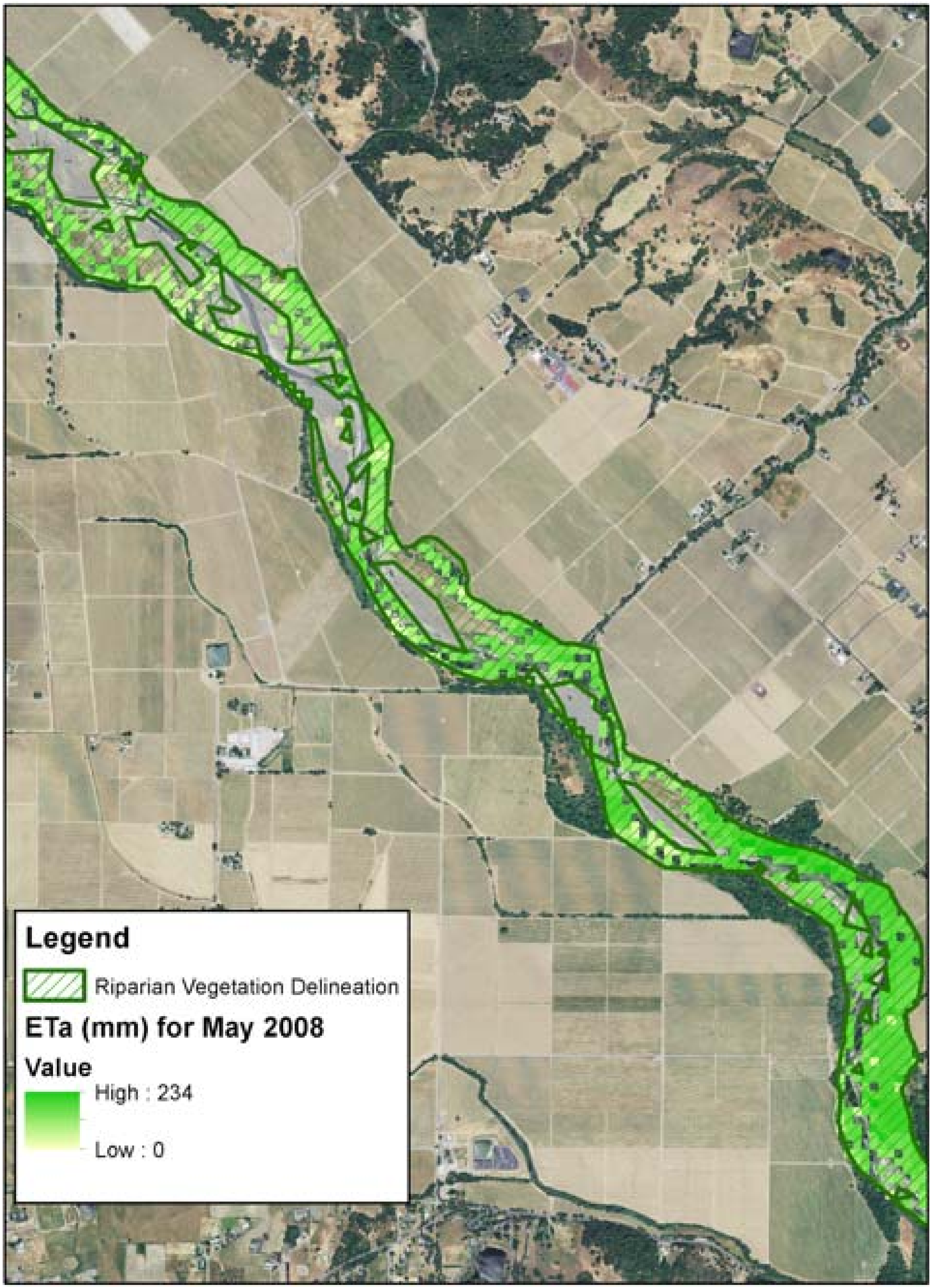
Upper Russian River Current and Future System Losses

Figure 8



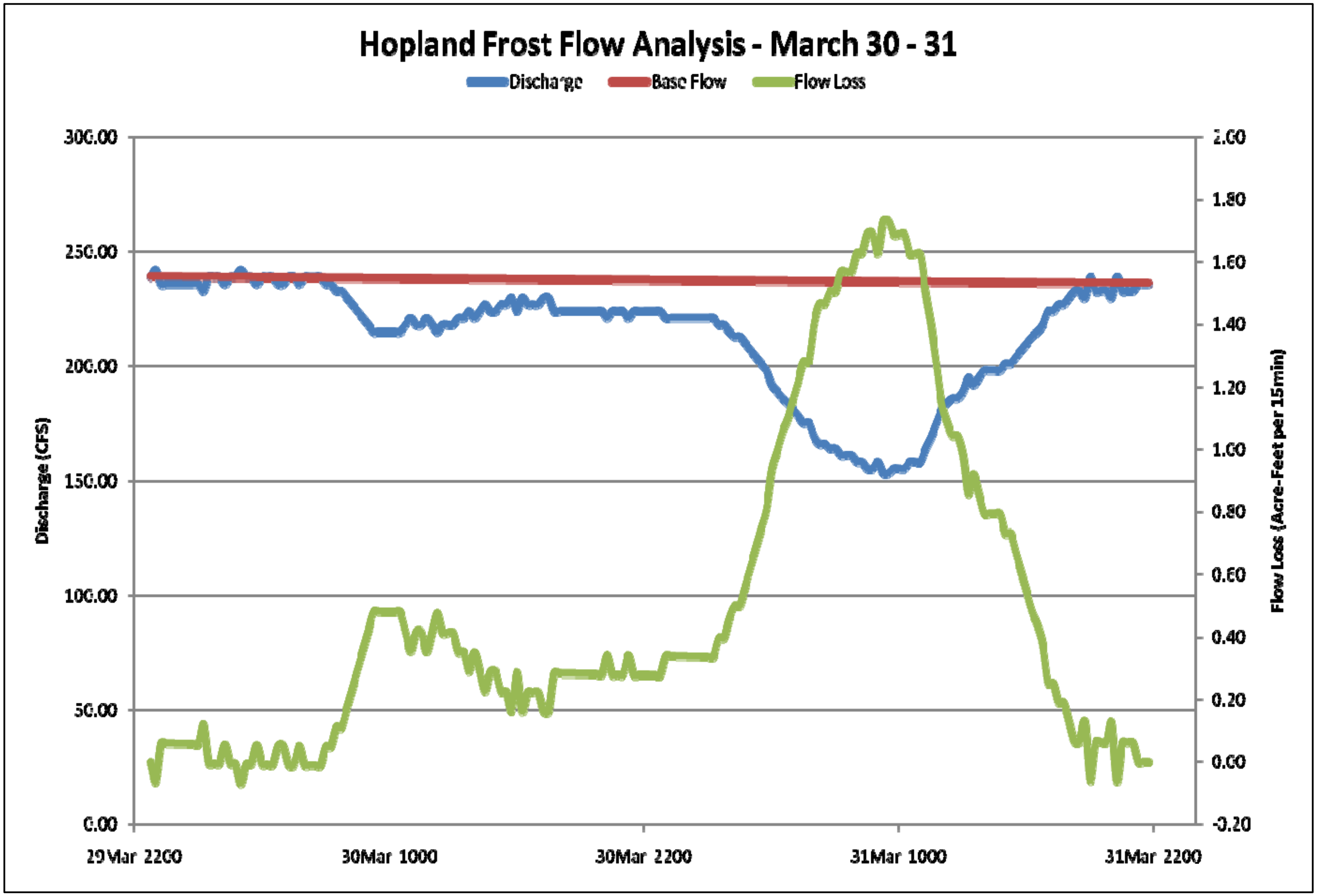
Upper Russian River Watershed
Agricultural Fields circa 2012

Figure 9



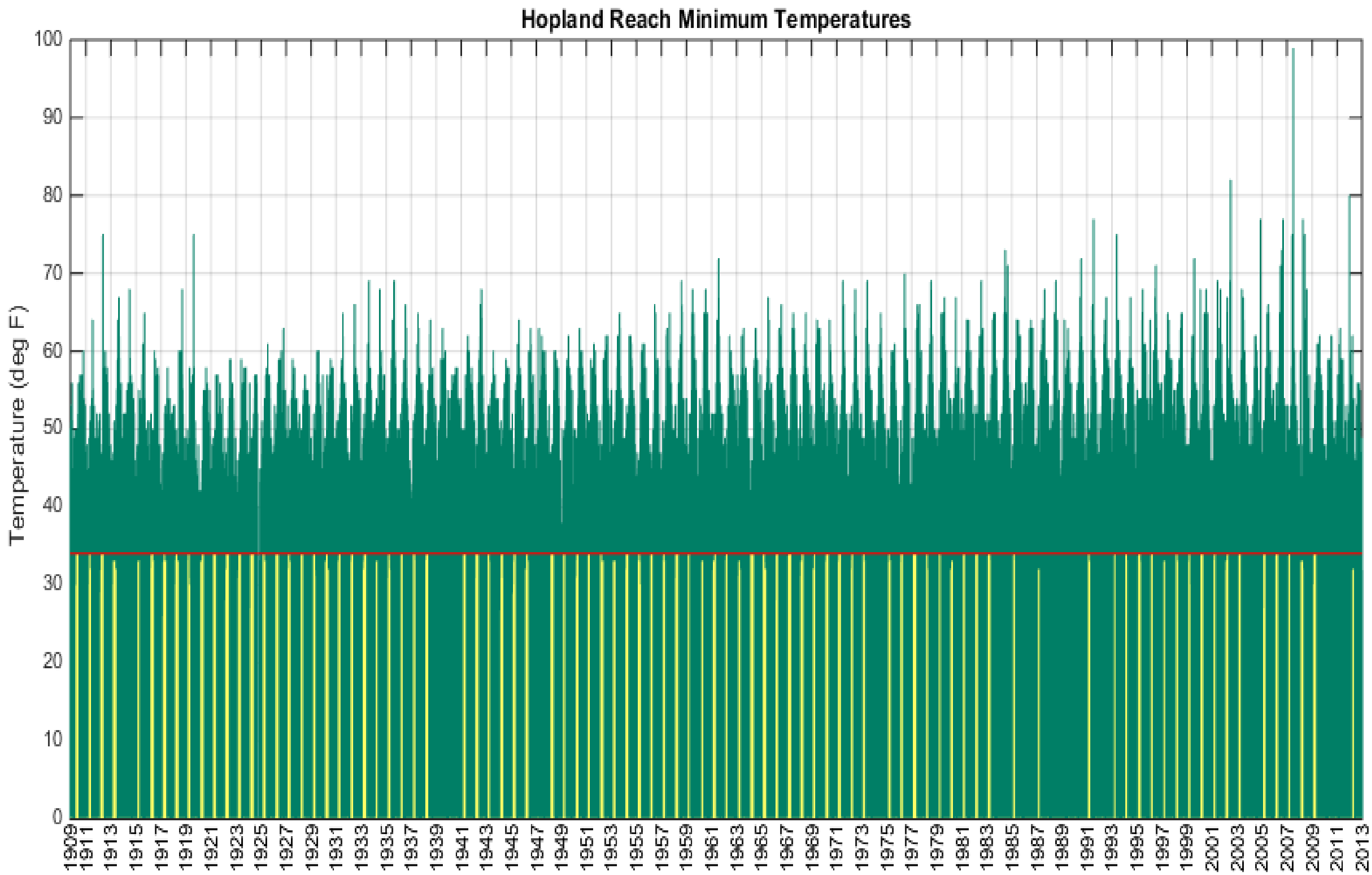
Delineation of Riparian Vegetation - Example Segment in Alexander Valley

Figure 10



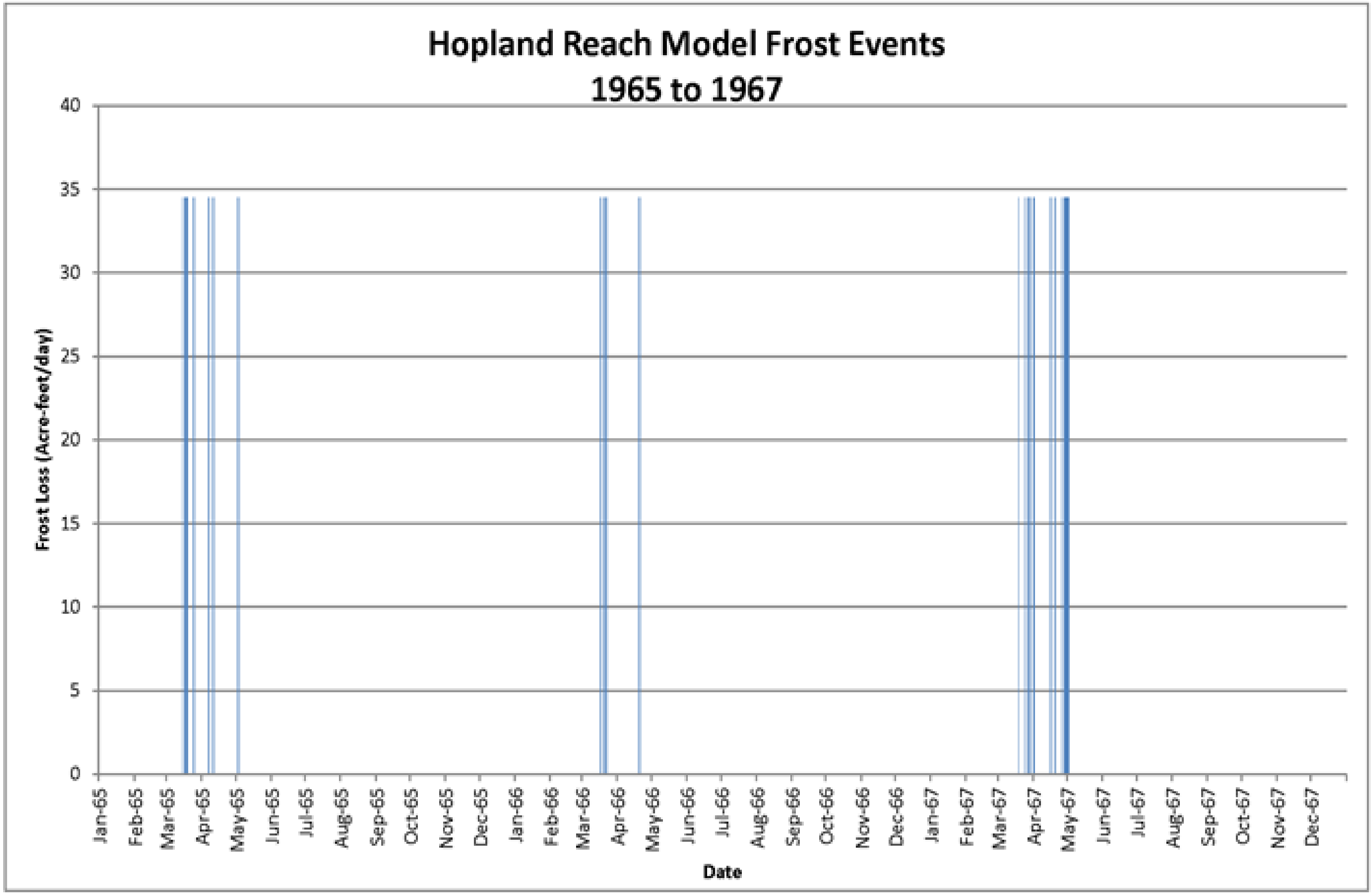
Water Losses Due to Frost Protection – Hopland Reach Example (2008)

Figure 11



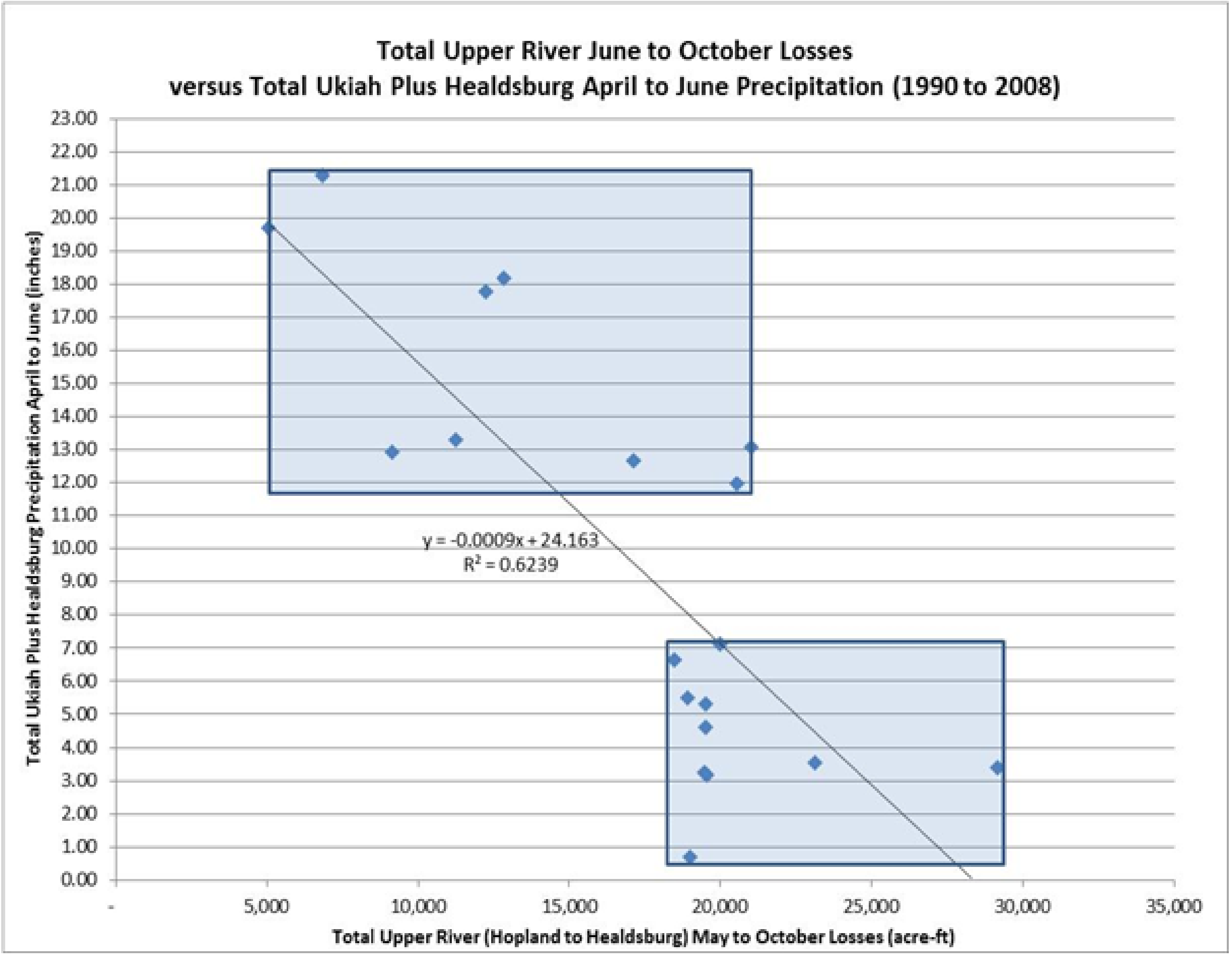
Minimum Daily Temperature Analysis – Hopland Reach Example

Figure 12



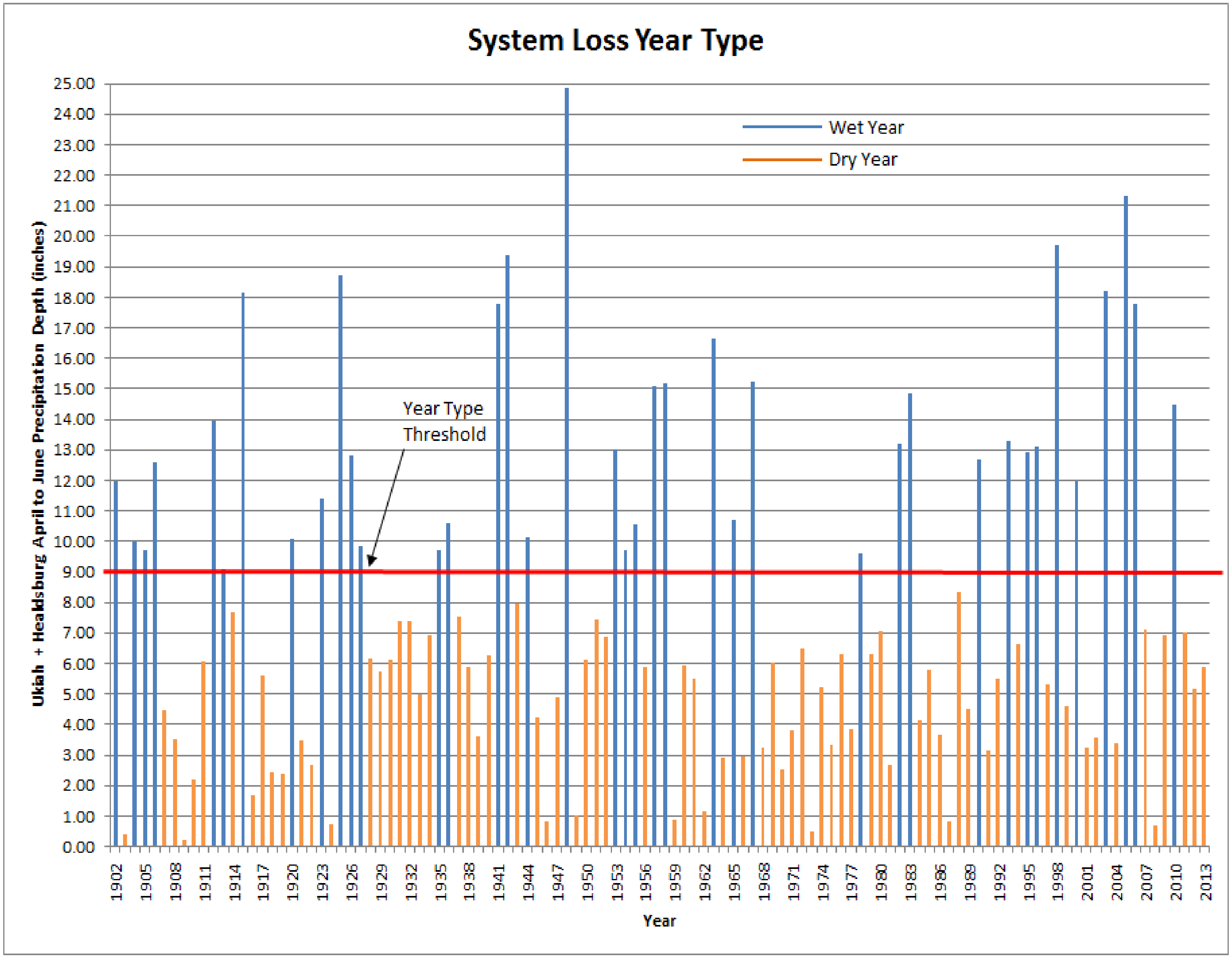
Water Losses Due to Frost Protection –
Model Dataset Development Hopland Reach Example

Figure 13



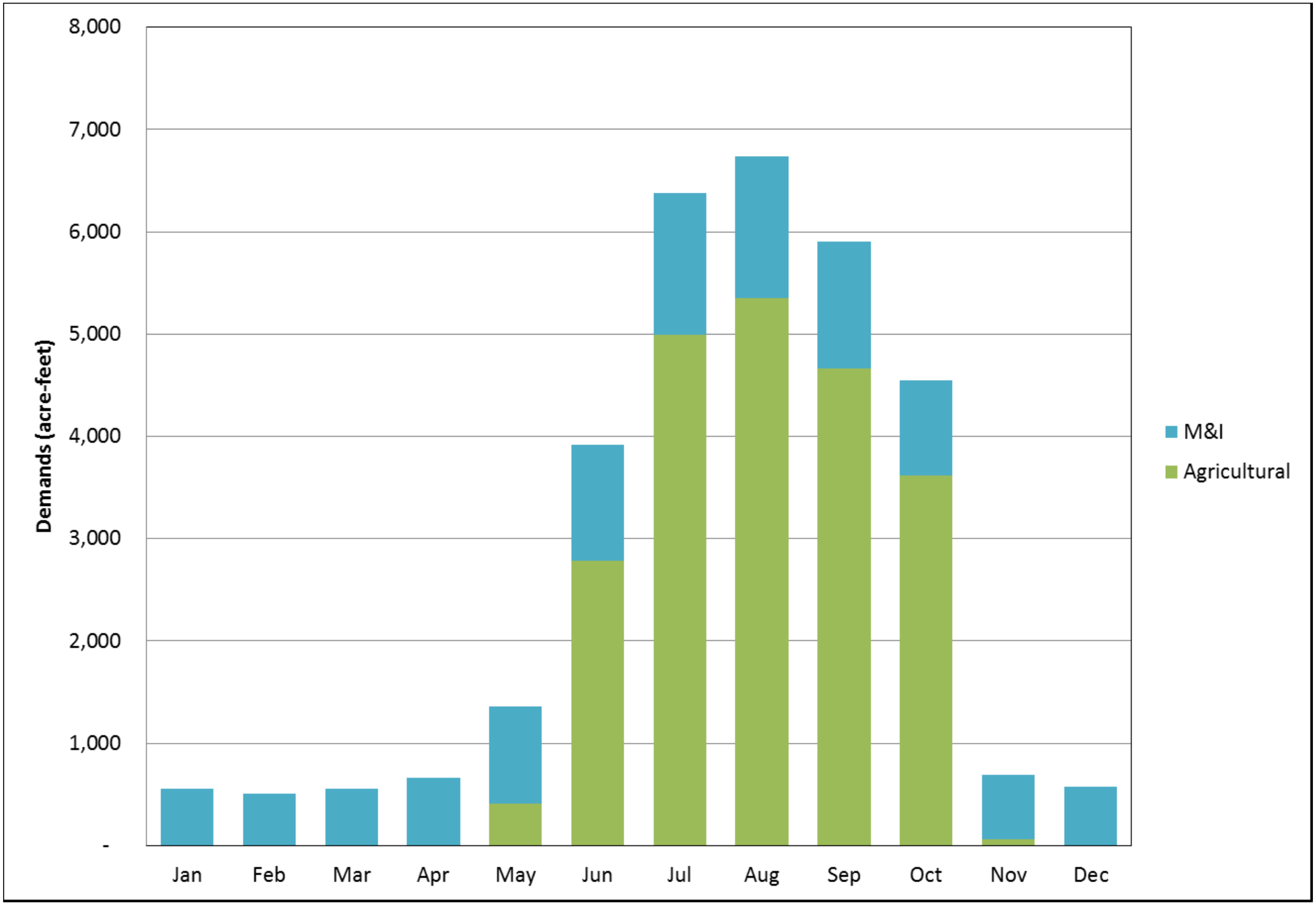
System Loss Year Type Analysis Summary

Figure 14



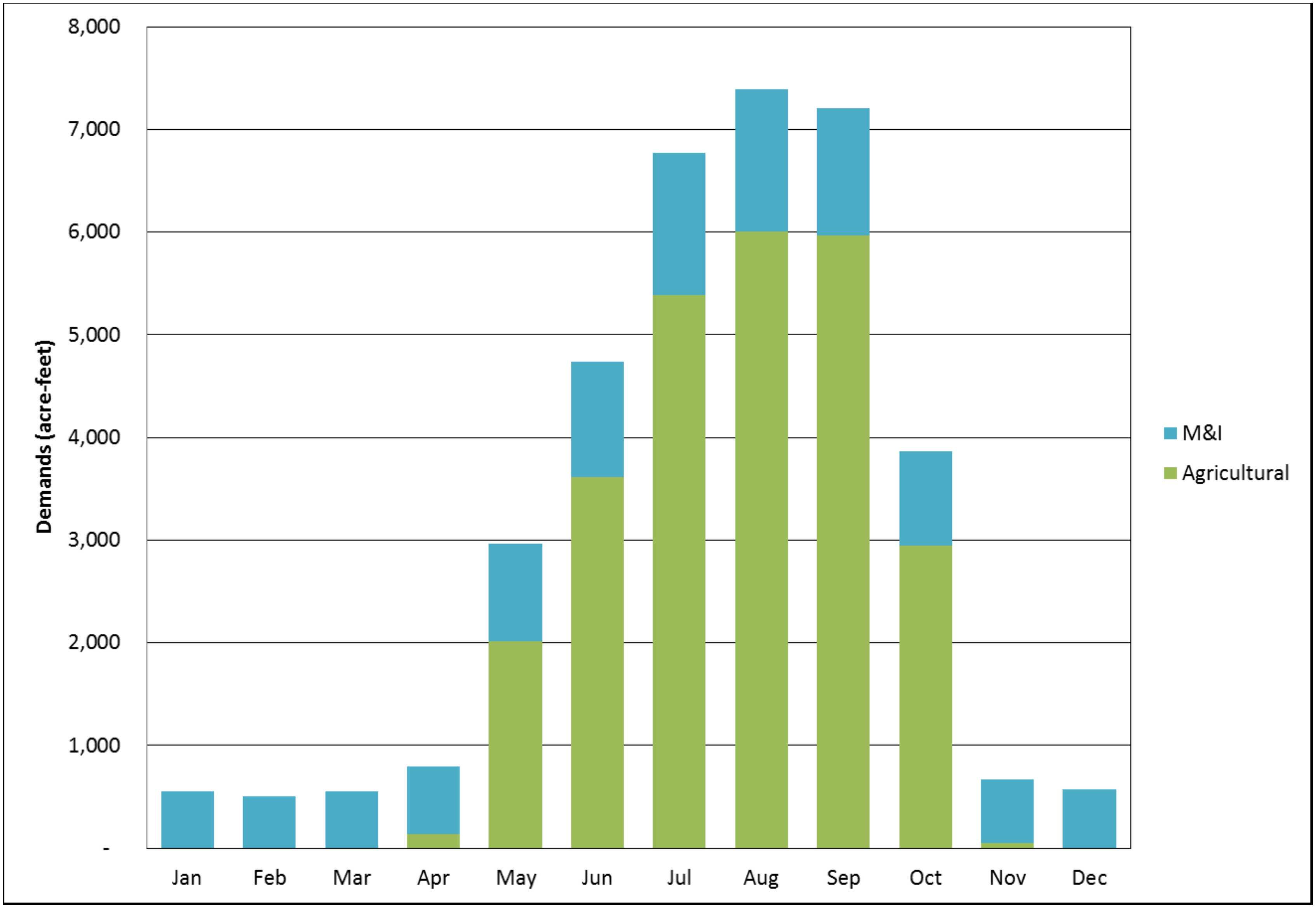
System Loss Model Year Types

Figure 15



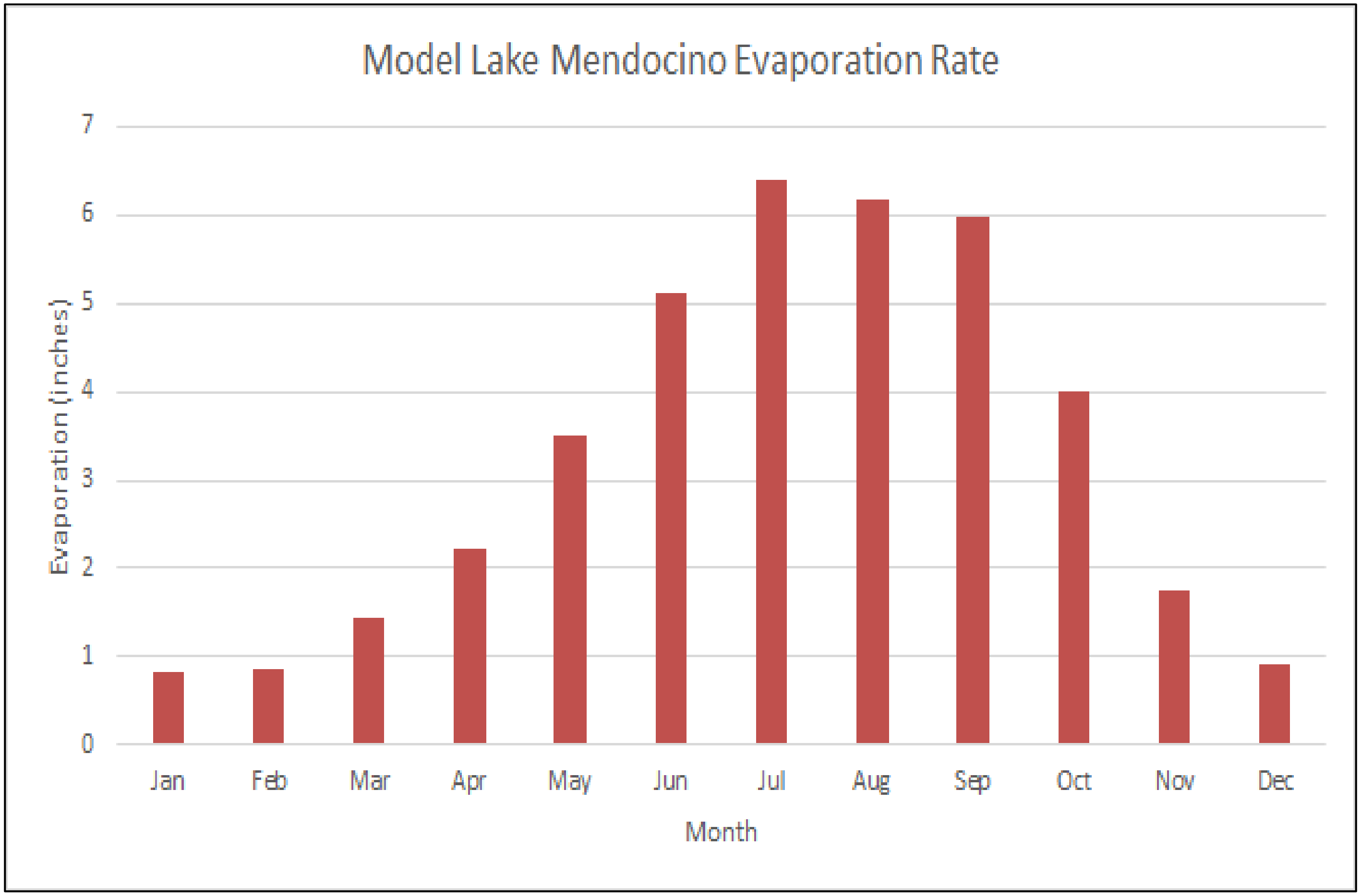
Upper Russian River Current Monthly Losses – Wet Year Type

Figure 16

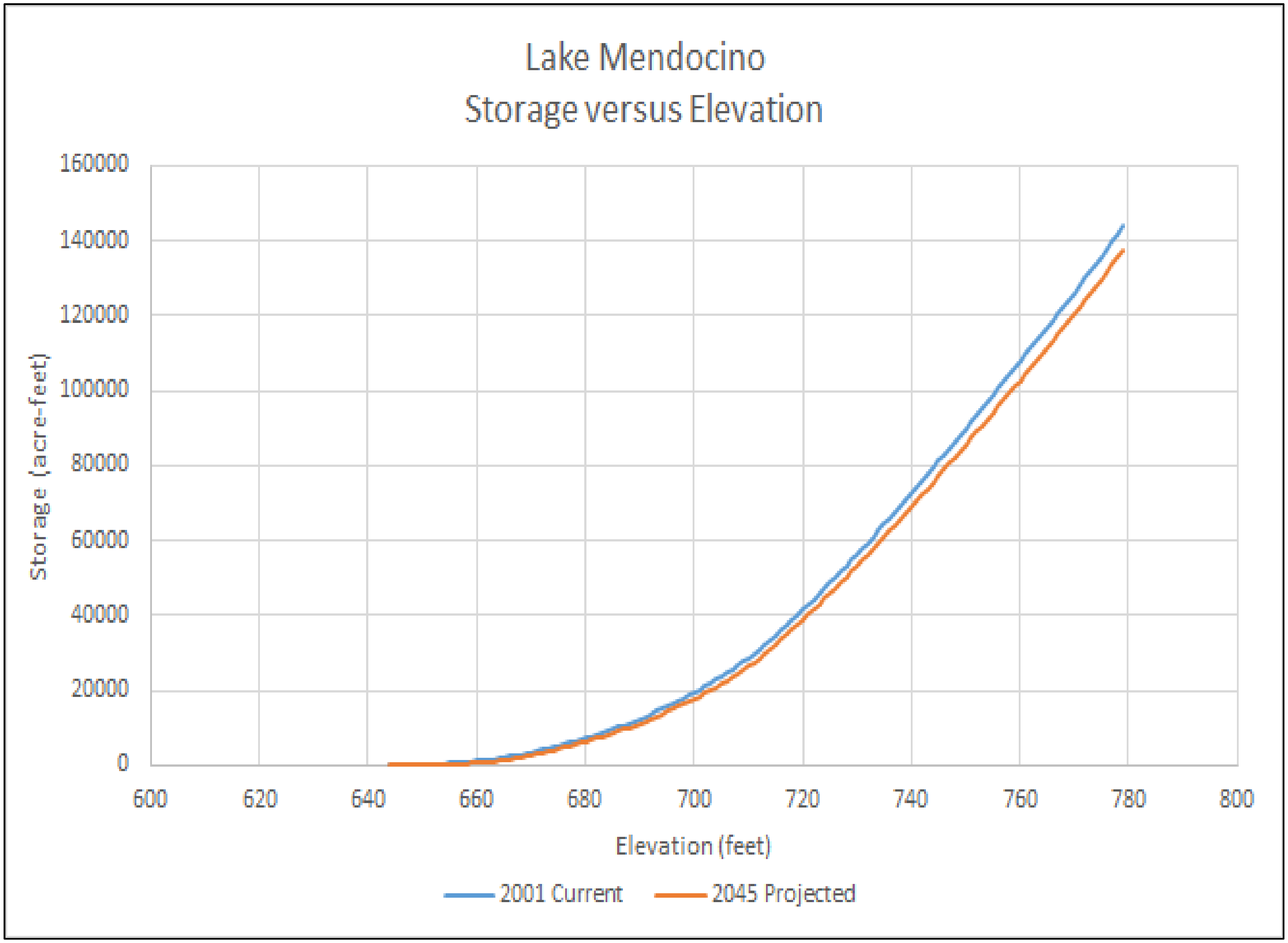


Upper Russian River Current Monthly Losses – Dry Year Type

Figure 17

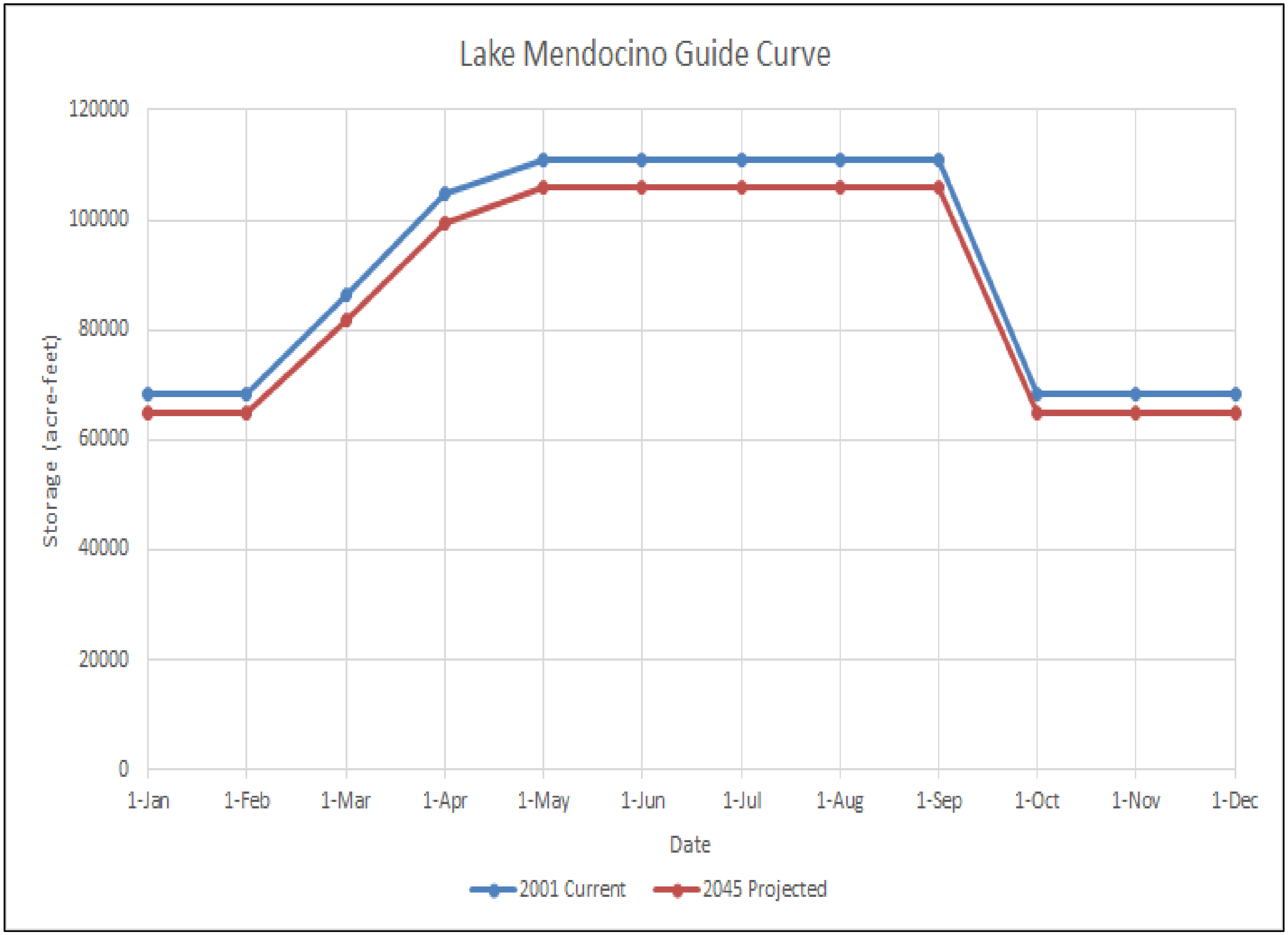


Lake Mendocino Monthly Average Evaporation Rate Figure 18



Lake Mendocino Storage versus Water Elevation

Figure 19



Lake Mendocino Guide Curves - Current and 2045

Figure 20

Cumulative inflow to Lake Pillsbury (acre-feet) from Oct 1 through

	1/1	2/1	3/1	4/1	5/1	6/1	Water Supply Conditions Prevailing on 6/1 Apply Through 12/31
NORMAL	≥8,000	≥39,200	≥65,700	≥114,500	≥145,600	≥160,000	
DRY	<8,000	<39,200	<65,700	<114,500	<145,600	<160,000	
CRITICAL	<4,000	<20,000	<45,000	<50,000	<70,000	<75,000	

LEGEND

All flows are minimums, expressed in cubic feet per second.

* - Unless Lake Sonoma elevation is below 292.0, or if prohibited by the United States Government.

AF - Acre-Feet

● - USGS Stream Gage Compliance Points

East Fork — *Coyote Dam* / *Mouth of East Fork Russian River*

ALWAYS	East Fork Russian River Coyote Dam to Russian River	25 CFS

Russian River

NORMAL

1/1 - 3/31	150 CFS
4/1 - 5/31	185 CFS

If Combined Storage in Lake Pillsbury and Lake Mendocino on May 31 is

Normal	Normal - Dry Spring 1	Normal - Dry Spring 2
150,000 AF or >90% of Total Storage 6/1 - 8/31 185 CFS 9/1 - 12/31 150 CFS	130,000 - 150,000 AF or 80-90% of Total Storage whichever is less 6/1 - 12/31 150 CFS	<130,000 AF or <80% of Total Storage 6/1 - 12/31 75 CFS

(Normal - Dry Spring 1:) If Lake Mendocino <30,000 AF Storage 10/1 - 12/31 75 CFS

DRY

75 CFS

CRITICAL

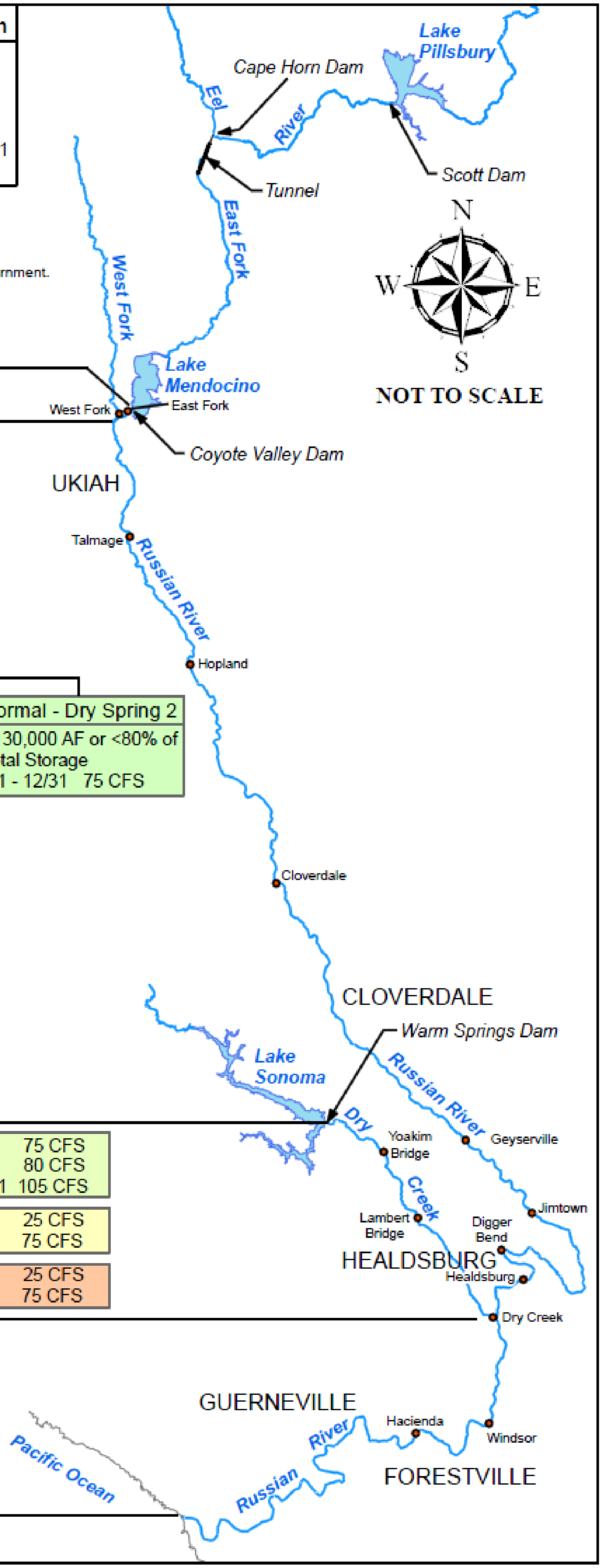
25 CFS

Dry Creek — *Mouth of Dry Creek*

NORMAL	1/1 - 4/30 5/1 - 10/31 11/1 - 12/31	75 CFS 80 CFS 105 CFS
DRY	4/1 - 10/31 11/1 - 3/31	25 CFS 75 CFS
CRITICAL	4/1 - 10/31 11/1 - 3/31	25 CFS 75 CFS

Russian River — *Mouth of Russian River*

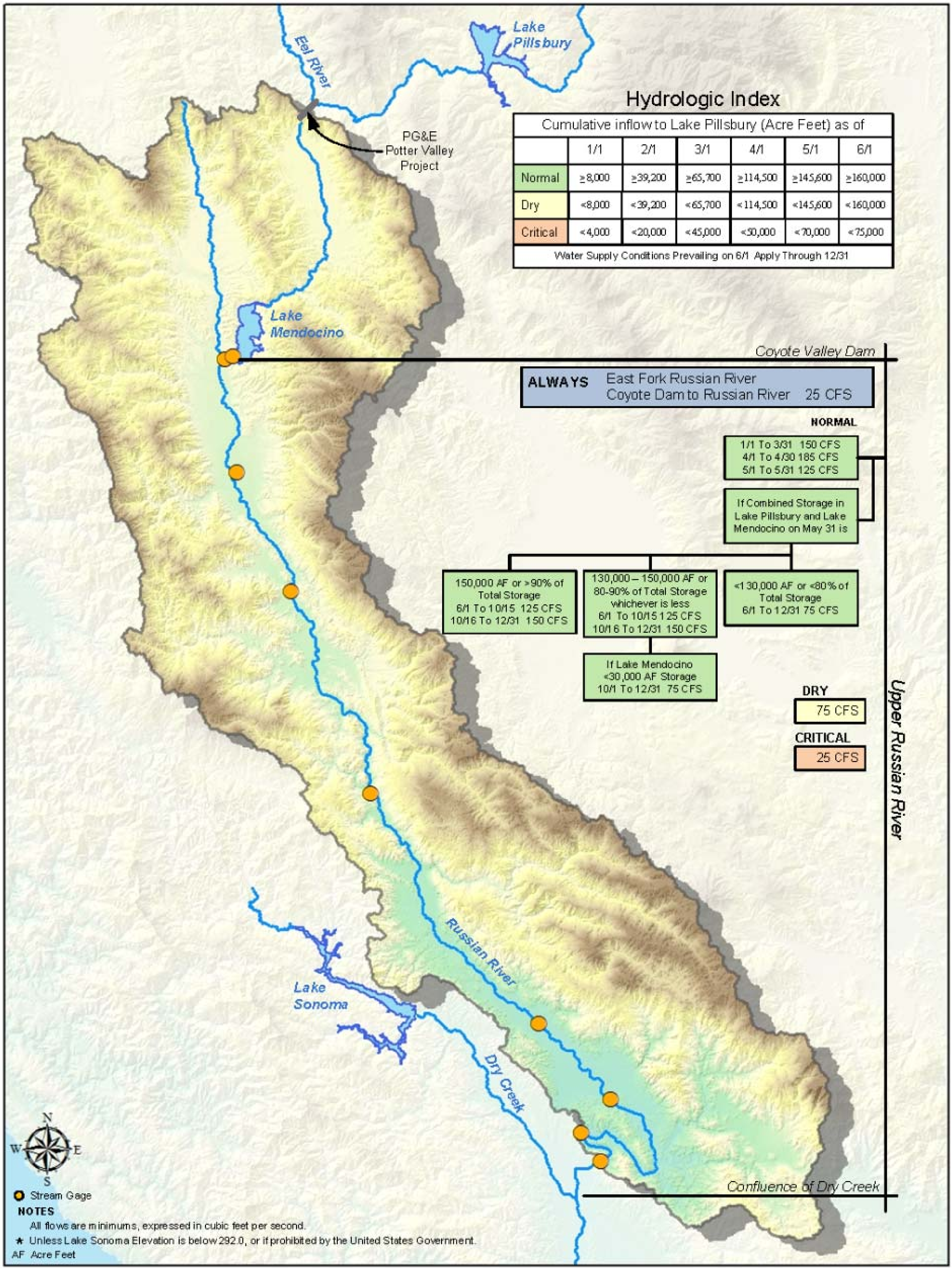
NORMAL	125 CFS*
DRY	85 CFS*
CRITICAL	35 CFS*



\\FILESERVER\Data\wp.nbasket\Schram_Projects\2011-USGS-Gage-Streamflow.mxd April 4, 2011 PDF MODIFIED ON 3/30/2015 TO ADD USGS GAGE AT GEYSERVILLE

Minimum Instream Flow Requirements per Decision 1610

Figure 21



Hydrologic Index

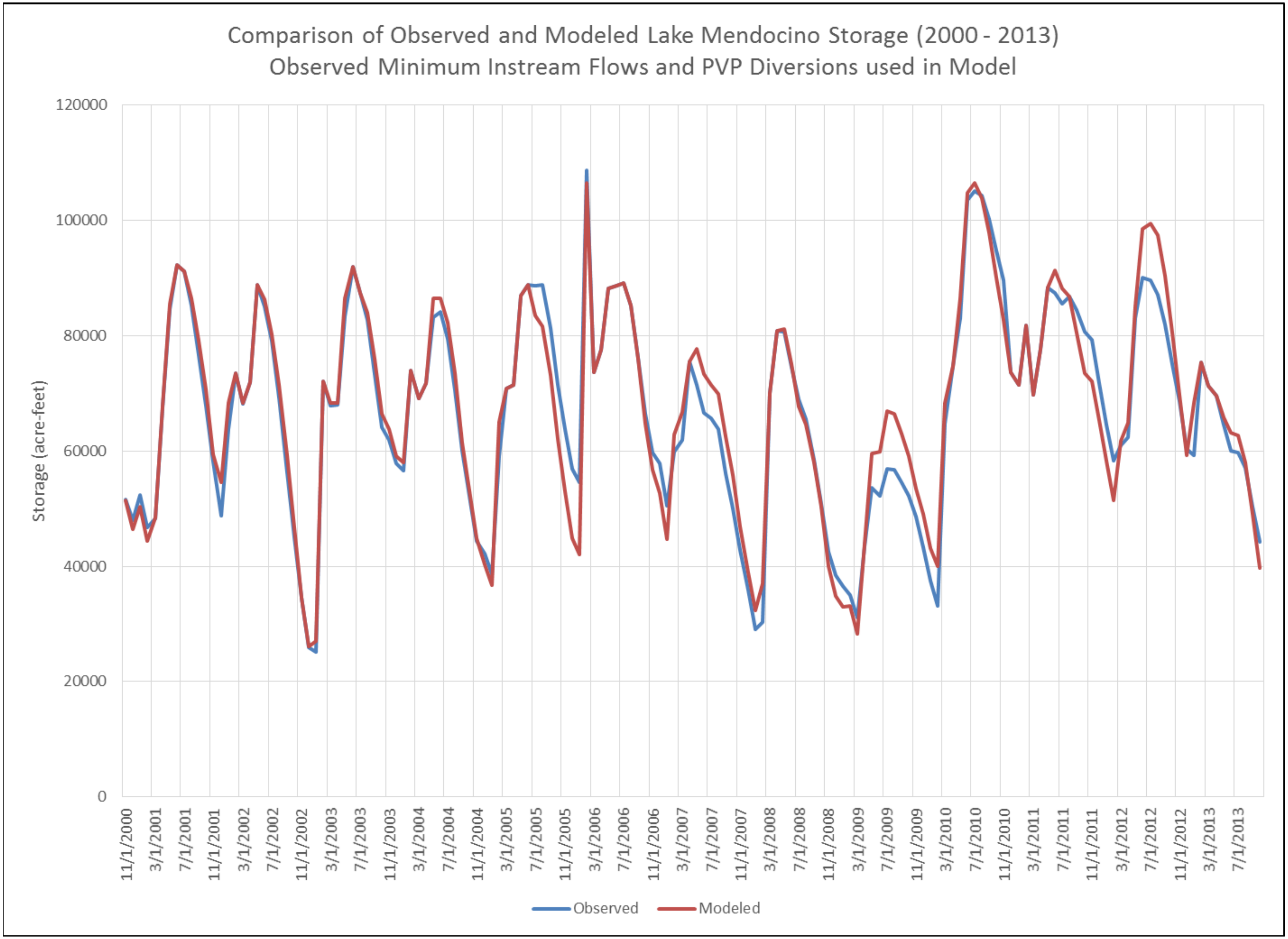
Cumulative inflow to Lake Pillsbury (Acre Feet) as of						
	1/1	2/1	3/1	4/1	5/1	6/1
Normal	≥8,000	≥39,200	≥65,700	≥114,500	≥145,600	≥160,000
Dry	<8,000	<39,200	<65,700	<114,500	<145,600	<160,000
Critical	<4,000	<20,000	<45,000	<50,000	<70,000	<75,000
Water Supply Conditions Prevailing on 6/1 Apply Through 12/31						

Minimum Instream Flow Requirements with Biological Opinion Interim Changes

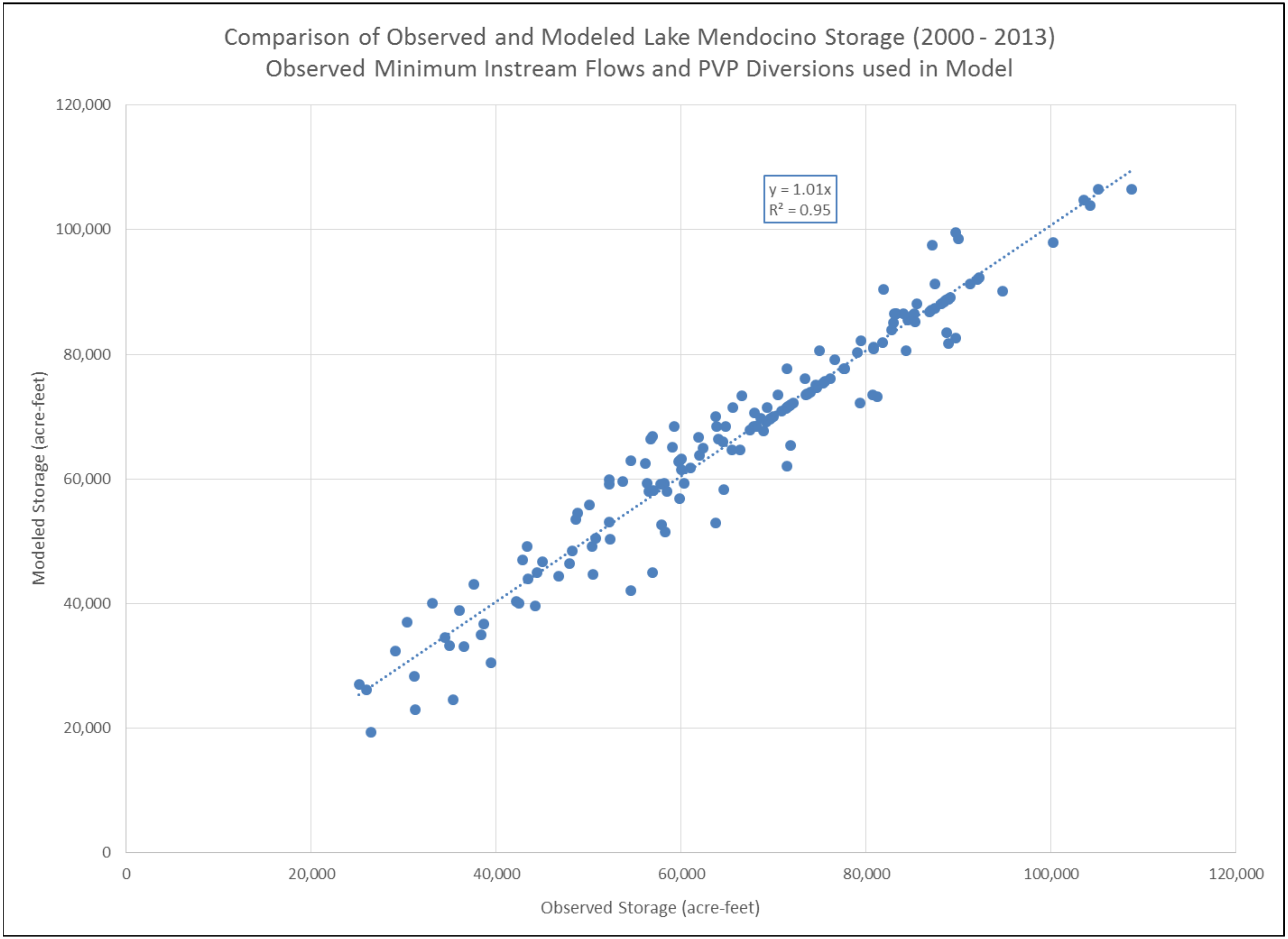
Figure 22

Upper Russian River Loss Variability Analysis

Figure 23

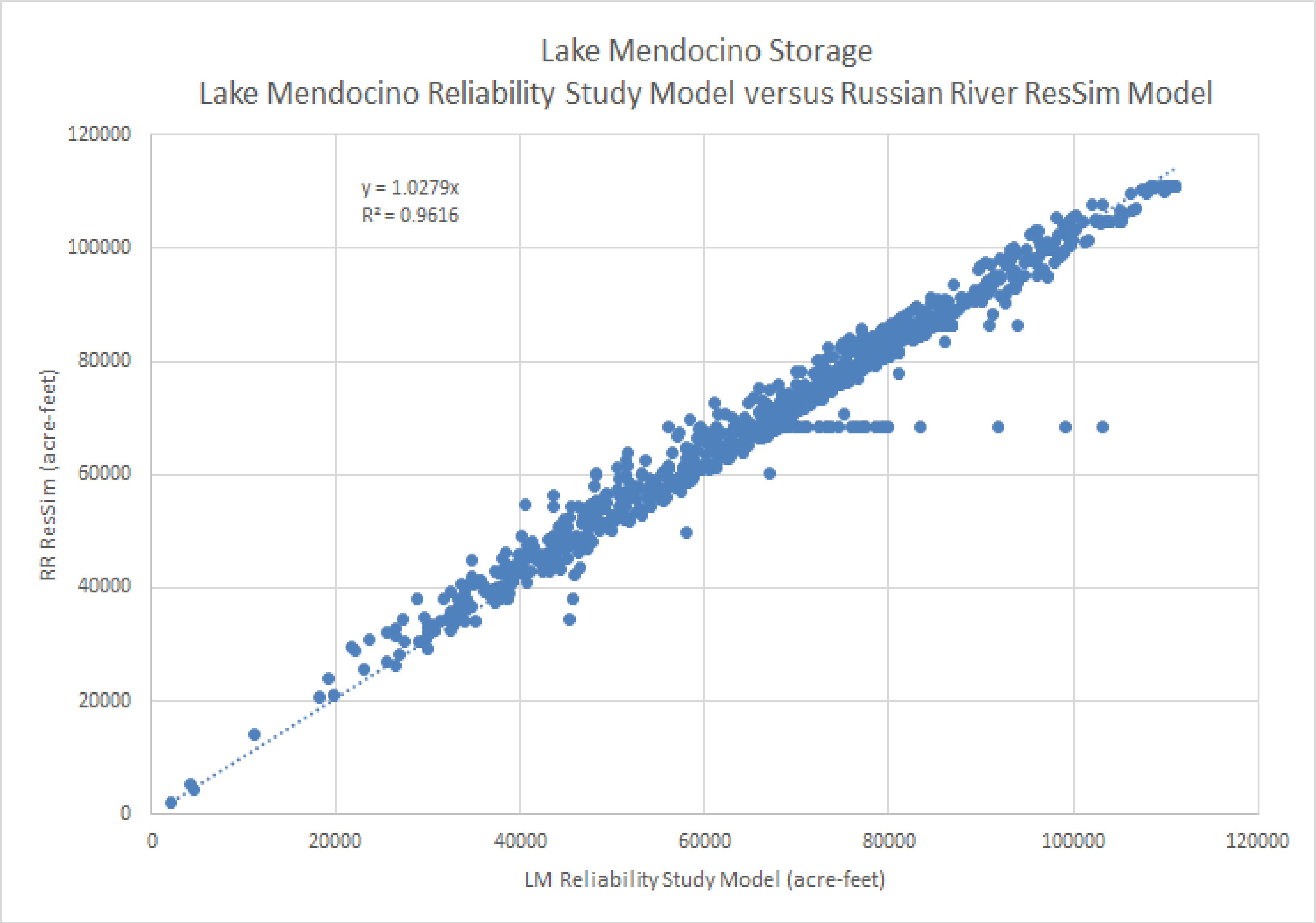


Verification Model Results - Lake Mendocino Storage Figure 24



Verification Model Results –
Modeled Storage versus Observed Storage

Figure 25



Comparison of Reliability Study Model to Russian River ResSim

Figure 26

Public Water System	2012 Service Population
City of Cloverdale	8,634
City of Healdsburg	11,442
City of Ukiah	16,075
Geyserville Water Works	1,000
Hopland Public Utility District	1,020
Millview County Water District	5,500
Redwood Valley County Water District	3,969
Rogina Water Company	3,700
Willow County Water District	3,800
Total	**55,140**

Source: CA Department of Water Resources Public Water System Statistics Annual Reports

Current Municipal Water System Service Populations

Table 1

	Annual Total Water Production (ac-ft per year)				
Public Water System	**2009**	**2010**	**2011**	**2012**	**2013**
City of Cloverdale	n/a	1,344.8	n/a	1,643.2	1,741.0
City of Healdsburg	2,139.1	n/a	1,984.1	2,176.6	2,207.2
City of Ukiah	3,064.4	2,952.1	2,918.9	3,173.6	3,316.3
Geyserville Water Works	156.0	137.8	155.4	177.2	213.6
Hopland Public Utility District	225.3	210.5	204.5	226.5	244.5
Millview County Water District	1,018.8	1,122.9	1,142.1	1,327.1	1,354.4
Redwood Valley County Water District	355.6	388.3	392.2	443.0	461.7
Rogina Water Company	565.5	565.5	520.6	629.2	579.7
Willow County Water District	811.4	756.3	752.4	832.0	895.0

Source: CA Department of Water Resources Public Water System Statistics Annual Reports

Historical Municipal Water Use (2009-2013)

Table 2

Public Water System	Current Demand (ac-ft per year)
City of Cloverdale	1,576
City of Healdsburg	2,127
City of Ukiah	3,085
Geyserville Water Works	196
Hopland Public Utility District	222
Millview County Water District	1,442
Redwood Valley County Water District	462
Rogina Water Company	572
Willow County Water District	809
Total	**10,491**

Source: CA Department of Water Resources Public Water System Statistics Annual Reports

Municipal Water Use under Current Conditions (2015)

Table 3

Demands in acre-feet per year *unless otherwise noted

Water Provider	Source	2010	2015	2020	2025	2030	2035	2040	2045	2050
City of Ukiah										
Reference Projection - High	*2010 Urban Water Management Plan*	2,952	3,848	3,595	3,778	3,971				
Reference Projection - Low	*Ukiah Valley Area Plan 2010*	3,354	3,437	3,518	3,602	3,734	4,173			
Rogina Water Company										
Reference Projection - High	*Ukiah Valley Area Plan 2010*	695	739	784	828	872				
Reference Projection - Low		556	591	627	662	698				
Millview County Water District										
Reference Projection - High	*Ukiah Valley Area Plan 2010*	1,787	2,223	2,666	3,104	3,541				
Reference Projection - Low		1,430	1,778	2,133	2,483	2,833				
Willow County Water District										
Reference Projection - High	*Ukiah Valley Area Plan 2010*	1,301	1,451	1,602	1,752	1,904				
Reference Projection - Low		1,041	1,161	1,282	1,402	1,523				
City of Cloverdale										
Reference Projection - High	*2010 Water System Master Plan Update*						2,223			
Reference Projection - Low	*Asssumed 20% reduction in current gpcd and 2010 Water System Master Plan Update population projection of 12,000 for 2035*						1,753			
City of Healdsburg										
Reference Projection - High	*2005 Urban Water Management Plan*	2,950	3,125	3,215	3,372					
Reference Projection - Low	*Asssumed 20% reduction in 2005 UWMP projections*		2,500	2,572	2,698					
Redwood Valley CWD										
Reference Projection - County Population Projection	*2009 Mendocino County General Plan Population Projection*	pop. 93,166		pop. 102,017		pop. 111,708		pop. 122,321		pop. 134,358
Population Projection for Service Area		pop. 3,969		pop. 4,346		pop. 4,759		pop. 5,211		pop. 5,724
Hopland PUD										
Reference Projection - County Population Projection	*2009 Mendocino County General Plan Population Projection*	pop. 93,166		pop. 102,017		pop. 111,708		pop. 122,321		pop. 134,358
Population Projection for Service Area		pop. 1,020		pop. 1,117		pop. 1,223		pop. 1,339		pop. 1,471
Geyserville Water Works										
Population Projection for Service Area - High	*Projections based on system owner's estimates*		pop. 1,000		pop. 1,039		pop. 1,077		pop. 1,116	
Population Projection for Service Area - Low			pop. 1,000		pop. 1,015		pop. 1,031		pop. 1,046	

	Water Use Projections (ac-ft per year)			
Public Water System	**2015**	**2025**	**2035**	**2045**
City of Cloverdale	1,576	1,507	1,753	1,999
City of Healdsburg	2,127	1,899	2,097	2,294
City of Ukiah	3,085	3,250	3,465	3,660
Geyserville Water Works	196	179	182	185
Hopland Public Utility District	222	204	223	245
Millview County Water District	1,442	1,857	2,559	3,262
Redwood Valley County Water District	462	492	523	553
Rogina Water Company	572	529	600	671
Willow County Water District	809	889	1,130	1,372
Total	**10,491**	**10,806**	**12,532**	**14,241**

Municipal Water Use Projections - Low Growth Scenario

	Water Use Projections (ac-ft per year)			
Public Water System	**2015**	**2025**	**2035**	**2045**
City of Cloverdale	1,576	1,884	2,223	2,498
City of Healdsburg	2,127	2,374	2,621	2,868
City of Ukiah	3,085	3,654	4,048	4,415
Geyserville Water Works	196	204	211	219
Hopland Public Utility District	222	255	279	306
Millview County Water District	1,442	2,321	3,199	4,078
Redwood Valley County Water District	462	616	654	692
Rogina Water Company	572	661	750	839
Willow County Water District	809	1,111	1,413	1,715
Total	**10,491**	**13,080**	**15,398**	**17,630**

	Water Use Projections (ac-ft per year)						
	2015	2025		2035		2045	
River Reach	**Base**	**Low**	**High**	**Low**	**High**	**Low**	**High**
Lake Mendocino	462	492	616	523	654	553	692
Talmage	5,099	5,636	6,636	6,624	7,997	7,593	9,332
Hopland	809	889	1,111	1,130	1,413	1,372	1,715
Cloverdale	222	204	255	223	279	245	306
Healdsburg	3,899	3,585	4,462	4,032	5,055	4,478	5,585
Total	**10,491**	**10,806**	**13,080**	**12,532**	**15,398**	**14,241**	**17,630**

Note: River reaches are defined by USGS stream gage locations and naming is based on the corresponding downstream gage.

Municipal Water Use Projections by River Reach

River Reach	Monthly Average Demand / Annual Average Demand											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Cloverdale	0.677	0.615	0.685	0.724	0.912	1.161	1.490	1.615	1.453	1.156	0.762	0.749
Geyserville	0.692	0.628	0.747	0.804	1.127	1.318	1.453	1.412	1.299	1.079	0.753	0.688
Healdsburg	0.613	0.593	0.619	0.824	1.173	1.258	1.512	1.480	1.384	1.138	0.737	0.668
Hopland	0.646	0.579	0.650	0.779	1.012	1.266	1.695	1.694	1.414	0.937	0.666	0.662
Lake Mendocino	0.797	0.618	0.656	0.763	0.936	1.297	1.437	1.484	1.403	1.035	0.787	0.787
Talmage	0.609	0.550	0.593	0.712	1.071	1.304	1.668	1.676	1.461	1.035	0.698	0.622

Municipal Water Use Monthly Distribution by Reach

Table 8

		Calpella Estimated Agricultural Water Use (ac-ft)													
Year	**Year Type**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**May-Oct**	**Total**
2002	Dry	0	0	0	0	1,377	1,930	2,494	2,224	1,800	1,187	0	0	11,012	9,635
2003	Wet	0	0	0	0	239	2,623	2,859	2,698	2,134	1,749	0	0	12,301	12,062
2004	Dry	0	0	0	0	289	1,797	2,492	2,445	2,228	602	0	0	9,854	9,564
2005	Wet	0	0	0	0	0	588	2,527	2,044	1,425	844	0	0	7,427	7,427
2006	Wet	0	0	0	0	636	1,888	2,452	2,093	1,719	310	0	0	9,098	8,463
2007	Dry	0	0	0	0	1,297	2,492	1,632	1,730	1,102	859	0	0	9,113	7,816
2008	Dry	0	0	0	0	739	1,373	1,761	1,596	1,732	620	0	0	7,822	7,083
2009	Dry	0	0	0	0	832	1,365	2,100	1,803	1,334	405	0	0	7,839	7,007
2010	Wet	0	0	0	0	706	385	1,611	1,585	925	1,665	0	0	6,877	6,171
2011	Dry	0	0	0	0	366	638	2,018	2,260	2,123	420	0	0	7,825	7,459
2012	Dry	0	0	0	0	827	1,497	401	1,201	849	322	0	0	5,097	4,270
2013	Dry	0	0	0	0	1,098	1,088	2,032	1,924	916	456	0	0	7,515	6,416
Average	Total	0	0	0	0	654	1,813	2,317	2,119	1,734	881	0	0	9,518	8,864
	Dry	0	0	0	0	853	1,523	1,866	1,898	1,511	609	0	0	8,322	7,399
	Wet	0	0	0	0	395	1,371	2,362	2,105	1,551	1,142	0	0	8,926	8,531

Note: River reaches are defined by USGS stream gage locations and naming is based on the corresponding downstream gage.

Historical Streamflow Losses Due to Agricultural Irrigation - Calpella

Table 9

		Hopland Estimated Agricultural Water Use (ac-ft)													
Year	**Year Type**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**May-Oct**	**Total**
2002	Dry	0	0	0	84	1,028	1,562	3,445	3,432	2,549	1,417	23	2	13,433	13,543
2003	Wet	0	0	0	0	0	1,540	3,238	2,546	1,113	1,546	14	0	9,984	9,998
2004	Dry	0	0	0	84	384	614	684	1,186	1,255	890	23	2	5,014	5,123
2005	Wet	0	0	0	0	0	318	548	1,611	1,003	1,044	14	0	4,524	4,538
2006	Wet	0	0	0	0	0	280	1,434	1,433	1,411	1,211	14	0	5,770	5,784
2007	Dry	0	0	0	84	674	898	2,358	1,827	1,784	1,265	23	2	8,806	8,916
2008	Dry	0	0	0	84	384	614	1,579	1,071	1,005	365	23	2	5,018	5,127
2009	Dry	0	0	0	84	335	634	970	1,092	1,023	328	23	2	4,382	4,492
2010	Wet	0	0	0	0	0	316	587	1,033	1,001	1,673	14	0	4,610	4,623
2011	Dry	0	0	0	84	330	636	707	1,095	1,214	330	23	2	4,312	4,421
2012	Dry	0	0	0	84	317	641	713	1,101	1,030	334	23	2	4,135	4,245
2013	Dry	0	0	0	84	390	729	1,203	1,228	1,003	539	23	2	5,091	5,201
Average	Total	0	0	0	56	320	732	1,456	1,555	1,283	912	20	1	6,257	6,334
	Dry	0	0	0	84	480	791	1,457	1,504	1,358	684	23	2	6,274	6,384
	Wet	0	0	0	0	0	614	1,452	1,656	1,132	1,368	14	0	6,222	6,236

Note: River reaches are defined by USGS stream gage locations and naming is based on the corresponding downstream gage.

Historical Streamflow Losses Due to Agricultural Irrigation - Hopland

Table 10

Year	Year Type	Cloverdale Estimated Agricultural Water Use (ac-ft)													
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	May-Oct	Total
2002	Dry	0	0	0	33	94	214	260	487	475	165	12	1	1,695	1,741
2003	Wet	0	0	0	0	0	200	145	451	457	677	7	0	1,932	1,939
2004	Dry	0	0	0	33	181	742	722	398	408	808	12	1	3,258	3,304
2005	Wet	0	0	0	0	0	227	234	474	478	122	7	0	1,535	1,542
2006	Wet	0	0	0	0	0	231	173	477	480	125	7	0	1,485	1,492
2007	Dry	0	0	0	33	103	366	308	478	467	134	12	1	1,854	1,900
2008	Dry	0	0	0	33	111	353	371	540	459	161	12	1	1,995	2,041
2009	Dry	0	0	0	33	116	271	250	464	454	538	12	1	2,093	2,139
2010	Wet	0	0	0	0	0	183	452	437	444	666	7	0	2,182	2,190
2011	Dry	0	0	0	33	93	215	262	488	476	142	12	1	1,675	1,722
2012	Dry	0	0	0	33	124	475	226	684	591	137	12	1	2,238	2,284
2013	Dry	0	0	0	33	109	195	597	471	461	129	12	1	1,962	2,008
Average	Total	0	0	0	22	78	306	333	487	471	317	10	1	1,992	2,025
	Dry	0	0	0	33	116	354	375	501	474	277	12	1	2,096	2,143
	Wet	0	0	0	0	0	211	251	460	465	398	7	0	1,784	1,791

Note: River reaches are defined by USGS stream gage locations and naming is based on the corresponding downstream gage.

		Healdsburg Estimated Agricultural Water Use (ac-ft)													
Year	Year Type	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	May-Oct	Total
2002	Dry	0	0	1	17	0	332	882	1,075	1,394	968	9	0	4,652	4,679
2003	Wet	0	0	0	0	0	0	0	429	1,080	530	43	0	2,039	2,082
2004	Dry	0	0	1	17	0	450	967	1,211	1,964	413	9	0	5,005	5,032
2005	Wet	0	0	0	0	0	0	0	406	670	600	43	0	1,677	1,719
2006	Wet	0	0	0	0	0	0	644	344	1,516	235	43	0	2,738	2,781
2007	Dry	0	0	1	17	0	0	1,190	1,146	1,352	1,078	9	0	4,766	4,793
2008	Dry	0	0	1	17	0	99	1,380	2,191	2,229	1,138	9	0	7,037	7,064
2009	Dry	0	0	1	17	0	0	256	1,202	1,533	227	9	0	3,218	3,245
2010	Wet	0	0	0	0	0	0	0	409	672	538	43	0	1,619	1,662
2011	Dry	0	0	1	17	0	0	0	910	4,587	1,118	9	0	6,615	6,642
2012	Dry	0	0	1	17	0	183	1,076	1,027	966	889	9	0	4,140	4,167
2013	Dry	0	0	1	17	0	57	920	1,242	1,865	1,296	9	0	5,381	5,408
Average	Total	0	0	1	11	0	93	610	966	1,652	753	20	0	4,074	4,106
	Dry	0	0	1	17	0	140	834	1,250	1,986	891	9	0	5,102	5,129
	Wet	0	0	0	0	0	0	161	397	985	476	43	0	2,018	2,061

Note: River reaches are defined by USGS stream gage locations and naming is based on the corresponding downstream gage.

Crop Type	Region	Irrigation (ac-ft/ac)
Vineyard	Mendocino County	0.79
	Sonoma County	0.58
Orchard	Mendocino County	2.61
	Sonoma County	1.70
Perennials	All	1.50
Row Crops	All	1.50
Pasture	Mendocino County	2.20
	Sonoma County	1.78
Other	All	1.50

Source: Davids Engineering, 2013

Agricultural Irrigation Water Use Crop Duties

Table 13

	Total Land Area in 2012 (acres)						
River Reach	**Vineyard**	**Orchard**	**Perennials**	**Row Crops**	**Pasture**	**Other**	**Total**
Calpella	2,352	89	4	7	2,821	0	5,272
Lake Mendocino	28	2	0	0	0	0	31
West Fork	3,600	155	2	5	464	0	4,226
Talmage	2,736	499	0	0	357	0	3,592
Hopland	3,733	512	12	0	120	0	4,377
Cloverdale	3,966	241	1	0	520	14	4,742
Healdsburg	18,530	279	14	59	1,628	8	20,517
Total	**34,945**	**1,778**	**34**	**70**	**5,909**	**21**	**42,757**

Note: River reaches are defined by USGS stream gage locations and naming is based on the corresponding downstream gage.

Agricultural Field Acreages by River Reach – Current Conditions

Table 14

	Estimated Seasonal Irrigation Use (ac-ft)						
River Reach	**Vineyard**	**Orchard**	**Perennials**	**Row Crops**	**Pasture**	**Other**	**Total**
Calpella	1,856	233	6	10	6,197	0	8,302
Cloverdale	3,129	629	2	0	1,142	20	4,923
Healdsburg	12,109	475	22	88	2,902	11	15,607
Hopland	2,946	1,337	18	0	263	0	4,564
Lake Mendocino	22	6	0	0	0	0	29
Talmage	2,158	1,303	0	0	784	0	4,245
West Fork	2,841	405	3	7	1,019	0	4,275
Total	**25,061**	**4,388**	**51**	**105**	**12,308**	**32**	**41,946**

Note: River reaches are defined by USGS stream gage locations and naming is based on the corresponding downstream gage.

River Reach	West Fork	Calpella / Lake Mendocino	Talmage	Cloverdale	Healdsburg
Duration of Frost Protection Events (hrs)	10	11	6	6	6
No. of Frost Protection Events for Vineyards					
March 15 - 30	2	2	1	2	1
April	4	6	3	3	3
May 1 - 15	2	2	1	1	1
No. of Frost Protection Events for Orchards					
March 15 - 30	3	5	3	3	3
April	8	9	5	5	5
May 1 - 15	3	4	2	2	2

Note: All data for river reaches developed by University of California Cooperative Extension Ukiah (MCWA, 2008) except for Healdsburg reach data which was assumed to be equivalent to Talmage reach

Frost Protection Water Use Assumptions

Table 16

	Estimated Water Use (ac-ft)				Estimated Net Water Use (ac-ft)			
River Reach	**Mar 15 - 30**	**Apr**	**May 1 - 15**	**Total**	**Mar 15 - 30**	**Apr**	**May 1 - 15**	**Total**
Calpella	355.5	1,028.6	349.2	1,733.4	195.5	565.8	192.1	953.3
Cloverdale	116.6	296.6	103.3	516.5	93.3	237.3	82.6	413.2
Healdsburg	534.9	1,573.9	527.2	2,636.1	107.0	314.8	105.4	527.2
Hopland	157.1	358.0	128.8	643.8	86.4	196.9	70.8	354.1
Lake Mendocino	3.0	7.9	2.8	13.7	1.6	4.4	1.5	7.5
Talmage	135.6	296.5	108.0	540.1	74.6	163.1	59.4	297.1
West Fork	60.4	167.0	56.9	284.3	33.2	91.9	31.3	156.4
Total	**1,363.1**	**3,728.6**	**1,276.2**	**6,367.9**	**591.6**	**1,574.0**	**543.2**	**2,708.9**

Note: River reaches are defined by USGS stream gage locations and naming is based on the corresponding downstream gage.

Frost Protection Water Use by River Reach – Current Conditions

Table 17

River Reach	Vineyard Acres Applying Post-Harvest	Water Use (ac-ft)
Calpella	1,058.4	350.8
Cloverdale	198.3	65.7
Healdsburg	9,265.1	3,070.8
Hopland	112.0	37.1
Lake Mendocino	12.8	4.2
Talmage	82.1	27.2
West Fork	468.0	155.1
Total	**11,196.6**	**3,711.0**

	% of Existing Crop Field Acres Converted by 2045	
	Low Demand	**High Demand**
	Sonoma County	
Orchard Conversion	50%	0%
Pasture Conversion	10%	0%
	Mendocino County	
Orchard Conversion	80%	0%
Pasture Conversion	15%	0%

Projection Assumptions for Crop Land Conversion

Table 19

	Total Estimated Cultivated Land Area in 2045 (acres)						
River Reach	**Vineyard**	**Orchard**	**Perennials**	**Row Crops**	**Pasture**	**Other**	**Total**
Calpella	2,851	18	4	7	2,397	0	5,277
Cloverdale	4,355	48	1	0	442	14	4,860
Healdsburg	26,402	139	14	59	1,465	8	28,087
Hopland	4,347	102	12	0	102	0	4,564
Lake Mendocino	37	0	0	0	0	0	37
Talmage	3,425	100	0	0	303	0	3,828
West Fork	4,183	31	2	5	394	0	4,615
Total	**45,601**	**439**	**34**	**70**	**5,104**	**21**	**51,269**

Note: River reaches are defined by USGS stream gage locations and naming is based on the corresponding downstream gage.

Agricultural Field Acreages by River Reach – Projected 2045 Low Demand Scenario

Table 20

	Total Estimated Cultivated Land Area in 2045 (acres)						
River Reach	**Vineyard**	**Orchard**	**Perennials**	**Row Crops**	**Pasture**	**Other**	**Total**
Calpella	2,357	89	4	7	2,821	0	5,277
Cloverdale	4,084	241	1	0	520	14	4,860
Healdsburg	26,402	279	14	59	1,628	8	28,389
Hopland	3,920	512	12	0	120	0	4,564
Lake Mendocino	35	2	0	0	0	0	37
Talmage	2,972	499	0	0	357	0	3,828
West Fork	3,989	155	2	5	464	0	4,615
Total	**43,760**	**1,778**	**34**	**70**	**5,909**	**21**	**51,572**

Note: River reaches are defined by USGS stream gage locations and naming is based on the corresponding downstream gage.

Agricultural Field Acreages by River Reach – Projected 2045 High Demand Scenario

Table 21

	Estimated Seasonal Irrigation Use (ac-ft)						
River Reach	**Vineyard**	**Orchard**	**Perennials**	**Row Crops**	**Pasture**	**Other**	**Total**
Calpella	2,250	47	6	10	5,267	0	7,580
Cloverdale	3,436	126	2	0	971	20	4,555
Healdsburg	17,776	238	22	88	2,612	11	20,746
Hopland	3,430	267	18	0	224	0	3,940
Lake Mendocino	29	1	0	0	0	0	30
Talmage	2,702	261	0	0	666	0	3,629
West Fork	3,301	81	3	7	866	0	4,259
Total	**32,924**	**1,020**	**51**	**105**	**10,607**	**32**	**44,740**

Note: River reaches are defined by USGS stream gage locations and naming is based on the corresponding downstream gage.

Agricultural Irrigation Water Use by River Reach – Projected 2045 Low Demand Scenario

Table 22

	Estimated Seasonal Irrigation Use (ac-ft)						
River Reach	**Vineyard**	**Orchard**	**Perennials**	**Row Crops**	**Pasture**	**Other**	**Total**
Calpella	1,860	233	6	10	6,197	0	8,306
Cloverdale	3,223	629	2	0	1,142	20	5,016
Healdsburg	17,776	475	22	88	2,902	11	21,274
Hopland	3,093	1,337	18	0	263	0	4,711
Lake Mendocino	27	6	0	0	0	0	34
Talmage	2,345	1,303	0	0	784	0	4,432
West Fork	3,148	405	3	7	1,019	0	4,583
Total	**31,471**	**4,388**	**51**	**105**	**12,308**	**32**	**48,356**

Note: River reaches are defined by USGS stream gage locations and naming is based on the corresponding downstream gage.

Agricultural Irrigation Water Use by River Reach – Projected 2045 High Demand Scenario

Table 23

	Estimated Water Use (ac-ft)				Estimated Net Water Use (ac-ft)			
River Reach	**Mar 15 - 30**	**Apr**	**May 1 - 15**	**Total**	**Mar 15 - 30**	**Apr**	**May 1 - 15**	**Total**
Calpella	399.0	1,189.5	397.8	1,986.3	219.5	654.2	218.8	1,092.5
Cloverdale	176.4	265.9	89.5	531.8	141.1	212.7	71.6	425.5
Healdsburg	1,470.0	2,207.0	736.9	4,413.9	294.0	441.4	147.4	882.8
Hopland	185.1	280.5	95.4	560.9	101.8	154.2	52.5	308.5
Lake Mendocino	2.9	8.5	2.9	14.3	1.6	4.7	1.6	7.9
Talmage	149.0	226.2	77.2	452.4	81.9	124.4	42.5	248.8
West Fork	117.7	176.9	59.2	353.8	64.7	97.3	32.6	194.6
Total	**2,500.1**	**4,354.5**	**1,458.9**	**8,313.5**	**904.6**	**1,689.0**	**566.9**	**3,160.5**

Note: River reaches are defined by USGS stream gage locations and naming is based on the corresponding downstream gage.

Frost Protection Water Use by River Reach – Projected 2045 Low Demand Scenario

Table 24

	Estimated Water Use (ac-ft)				Estimated Net Water Use (ac-ft)			
River Reach	**Mar 15 - 30**	**Apr**	**May 1 - 15**	**Total**	**Mar 15 - 30**	**Apr**	**May 1 - 15**	**Total**
Calpella	356.2	1,030.7	349.9	1,736.8	195.9	566.9	192.4	955.2
Cloverdale	197.9	303.5	105.6	607.0	158.3	242.8	84.5	485.6
Healdsburg	1,481.6	2,226.2	744.6	4,452.4	296.3	445.2	148.9	890.5
Hopland	236.4	368.8	132.4	737.6	130.0	202.8	72.8	405.7
Lake Mendocino	3.4	9.3	3.3	16.1	1.9	5.1	1.8	8.8
Talmage	197.6	310.2	112.6	620.5	108.7	170.6	61.9	341.3
West Fork	120.9	183.1	62.2	366.3	66.5	100.7	34.2	201.5
Total	**2,594.1**	**4,431.9**	**1,510.6**	**8,536.7**	**957.7**	**1,734.3**	**596.6**	**3,288.5**

Note: River reaches are defined by USGS stream gage locations and naming is based on the corresponding downstream gage.

Frost Protection Water Use by River Reach – Projected 2045 High Demand Scenario

Table 25

River Reach	Vineyard Acres Applying Post-Harvest	Water Use (ac-ft)
Calpella	1,283.1	425.3
Cloverdale	217.8	72.2
Healdsburg	13,201.2	4,375.4
Hopland	130.4	43.2
Lake Mendocino	16.4	5.4
Talmage	102.7	34.1
West Fork	543.8	180.2
Total	**15,495.5**	**5,135.8**

Post-Harvest Water Use by River Reach – Projected 2045 Low Demand Scenario

Table 26

River Reach	Vineyard Acres Applying Post-Harvest	Water Use (ac-ft)
Calpella	1,060.6	351.5
Cloverdale	204.2	67.7
Healdsburg	13,201.2	4,375.4
Hopland	117.6	39.0
Lake Mendocino	15.6	5.2
Talmage	89.2	29.6
West Fork	518.6	171.9
Total	**15,207.0**	**5,040.2**

Post-Harvest Water Use by River Reach – Projected 2045 High Demand Scenario

Table 27

	Observed Reach Loss from Frost Events (acre-feet)			
Frost Event Date	**Calpella**	**Hopland**	**Cloverdale**	**Healdsburg**
April 1, 2004	29.98	7.29	2.71	
April 2, 2004	13.99	-	0.31	23.26
April 16, 2004	12.87	17.22	18.41	1.69
March 28, 2007	38.67	22.02	42.15	
March 29, 2007	42.72	16.97	36.64	69.03
March 16, 2008	3.37	15.12	57.58	6.78
March 20, 2008	10.70	18.43	18.63	8.68
March 21, 2008	-	27.81	48.26	12.60
March 26, 2008	17.49	18.20	26.34	-
March 27, 2008	44.45	36.38	48.53	6.26
March 28, 2008	21.88	32.73	17.95	
March 30, 2008	29.11		1.98	70.50
March 31, 2008	52.41	93.39	80.06	
April 1, 2008	36.07	-	-	
April 2, 2008	32.92	25.45	41.88	64.24
April 7, 2008	26.58	43.86	29.34	18.08
April 9, 2008	28.10	39.34	70.04	34.94
April 20, 2008	37.66	44.46	68.97	68.97
April 21, 2008	-	69.28	81.28	81.28
April 22, 2008	-	44.99	56.32	56.32
April 24, 2008	60.01	48.76	82.33	82.33
Average	**30**	**35**	**41**	**40**

	% of Crop Acreage Frost Protected	
River Reach	**Vineyard**	**Orchard**
Calpella	68%	70%
Cloverdale	35%	100%
Healdsburg	50%	50%
Hopland	35%	100%
Lake Mendocino	68%	70%
Talmage	35%	100%
West Fork	15%	25%

Percent of Acreage Frost Protected

Table 29

River Reach	Percent of Frost Protection Diversion that Returns to Russian River % Return Flow
Calpella	45%
Cloverdale	20%
Healdsburg	80%
Hopland	45%
Lake Mendocino	45%
Talmage	45%
West Fork	80%

River Reach	Ratio of Projected (2045) to Current (2015) Frost Diversions based on Land Use Estimates	
	High	Low
Calpella	1.0	1.2
Cloverdale	1.0	1.0
Healdsburg	1.4	1.4
Hopland	1.1	0.9
Lake Mendocino	1.2	1.1
Talmage	1.1	0.9
West Fork	1.1	0.9

	Average Number of Frost Events based on Historical Minimum Temperatures		
River Reach	**March**	**April**	**May**
Calpella	3.2	2.8	0.5
Cloverdale	0.9	0.8	0.0
Healdsburg	1.3	1.0	0.0
Hopland	3.2	2.8	0.5
Lake Mendocino	3.2	2.8	0.5
Talmage	3.2	2.8	0.5
West Fork	3.2	2.8	0.5

	Average Estimated Diversions from Frost Protection – Projected 2045 Low Demand Scenario (acre-feet)		
River Reach	**March**	**April**	**May**
Calpella	112.9	99.7	16.6
Cloverdale	128.6	113.6	18.9
Healdsburg	182.8	161.4	26.8
Hopland	99.0	87.4	14.5
Lake Mendocino	2.6	2.3	0.4
Talmage	99.0	87.4	14.5
West Fork	99.0	87.4	14.5

	Average Estimated Diversions from Frost Protection – Projected 2045 High Demand Scenario (acre-feet)		
River Reach	**March**	**April**	**May**
Calpella	96.4	85.1	14.1
Cloverdale	136.6	120.7	20.0
Healdsburg	183.7	162.3	27.0
Hopland	115.9	102.4	17.0
Lake Mendocino	2.7	2.4	0.4
Talmage	115.9	102.4	17.0
West Fork	115.9	102.4	17.0

Number	Scenario Name	MODEL ASSUMPTIONS				
		Russian River Hydrology	System Losses	Lake Mendocino Storage Capacity	PVP Hydrology	Lake Pillsbury Storage Capacity
1	Year 2015, Current Conditions	Historical 1911-2013	Current 2015	Current 2001	Historical 1911-2013	Current 2006
2	Year 2015, No PVP	Historical 1911-2013	Current 2015	Current 2001	No PVP Diversions	Current 2006
3	Year 2045 Low Growth	Historical 1911-2013	Projected 2045 Low Growth	Projected 2045	Historical 1911-2013	Projected 2045
4	Year 2045 High Growth	Historical 1911-2013	Projected 2045 High Growth	Projected 2045	Historical 1911-2013	Projected 2045
5	Year 2045 Low Growth, Future Climate Dry	Future Climate Dry 2000-2099	Projected 2045 Low Growth	Projected 2045	Future Climate Dry 2000-2099	Projected 2045
6	Year 2045 High Growth, Future Climate Dry	Future Climate Dry 2000-2099	Projected 2045 High Growth	Projected 2045	Future Climate Dry 2000-2099	Projected 2045
7	Year 2045 Low Growth, Future Climate Wet	Future Climate Wet 2000-2099	Projected 2045 Low Growth	Projected 2045	Future Climate Wet 2000-2099	Projected 2045
8	Year 2045 High Growth, Future Climate Wet	Future Climate Wet 2000-2099	Projected 2045 High Growth	Projected 2045	Future Climate Wet 2000-2099	Projected 2045

Scenario Model Assumptions

Table 35