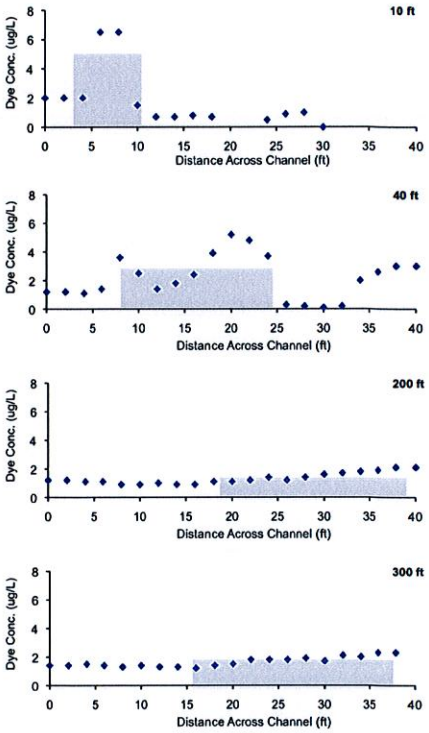
February 25, 2010

Town of Yountville

Effluent Mixing Zone / Dilution Credit Study



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Introduction

This report presents the findings of a study to characterize mixing and dilution of effluent discharges from the Town of Yountville/Veterans Home of California Joint Wastewater Reclamation Facility (Yountville WWRF) into the Napa River. A maximum dilution credit of D=12 and minimum actual river-to-effluent flow ratio of 40:1 are proposed. For these dilution ratios, the regulatory mixing zone extends less than 200 ft downstream of Outfall E-1. This regulatory mixing zone will provide full compliance for the Yountville WWRF while also complying with applicable regulations and policy.

YOUNTVILLE WASTEWATER RECLAMATION FACILITY DISCHARGES

The Yountville WWRF provides secondary-level treatment for domestic and commercial wastewater from the Town of Yountville and the Veterans Home of California (jointly referred to hereafter as "Yountville"). The treatment processes consist of headworks, primary clarification, first stage trickling filtration, intermediate clarification, second stage trickling filtration, aerated solids contact, final sedimentation, and disinfection (chlorination). The Yountville WWRF has an average dry-weather flow design capacity of 0.55 million gallons per day (MGD). After treatment, the effluent may be discharged to the Napa River from October 1 through May 15. Treated wastewater is discharged to a non-tidal reach of the Napa River through Outfall E-1 (referred to as "Outfall 001" in the new permit) located on the western bank of the river. During the remainder of the year, the wastewater is treated to disinfected secondary-2.2 recycled water standards, and then either distributed directly for recycled water use or stored for future use or disposal.

The facility is permitted for operation and discharge to the Napa River under NPDES Permit No. CA0038121 (Order No. R2-2004-0017). Currently, the Yountville WWRF may discharge its effluent to the Napa River only when the river-to-effluent flow ratio is at least 25:1. This minimum flow ratio is expected to increase to 40:1 in the next NPDES permit, scheduled for adoption at the February 2010 Regional Water Board hearing. In the 2004 NPDES Permit, the Regional Water Board allowed a dilution credit of 10:1 (equivalent to dilution credit D=9) for Outfall E-1.

The *Policy for Implementation of Toxics Standards for Inland Surface Waters, Enclosed Bays, and Estuaries of California* (State Implementation Policy, or SIP, [SWRCB, 2005]) procedures are being followed for the current NPDES permit renewal. Because the outfall does not have a diffuser, the Regional Water Board has determined that Yountville WWRF discharges are "incompletely mixed". Consequently, dilution credit is not included in the Tentative Order proposed for adoption in February 2010. Under those conditions, reasonable potential to cause or contribute to an exceedance of a water quality objective was identified for five pollutants *with no dilution credit*: copper, zinc, cyanide, dichlorobromomethane, and total ammonia.

STUDY AREA

The Yountville WWRF is shown in context with other local municipal wastewater dischargers to the Napa River in **Figure 1**. A close-up view of the Napa River reach identifying Outfall E-1 and the downstream receiving water monitoring station is shown in **Figure 2**.

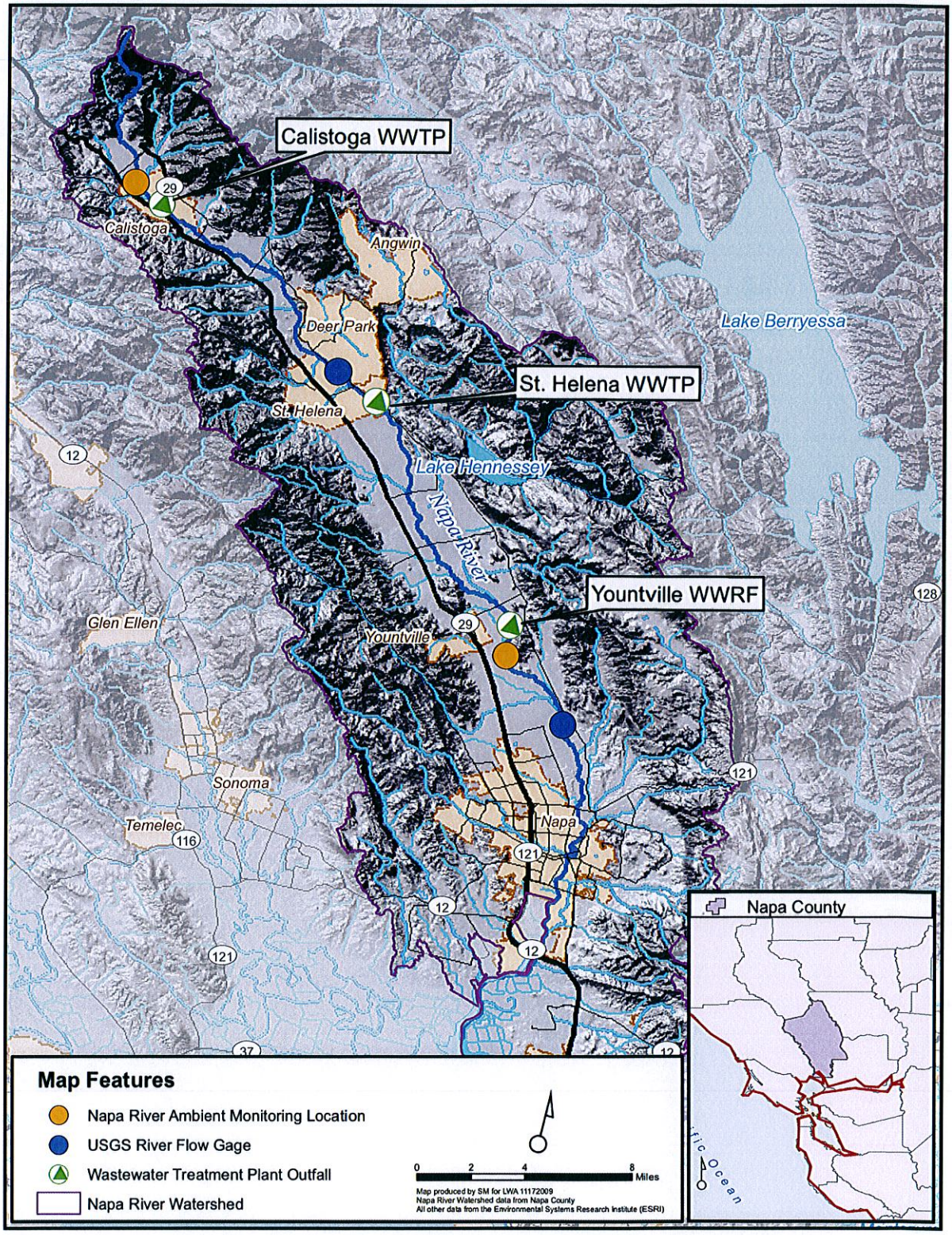

Figure 1. Yountville WWRF location in the Napa River Watershed.

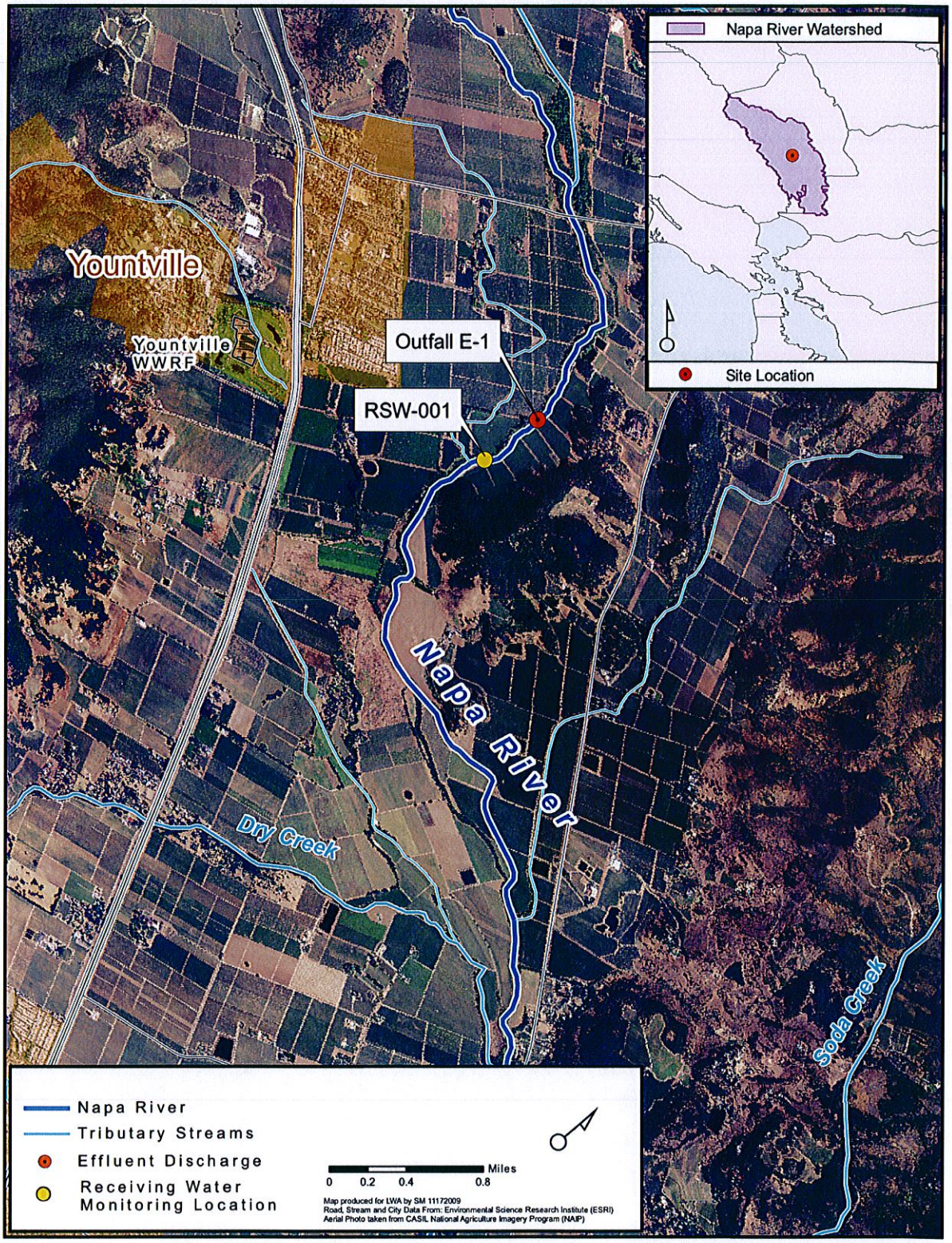

Figure 2. Napa River study reach identifying points of interest.

TERMINOLOGY

The SIP provides the following definitions:

- **Mixing Zone:** A limited volume of receiving water that is allocated for mixing with a wastewater discharge where water quality criteria can be exceeded without causing adverse effects to the overall water body. [In Yountville's case, the term regulatory mixing zone is used to distinguish from fully mixed conditions.]
- **Dilution Credit:** The amount of dilution granted to a discharge in the calculation of a water quality-based effluent limitation, based on the allowance of a specified mixing zone. It is calculated from the dilution ratio or determined through conducting a mixing zone study or modeling of the discharge and receiving water.

Once a regulatory mixing zone is established, the discharge limitations for some pollutants could receive a dilution credit thereby allowing concentrations only within the regulatory mixing zone to exceed otherwise applicable criteria. The SIP provides the Regional Water Board with the discretion to limit or deny dilution credits for specific pollutants.

The approach to making a mixing zone / dilution credit determination also depends on whether a discharge is completely mixed or incompletely mixed with the receiving water. A completely mixed discharge condition means not more than a 5 percent difference in the concentration of a pollutant across a transect two river widths downstream from the discharge. An outfall diffuser across the river channel would provide a completely mixed discharge. Because the Yountville WWRF outfall does not have a diffuser, effluent may not be completely mixed within two river widths downstream from the point of discharge. Effluent is therefore classified as incompletely mixed. An incompletely mixed discharge requires a mixing zone study to assure compliance with SIP conditions before dilution credits can be approved.

CONDITIONS FOR ALLOWING A MIXING ZONE

Conditions that must be met in allowing a mixing zone are the following (excerpted from SIP section 1.4.2.2):

A. A mixing zone shall not:

(1) compromise the integrity of the entire water body

(2) cause acutely toxic conditions to aquatic life passing through the mixing zone

(3) restrict the passage of aquatic life

(4) adversely impact biologically sensitive or critical habitats, including, but not limited to, habitat of species listed under federal or State endangered species laws

(5) produce undesirable or nuisance aquatic life

(6) result in floating debris, oil, or scum

(7) produce objectionable color, odor, taste, or turbidity

(8) cause objectionable bottom deposits

(9) cause nuisance

(10) dominate the receiving water body or overlap a mixing zone from different outfalls

(11) be allowed at or near any drinking water intake. A mixing zone is not a source of drinking water.

B. The RWQCB shall deny or significantly limit a mixing zone and dilution credit as necessary to protect beneficial uses, meet the conditions of this Policy, or comply with other regulatory requirements. Such situations may exist based upon the quality of the discharge, hydraulics of the water body, or the overall discharge environment (including water column chemistry, organism health, and potential for bioaccumulation). For example, in determining the extent of or whether to allow a mixing zone and dilution credit, the RWQCB shall consider the presence of pollutants in the discharge that are carcinogenic, mutagenic, teratogenic, persistent, bioaccumulative, or attractive to aquatic organisms…In the case of multiple mixing zones, proximity to other outfalls shall be carefully considered to protect the beneficial uses…

The results of this mixing zone study are assessed with regard to these conditions later in this memorandum.

CONDITIONS FOR SIZING A MIXING ZONE

Guidance on delineating mixing zones and calculating dilution credits is given in the *Technical Support Document for Water Quality-based Toxics Control* (USEPA, 1991). Section 2.2.2 of that document suggests that for application of acute and chronic aquatic life and human health criteria, there may be multiple regulatory mixing zones (and associated dilution credits). However, in this case Yountville is proposing a single regulatory mixing zone limiting dilution for all constituents.

The State of California does not provide any additional guidance on delineating regulatory mixing zones. However, the following examples of criteria have been applied elsewhere:

- On a case-by-case basis, the Los Angeles Regional Water Quality Control Board (1994) policy allows approval of mixing zones in rivers and streams less than 250 feet from the point of discharge or more than 500 feet from an adjacent mixing zone.
- Arizona (1992) rule R18-11-114 limits the length of a mixing zone shall not exceed 500 meters in a stream and provide a zone of passage of not less than 50 percent of the cross-sectional area of a river or stream.
- In Colorado guidance (Colorado Dept. Public Health and Envir., 2002), the *chronic* regulatory mixing zone has an area equal to 6 times the square of the channel width at bankfull flow. This regulatory convention is based on the concept of geomorphic units in streams: for streams that show pool and riffle structure, one sequence of pools and riffles is approximately 6 times the bankfull width. The channel area corresponding to this geomorphic sequence is length (6 times the bankfull width) times width (bankfull width). *Acute* mixing zones are scaled at 10% of the chronic mixing zone length but may be as much as 25% based on economic reasonableness, ecological risk, and other related factors.
- In Utah procedures (Utah Div. Water Qual., 2000), an appropriate mixing zone for *chronic* aquatic life and human health criteria shall not exceed 2,500 feet. The size of an

acute mixing zone for aquatic life criteria shall not exceed 50% of stream width nor have a residency time of greater than 15 minutes.

DILUTION EQUATIONS

The SIP defines "dilution ratio" as the critical low flow of the upstream receiving water divided by the flow of the effluent discharged. Thus, a 10:1 dilution ratio means, according to the SIP, that downstream of an effluent discharge there are 10 parts upstream receiving water to 1 part effluent. The concentration at the edge of the mixing zone (C_{ds}) can thus be calculated as (assuming no degradation):

$$C_{ds} = \frac{DB + C_{effl}}{D + 1}$$

Where D = dilution factor, dilution credit, or simply dilution

B = background concentration

C_{effl} = effluent concentration

Dilution can be calculated from model results that are presented as fractions of effluent (p) downstream of the mixing zone by:

$$D = \frac{1 - p}{p}$$

Although 10% effluent means D=9, a dilution ratio of 10:1 means, according to the SIP[1], D=10.

The equation used to calculate the effluent concentration allowance (ECA) for toxics based on dilution and a receiving water criterion (C_o) is then:

$$ECA = C_o + D\,(C_o - B)$$

No dilution credit (D=0) results in direct application of receiving water criteria. The dilution credit needed to attain the objective (C_o) can be calculated as:

$$D = \frac{C_{effl} - C_o}{C_o - B}$$

Concentration of a pollutant downstream of the mixing zone is a function of its load in effluent relative to the receiving water and of degradation processes. Its concentration at a distance x downstream of the mixing zone can be calculated as follows:

$$C_{ds} = \left[\frac{Q_{effl}C_{effl} + Q_r B}{Q_{effl} + Q_r}\right] e^{-kx/v}$$

Where Q = flow rate,

K = first-order decay rate of the pollutant,

v = stream velocity, and

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[1] The practice in the Bay Area has been to *state* that the dilution credit is 10:1 but *apply* a dilution credit of D=9. In this report, results typically are expressed relative to D values following the SIP.

Subscript *r* refers to upstream receiving water.

CRITICAL FLOWS

The SIP procedure for calculating water quality-based effluent limits (WQBELs) relies on the distribution of historical monitoring data and the monitoring frequency. The SIP stipulates critical flow rates to use for calculating dilution credits for acute, chronic, and human-health based objectives for year-round mixing zones. The flow conditions given in the SIP assume that relatively high discharged effluent flow could potentially coincide with relatively low critical receiving water flow. For Yountville WWRF discharges, the SIP's critical flow values are not applicable because effluent is discharged only sporadically (not year-round) and even then is limited to a minimum river-to-effluent flow ratio of 25:1 currently and 40:1 in the new permit.