Section 2: Recycled-Water Flow Projections

A water balance model (WBM) has been developed and implemented to simulate operation of the SWRS under a variety of hydrologic conditions. This model has undergone continuous development over the past several years, incorporating additional hydrology, potential reuse facility elements, and other modifications, to provide analytical assessment of options for anticipated scenarios of reuse and disposal.

The WBM was constructed from a 67-year period of record from 1929 to 1995; however, this period of record is in the process of being extended to span the period from 1910 to 2004. A daily water balance of flows and storage within the system was completed for each water year (1 October to 30 September) from output from a separate Sonoma County Water Agency (SCWA) Simulation Model (Flugum, 1988). The period of record available from the SCWA Simulation Model for this analysis was 1929 to 1995. The SCWA Simulation Model analyses are based on historical flows adjusted for future diversions and dam operations, as well as the key criteria of estimated municipal and industrial demand under current and future conditions.

The annual demand estimate for future hydrology is 101,000 acre-feet, which is based on the current SCWA water right of 75,000 acre-feet, plus an additional 26,000 acre-feet of unallocated water in Lake Sonoma (SCWA, 1998). The hydrology includes an estimate of potential flow reductions considered by the Federal Energy Regulating Commission in the current relicensing of the Potter Valley Project under Endangered Species Act Section 7 in consultation with the National Marine Fisheries Service.

The following sections briefly describe the key features of the WBM.

- Section 2.1 outlines how the WBM simulates recycled-water production within the SWRS, including facilities, types of output, and analysis and computation methods. Also given are the quantities of actual and modeled recycled-water production from 1990 to 1999.

- Modeling of recycled-water storage in the Laguna Storage Ponds is addressed in Section 2.2.

- Section 2.3 discusses how the WBM incorporates current and future options for recycled-water use, including irrigation, delivery to the Geysers, and urban reuse.

- Finally, the applications of the modeling results are discussed in Section 2.4. Important model output is also given in Table 2.4-1, which shows daily and annual recycled water discharge flows for driest, wettest, and median years. These values are a key aspect of the assumptions for the analyses described in the rest of this report.

For greater detail on the WBM, MSC 2002 and 2003 (see the References section) should be consulted.

2.1 Recycled Water Production from the Subregional Water Reclamation System

The SWRS consists of wastewater treatment facilities, storage ponds, conveyance facilities, and discharge works. The WBM represents these elements, or operations associated with these elements. The key attribute of the reclamation system simulated by the WBM to assess recycling and discharge options is the total recycled water production – the amount of water produced on a daily basis that must be discharged, stored, or used for other purposes (e.g., agriculture, urban reuse). Recycled water production is computed within the WBM as the sum of the ADWF and a wet-weather increment (e.g., storm inflows during winter precipitation events), where ADWF can be thought of as a base level of production.

The wet-weather increment computation in the WBM is based on a regression relationship that was developed using observed recycled water production during wet weather and the local inflow to the Russian River system between Healdsburg and Guerneville (accounting for Dry Creek inflows and SCWA withdrawals). The local inflow component of this relationship was computed from data produced by the SCWA Simulation Model. Recycled water production data used in development of the regression relationship were obtained from the City of Santa Rosa for the period from 1990 through 1999.

The average value for the period of analysis used in the analysis was 17.6 mgd (Table 2.1-1).

Table 2.1-1 Seasonal (May through October) Average Dry Weather Flow

Year	ADWF (mgd)
1999	17.77
1998	18.82
1997	17.09
1996	18.42
1995	18.06
1994	17.32
1993	17.05
1992	17.88
1991	17.01
1990	16.10
Average	**17.6**

The final form of the regression equation for estimating recycled water production employs the square root of the local inflow (Q_i) as the dependent variable and the ADWF as indicated below:

Recycled water production = $0.2882*(Q_i - 250)^{0.5}$ + ADWF for $Q_i \geq 250$ cfs ($r^2 = 0.55$[1]).

Recycled water production = ADWF for $Q_i < 250$ cfs

[1] The regression relationship represents the wet-weather increment – that flow above the ADWF. All incremental flow values below a user-specified limit were dropped from the analysis to minimize the “noise” (day-to-day variability in the data) when local inflows were small. This user-specified limit was set at 250 cubic feet per second.

These equations are used in the WBM to forecast recycled water production.

In Table 2.1-2 and Figure 2.1-1, actual historical annual recycled water production is compared with that computed with the regression equation. On average, the modeled production is within ±6 percent of the historical values on an annual basis and within ±1.5 percent of the historical values for the total recycled water production over the period of analysis.

Table 2.1-2 Actual and Modeled Recycled Water Production: 1990-99

Year	Actual Prod. (MG)	Calculated Prod. (MG)	Difference (Percent)
1990	6,096	6,096	0.0%
1991	6,652	6,894	3.6%
1992	7,060	7,157	1.4%
1993	7,361	7,696	4.6%
1994	7,021	6,857	-2.3%
1995	8,401	8,069	-4.0%
1996	8,283	7,845	-5.3%
1997	7,508	7,312	-2.6%
1998	8,784	8,245	-6.1%
1999	6,071	5,836	-3.9%
Total	**73,235**	**72,008**	
Average	**7,324**	**7,201**	**-1.5%**

Figure 2.1-1 illustrates measured and modeled monthly average recycled water production.

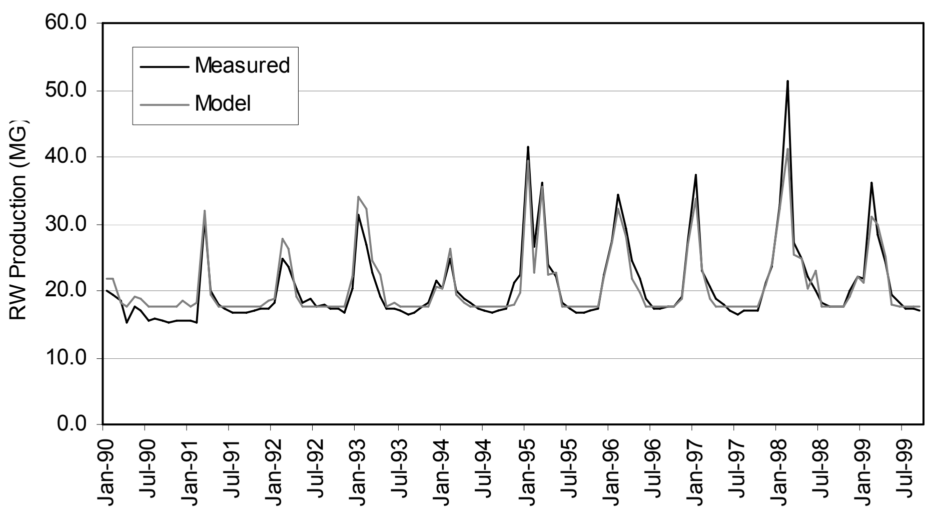

Figure 2.1-1 Measured and Modeled Monthly Average Recycled Water Production

2.2 Laguna Storage

Laguna Storage is primarily comprised of the Delta and Meadowlane Ponds and is explicitly incorporated into the WBM. Total storage volume, maximum operating volumes, and target operating volumes are included. Target operating volumes are defined by daily nominal upper and lower active volume. These storage “rule curves” form an envelope within which storage is allowed to vary. These rule curves serve to determine the amount of water available for reuse and disposal on each day, and they can be modified for any particular scenario.

Figure 2.2-1 is an example of a WBM Laguna storage rule curve that provides winter storage flexibility, spring storage increases to meet summer irrigation demand, and fall storage decreases to reduce carryover storage and prepare the system for the subsequent wet season.

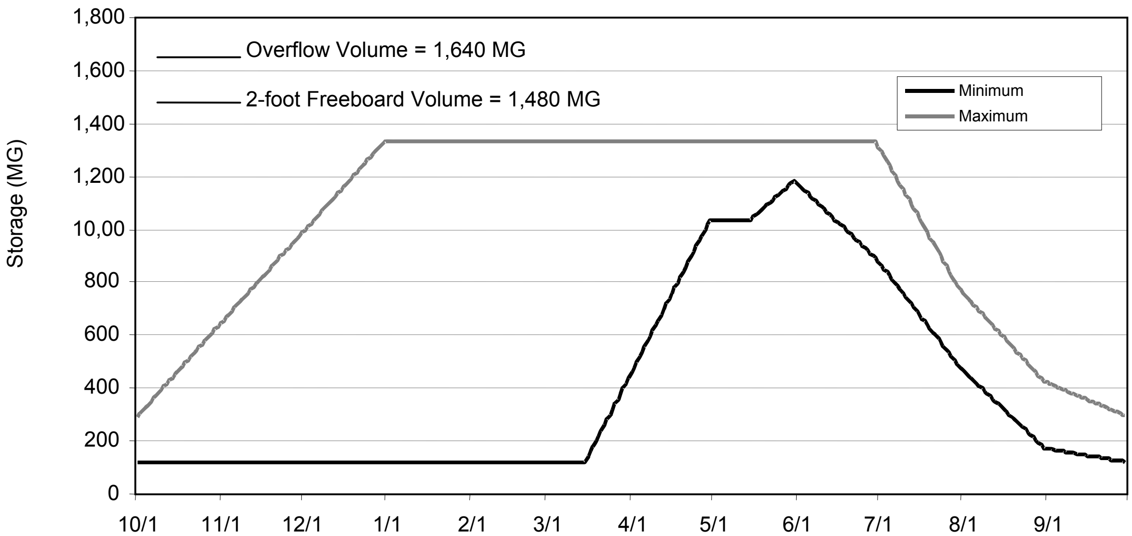

Figure 2.2-1 Storage Envelope as Defined by Daily Nominal Upper and Lower Active Volume

Maximum desired operating storage is approximately 1,330 MG (million gallons), 2-foot freeboard storage (2 feet from the pond capacity) is 1,480 MG, and maximum total Laguna storage (combined storage of all ponds in the Laguna that are used by the City) is 1,640 MG. The WBM may simulate storage conditions that exceed the upper limit, if insufficient means to discharge or reuse recycled water is simulated, or that fall below the lower limit, if insufficient recycled water production is simulated.

2.3 Use of Recycled Water: Model Features

The model incorporates several features of current and future options for recycled water use. Water reuse activities included in the WBM include:

- Irrigation of City farms and the existing Santa Rosa Plain irrigation system (Laguna irrigation)
- Delivery to the Geysers via the Geysers Pipeline
- Agricultural irrigation and storage deliveries via the Geysers Pipeline
- Urban reuse
- Agriculture east of Rohnert Park

These model components are briefly discussed below.

2.3.1 Laguna Irrigation

Irrigated agriculture in the Laguna is a current and potentially ongoing use of recycled water. The WBM accounts for this feature through user-specified inputs for total irrigated acreage, vineyard acreage, and monthly evapotranspiration (ET). Demands for frost control are included, as is logic to reduce irrigation ET, and hence irrigation demand, when river flows reflect precipitation events.

Existing agriculture is on the order of 6,000 acres; variable quantities can be defined within the model. Five hundred acres of this total acreage is currently designated as vineyards. The summertime (May through October) ET potential for the vineyard acreage is set at a nominal rate of 0.7 feet. The total summertime ET potential (1 May through 31 October) of the remaining acreage is defined as total inches over the 6-month period. The nominal ET rates, which are input monthly, are scaled to conform to the total summertime ET and can be varied by the user (Table 2.3-1).

Table 2.3-1 Monthly Evapotranspiration (ET) Rates Incorporated in the Water Balance Model

Month	ET Rate (in./mo.)	Month	ET Rate (in./mo.)
October	2.7	April	2.3
November	1.5	May	3.4
December	0.8	June	4.2
January	0.8	July	5.5
February	0.8	August	5.5
March	1.5	September	3.7

WBM priorities require that Geysers deliveries at current contract amounts (see below) are met prior to deliveries to Laguna area agriculture (current contract amount).

2.3.2 Geysers Delivery

Recycled water delivery to the Geysers Recharge Project occurs via the Geysers Pipeline. In the WBM, deliveries are specified by the model user and can vary monthly. The baseline delivery consists of the current contract volumes: 11 mgd on average over the year, varying between 9.0 and 12.1 mgd (Table 2.3-2). Increases in delivery to the Geysers above this contract amount to 30 mgd can be specified, and pipeline conveyance capacity can be varied to up to 80 mgd. The WBM has not been tested at Geysers Pipeline capacities in excess of 80 mgd.

Table 2.3-2 Monthly Geysers Delivery Rate

Month	Geysers Pipeline Rate (mgd)	Month	Geysers Pipeline Rate (mgd)
October	11.7	April	9.0
November	12.1	May	9.0
December	12.1	June	10.1
January	12.1	July	11.0
February	12.0	August	11.0
March	10.5	September	11.0

2.3.3 Agricultural Irrigation and Storage Deliveries via the Geysers Pipeline

One option that can be assessed using the WBM is conveyance of recycled water via the Geysers Pipeline to agricultural areas north of the City of Santa Rosa, often termed North County Storage. This model feature simulates the conveyance of excess recycled water (i.e., flow in excess of that required to meet Laguna irrigation and Geysers demand), based on availability and pipeline capacity, to a storage facility or facilities presumed to be located in the North County irrigation area.

The model includes a user-specified total storage and monthly demand schedule (including frost control), as shown in Table 2.3-3. Unlike the modeled Laguna irrigation, for which several years of operations data were available to develop irrigation application rates based on ET, modeling of irrigation in the North County area follows a more generic approach. Monthly demand is calculated as the total specified storage, representing an assumed irrigation application area, multiplied by the demand percentages.

Because the demand for irrigation supply is assumed to exceed recycled water supply, the model simulates storage only. The model is set up to reflect an assumption that recycled water in storage is completely utilized by agriculture in any given year and that the full volume of storage is available in the subsequent year.

Table 2.3-3 Monthly North County Storage Demand by Percentage

Month	Demand (percent/mo.)[(a)]	Month	Demand (percent/mo.)[(a)]
October	0.0[(b)]	April	20.0
November	0.0[(b)]	May	2.2
December	0.0	June	17.8
January	0.0	July	30.0
February	0.0	August	11.1
March	8.9	September	10.0[(b)]

(a) Demand is presented as a percentage of annual total demand. Demand percentages are based on typical wine grape production.
(b) October and November demand are estimated to be 6.7 and 3.3 percent of the total annual demand, respectively, and September demand is estimated to be zero; however, to avoid carryover storage from one water year to the next, these two months are combined (total of 10 percent of annual demand) and applied in September.

2.3.4 Urban Reuse

Use of recycled water demand to meet urban demands (e.g., urban landscaping, golf courses, parks, and other urban reuse) is another feature simulated by the WBM. Urban reuse is specified within the model on a monthly basis. Additional storage, designated specifically to support an urban reuse program, can be specified. A maximum conveyance rate from the treatment plant/system to storage and/or demand is specified.

(The model simulates recycled water in storage to be consumed by urban reuse; urban reuse demand volume is highly seasonal) (Table 2.3-4).

Table 2.3-4 Monthly Urban Reuse Demand by Volume

Month	Demand (mgd)[(a)]	Month	Demand (mgd)[(a)]
October	6.36	April	3.63
November	2.60	May	6.25
December	0.88	June	9.67
January	0.60	July	11.3
February	0.59	August	11.1
March	1.48	September	9.90

(a) Demand is assumed to be constant over month.

2.3.5 Agriculture East of Rohnert Park

Recycled water reuse for agriculture in the area east of Rohnert Park is another feature of potential reuse simulated in the WBM. Because of the proximity of Rohnert Park to the Laguna, the model determines Rohnert Park water use in the same fashion as it does Laguna irrigation demand, where total irrigated acreage, vineyard acreage, and monthly ET are user-specified inputs to the model (Table 2.3-5). Additional storage, designated specifically to support Rohnert Park agriculture, can be specified. A maximum conveyance rate from the treatment plant/system to the storage and/or demand is specified.

The model is set up to simulate recycled water in storage being consumed by Rohnert Park agriculture, with the full volume of storage available in the following year.

Table 2.3-5 Monthly Rohnert Park Agriculture Irrigation Evapotranspiration Rates

Month	ET Rate (in./mo.)	Month	ET Rate (in./mo.)
October	2.25	April	0.63
November	0.69	May	2.12
December	0.00	June	4.08
January	0.00	July	5.13
February	0.00	August	4.95
March	0.28	September	3.34

2.4 Model Applications

The WBM has been and continues to be employed in various aspects of recycled water management (e.g., discharge, storage, and reuse) studies.

Key attributes of WBM output that are used in the assessment of facilities design and operation include recycled water production, Laguna storage, Laguna agriculture, supply and storage systems for potential future urban and Rohnert Park agricultural reuse, discharge (Laguna, river, and indirect), and Geysers Pipeline delivery.

The key discharge components of the model output shown in Table 2.4-1 are used in the assessment of alternatives within this engineering report.

Table 2.4-1 WBM Output Discharge Flows and Volumes

	Driest Year	Median Year	Wettest Year
Average Daily Discharge Flow (mgd)	7.6	11.5	21.5
Annual Discharge Volume (MG)	1,600	2,400	4,500

The allocation of recycled water was derived using an optimized simulation performed by the WBM and, therefore, it is based on various assumptions and representations of system elements/components – some of which were coarse representations of the actual physical system components.

The model continues to be refined and updated as appropriate data become available and the need to assess different potential activities is identified. Some of the refinements currently being completed include these:

- Extending the model hydrologic data set from 67 years to 95 years based on SCWA operations model output
- Revising operations for Rohnert Park and urban reuse storage facilities

- Updating wastewater production relationships and making other refinements

These refinements may lead to modest changes in the results, but they also will add flexibility and enhance the ability of the model to represent the various system operations and features considered within the discharge relocation analyses.

For this engineering report, the WBM has supplied information that was used several ways including the following:

- To identify available recycled water, which helped the analysis size indirect discharge facilities. The volume of available recycled water was examined according to season and year type, which helped identify the range of potential conditions.

- To identify available storage and compare it with required storage to determine the necessary additional storage to avoid temperature and dissolved oxygen non-compliance.

- To identify overall operational strategies of Laguna storage and to assess future elements of recycled water management, such as Laguna agriculture, urban reuse, and Rohnert Park agriculture.