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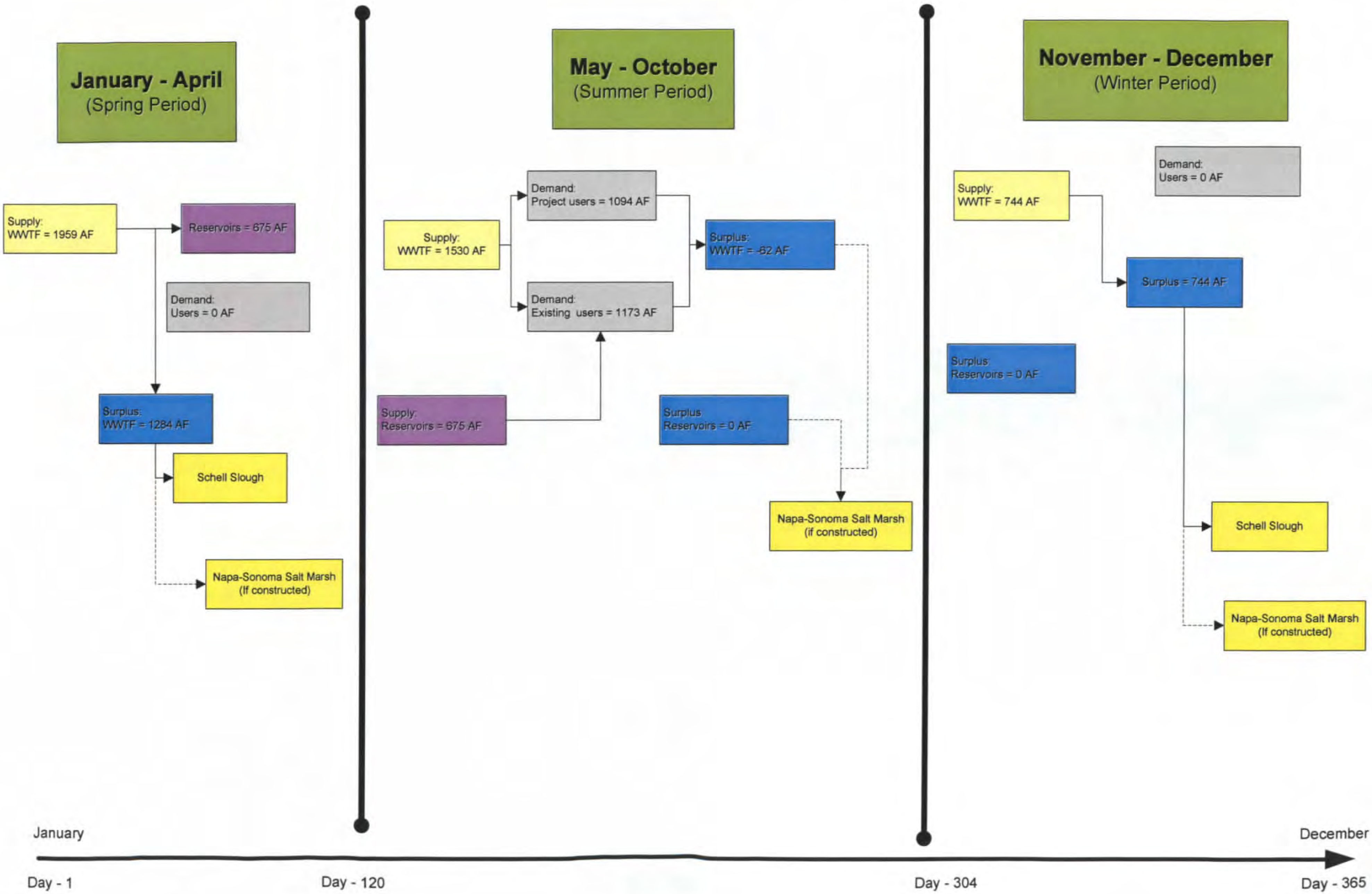

Alternative 1A Existing Average Annual Inflow, WWTF Effluent vs Total System Demand

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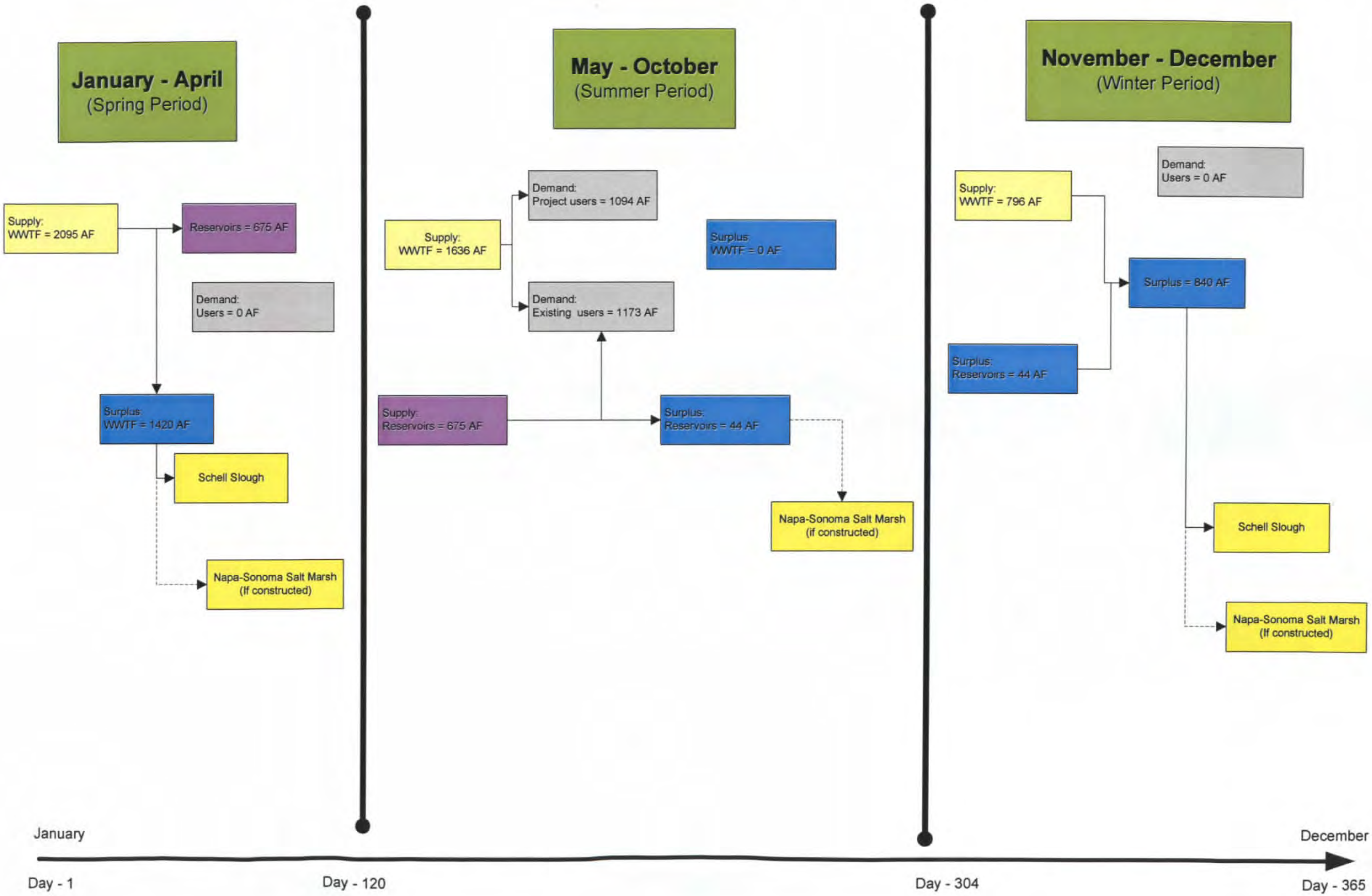

Alternative 1A Buildout Low Annual Inflow, WWTF Effluent vs Total System Demand

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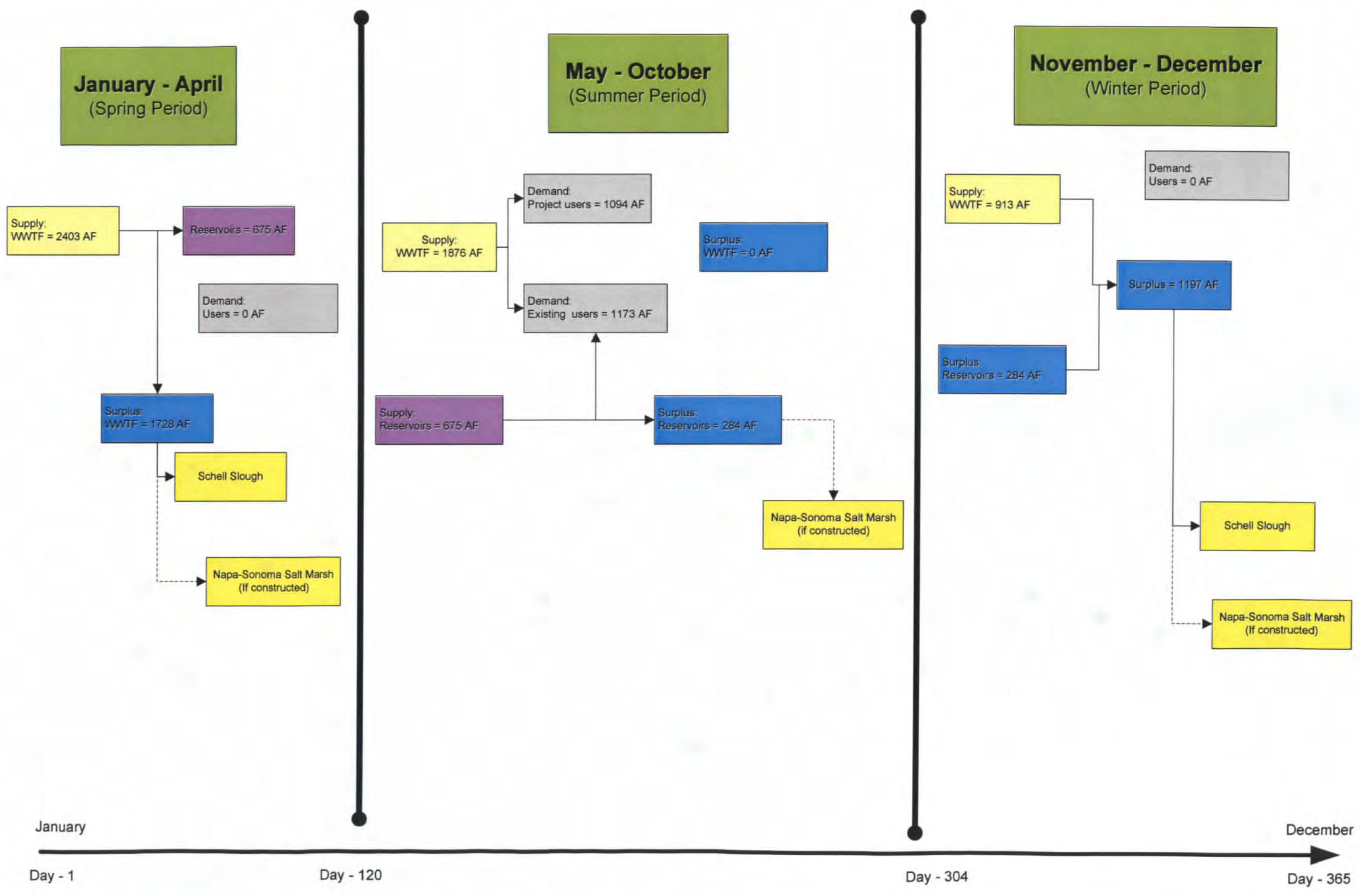

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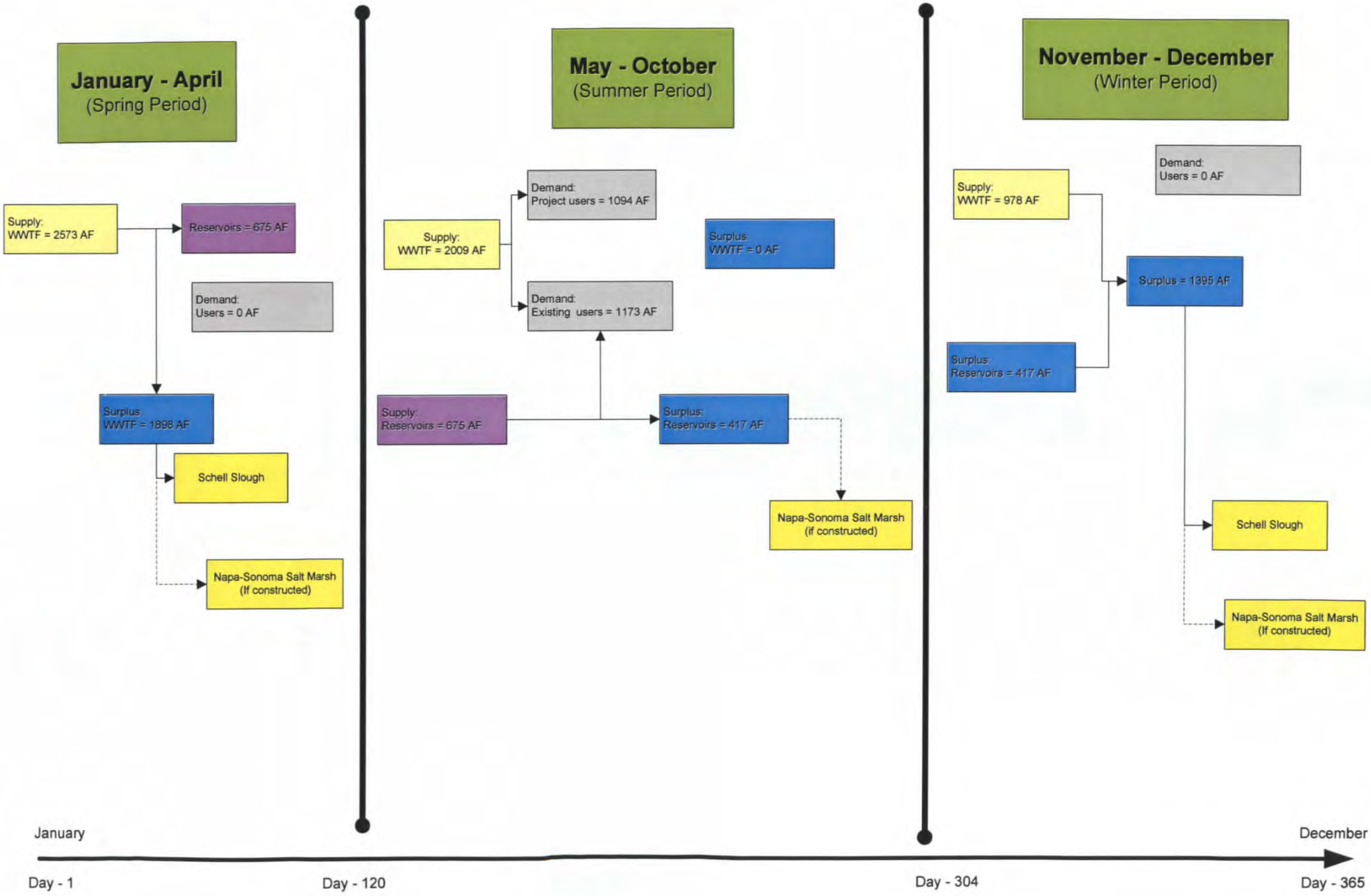

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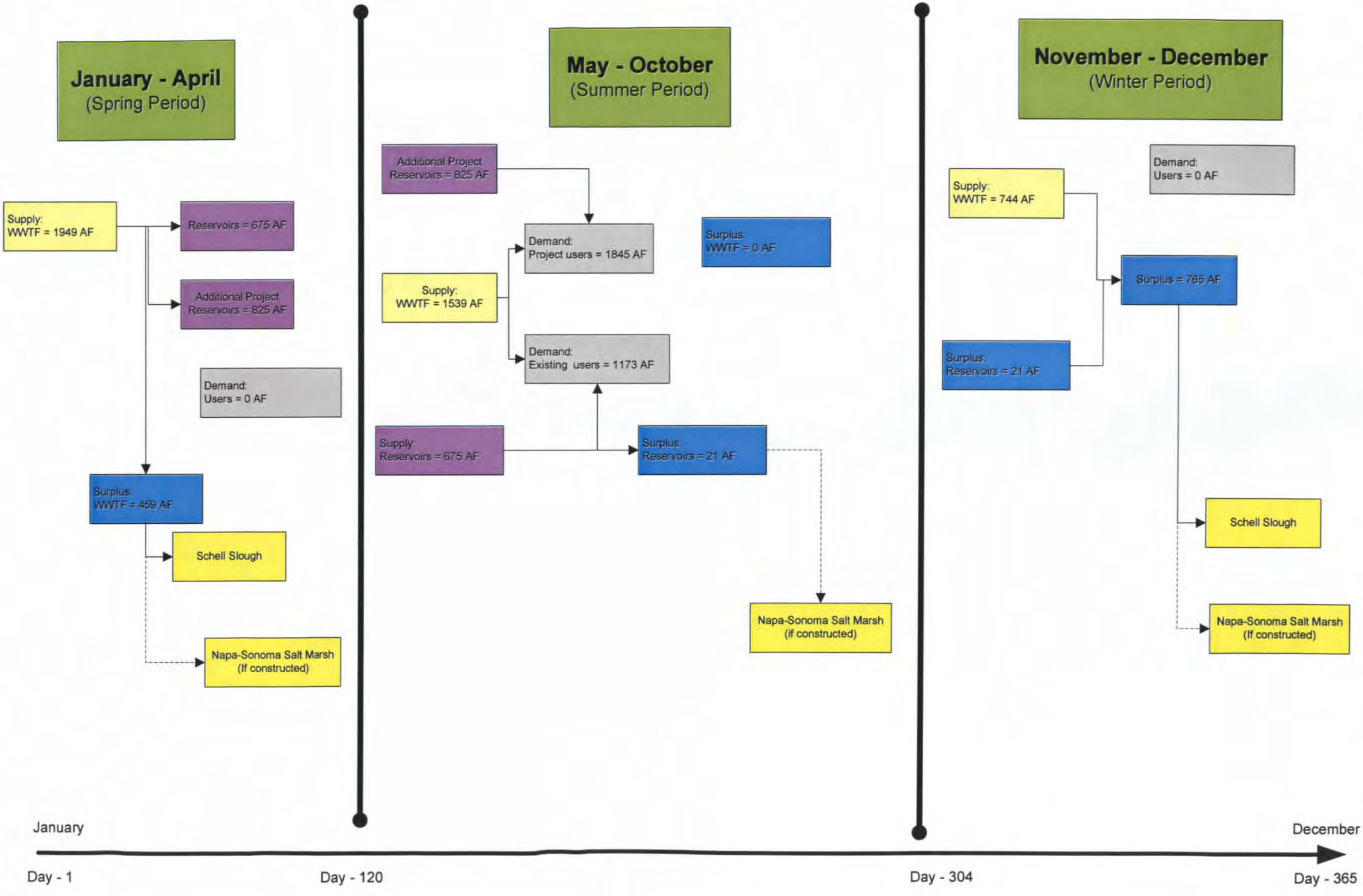

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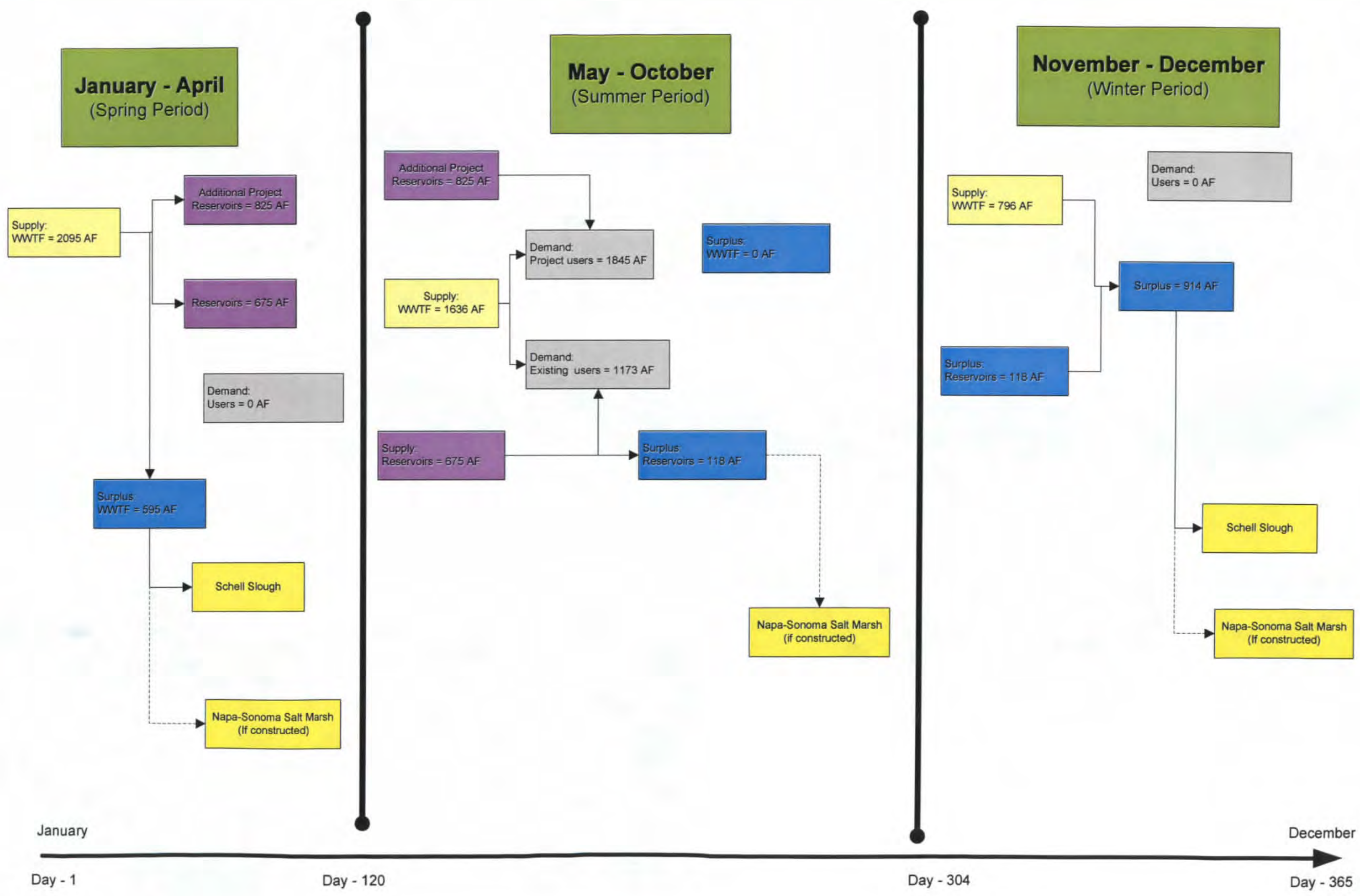

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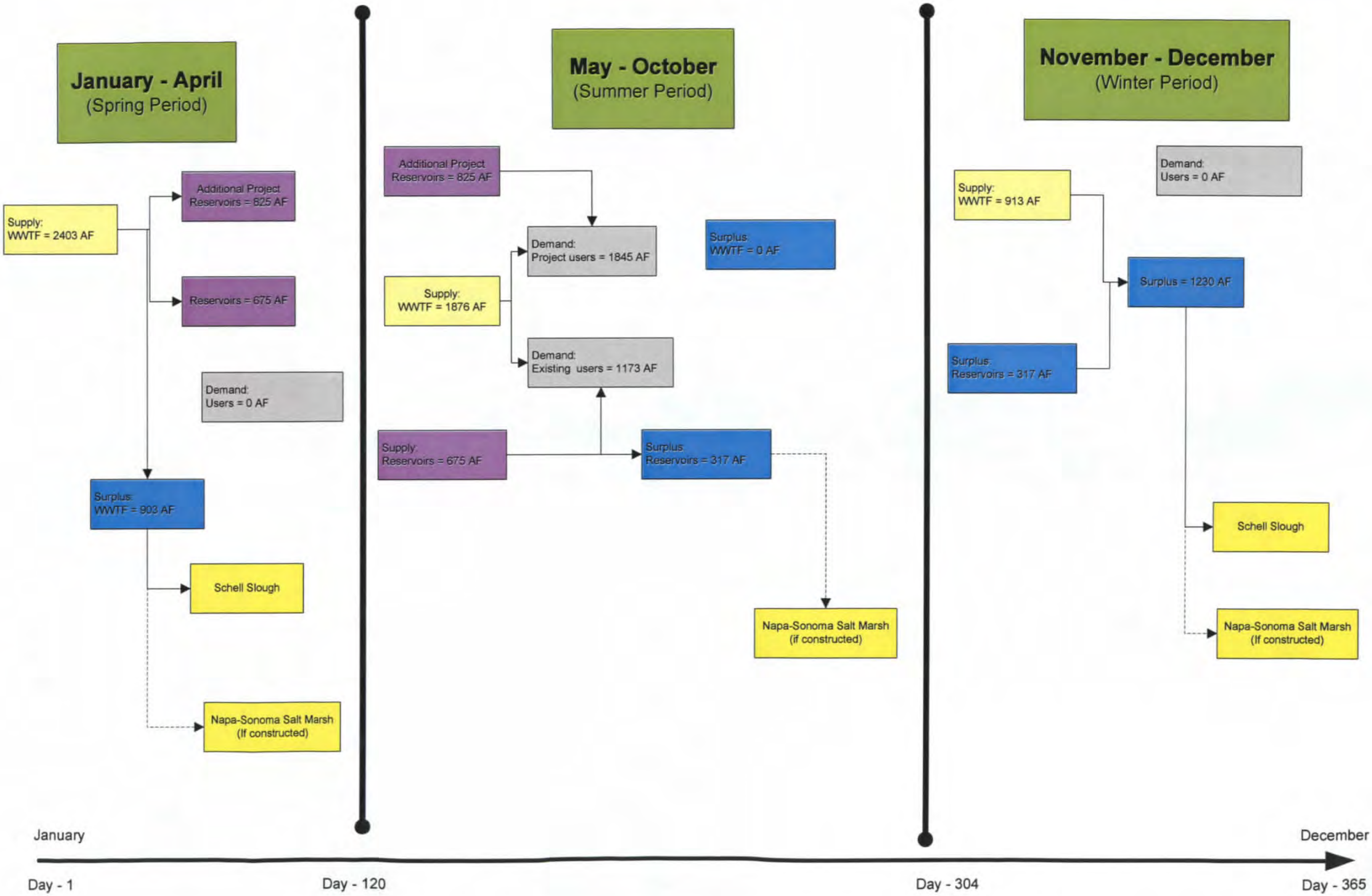

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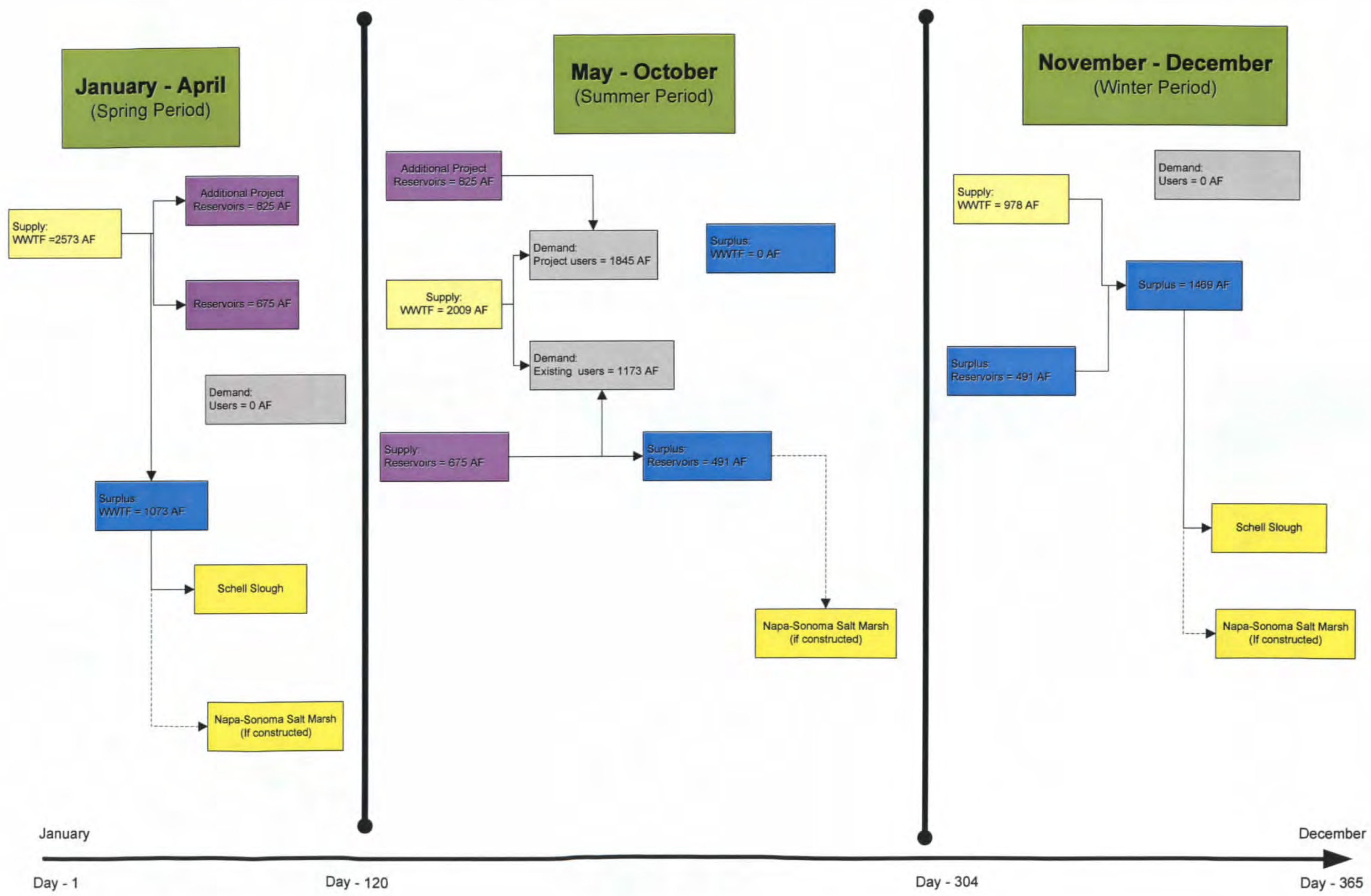

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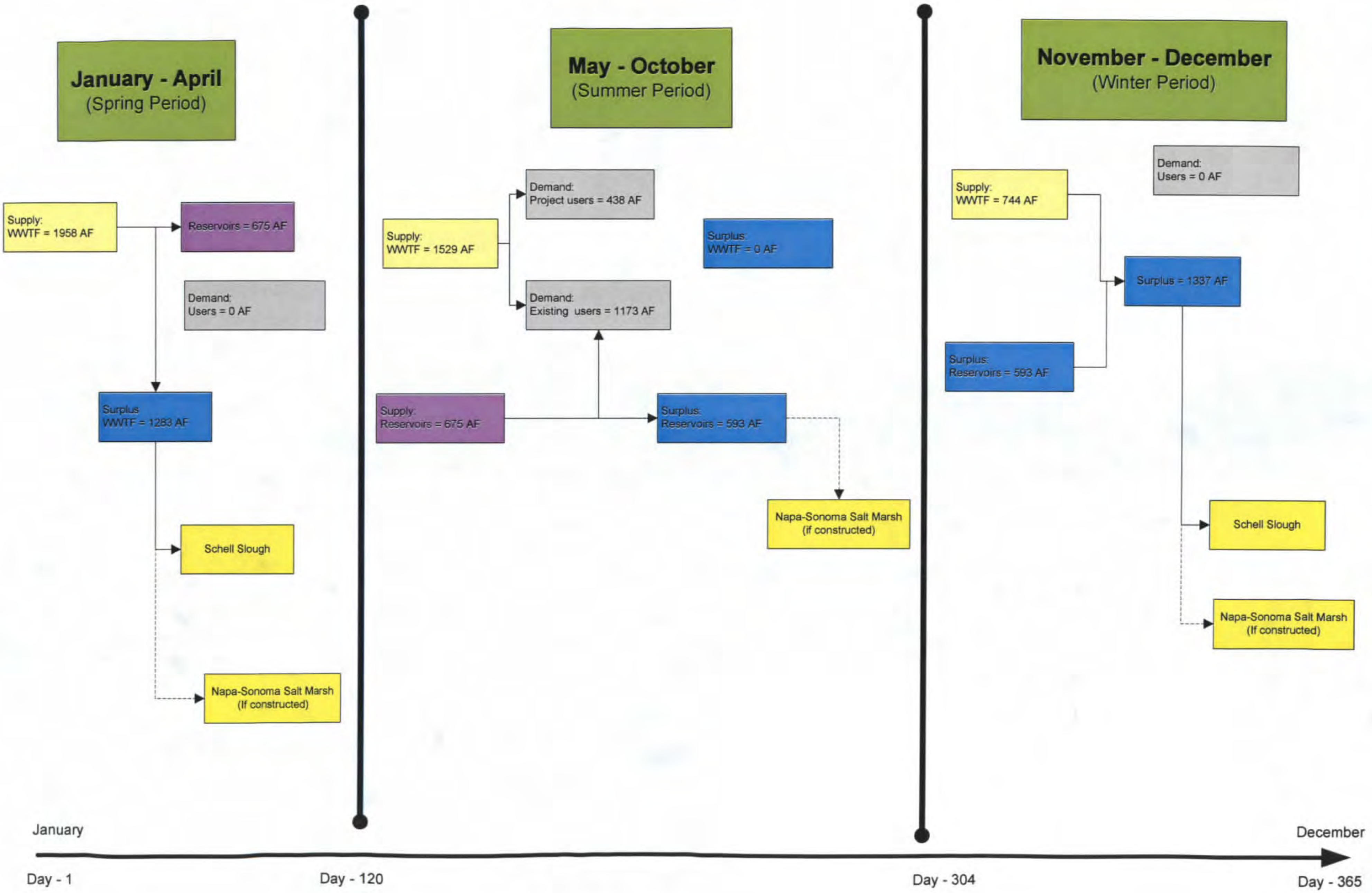

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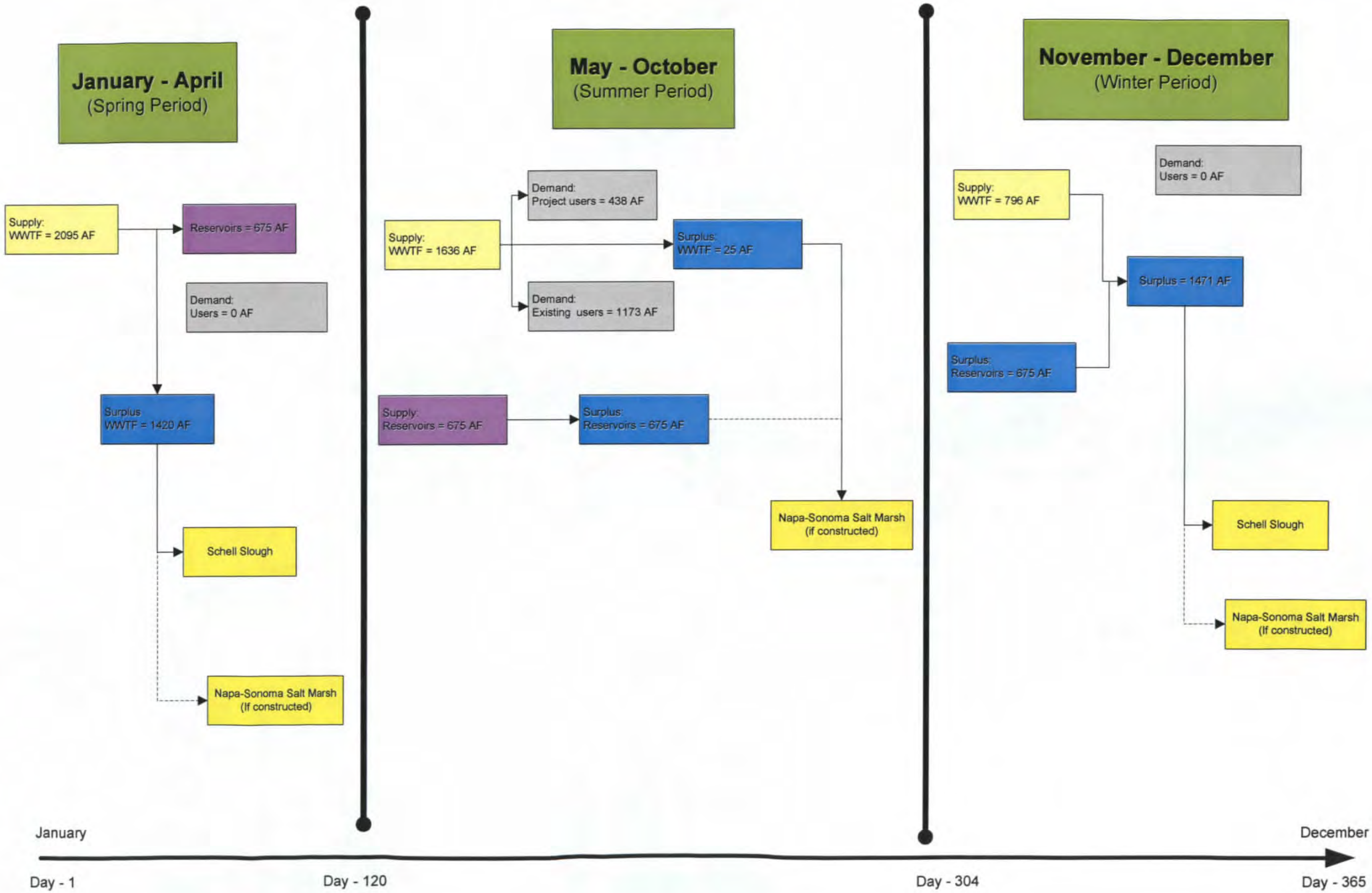

Alternative 2 Buildout Low Annual Inflow, WWTF Effluent vs Total System Demand

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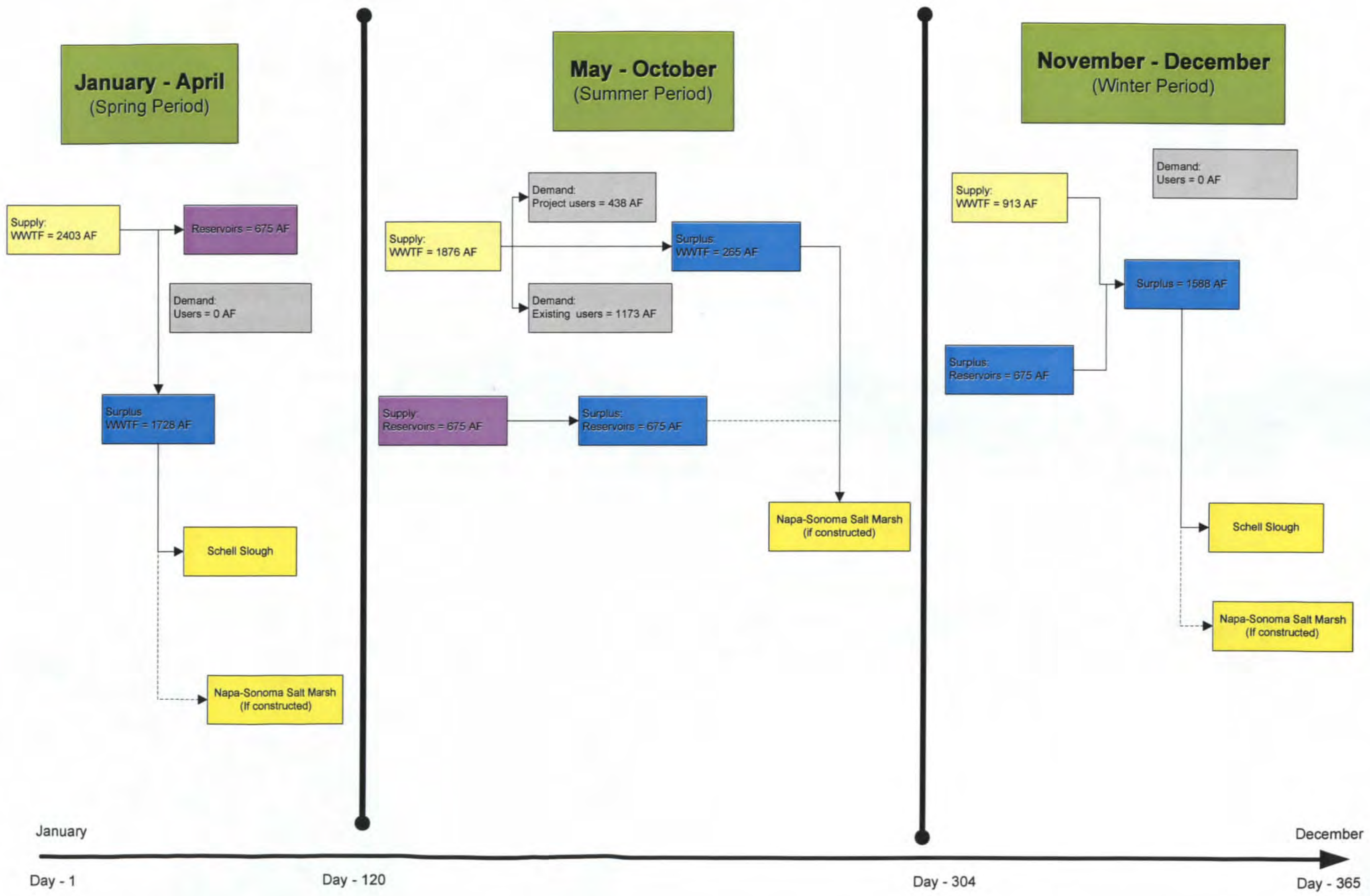

Alternative 2 Buildout Average Annual Inflow, WWTF Effluent vs Total System Demand

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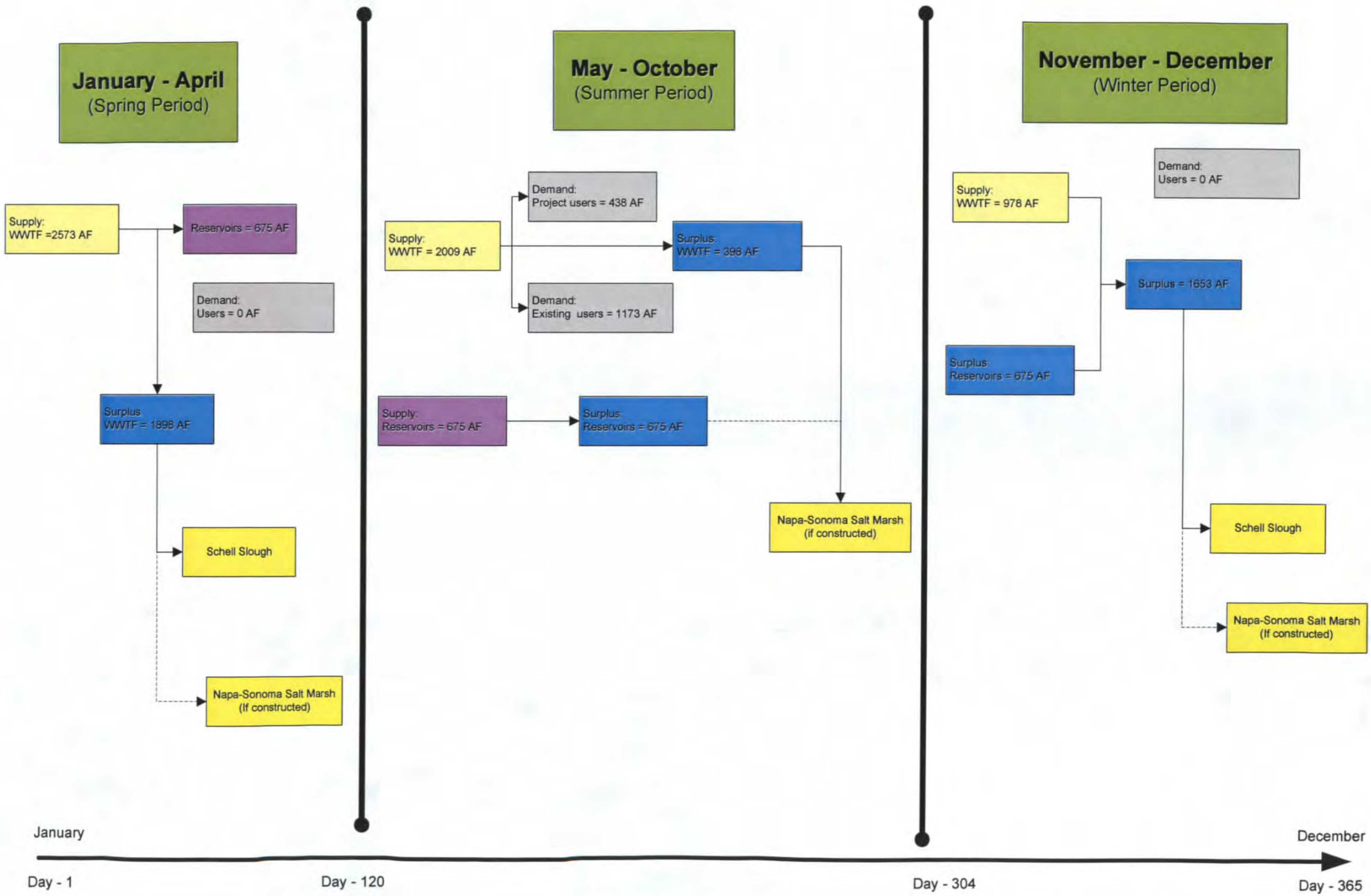

Alternative 3 Existing Low Annual Inflow, WWTF Effluent vs Total System Demand

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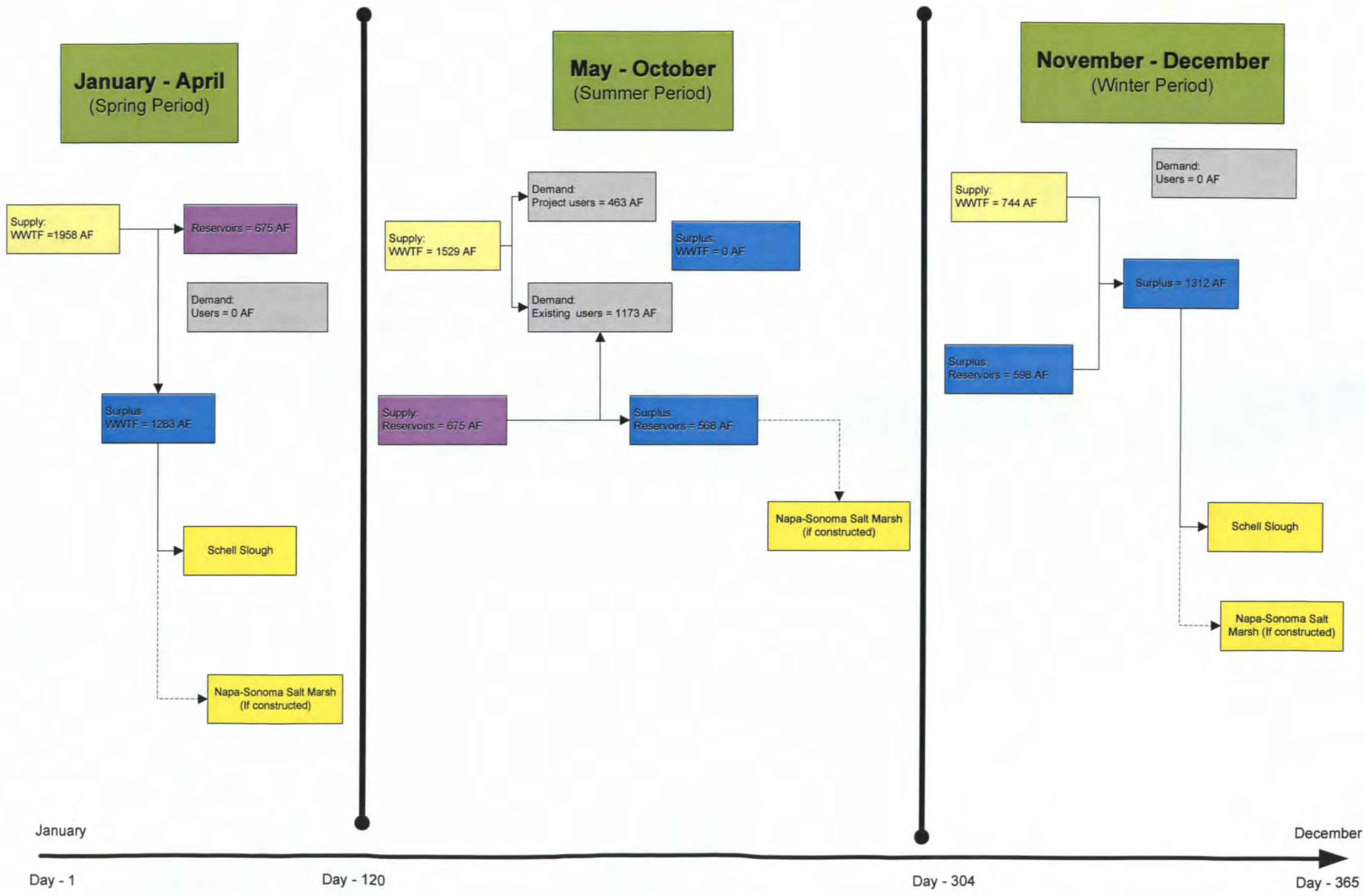

Alternative 3 Existing Average Annual Inflow, WWTF Effluent vs Total System Demand

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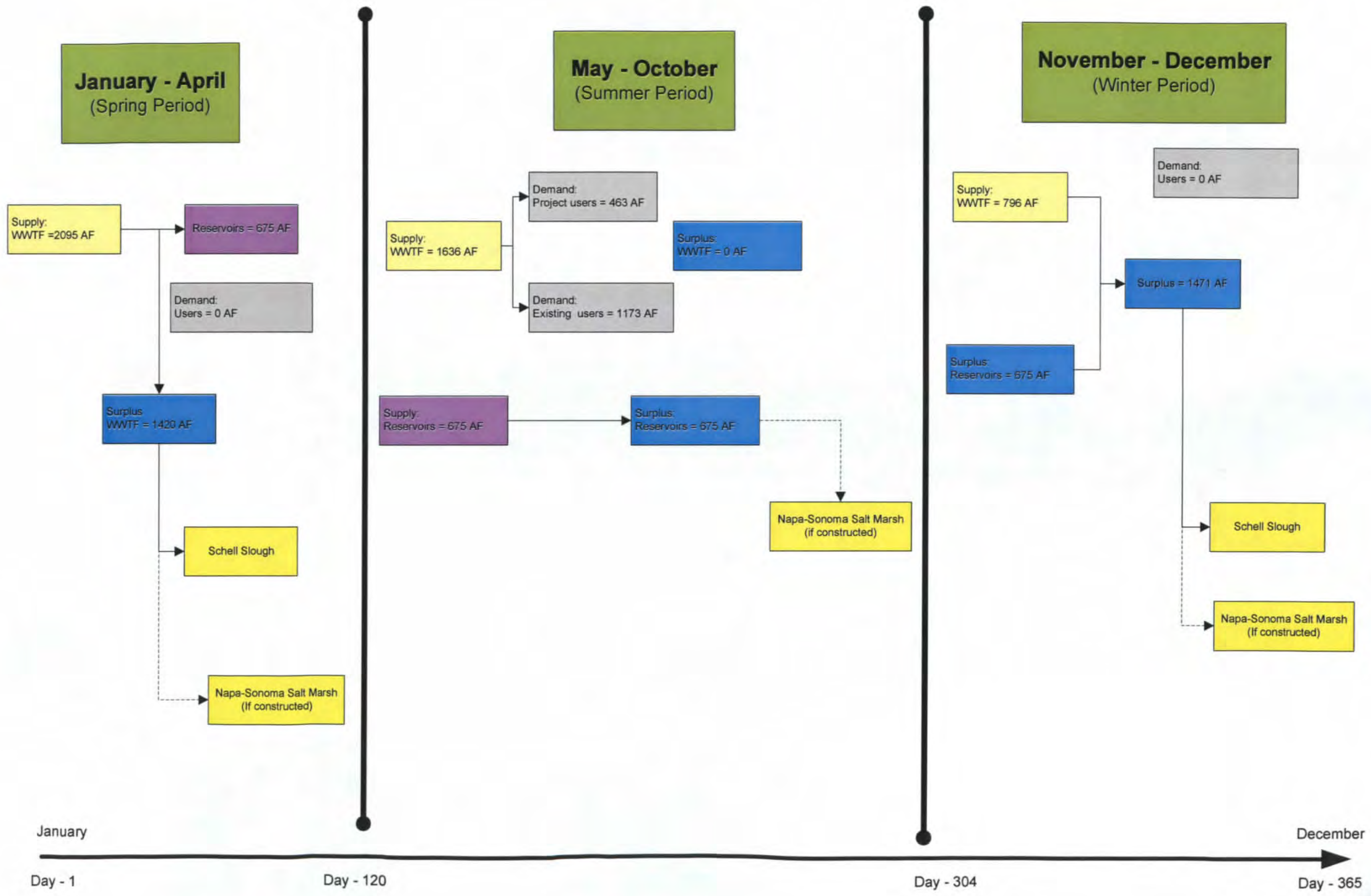

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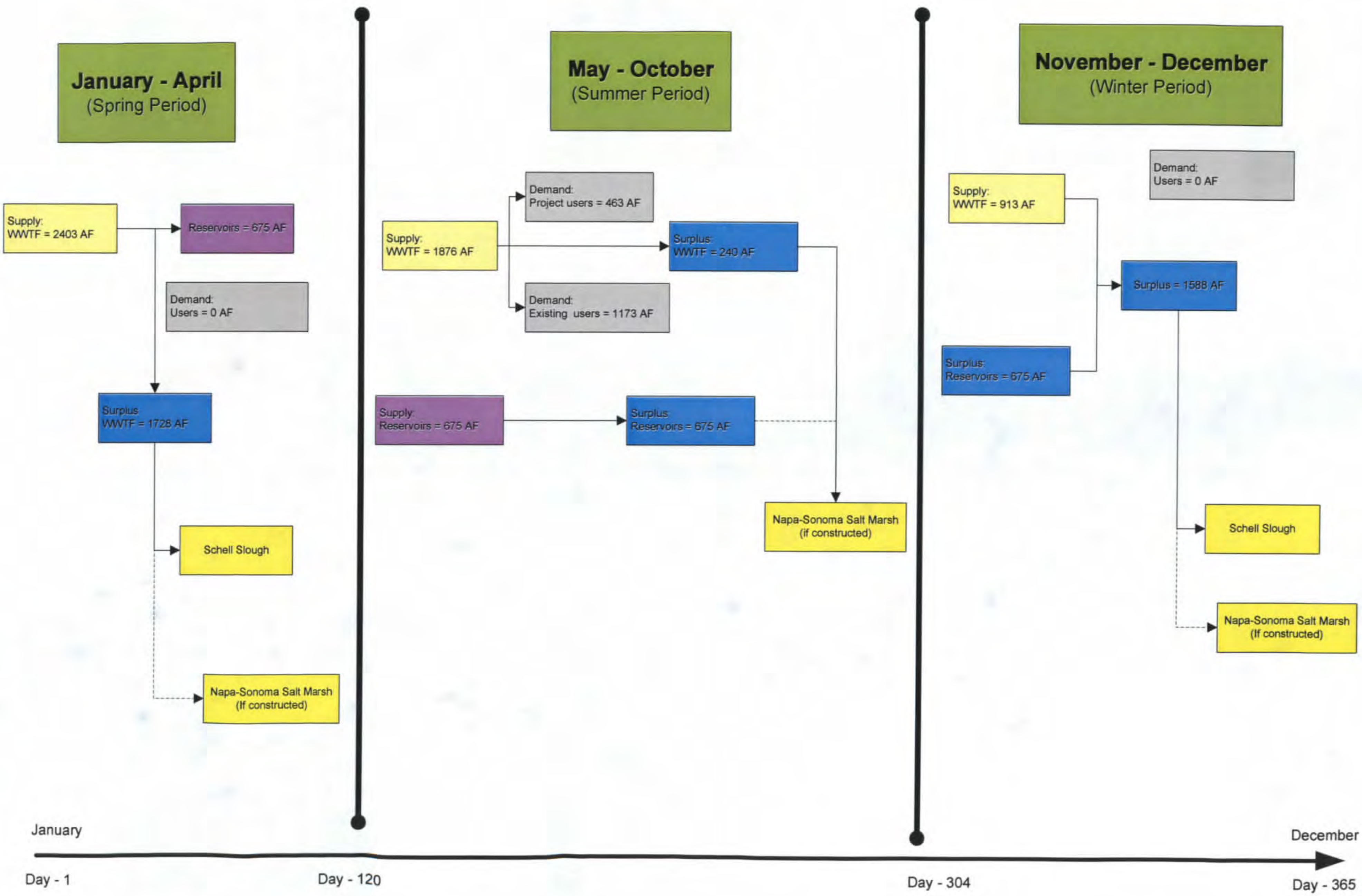

Alternative 3 Buildout Average Annual Inflow, WWTF Effluent vs Total System Demand

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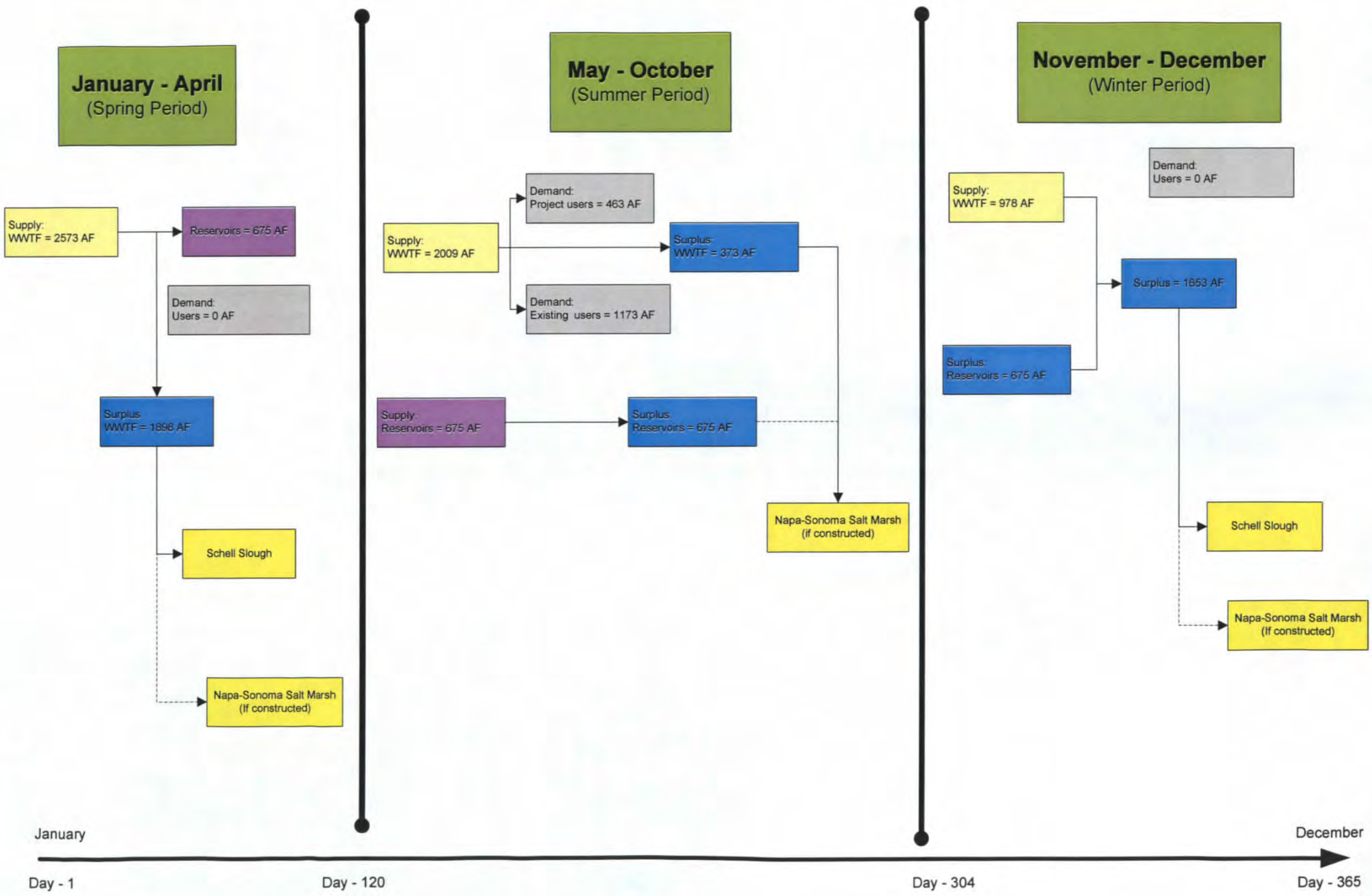


APPENDIX E

SATELLITE TREATMENT PLANT STUDY

APPENDIX E

SATELLITE TREATMENT PLANT STUDY

NORTH BAY WATERSHED ASSOCIATION

Satellite Treatment Plant Project

Executive Summary Report

February 2005

RMC

NBWA Satellite Treatment Plant Project

EXECUTIVE SUMMARY

Introduction

The North Bay Watershed Association (NBWA) was created to promote cooperation between local and regional public agencies on water resources issues related to the North Bay watershed. In accordance with that goal, NBWA's Integrated Water Resources Committee initiated the North Bay Regional Water Recycling Feasibility Study. Phase One of the Study looked at the feasibility of the water and wastewater agencies of the North Bay acting together on a regional recycling project in order to achieve zero wastewater discharge into the Bay. Once this study was complete, the focus turned to finding innovative ways to deliver recycled water within each agency's sphere of influence. This report consists of Phase Two of this Regional Recycling Study: The Satellite Treatment Plant Project.

The NBWA Member Agencies

Central Marin Sanitation Agency
County of Marin
Las Gallinas Valley Sanitary District
Marin County Sanitary District #5
Marin County Stormwater Pollution Prevention Program
Marin Municipal Water District
Napa Sanitation District
North Marin Water District
Novato Sanitary District
City of Petaluma
City of San Rafael
City of Sonoma
Sonoma County
Sonoma County Water Agency
Sonoma Valley County Sanitary District

The purpose of this study is to determine the feasibility of locating a Satellite Water Recycling Facility within the water service areas of several of the NBWA Member Agencies:

- Marin Municipal Water District,
- North Marin Water District,
- Sonoma Valley County Sanitation District, and
- The Silverado Area of the City of Napa.

This feasibility study consisted of a 2-part approach. The first step was to define satellite recycled water treatment, determine its cost, and establish the criteria under which it should be considered as a water supply option. The second step was to apply these costs assumptions and siting criteria to the different study areas identified by the NBWA Integrated Water Resources Committee. The feasibility of siting satellite treatment plants in these study areas was preliminarily determined.

The results of this analysis are outlined in this executive summary.

Definition of Satellite Treatment

In order to determine the feasibility of locating a satellite treatment plant, it is first important to define what a satellite treatment plant is. The following is the definition of a satellite water recycling facility as used for this study:

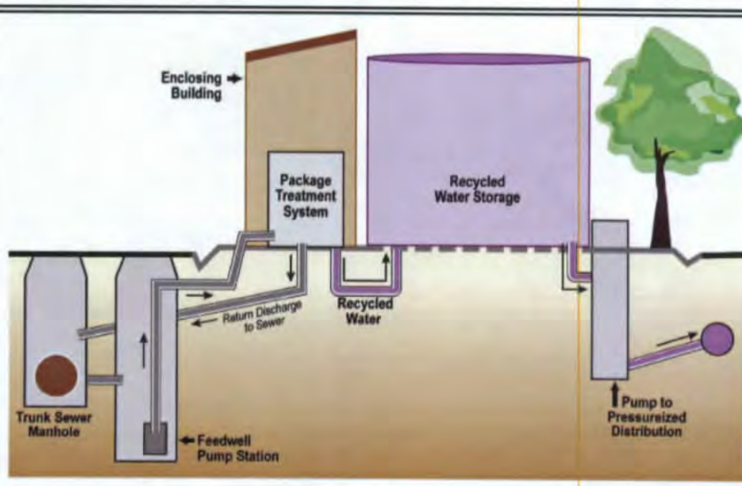
> ***Satellite Water Recycling Facility***: a package treatment plant that allows an agency to produce high quality effluent for beneficial reuse. Satellite facilities are relatively small (typically less than 1 mgd) compared to a centralized treatment facility and will generally be located adjacent to a trunk sewer, allowing raw wastewater to be diverted to feed the plant and allowing solids generated from the treatment process to be discharged directly back to the trunk sewer.

Satellite facilities can be operated as small "water factories", which generate recycled water when there is adequate demand and that can be by-passed when there is no need for the additional water supply. This type of facility is also occasionally referred to a "scalping plant".

Satellite Treatment Feasibility

There are two situations in which agencies should consider satellite recycled water treatment. These are:

1. A significant single water user or a concentration of water users is located at some distance from a central wastewater treatment or water recycling facility. In this case the cost of the package treatment plant and local recycled water distribution system may be less than the cost of adding tertiary treatment facilities and extending the distribution system from the central wastewater treatment plant.
2. Influent quality to the central wastewater treatment plant or water recycling facility is poor, typically from high total dissolved solids, or salty due to salt water intrusion or industrial discharges into the sewer collection system. In this case the cost of a package treatment plant, located upstream outside of the salt water intrusion or industrial discharge area, may be less than the cost of the advanced treatment technology, such as reserve osmosis needed to remove salts and produce water suitable for reuse.



Satellite treatment plants collect raw wastewater from trunk sewers in the vicinity of the recycled water users, minimizing pumping and piping costs for recycled water delivery.

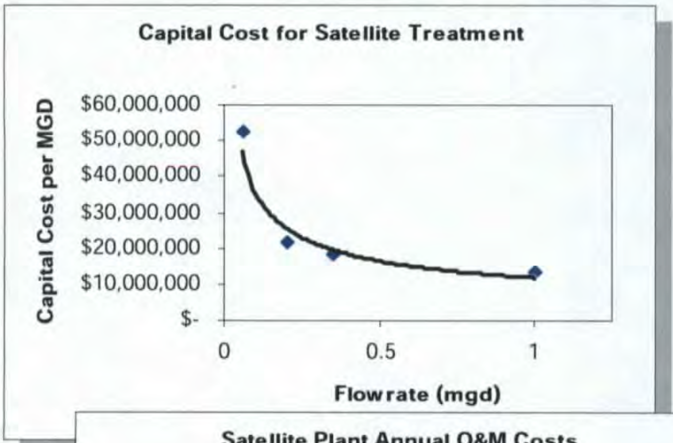
In order to find a reasonable potential location for satellite treatment, a location with high water demand can be matched up with a nearby trunk sewer with a high average flowrate. Locations with high water demand can be determined based on water use assumptions or records. Similarly, wastewater flowrates can be determined based on wastewater flow assumptions or collection system modeling.

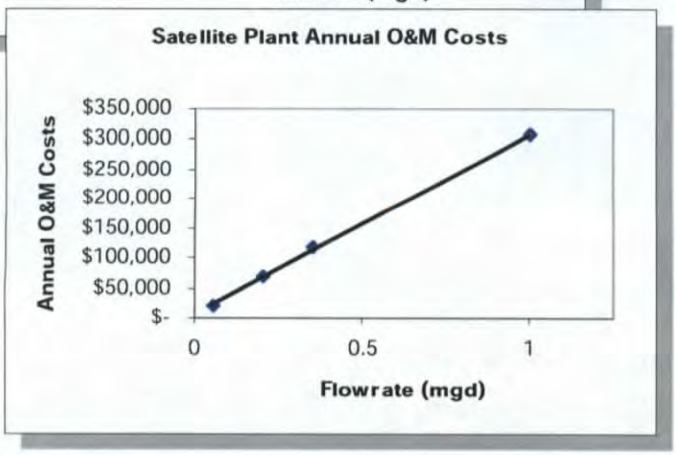
While initial identification of candidate users for satellite-treated recycled water is based on water demand and location relative to a sewer trunk, several other factors should be considered when choosing the physical site for the satellite treatment plant. These factors can vary widely between sites and need to be analyzed on a case-by-case basis. These considerations include:

- Land Area Available
- Utility Systems in Area
- Storage Needs
- Backup Water Supply Needs
- Solids Disposal
- Community Acceptability

Cost Development and Comparison Methods

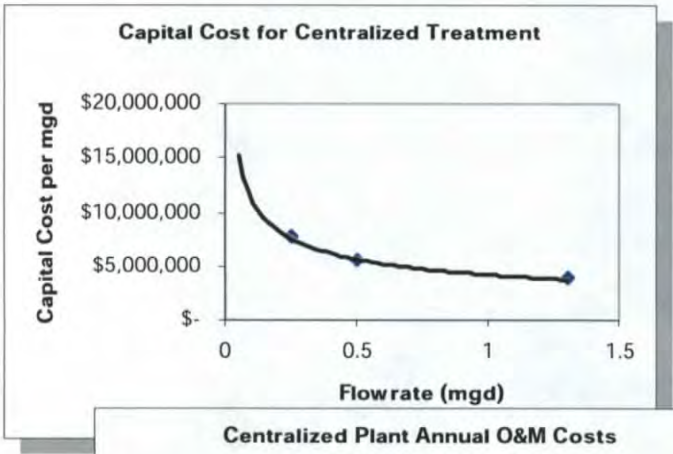
In order to determine the unit costs of satellite treatment, a preliminary cost analysis was done for a satellite plant with the following unit processes:

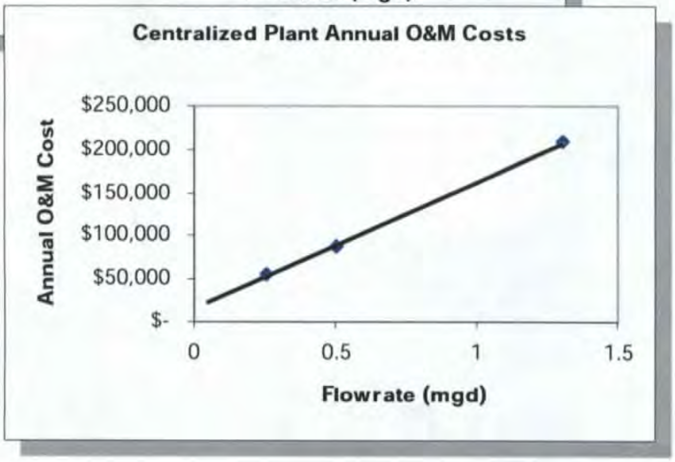




- A feedwell pump station from the sanitary sewer
- Screening
- A Membrane Bioreactor to provide secondary and tertiary treatment
- Ultraviolet Disinfection
- Solids return to the sanitary sewer
- An enclosing building for the treatment process train
- Power, instrumentation, controls
- Process chemical storage and feed
- A recycled water storage tank sized for 80% of plant capacity
- A recycled water pump station
- An allowance for landscaping

For feasibility analysis, it was necessary to develop a set of cost curves for central recycled water treatment. In the development of the centralized cost curves it was assumed that the cost would consist of adding tertiary treatment process to an existing secondary wastewater treatment plant. The cost curves for centralized treatment included:





- A granular media direct filtration unit
- Ultraviolet Disinfection
- Power, instrumentation, controls
- Process chemical storage and feed
- A recycled water storage tank sized for 80% of the filter capacity
- A recycled water pump station
- An allowance for modest landscaping

These cost curves were coupled with the Capital and O&M costs for recycled water distribution in order to determine if on-site satellite treatment is more or less feasible than centralized treatment and transmission.

Feasibility of Satellite Treatment in the North Bay

Once the planning level cost curves were developed and the criteria for determining satellite treatment feasibility determined, these tools were used to analyze the feasibility of satellite treatment in several locations in the North Bay.

Marin Municipal Water District Service Area

In the Marin Municipal Water District service area a range of candidate satellite treatment plant sites were identified using GIS-based water use records and sewer maps. Three locations were found do be potential satellite treatment candidates based on their distance from the central wastewater treatment plant, their large recycled water demand, and their proximity to a sewer main. These locations were:

- The Mill Valley Golf Course in Mill Valley
- The Peacock Gap area of San Rafael
- The Sir Francis Drake corridor in San Anselmo

Water demand within the MMWD service area was quantified using MMWD's user database. This database includes information on each users "entitlement", which is the total capacity that user can purchase in the system. The analysis focused primarily on irrigation demand and, as appropriate, the entitlement data was reviewed with respect to water use records.

For analysis of recycled water as a water supply, the cost of satellite treatment was compared to the District's next increment of water supply. For MMWD, this supply has been identified as desalination. MMWD anticipates that cost of future water supply through desalination will be $1,525 acre-foot.

The result of the cost analysis is shown in the following table. The cost of a satellite plant is evaluated for each site if sized for entitlement or estimated usage and these costs are compared to the identified cost of desalination.

Satellite Location	**Unit Cost $/AF (based on Entitlement)**	**Unit Cost $/AF (based on Estimated Usage)**
Mill Valley Golf Course	$6,140	$6,470
Peacock Gap	$3,420	$3,420
Sir Francis Drake – San Anselmo	$3,600	$5,950
Potable Service	**$/AF**	**$/AF**
Desalination – next increment of water supply	$1,525	$1,525

Sonoma Valley Service Area

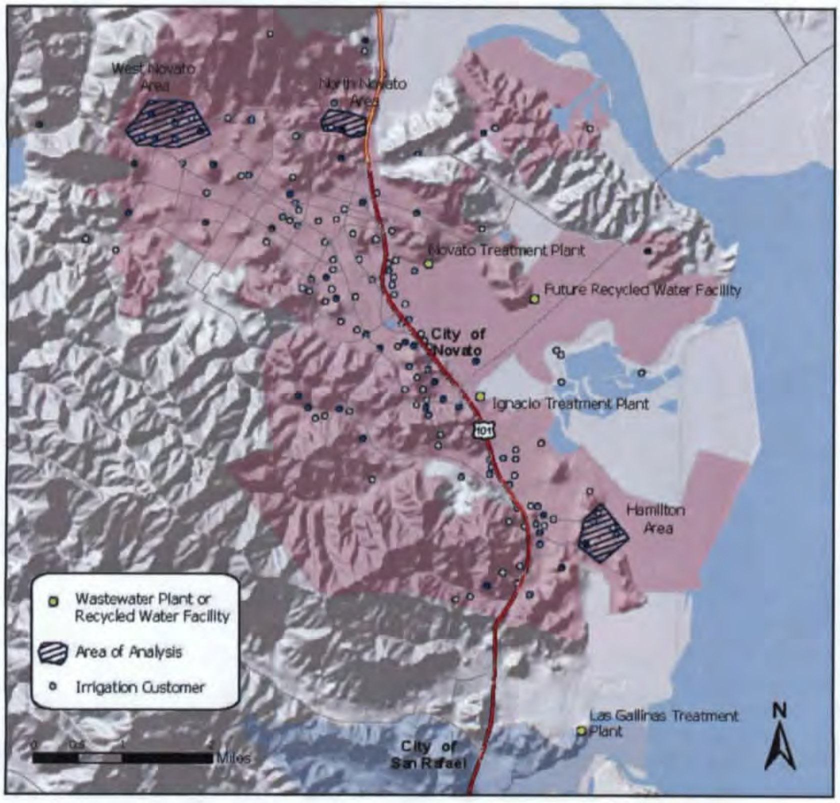
The Sonoma County Water Agency provided recycled water demand data for the water users identified in its recycled water master plan. This water demand data was matched up with sewer flowrate estimates from recent sewer modeling efforts. Applying this strategy to Sonoma Valley resulted in a focus on the Boyes Hot Springs area. The irrigation users in the area were discussed in two separate sets of analysis. The first analysis estimates the cost of supplying only the current Valley of the Moon Water District (VOMWD) customers with recycled water. The second estimates the cost of supplying all of the major users in the area, including those that are currently irrigated using private wells.

Supplying recycled water to the current VOWMD customers would require recycled water facilities sized to treat 150,000 gallons per day. Supplying all of the potential recycled water users in the area would require a 720,000 gpd plant. The costs of both of these scenarios are outlined in the table below.

Alternative	**Unit Cost for Satellite Treatment $/AF**	**Unit Cost for Centralized Recycled Water $/AF**
720,000 gpd Satellite Facility – Supplying all potential recycled water customers	$2,609	$2,249
150,000 gpd Satellite Facility – Supplying only current VOMWD customers	$5,881	$6,891

North Marin Service Area

Recycled water demand within the NMWD service area was quantified using the demand tables outlined in the April 2003 Recycled Water Master Plan, prepared by Nute Engineering. The recycled water demand was combined with land uses estimates of sanitary sewer flow to identify three potential satellite locations in Novato. There was a location in West Novato, North Novato, and the Hamilton Field area.

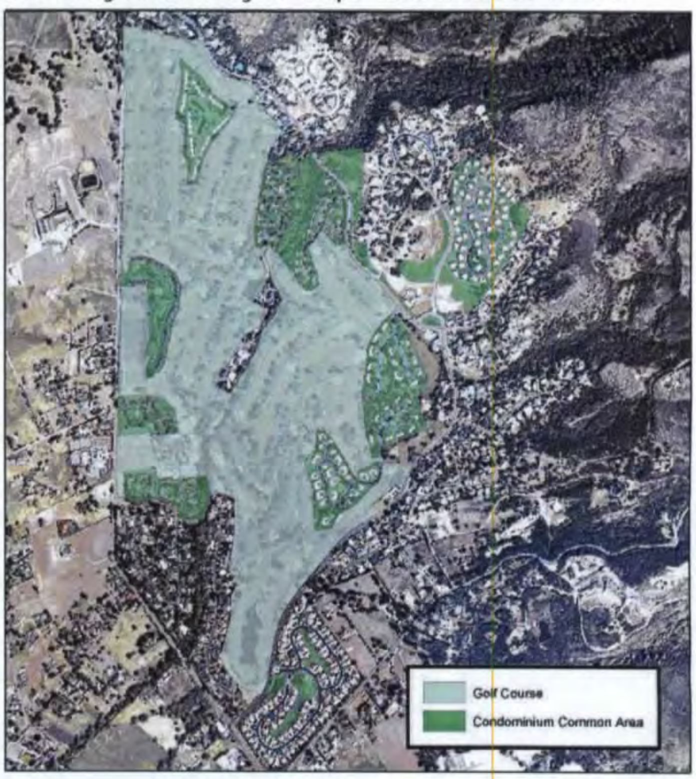


For analysis of recycled water as a water supply, the cost of satellite treatment was compared to the estimated value to North Marin Water District (NMWD) of the potable water replaced by recycled. This estimated value was determined based on NMWD's current water charges. The following table summarizes the cost analysis for each of the potential satellite treatment plant locations.

Satellite Location	Unit Cost for Satellite Treatment $/AF	Unit Cost for Centralized Recycled Water $/AF	Value of Potable Water Replaced $/AF
West Novato	$3,290	$4,197	$2,720
North Novato	$2,680	$2,670	$2,650
Hamilton Field	$2,920	$2,330	$2,630

Napa Service Area

The study of the satellite treatment feasibility in the City of Napa was focused on the Silverado area of the City. There are several irrigation water users in the Silverado area, most notably, the Silverado Country Club and Resort. The users were identified using parcel maps and land use information from the Napa County GIS system. According to the land use information, the two largest water users in the Silverado Area are the Silverado Country Club golf courses, and the common use areas of the surrounding condominiums.



The feasibility of placing a satellite plant in the Silverado area is constrained by the flowrate in the Silverado sewer main. Whereas the estimated demand of the area was approximately 2.2 mgd, there was only enough raw wastewater to support a 150,000 gpd plant. The cost of a satellite plat was compared to the cost of supplying the same amount of water from the centralized wastewater treatment plant (Soscol), as well as the unit cost of supplying recycled water from the Soscol plant to meet the entire demand. These costs are compared to the unit cost of potable water in the table below.

Water Source	Unit Cost $/AF
150,000 gpd satellite recycled water plant	$4,300
150,000 gpd recycled water supply from Soscol	$8,670
2.2 mgd recycled water supply from Soscol	$1,670
Potable water provided by City of Napa	$1,050

Conclusions

Part 1 of this study (Technical Memorandum No. 1) established criteria and cost assumptions for siting satellite recycled water plants near areas with high recycled water demand. This set of criteria can be used to generally assess the feasibility of utilizing satellite treatment in a given setting.

When these criteria were applied to the communities that the North Bay Watershed Association identified, the analysis led to no identified feasible locations for satellite treatment.

This feasibility analysis focused on satellite treated recycled water as a water supply option. For this reason, even when satellite treatment and distribution resulted in lower unit costs providing recycled water from centralized wastewater treatment plants, the costs were still higher than providing potable water to these locations. Satellite treatment becomes more feasible if other factors, such as wastewater discharge prohibitions, or wastewater treatment plant capacity issues are taken into account.

Technical Memorandum No. 1

RMC
Raines, Melton & Carella, Inc.
Consulting Engineers/Project Managers

Subject: General Process and Distribution System Overview

Prepared For: North Bay Watershed Association – Integrated Water Resources Committee

Prepared By: Raines, Melton & Carella, Inc.

Date: May 18, 2004

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Section 1 Introduction

The North Bay Watershed Association's (NBWA's) Integrated Water Resources Committee is conducting a study to understand the feasibility of locating a Satellite Water Recycling Facility within the water service areas of Marin Municipal Water District, North Marin Water District, the Sonoma Valley County Sanitation District, and the City of Napa. This work grows out of the North Bay Regional Water Recycling Study (the Regional Study) but has a different perspective. The Regional Study asked the question, "If the North Bay agencies were to act together on a regional recycling project, would it be possible to go to zero discharge?" This study asks the question, "If we look closely at our neighborhoods, can we generate a viable water supply from what would otherwise be wastewater?" The Regional Study has a discharge elimination focus and this study has a water supply focus.

All water recycling projects require cooperation between the water supply agency and the agency responsible for wastewater treatment. In this case, the water service areas described above include the service area of the following agencies responsible for wastewater treatment:

- Marin County Sanitary District #5
- Sausalito-Marin City Sanitary District
- Sewerage Agency of Southern Marin
- Richardson Bay Sanitary District
- Central Marin Sanitation Agency
- Las Gallinas Valley Sanitary District
- Novato Sanitary District
- Sonoma Valley County Sanitation District
- Napa Sanitation District

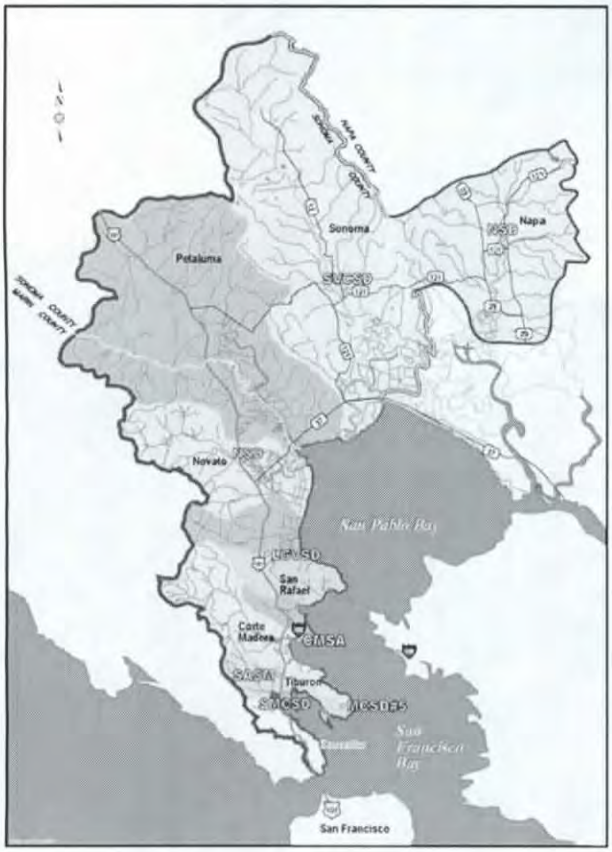

Figure 1 Study Area

Figure 1 illustrates the study area, the approximate limits of each water supply agency's service area and the location of the central wastewater treatment facilities.

1.1 Purpose

The overarching purpose of the Satellite Treatment Study is to identify feasible locations for remote water recycling facilities, in which "remote" means located away from the centralized wastewater treatment plant. This first Technical Memorandum is focused on outlining the general considerations that go into siting a satellite water recycling facility and developing some basic cost estimating tools that can be used in evaluating candidate locations. Subsequent Technical Memoranda will apply these general criteria in each specific water service area in order to analyze the feasibility of a satellite plant.

Figure 2 illustrates the decision process that guides this study. It is based on comparing the cost of recycled water to the cost of providing potable water for the same purpose. The remainder of this Technical Memorandum discusses the steps illustrated in this decision process and is intended to provide a general overview of the screening process used to identify candidate satellite water recycling projects.

However, other factors should also be considered by agencies in evaluating the feasibility of recycled water projects. For example, recycled water projects can provide wastewater related benefits by reducing the mass of wastewater discharged to the receiving water, environmental benefits by postponing development of new potable water sources, public education benefits by illustrating the value of water, etc. The value of these other benefits will vary widely depending on the driving forces behind implementation of a particular recycled water project. The economic evaluations is this Technical Memorandum should be supplemented by these site-specific factors, if possible by monetizing the benefits and including them in the benefit/cost comparison. If the benefits can not be translated into monetary values, a supplemental decision process that incorporates economic and non-economic factors can be used.

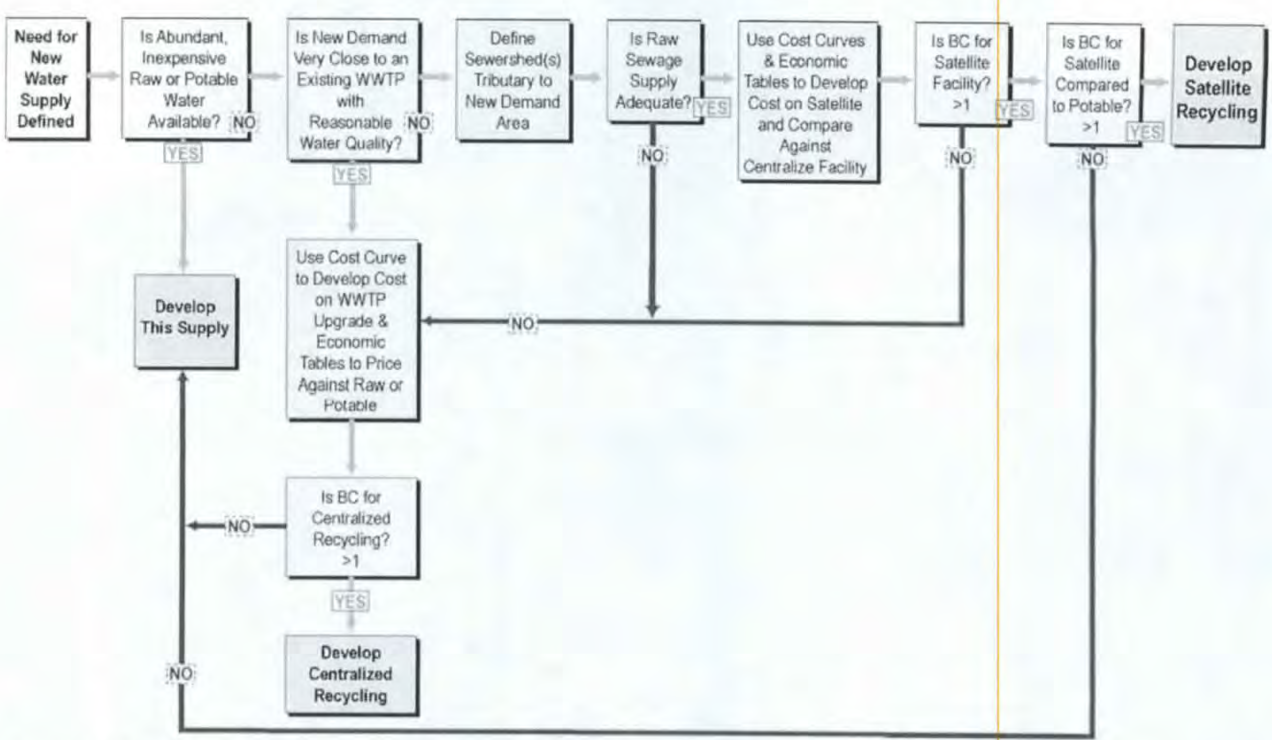

Figure 2 Decision Process Flow Chart Based on Comparative Costs of Water Supplies

1.2 Definitions and Assumptions

This study is focused on a specific type of facility intended to satisfy a water demand in a relatively remote location. This study limits both the flow range and technology options reviewed in order to focus on systems that do not require custom process design, can be delivered to remote sites affordably and which lend themselves to a general evaluation technique that can be used by many different agencies as a first-order screening tool. In addition, because this study is prepared for northern California agencies, the study assumes that all beneficial reuse will be governed by the standards outlined in California's Code of Regulations, Title 22 (Title 22). Title 22 proscribes very high standards for recycled water quality effluent, which may not be universally required.

Two definitions are offered below which will be utilized to limit the range of analysis considered in this study.

Satellite Water Recycling Facility: a satellite water recycling facility is defined as a package treatment plant that allows an agency to produce high quality effluent for beneficial reuse. Satellite facilities are relatively small (typically less than 1 mgd) compared to a centralized treatment facility and will generally be located adjacent to a trunk sewer, allowing raw wastewater to be diverted to feed the plant and allowing solids generated from the treatment process to be discharged directly back to the trunk sewer. Satellite facilities can be operated as small "water factories", which generate recycled water when there is adequate demand and that can be by-passed when there is no need for the additional water supply. This type of facility is also occasionally referred to a "scalping plant". Figure 3 provides a conceptual illustration of a satellite water recycling facility.

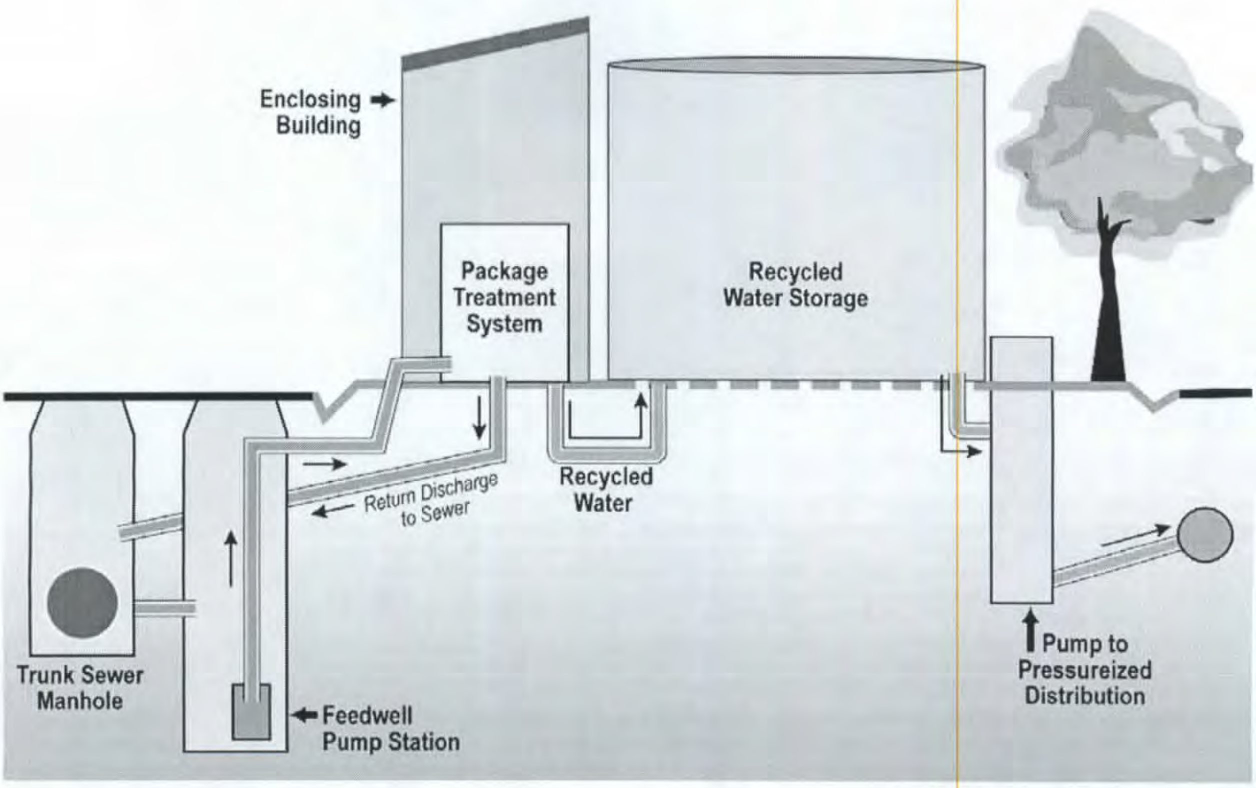

Figure 3 Satellite Plant Conceptual Illustration

Package Treatment Plant: a package treatment plant is a wastewater treatment plant capable of producing effluent that meets at least secondary quality, in which each process component is designed and produced by a single manufacturer and which is generally available for delivery to the site as a complete unit. For those package plants producing secondary quality effluent, additional tertiary filtration and disinfection are required to meet Title 22 requirements.

1.3 When to Consider a Satellite Water Recycling Facility

Satellite water recycling facilities bear consideration under several different sets of circumstances.

1. A significant single water user or a concentration of water users is located at some distance from a central wastewater treatment or water recycling facility. In this case the cost of the package treatment plant and local recycled water distribution system may be less than the cost of adding tertiary treatment facilities and extending the distribution system from the central wastewater treatment plant.
2. Influent quality to the central wastewater treatment plant or water recycling facility is poor, typically from high total dissolved solids, or salty due to salt water intrusion or industrial discharges into the sewer collection system. In this case the cost of a package treatment plant, located upstream outside of the salt water intrusion or industrial discharge area, may be less than the cost of the advanced treatment technology, such as reserve osmosis needed to remove salts and produce water suitable for reuse.

1.4 Alternatives for Comparison

Although this Technical Memorandum focuses on recycled water as a water supply, recycled water can also provide benefits to a wastewater agency by reducing the mass loading of wastewater discharged. If, for example, a wastewater agency is required to reduce its mass loading of discharge, it could proceed in two directions:

- Develop a recycled water to divert flow, and therefore mass, from the discharge
- Upgrade the treatment processes to increase the removal efficiency through the plant.

Often, development of a recycled water project is a more cost-effective alternative and provides ancillary water supply and environmental benefits. The benefits of reduced wastewater discharge tend to be site-specific depending on whether this is an issue of concern for the wastewater agency. Therefore, in addition to the water supply benefits discussed in this memorandum, evaluation of recycled water projects should also determine whether there are specific wastewater-related benefits that should be incorporated in the economic evaluation.

As related to water supply benefits, a satellite treatment plant's feasibility as a water supply can be determined by comparing its cost-effectiveness to two basic alternatives. The first alternative water supply strategy is expansion of the existing water system to serve the need. This can generally be modeled as the cost of the next "new" increment of water supply that an agency needs to purchase. The next "new" increment could be conserved water and this comparison should be made if possible. The second alternative water supply strategy is development or expansion of a centralized water recycling facility. Figure 4 illustrates how in a single water service area, some customers might be most affordably served with recycled water processed at a central plant, some by recycled water processed at a satellite plant and some customers might be most affordably served by potable water.

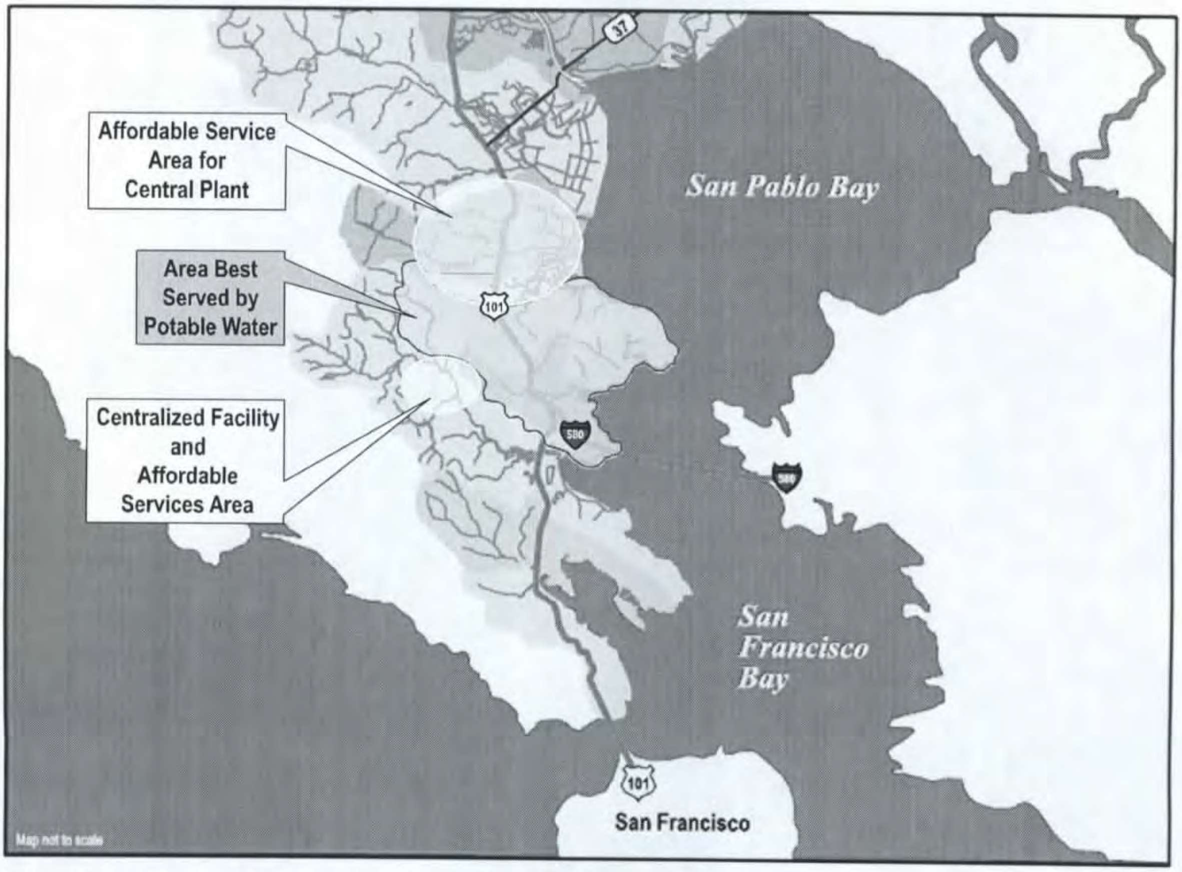

Figure 4 Example of Economically Viable Supply Strategies

Section 2 Types of Demand

Since a satellite water recycling facility acts as a water factory, determining the location and water quality requirements of the customer is primary to the analysis. The decision to begin a feasibility analysis for a satellite water recycling facility is essentially the identification of the water demand that needs to be met. Solutions for meeting this demand could include providing potable water, if available, or providing recycled water from either a centralized wastewater plant or from a satellite recycled water facility. This section outlines the regulatory requirements that need to be satisfied for various classes of recycled water users and additional requirements that may be specific to certain types of customers. This section goes on to present several techniques for determining potential recycled water customers within a water service area and accounting for their demand patterns.

2.1 Regulatory Treatment Standards for Various Types of Water Users

In California, water recycling criteria is outlined in Title 22 of the California Code of Regulations beginning with Section 60301 (the "State Water Recycling Criteria"). The State Water Recycling Criteria outlines several types of recycled water including:

- Disinfected Tertiary Recycled Water-the highest regulated water quality which includes a filtration step to achieve a turbidity of less than 2 Nephelometric Turbidity Units (a measure of the clarity of water, commonly abbreviated as ntu) in addition to disinfection to achieve a final median concentration of total coliform bacteria of less than 2.2 per 100 milliliters.

- Disinfected Secondary-2.2 Recycled Water-an unfiltered water quality that is disinfected to the same bacteriological standard as Disinfected Tertiary.
- Disinfected Secondary-23 Recycled Water- an unfiltered water quality that is disinfected to achieve a final median concentration of total coliform bacteria of 23 per 100 milliliters.
- Undisinfected Secondary Recycled Water-an unfiltered, undisinfected water quality that is produced through a secondary wastewater treatment process. [1]

Table 1 outlines the approved end uses for each type of recycled water. This Technical Memorandum assumes that most water agencies will be looking to satisfy demands that require Disinfected Tertiary Recycled Water.

Table 1 Regulatory Standards for Water Quality

	Treatment Levels			
Irrigation	**Disinfected Tertiary Recycled Water**	**Disinfected Secondary-2.2 Recycled Water**	**Disinfected Secondary-23 Recycled Water**	**Undisinfected Secondary Recycled Water**
Food crops where recycled water contacts the edible portion of the crop, including all root crops	**Allowed**	Not allowed	Not allowed	Not allowed
Parks and playgrounds	**Allowed**	Not allowed	Not allowed	Not allowed
School yards	**Allowed**	Not allowed	Not allowed	Not allowed
Residential landscaping	**Allowed**	Not allowed	Not allowed	Not allowed
Unrestricted access golf courses	**Allowed**	Not allowed	Not allowed	Not allowed
Any other irrigation uses not prohibited by other provisions of the California Code of Regulations	**Allowed**	Not allowed	Not allowed	Not allowed
Food crops where edible portion is produced above ground and not contacted by recycled water	**Allowed**	**Allowed**	Not allowed	Not allowed
Cemeteries	**Allowed**	**Allowed**	**Allowed**	Not allowed
Freeway landscaping	**Allowed**	**Allowed**	**Allowed**	Not allowed
Restricted access golf courses	**Allowed**	**Allowed**	**Allowed**	Not allowed
Ornamental nursery stock and sod farms	**Allowed**	**Allowed**	**Allowed**	Not allowed
Pasture for milk animals	**Allowed**	**Allowed**	**Allowed**	Not allowed
Nonedible vegetation with access control to prevent use	**Allowed**	**Allowed**	**Allowed**	Not allowed

[1] California Code of Regulations, Title 22, Section 60301 et. seq., "Definitions"

Irrigation	Treatment Levels			
	Disinfected Tertiary Recycled Water	Disinfected Secondary-2.2 Recycled Water	Disinfected Secondary-23 Recycled Water	Undisinfected Secondary Recycled Water
as a park, playground or school yard				
Orchards with no contact between edible portion and recycled water	**Allowed**	**Allowed**	**Allowed**	**Allowed**
Vineyards with no contact between edible portion and recycled water	**Allowed**	**Allowed**	**Allowed**	**Allowed**
Non food-bearing trees, including Christmas trees not irrigated less than 14 days before harvest	**Allowed**	**Allowed**	**Allowed**	**Allowed**
Fodder crops (e.g. alfalfa) and fiber crops (e.g. cotton)	**Allowed**	**Allowed**	**Allowed**	**Allowed**
Seed crops not eaten by humans	**Allowed**	**Allowed**	**Allowed**	**Allowed**
Food crops that undergo commercial pathogen-destroying processing before consumption by humans	**Allowed**	**Allowed**	**Allowed**	**Allowed**
Ornamental nursery stock, sod farms not irrigated less than 14 days before harvest	**Allowed**	**Allowed**	**Allowed**	**Allowed**

Supply for Impoundment	Treatment Levels			
	Disinfected Tertiary Recycled Water	Disinfected Secondary-2.2 Recycled Water	Disinfected Secondary-23 Recycled Water	Undisinfected Secondary Recycled Water
Non-restricted recreational impoundments, with supplemental monitoring for pathogenic organisms	**Allowed** [2]	Not allowed	Not allowed	Not allowed
Restricted recreational impoundments and publicly accessible fish hatcheries	**Allowed**	**Allowed**	Not allowed	Not allowed
Landscape impoundments without decorative fountains	**Allowed**	**Allowed**	**Allowed**	Not allowed

	Treatment Levels			
Supply for Cooling or Air Conditioning	**Disinfected Tertiary Recycled Water**	**Disinfected Secondary-2.2 Recycled Water**	**Disinfected Secondary-23 Recycled Water**	**Undisinfected Secondary Recycled Water**
Industrial or commercial cooling or air conditioning involving cooling tower, evaporative condenser, or spraying that creates a mist	**Allowed 3**	Not allowed	Not allowed	Not allowed
Industrial or commercial cooling or air conditioning not involving a cooling tower, evaporative condenser, or spraying that creates a mist	**Allowed**	**Allowed**	**Allowed**	Not allowed

	Treatment Levels			
Other Uses	**Disinfected Tertiary Recycled Water**	**Disinfected Secondary-2.2 Recycled Water**	**Disinfected Secondary-23 Recycled Water**	**Undisinfected Secondary Recycled Water**
Groundwater recharge	**Allowed under special case-by-case permits by RWQCBs [4]**			
Flushing toilets and urinals	**Allowed**	Not allowed	Not allowed	Not allowed
Priming drain traps	**Allowed**	Not allowed	Not allowed	Not allowed
Industrial process water that may contact workers	**Allowed**	Not allowed	Not allowed	Not allowed
Structural fire fighting	**Allowed**	Not allowed	Not allowed	Not allowed
Decorative fountains	**Allowed**	Not allowed	Not allowed	Not allowed
Commercial laundries	**Allowed**	Not allowed	Not allowed	Not allowed
Consolidation of backfill material around potable water pipelines	**Allowed**	Not allowed	Not allowed	Not allowed
Artificial snow making for commercial outdoor uses	**Allowed**	Not allowed	Not allowed	Not allowed
Commercial car washes not done by hand & excluding the general public from washing process	**Allowed**	Not allowed	Not allowed	Not allowed
Industrial boiler feed	**Allowed**	**Allowed**	**Allowed**	Not allowed
Nonstructural fire fighting	**Allowed**	**Allowed**	**Allowed**	Not allowed
Backfill consolidation around nonpotable piping	**Allowed**	**Allowed**	**Allowed**	Not allowed
Soil compaction	**Allowed**	**Allowed**	**Allowed**	Not allowed

	Treatment Levels			
Other Uses	**Disinfected Tertiary Recycled Water**	**Disinfected Secondary-2.2 Recycled Water**	**Disinfected Secondary-23 Recycled Water**	**Undisinfected Secondary Recycled Water**
Mixing concrete	**Allowed**	**Allowed**	**Allowed**	Not allowed
Dust control on roads and streets	**Allowed**	**Allowed**	**Allowed**	Not allowed
Cleaning roads, sidewalks and outdoor work areas	**Allowed**	**Allowed**	**Allowed**	Not allowed
Flushing sanitary sewers	**Allowed**	**Allowed**	**Allowed**	**Allowed**

[1] Refer to the full text of the latest version of Title-22: California Water Recycling Criteria. This chart is only a guide to the September 1998 version.
[2] With "conventional tertiary treatment." Additional monitoring for two years or more is necessary with direct filtration.
[3] Drift Eliminators and/or biocides are required if public or employees can be exposed to mist.
[4] Refer to Groundwater Recharge Guidelines, California Department of Health Services.

2.2 Additional Customer Requirements for Treatment

In addition to the basic regulatory requirements for water quality, water users may have specific water quality requirements. Customers that utilize water for agricultural or horticultural purposes can be particularly sensitive to the salt content of the water supply (indeed a satellite recycling facility may prove practical if it can capture wastewater prior to saltwater contamination). Certain types of industrial process use are also sensitive to salts and total dissolved solids (TDS) in process water. Often times these types of users will employ additional point-of-use treatment devices to meet their water quality requirements, even if the water source is the potable supply. In every case it is important for the agency considering a recycled water project to understand its customers' water quality requirements and willingness to provide point-of-use treatment prior to beginning the initial feasibility and screening process.

2.3 Identifying Water Users

There are two basic techniques for identifying water users that could potentially be serviced by or converted to a recycled water supply, were it available. The first, and preferred method, is to use the historical water use records available to the local water purveyor. The second is to use land use mapping and generally accepted water demand factors. The second method is appropriate if metered use records are not available (i.e. for new water users or for users that have historically supplied their needs from unmetered groundwater).

2.3.1 Historical Water Use Method

This method utilizes the historical billing records of the water agency to identify large water users that could serve as "anchor tenants" for a satellite water recycling system. If an agency also has access to a GIS system, that tool can be utilized to plot the large water users graphically making clusters even easier to identify. Marin Municipal Water District has successfully used this method in its recently produced "Review of Water Recycling and Graywater"[2] . Figure 5 illustrates the graphic nature of this tool.

Figure 5 GIS Analysis Example

2.3.2 Land Use Method

This method is generally utilized when historical billing records aren't available. It is most commonly used when bringing customers onto the recycled water system, when they had previously used wells or if the "customer" is a new development project that has never been on the system before. This method basically applies a standard water consumption factor to known land uses in order to calculate an approximate demand. The North Bay Watershed Association has employed this method in its "Regional Water Recycling Study"[3]. Table 2 below illustrates the water consumption factors applied for various categories of land use. Note that is preferable to use local information whenever possible since local water usage can vary widely. For example, irrigation rates for golf courses in the North Bay range from 8.5 to 17 AF/year/hole, depending on the type of landscaping and the irrigation management practices.

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[2] Marin Municipal Water District, "Review of Water Recycling & Graywater", Bahman Sheikh Ph.D., P.E. with Parsons Engineering Science.

[3] North Bay Watershed Association "North Bay Regional Water Recycling Feasibility Study", RMC, 2002.

Table 2 Land Use Based Demand Factors

Land Use	Demand Rate (AF/acre/year)
Vineyards	0.5
Irrigated Agriculture	2.0
Irrigated Pasture	2.5
Golf Courses	3.5
Urban Irrigation	3.0
Commercial/Industrial Process	1.7
Toilet Flushing	1.5 gal/flush

2.4 User Demand Patterns

Different classes of water users will place demand on the system at different times during the day. For example, industrial processing uses will often place demand during business hours as will commercial cooling and indoor plumbing uses (toilet flushing, institutional laundries etc.). Large irrigation users, however, will often place their full demand during a 6 to 8 hour night-time irrigation cycle. User patterns will also vary seasonally, with cooling and irrigation demand being reduced or even eliminated during the winter months. Implicit to this analysis is the assumption that the satellite treatment plant can be "turned-off" for the winter, when the irrigation demand is nonexistent. The cost curves in Section 7 are developed assuming the construction of process technology that lends itself to this mode of operation, which can be more expensive than technology that is designed to run year round.

As with water quality requirements, water demand patterns need to be generally understood prior to beginning the initial screening process. Figure 3 illustrates a conceptual satellite recycling facility including some onsite recycled water storage, under the assumption that the users' preferred demand pattern may not precisely match the plant's production rate. The cost curves, developed in Section 7, include an allowance for storage equal to 80% of average daily demand. The Cost Estimating Templates, included in the Appendix of this Technical Memorandum can be used modify this allowance and adjust the standard cost curve for a local agency's unique situation.

Section 3 Influent Flow Considerations

3.1 Locating Appropriate "Sewersheds"

A satellite water recycling facility can be reasonably considered when there is enough wastewater generated in the vicinity to actually meet the water demand needs on an average daily basis. Once water demands have been identified, the local agency will need to compare these to wastewater flows from tributary sewersheds. Determining wastewater flows in the sewershed can be done through historical flow records maintained by the local wastewater collection or treatment agency providing service in the area. Collection system flow records are often not available for individual sewersheds. Lacking that information, wastewater flow can be estimated by using land use mapping and applying design criteria for wastewater flow. However, if a satellite facility is determined to be feasible and metered flow data isn't available, the implementing local agency may wish to conduct wastewater flow monitoring as part of predesign to verify the actual wastewater flow available.

3.1.1 Historical Flow Method

This method utilizes flow monitoring data that is available to the wastewater agency. There are several common sources of this data that may be available to a local sewer agency. The first source of the data is a Sanitary Sewer System Evaluation (SSES) or Flow Monitoring Report. This type of reporting typically includes data from recording meters placed in manholes and can provide very reliable information on wastewater flows. A wastewater agency may have undertaken this work either as part of developing a system master plan or as a result of a regulatory requirement to manage its collection system.

If flow monitoring data is not available, but the tributary sewershed drains to a lift station, metered data may be available directly from the lift station or it may be possible to approximate the flow rates by understanding the lift station capacity and its operational pattern (i.e. Elapsed time meters show how often the lift stations run. This run time can be multiplied by the station capacity in order to approximate an average daily flow). As with large water users, sewershed capacity can be plotted from a GIS system, providing graphic illustration of the match between supply and demand.

3.1.2 Land Use Method

This method would be used when historical flow records aren't available. The method basically applies a standard waste water flow rate to known land uses in order to calculate approximate daily flows. Again, the local wastewater agency may have developed this work as part of its Master Planning efforts and local design criteria should always be used when possible. Table 3, on the following page, summarizes flow rates published by the State Water Resources Control Board, which can serve as "standard" data if local information is unavailable.

Table 3 Standard Wastewater Flow Rates for Various Establishments

Estimated Water Consumption at Different Types of Establishments			
TYPE OF ESTABLISHMENT	Flow in gpd per person or unit [(1)]	TYPE OF ESTABLISHMENT	Flow in gpd per person or unit [(1)]
Dwelling units, residential		Institutions	
Private dwellings on individual wells or metered supply	50-75	Average type	75-125
Private dwellings on public water supply, unmetered	100-200	Hospitals	150-250
Dwelling units, mulitple		Schools	
Apartment houses on individual wells	75-100	Day	5-10
Apartment houses on public water supply, unmetered	100-200	Day, with cafeteria or lunchroom	10-15
Hotels	50-100	Day, with cafeteria and showers	15-20
Boarding houses	50	Boarding	75
Lodging houses and tourist homes	40	Theaters	
Motels, without kitchens, per unit	100-150	Indoor, per seat, two showings per day	3
Camps		Outdoor, including food stand, per car	3-5
Pioneer type	25	Automobile service station	
Children's, central toilet and bath	40-50	Per vehicle served	10
Day camp, no meals	15	Per set of pumps	500
Luxury, private bath	75-100	Stores	
Labor	35-50	First 25 feet of frontage	450
Trailer with private toilet and bath, per unit	125-150*	Each additional 25 feet of frontage	400
Restaurants (including toilet)		Country clubs	
Average	7-10	Resident type	100
Kitchen wastes only	2.5-3	Transient type, serving meals	17-23
Short order	4	Offices	10-15
Short order, paper service	1-2	Factories, sanitary wastes, per shift	15-35
Bars and cocktail lounges	2	Self-service laundry	250-500
Average type, per seat	35	Bowling alleys, per alley	200
Average type, 24 hour, per seat	50	Swimming pools and beaches, toilet and shower	10-15
Tavern, per seat	20	Picnic parks, with flush toilets	5-10
Service area, per counter seat (highway)	350	Fairgrounds (based on daily attendance)	1
Service area, per table seat (highway)	150	Assembly halls, per seat	2
		Airport, per passenger	2

[(1)] Figures are flows per capita per day unless otherwise stated.
Source: Water Recycling Funding Guidelines, April 1997, California State Water Resources Control Board Office of Water Recycling

3.2 Wastewater Flow Patterns

As with water use, wastewater flow patterns vary over the course of any given day, meaning that the influent (or source water) for the satellite treatment plant will ebb and flow each day. In a large sewershed, this pattern may be dampened by storage provided in the sewer collection system. In a small sewershed, with uniform land use, the influent flow rate can show dramatic peaks. In general, the treatment processes described in Section 5 have sufficient hydraulic retention time so that diurnal peaking of the wastewater stream will not present an operational problem. However, the satellite facility, because of its small size and dependence on the local wastewater stream, will not provide as much hydraulic buffer as a centralized water recycling facility that can draw on the capacity of a larger treatment plant. The diurnal peaking of the wastewater stream should be considered when sizing any recycled water storage to make sure that decreases in influent flow rate do not create operational problems for the wastewater treatment process selected or the recycled water supply system.

3.3 Wastewater Quality Considerations

Because raw wastewater provides the "raw source" for a satellite treatment plant facility, it is important to make sure that this source water can meet a customer's water quality needs. While the satellite plant facility will produce water that meets the requirements of State Water Recycling Criteria, the facility typically is not intended to remove unregulated constituents that can be of concern to customers. Irrigation and cooling demands are two of the large and more common water demands that may anchor a satellite recycling facility. General considerations for each type of use are outlined below. As noted above, some users will employ additional point-of-use treatment devices to meet their water quality requirements and in every case it is important for the agency considering a recycled water project to understand its customers' water quality requirements and willingness to provide point-of-use treatment prior to beginning the initial feasibility and screening process.

3.3.1 General Considerations for Irrigation Customers

Irrigation management for turf, ornamental and agronomic crops is a science unto itself. At times a sound water management strategy can offset some of the effects of poor water quality. However, there are general standards for water quality with respect to irrigation use. These standards are reproduced as Table 4. Before embarking on an irrigation based recycling program, an agency should understand how its influent water quality matches these general standards in order to avoid too much investment in a poor quality source.

Table 4 Water Quality Standards for Irrigation Use

Quality Factor	Threshold Concentration [1]	Limiting Concentration [2]
Total Dissolved Solids, mg/l	500 [5]	1500 [5]
Electrical Conductivity mmhos/cm	750 [5]	2250 [5]
Range of pH	7.0-8.5	6.0-9.0
Sodium Adsorption Ratio [3]	6.0 [5]	15
Residual Sodium Carbonate meq [4]	1.25 [5]	2.5
Arsenic, mg/l	1.0	5
Boron, mg/l	0.5	2
Chloride, mg/l	100 [5]	250
Sulfate, mg/l	200 [5]	100
Copper, mg/l	0.1 [5]	1

(1) Threshold values at which irrigator might become concerned about water quality and might consider using additional water for leaching. Should be satisfactory for most species in arable soil.

(2) Limiting value at which landscape or crop quality will be drastically affected by water quality.

(3) Sodium adsorption ratio is defined by the formula $SAR = Na/(CA+Mg)^{1/2}$ where the concentrations are expressed in milli-equivalents per liter.

(4) Residual sodium carbonate is the sum of the equivalents of normal carbonate and bicarbonate minus the sum of the equivalents of calcium and magnesium.

(5) Values not to be exceeded more than 20% of the time.

Source: Todd. D.K. (1970) Water Encyclopedia (Port Washington NY, Water Information Center)

3.3.2 General Considerations for Cooling Towers

Use of recycled water for cooling tower purposes requires consideration for three general water quality parameters. Ammonia and phosphorus concentrations in recycled water can have a detrimental affect on the materials of construction of some cooling towers. Understanding the users' specific site is important for this reason. Ammonia and phosphorus are essentially nutrients found in wastewater, and some treatment processes can be managed for nutrient removal if this is important to the end uses. Cooling tower use is also sensitive to the Total Dissolved Solids (TDS) in the recycled water. The higher the TDS concentrations in the water, the fewer the cooling cycles that can be accomplished. This has the effect of increasing water demand from the cooling use and can also increase the energy demand associated with the overall system, as more pumping is required.

Section 4 Siting Considerations and Assumptions

While initial identification of candidate users for satellite-treated recycled water is based on water demand and location relative to a sewer trunk, several other factors should be considered when choosing the physical site for the satellite treatment plant. These factors can vary widely between sites and need to be analyzed on a case-by-case basis. These considerations include:

- Land Area Available
- Utility Systems in Area
- Storage Needs
- Backup Water Supply Needs
- Solids Disposal
- Community Acceptability

All of the above considerations have significant cost impacts and may determine which treatment technologies are most favorable for recycled water production. Because of this, it is important to consider each of these factors early in the decision-making process for satellite treatment feasibility.

4.1 Land Area Available

The first priority for finding a candidate site is to find a site that is large enough to accommodate the satellite plant. As discussed in Section 5, package plants can significantly vary in footprint size. Size of plant (and therefore land area required) depends on the treatment process chosen as well as the volume of wastewater treated.

Site selection must review, in part,

- Adequacy of existing or planned support and service facilities including utilities, roads, and parking areas
- Architectural and functional compatibility with the surrounding environment
- Interrelationships between facilities and aesthetic compatibility
- Noise control
- Odor control
- Natural topographic conditions
- Existing cultural and archeological resources

The cost analysis developed in Section 7 assumes that the package treatment plant unit is a Membrane Bioreactor. This package technology accomplishes secondary treatment and filtration in a single tank, with a minimal footprint. The technology is also reasonably resilient and can tolerate variations in influent flow rates without process upsets. The technology is, on a unit basis, more expensive than a package secondary plant (i.e. a sequencing batch reactor) followed by a direct filter. However given that satellite plants will often be located in areas where land is at a premium, the benefits of minimal footprint and smaller land requirements are likely to be significant decision criteria. The cost analysis developed in Section 7 is attempting to provide some conservatism by assuming the higher cost, smaller footprint unit. Once again, local agencies can modify the cost curves, using the templates included in the Appendix, to adjust for local conditions that may not place such a premium on small footprint.

Cost of land is also a site-specific factor that should be taken into account when performing cost analysis. Cost analysis will be discussed further in Section 7.

4.2 Utility Systems in Area

All package plants require connections to water and electrical systems. Water use at the plant would be primarily disinfected effluent and would place a minimal demand on the system that serves the area. The electrical load of the plant, however, may be more than the current electricity infrastructure can handle, especially if the plant is to be sited in a residential neighborhood. It is important to enter discussions with the electrical utility when considering a satellite plant because upgrades to the electrical system can prove to be a large addition to capital costs.

The cost curves presented in Section 7 assume that the electrical system serving the area is adequate. The cost curves do not make an allowance for a standby power supply because the satellite treatment plant is not a critical facility. Should the main power supply be interrupted, raw sewage would remain in the trunk sewer and recycled water would be temporarily unavailable.

4.3 Storage Needs

As discussed in Sections 2 and 3, above, wastewater flow and recycled water demand don't always occur at the same time. Satellite treatment plants will need to include some onsite storage in order to hold water that is produced during peak wastewater flows until it is needed.

Agencies will need to balance the need for storage with the water quality desires. Because recycled water often has a higher nutrient content than potable water, biological regrowth can be an issue in storage and distribution systems. The cost curves presented in Section 7 assume storage equal to 80% of demand. Some agencies and/or end users may prefer more than one day of storage and they may want to have supplies available in case of an extended period of time in which the demand for water surpasses the capacity of the satellite plant (for example, an extended heat wave that requires additional irrigation water).

4.4 Backup Water Supply Needs

In some instances where a steady water supply is critical, the district or the end user may want backup water supplies available if recycled water is not available. If a backup potable water supply is to be included as part of the storage and distribution system, it should be separated from the recycled water system with appropriate backflow prevention devices in accordance with State requirements (in California, State Requirements are found in the California Code of Regulations, Title 17) and the local water purveyor.

4.5 Solids Disposal

Onsite solids treatment can double the cost of a treatment plant, requires a large amount of operational attention, and creates odors. Generally, if onsite solids treatment is required, the prospect of a satellite treatment plant quickly becomes infeasible.

The ideal mechanism for solids disposal for a satellite plant is to route the solids back into the sanitary sewer to be processed at the main wastewater treatment plant. This solids disposal solution is very site sensitive. There must be sufficient flow in the sewer after the portion to be treated has been scalped to be able to keep the disposed solids in suspension and deliver them to the plant. Generally, the remaining wastewater should flow at 2 fps at all times to keep the solids flowing, or if the solids have settled, a minimum velocity of 5 fps is needed to re-suspend them.

Another alternative for solids disposal is to haul the solids to the central plant using trucks. This is less desirable than allowing the solids to go back into the sewer because it is more expensive and it causes truck traffic, potentially through residential neighborhoods.

4.6 Community Acceptability

Siting new wastewater facilities can be difficult, particularly in an established neighborhood. It is incumbent upon an agency to work with the local community during the planning and design period in order that "good neighbor" features are an intrinsic part of the facility. The following steps can be included as part of the outreach plan to include the affected community in the planning process.

1. Invite public participation in all critical decisions for a project, and provide ample opportunity for public input to be given directly to top project decision-makers;

2. Be flexible to adjusting plans, where feasible, to meet public needs and desires;

3. Keep the public to be directly impacted by the siting decision fully informed throughout the process;

4. Involve and incorporate community values into the project; and,

5. Engage and solicit the advice of nearby community members at every level and every stage, from planning and construction through operation of the proposed facility.

The facilities should be designed to eliminate any impacts for neighboring businesses or residents. Consideration should be given to the following:

- Containment of all noise-generating equipment inside an acoustically protected building
- Containment and scrubbing of all air inside the process building.
- Minimization of automatic yard lighting, i.e. use of manually operated lighting only when needed for nighttime operation rather than the typical photo-activated lighting.
- Minimization of truck deliveries, for example disposing of biosolids into the collection system, use of UV rather than sodium hypochlorite for disinfection
- Security features that blend into the neighborhood such as decorative fencing rather than chain-link fencing
- Use of buried reservoirs or pump stations rather than above-ground facilities
- Architectural style that is complementary to the context of the surrounding neighborhood.
- Landscaping that enhances the site and is compatible with neighboring landscaping
- Local building and zoning permitting requirements

Figure 6 illustrates an example satellite plant facility layout in which the treatment processes are contained within a building and the storage reservoir is located underground.

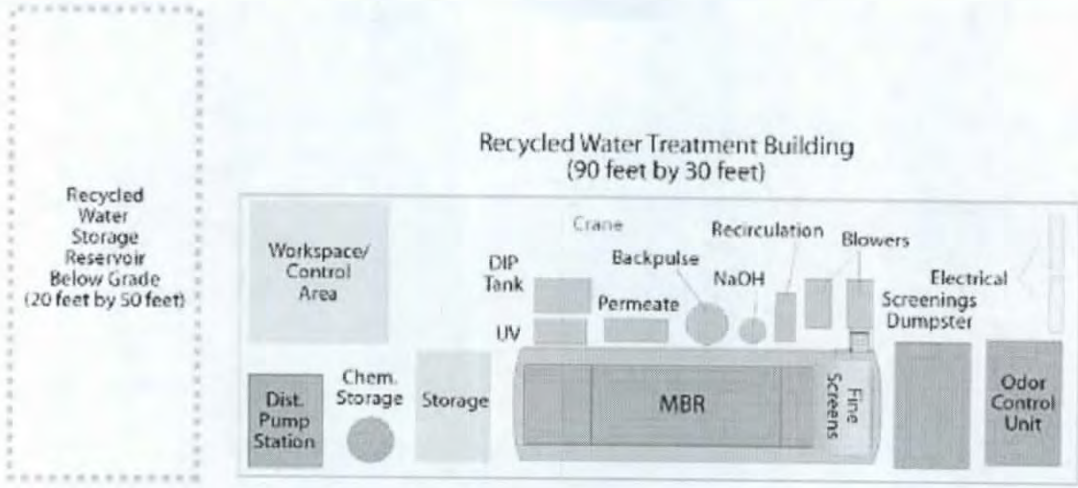

Figure 6 Example Layout for a 50,000 gpd Satellite Plant

The type of architectural treatment chosen for the containment structure should reflect the surrounding land uses, i.e. residential, industrial, or rural. The following figures are examples of the architectural treatments that have been used for other satellite plants.

Photo Credit – Oakwood Satellite Plant, Zenon Corp

Figure 7 Satellite Plant with Residential Style Architectural Treatment

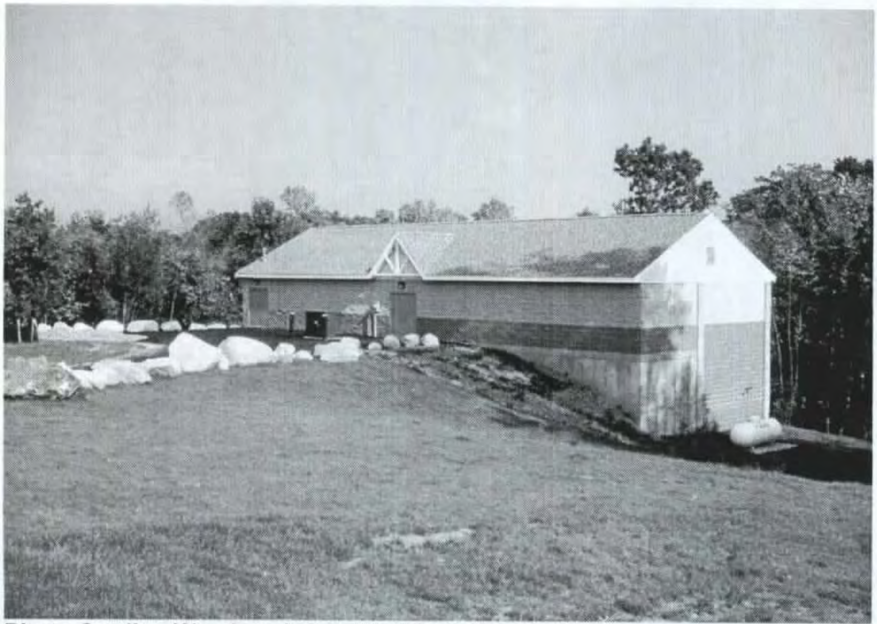

Photo Credit – Westbrook Satellite Plant, Zenon Corp.

Figure 8 Satellite Plant with Rural Style Architectural Treatment

Photo Credit – Zenon Corporation

Figure 9 Satellite Plant in Industrial Area

Photo Credit – Powel River Satellite Plant, Zenon Corp.

Figure 10 Satellite Plant Housed Within Marina Building

Section 5 General Process Overview

5.1 Introduction

Section 2 of this study discussed the regulatory treatment standards established by the State of California for various recycled water demands. There are some uses with restricted public access such as irrigation of cemeteries or freeway medians that require treatment only to secondary disinfected levels. However, typical recycled water demands such as irrigation of parks, schools, and unrestricted access golf courses, or most industrial uses require treatment to a level defined as "Disinfected Tertiary Recycled Water" by the State Water Recycling Criteria.

Producing disinfected tertiary recycled water involves three process steps. The wastewater must first be oxidized. It then must be filtered and disinfected in accordance with guidelines established by the California Department of Health Services. These steps are illustrated in Figure 11.

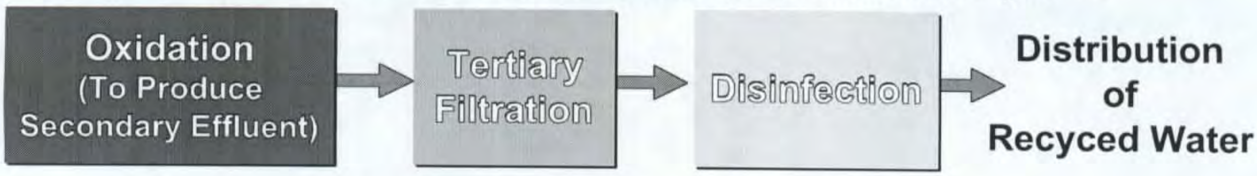

Figure 11 Conceptual Process Flow Train

In a traditional centralized approach to recycled water production, the oxidation step is accomplished at an existing secondary treatment plant and tertiary filtration and disinfection are added to the existing treatment train to produce recycled water. In a satellite treatment approach, the satellite plant must include not only the tertiary facilities, but also the oxidation step, i.e. it must first treat raw sewage to secondary treatment standards before the water is filtered and disinfected for recycling.

The following discussion describes alternatives for providing oxidation at a satellite treatment plant. It is followed by discussion of tertiary treatment alternatives for both filtration and disinfection.

5.2 Treatment to Secondary Levels

The State Water Recycling Criteria defines oxidized wastewater as "wastewater in which the organic matter has been stabilized, is nonputrescible, and contains dissolved oxygen." This oxidation step is typically provided through traditional primary and secondary wastewater treatment. When providing recycled water from a centralized plant wastewater treatment plant, it is only necessary to consider the filtration and disinfection requirements. Since satellite treatment plants must treat raw wastewater to recycled water levels, they need to include this oxidation step.

Many package plants are available that can provide the primary and secondary treatment steps of the water recycling process. These include conventional activated sludge plants as well as other, less conventional technologies. The package plants can often be field assembled with construction on site limited to pouring a foundation pad, mounting the equipment, plumbing, supplying electricity, and providing a building to house the units.

5.2.1 Traditional Package Plants

Conventional activated sludge package plants have the same basic process train as many traditional activated sludge wastewater treatment plants. The equipment includes initial screening and solids removal followed by an aeration basin and secondary clarification basin, with a return activated sludge cycle. The process lowers BOD and TSS to levels that are acceptable for ultimate treatment through filtration and disinfection.

Other biological processes are available as package plants, with various advantages and disadvantages. These include extended aeration plants, sequencing batch reactors (SBRs), and oxidation ditches.

5.2.2 Emerging Package Plants

Many promising products are emerging to address specific perceived faults in the traditional package plant options. These include processes that are almost solely mechanical in order to lower energy costs and avoid the operational difficulty of maintaining a biological culture. There are also products that biologically treat wastewater in the root zone of aquatic plants, creating a greenhouse type of environment.

5.2.3 Package Plant Selection

The selection of package plant is very site specific. Factors such as land area, wastewater quality, and community acceptance will drive the selection as much as cost will.

5.3 Treatment to Tertiary Levels

The State of California Department of Health Services (DHS) has established the following standards for filtration and disinfection of recycled water.

> "The California Water Recycling Criteria (adopted December 2000) define *Disinfected* Tertiary Recycled Water as a wastewater, which has been oxidized and meets the following:

A. Has been coagulated* and passed through natural undisturbed soils or a bed of filter media pursuant to the following:
   1. At a rate that does not exceed 5 GPM/ft 2 in mono, dual or mixed media gravity or pressure filtration systems, or does not exceed 2 GPM/ft 2 in traveling bridge automatic backwash filters; and
   2. The turbidity does not exceed any of the following; a daily average of 2 NTU, 5 NTU more than 5% of the time within a 24-hour period, and 10 NTU at any time.

*Note: Coagulation may be waived if the filter effluent does not exceed 2 NTU, the filter influent is continuously measured, the filter influent turbidity does not exceed 5 NTU, and automatically activated chemical addition or diversion facilities are provided in the event filter effluent turbidity exceeds 5 NTU.

OR

B. Has been passed through a micro, nano., or R.O. membrane following which the turbidity does not exceed any of the following: 0.2 NTU more than 5% of the time within a 24-hour period and 0.5 NTU at any time.

AND

C. Has been disinfected by either:
   1. A chlorine disinfection process that provides a CT of 450 mg-min/l with a modal contact time of not less than 90 minutes based on peak dry weather flow, or
   2. A disinfection process that, when combined with filtration, has been demonstrated to achieve 5-log inactivation of virus."[4]

DHS considers a properly filtered and disinfected recycled water meeting the turbidity performance and coliform requirements outlined in the criteria to be essentially pathogen free. The treatment scheme is intended to remove solids (including some pathogens) and properly prepare the water for effective disinfection in order to achieve an approximately five-log reduction of virus.

5.3.1 Filtration:

Manufacturers of filtration equipment must submit pilot test data to DHS before their equipment is certified as an acceptable filtration technology under the State Water Recycling Criteria. In the certification letters for each technology DHS includes criteria such as allowable loading rates for the specific filtration equipment. There are four general types of filtration systems certified by DHS. They are:

- Granular media type filters
- Other media type filters
- Membrane Technologies
- Cloth Filters

Selection of the specific type of filter depends on site-specific issues such as capital and operating costs, availability, schedule, size, operator preference, etc. Filter performance on a given wastewater is dependent on the type of upstream treatment process, particle size distribution, particle charge, pH. In general, wastewaters with smaller particle size such as that from a trickling filter effluent, are more difficult to filter.

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[4] State Of California Division Of Drinking Water And Environmental Management Treatment Technology Report For Recycled Water, August 2003

Filters for recycled water production generally are operated in a direct filtration mode. In this mode a chemical coagulant is mixed with the filter influent in the pipeline upstream of the filter. The coagulant helps the solids to flocculate resulting in solids that are larger and easier to filter. If the filter influent turbidity is below 5 ntu and the effluent turbidity is below 2 ntu, adding the coagulant chemical can be waived, although provisions for chemical addition are generally still provided in case the wastewater characteristics change.

If the water is more difficult to filter and the flocculation processes requires a longer residence time, more robust flocculation processes may be needed. These include having a separate upstream flocculation tank to enhance the flocculation process through slow mixing after the chemical addition or having a separate upstream flocculating clarifier in which the solids are flocculated and also settled out and removed from the process stream before the filter.

It is prudent that, at a minimum, bench scale filterability testing be done on the wastewater before selecting a particular filter type. This can be done by sending samples of the wastewater to the manufacturer's testing facilities where they will determine if the water can be filtered to meet the State Water Recycling Criteria, the type and dosage of chemicals needed to aid filtration, and the type of upstream flocculation that may be needed.

The following table summarizes the filter technologies that have been certified by DHS as of August 2003. This list is updated periodically as additional filtration technologies are certified. Updates are available from DHS.

Table 5 Filter Technologies Certified by DHS

Filter Type	Manufacturer
Granular Media	DynaSand (Parkson Corp)
	TechnaSand (WestTech Engineering)
	Hydro-Clear (U.S. Filter-Zimpro)
	ABW, Infilco-Degremont
	AquaABV (Aqua Aerobics Systems, Inc.)
	Tetra-Denit. (Tetra Technologies, Inc.)
	Centra Flow (Applied Process Technology)
	Fluidsand (Fluidyne, Corp)
	Hydrasand (Andritz Ruthner, Inc.)
	Strata-Sand (Ashbrook Corp)
Disc Filters	Aqua Disk (Aqua Aerobics Systems, Inc.)
Other Media Types	Fuzzy Filter (Schreiber LLC)
Membrane Technologies	Zenon Environmental Cycle-let, ZeeWeed/Zeno-gem, ZeeWeed 1000 UF
	US Filter/Memcor CMF (0.2 micron-PP and 0.1 micron-PVDF CMF Submerged (0.2 micron-PP and 0.1 micron-PVDF US Filter/Jet Tech

Filter Type	Manufacturer
	PALL Corporation
	Mitsubishi
	Kubota

5.3.2 Disinfection

The State Water Recycling Criteria lists the criteria for chlorine-based disinfection as a CT of 450 mg-min/l with a modal contact time of not less than 90 minutes based on peak dry weather flow. A baffling efficiency factor, typically 75%, is applied by DHS to the 90 minute modal contact time meaning, in practice, that a 120 minute theoretical contact time must be provided to meet the Title 22 requirement. Typically, chlorine-based disinfection systems use liquid sodium hypochlorite rather than gaseous chlorine for safety reasons. However, chlorine-based disinfection at a satellite plant can have several disadvantages:

- Relatively large footprint required for the chlorine contact basin
- Production of disinfection by-products (DBP) in particular trihalomethanes (THMs) and N-nitrosodimethylamine (NDMA)
- Periodic truck deliveries of sodium hypochlorite are required, approximately every two weeks depending on on-site storage volume required. Since satellite plants are often located in sensitive neighborhoods, transport and storage of hazardous chemicals is often unacceptable. On-site generation of sodium hypochlorite can be a possibility, but this increases the mechanical and operational complexity of the system and deliveries of supplies to generate the sodium hypochlorite are still needed.

The alternative disinfection process that has been accepted by DHS is disinfection by ultraviolet light. In December 2000, "Ultraviolet Disinfection Guidelines for Drinking Water and Water Reuse" were published by the National Water Research Institute (NWRI) and the American Water Works Association Research Foundation (AWWARF) in December 2000. DHS endorses these Guidelines and refers to them when evaluating UV disinfection proposals. Design of UV disinfection facilities therefore needs to be done in accordance with the NWRI Guidelines.

As with the filtration technologies, DHS has certified specific UV manufacturers and equipment for Title 22 compliance, provided the design is done in accordance with NWRI guidelines. Also as with filtration, the following list is updated periodically as additional UV technologies are certified and updates are available from DHS. Table 6 outlines the currently approved technologies.

Table 6 UV Technologies Certified by DHS

UV Equipment Manufacturers
Trojan Technologies
PCI-Wedeco
Wedeco-Ideal Horizons
Aquionics
Ultraguard (Service Systems)
Aquaray (Infilco-Degremont)
Ultra Tech

5.3.3 Membrane Bioreactors

One of the California DHS approved technologies, the membrane bioreactor (MBR), belongs to its own category of treatment processes. In the MBR process the unit processes of aeration, clarification, and filtration are combined into one process. An MBR package, approved by DHS, meets the requirements for both secondary and tertiary treatment. It needs to be preceded with preliminary fine screening. The aeration process takes place in the bioreactor, stabilizing and lowering the BOD of the wastewater. The traditional clarifier step is skipped, and the water is pulled via a suction pump directly through ultrafiltration membranes that are submerged in the mixed liquor. The membranes provide for both the solid/liquid separation step usually carried out by clarifiers and the filtration step required for recycled water use. It is possible to configure the tank to provide for nutrient removal as well. The resulting effluent meets State Water Recycling Criteria requirements for tertiary treated water and needs only to be disinfected for use as recycled water.

Because the MBR is essentially a complete "package" in itself, the cost curves in Section 7 are based on this process.

5.4 Treatment Technology Comparison

As was discussed in Section 5.1, the process that must be undergone in a satellite treatment facility is a three-step process. Step 1 is treatment to the secondary treatment level. Step 2 is filtration, and Step 3 is disinfection. The technologies available for satellite treatment vary widely in cost and footprint. They also vary greatly in their energy usage. Table 7 represents some of the technologies and compares them in terms of capital equipment cost, energy use, and footprint. The technologies are organized by the treatment level that they achieve. Note that a complete satellite plant has equipment that achieve all three steps. The costs presented in this table are only equipment costs and are presented for comparison amongst each other. Section 7 of this TM has a more detailed cost analysis technique.

Table 7 Treatment Technology Summary

Level of Treatment Achieved	Step	Process	Type of Equipment	Equipment Cost ($/mgd)[1,2]	Energy Used (kWh/mgd)[1]	Footprint (sq feet)[1]
Filtered Water	1	Secondary Plant	Sequencing Batch Reactor (SBR)	$580,000	1330	10,000
			Activated Sludge Package Plant	$920,000	3220	22,000
			Natural Treatment System[3]	$4,040,000	2200	20,000
	2	Title 22 Filter	Continuous Backwash	$540,000	450	1,600
			Disc Filter	$530,000	4	1,300
	1 and 2	Combined Processes	Membrane Bioreactor	$1,600,000	790	15,000
			Physical/ Chemical System[4]	$2,280,000	6120	3,200
Disinfected Water	3	Chemical	Sodium Hypochlorite	$124,000	20	4,000
		Non-chemical	UV	$720,000	580	160

[1] Costs and footprint have been normalized from equipment quotes of various sized systems and my not accurately reflect economies of scale

[2] Eqipment cost does not include allowances for construction, electrical, yard piping, engineering, contractor's O&P, etc. and are only provided for comparison amongst each other

[3] Data based on ARZ-IFAS Living Machine® System. This is an alternative technology, and it has yet to be determined how well it will comply with DHS Title 22 requirements. See Appendix C for product information.

[4] Data based on Great Circle Water, Inc. System. This is an alternative technology that is currently undergoing DHS Title 22 testing. See Appendix C for product information.

Section 6 General Distribution System Overview

This Distribution System overview is intended to provide general guidance for developing a recycled water distribution system from the satellite treatment facility and also for developing the main extensions from the centralized wastewater treatment plant. It also provides context for interpreting the cost curves presented in the subsequent sections. In some jurisdictions, the main extension from the centralized plant may be technically classified as a "transmission main". However given the sizing assumptions and definitions outlined in Section 1 of this Technical Memorandum, this main extension will be relatively small diameter (10-inches or less) and can be planned and estimated using the same criteria as distribution system piping.

This distribution system overview is intended to cover those facilities located in public rights-of-way and operated and maintained by the public agency. Recycled water system facilities located on private property ("onsite facilities") are regulated by the State Water Recycling Criteria.[5] Before connecting new users, a local agency must file an Engineering Report with Department of Health Services describing the onsite facilities and the methods used to comply with the State Water Recycling Criteria. These site specific criteria are not included in this discussion.

In general, distribution systems for recycled water will be designed according to technical standards that are similar to the standards for a potable water system, because the recycled water system is intended to provide the same type of service. Well-codified criteria are available from the Irvine Ranch Water District[6]. The additional considerations presented below incorporate planning criteria and or operational experience gleaned from North Bay Watershed Association Member agencies.

6.1 Pipeline Considerations

In general recycled water distribution system piping is designed as pressurized water piping. Common requirements that reflect the State Water Recycling Criteria, and are found in local agency's published criteria include the following:

- Pipelines are 4-inch diameter or larger and looped.
- Distribution piping is sized to maintain velocities of 4 to 8 feet per second.
- Pipelines are C-900 PVC, Class 150 or 200 and colored purple.
- Pipelines are separated from the potable water line by 1-vertical foot and 4-horizontal feet.
- Water services are also colored purple or continuously wrapped in purple marking tape.

6.2 Pumping System Considerations

For a satellite treatment facility, the recycled water pump station needs to maintain acceptable system pressures. Since users will frequently be converting from the potable water system, distribution system pressures of 40psi-80psi are generally considered in the acceptable range.

The basic configuration of the recycled water facilities can affect the sizing of pumps and the energy costs associated with pumping. Figure 3 presented earlier in this Technical Memorandum illustrates a conceptual satellite water recycling facility located on a single site. In this case, the recycled water pump station must maintain system pressures on demand. Energy demands will be variable and the local agency will need to budget its energy costs at peak rates.

An alternative configuration would utilize a recycled water storage reservoir located at an appropriate elevation to supply water at system pressure by gravity. In this case, the recycled water pump station delivers water based on tank level rather than system demand. Pumping can occur over controlled periods and the local agency may be able take advantage of off-peak energy rates. The single largest difficulty with this configuration is that a local agency must locate two sites (one for treatment and one for storage) instead of a single site.

The cost curves presented in Section 7 assume the configuration presented in Figure 3.

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[5] California Code of Regulations, Title 22 Section 60301 et. seq.

[6] www/irwd.com/water service/developer services/IRWD Procedural Guidelines and General Design Requirements, Section 5 Design Criteria Recycled Water Facilities.

6.3 Storage Considerations

As noted above, recycled water storage is a necessary feature for both satellite and centralized facilities because the wastewater production rate does not usually match the recycled water demand rate. However, since the recycled water is a supplemental supply, and potable water or raw water is typically also available, it is not necessary to design recycled water storage systems to the same criteria as potable water systems, where stored water is often the only protection against power outage or emergency demand. Anecdotal information from water agencies' operating recycled water systems indicates that because of the nutrient quality of recycled water, which can support biological regrowth, long storage retention times can adversely affect the quality of delivered recycled water.[7]

A brief review of the storage system design criteria for North Bay Watershed Association member agencies yielded designs that included no system storage (all storage provided onsite by the customer) to criteria varying from 65% to approximately 85% of daily demand.[8] In performing its initial screening, a local agency needs to understand its customers' demand patterns in order to account for appropriate system storage. The cost curves included in Section 7 assumes recycled water storage at 80% of the daily demand for both the satellite and centralized water recycling facilities. This assumption is on the conservative side for costing purposes.

6.4 Water Quality Considerations

As noted several times in this Technical Memoranda, recycled water quality can degrade within a distribution system much more quickly than potable water quality degrades. While recycled water purveyors are required to monitor bacteriological water quality as it leaves the treatment plant, there are not codified requirements for water quality or water quality monitoring within the distribution system. However, mature water recycling agencies have developed operational practices that include distribution system monitoring at storage reservoirs and key user sites on a weekly basis.[9] These agencies also indicate that charging the recycled water distribution system with potable water, during low demand periods improves the overall water quality performance of the system.

Section 7 Preliminary Economic Evaluation Techniques

7.1 Introduction

This section of Technical Memorandum presents the cost estimating system that will be used to evaluate candidate sites in each of the water service areas under study. The cost information developed here is somewhat general in nature in order to allow local agencies to perform screening analysis for the satellite treatment plant concept prior to investing in preliminary design activities.

The final costs of any project will depend on actual labor and material costs, competitive market conditions, final project costs, implementation schedule, and other variable factors. As a result, the final project costs will likely vary from initial estimate developed from the curves presented here.

The cost estimating approach used is based on guidelines developed by the American Association of Cost Engineers (AACE). During the 1970s, the American Association of Cost Engineers developed definitions for levels of accuracy commonly used by professional cost estimators. The AACE defined the three levels of cost estimates as *order-of-magnitude, budget,* and *definitive*

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[7] Marin Municipal Water District, personal communication.

[8] North Marin Water District and Marin Municipal Water District.

[9] Irvine Ranch Water District and Marin Municipal Water District, personal communication.

estimates. The cost curves presented here will yield order-of magnitude estimates, as defined below.

7.2 Order-of-Magnitude Cost Estimates

An order-of-magnitude estimate is made without detailed engineering data. Some examples include:

- An estimate from cost capacity curves
- An estimate using scale-up or scale-down factors
- An approximate ratio estimate

Typically, an order-of-magnitude estimate is prepared *at the end of the schematic design phase* of the design delivery process. It is normally expected that an estimate of this type would be accurate within plus 50 percent to minus 30 percent of the estimated cost. For example, if the estimated cost of an order-of-magnitude estimate is $1 million, then application of the plus-50-percent to minus-30-percent accuracy range would be appropriate. The plus-50-percent accuracy range means that the estimate may increase by 50 percent or that the actual cost may be up to 50 percent higher than the estimated cost. Similarly, the minus-30-percent accuracy range means that the estimated cost could be overstated by 30 percent or the actual cost may be 30 percent lower than the estimated cost. The range of expected costs in this instance would range from $.7 million to $1.5 million.

Because of the necessarily general nature of this analysis, local agencies may wish to consider the Benefit Cost Ratios they develop as having a “band of accuracy” essentially within plus 50% to minus 30%. This would mean that satellite water recycling plants, presenting Benefit Cost Ratios within the band 0.7 to 1.5 are potentially feasible.

7.3 Capital Cost Curves

Capital Cost Curves have been developed for the Satellite Water Recycling Plant, the Centralized Water Recycling Plant upgrade and for distribution system piping extension to the satellite site. These curves are presented as Figures 12, 13 and 14 respectively.

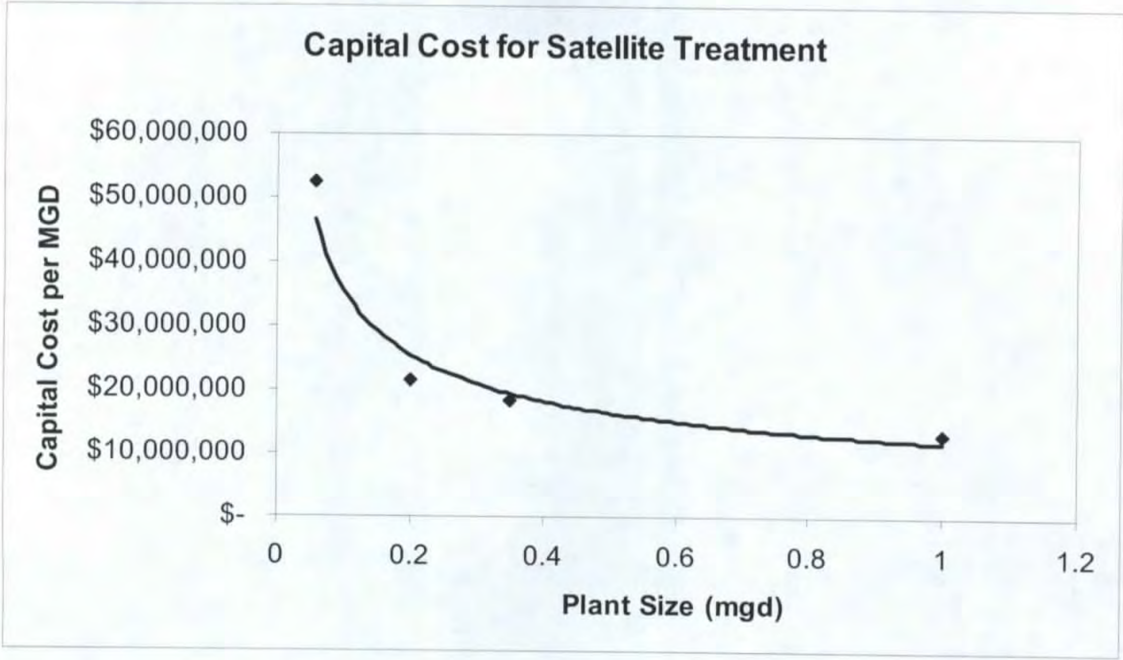


Figure 12 Capital Cost for Satellite Plant

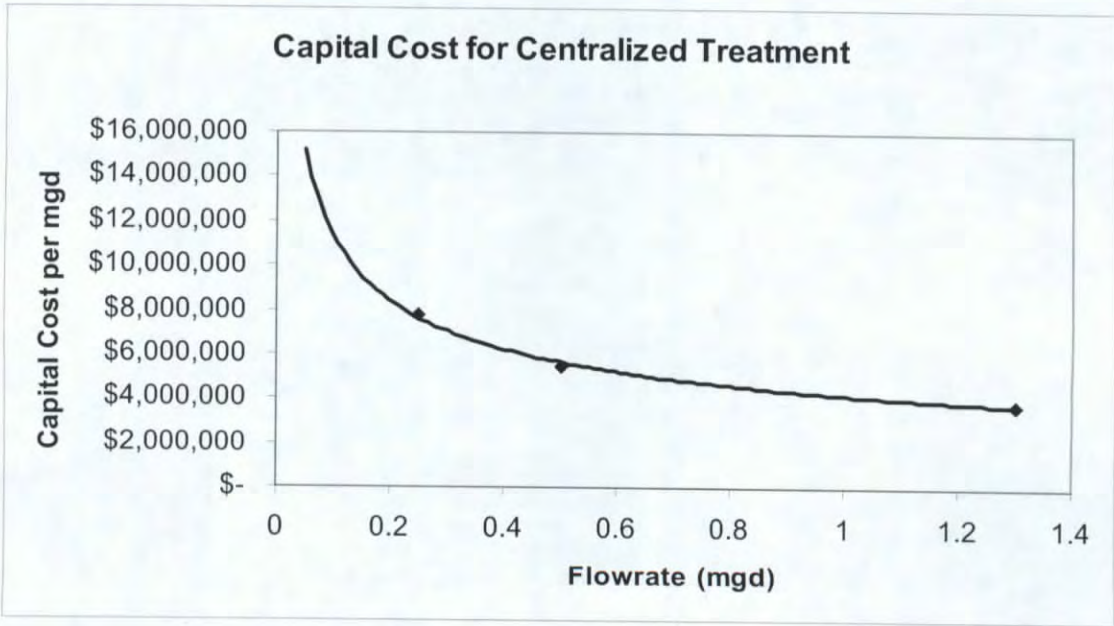


Figure 13 Capital Cost for Centralized Treatment

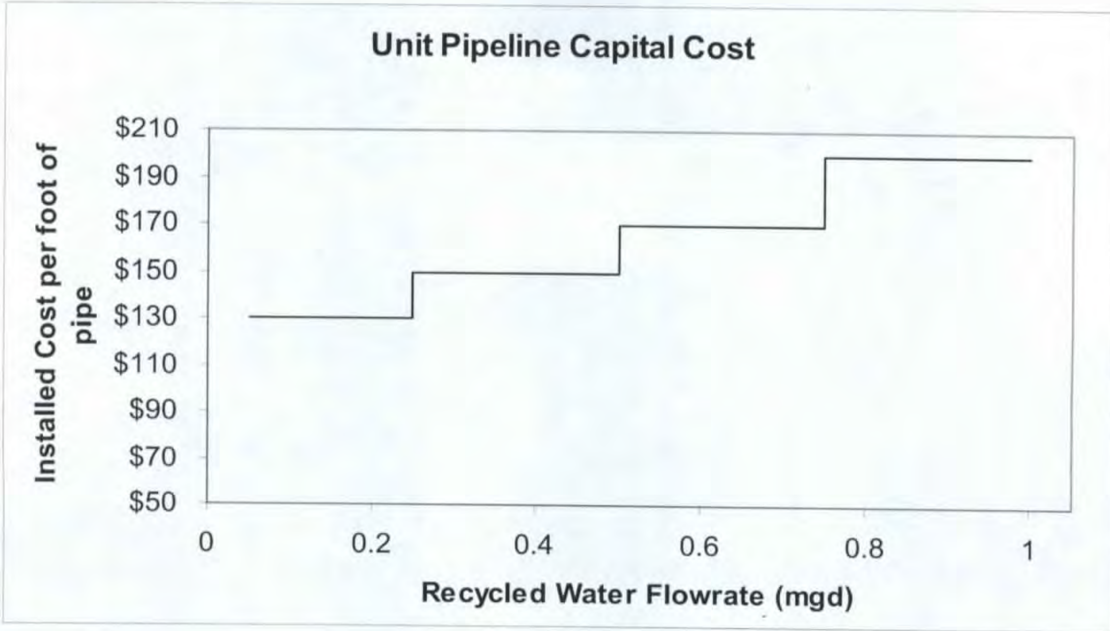


Figure 14 Unit Pipeline Capital Cost

The purpose of these cost curves is to allow an agency that knows both the water demand it is trying to satisfy and the distance between the central plant and the demand to quickly develop comparative estimates for screening purposes. The estimating templates used to develop these curves are included in the Appendix to this Technical Memorandum. A brief description of assumptions and application techniques follows.

7.3.1 Assumptions for the Satellite Water Recycling Facility:

The cost curve presented for the Satellite Water Recycling Facility includes the following items:

- A feedwell pump station from the sanitary sewer
- Screening
- A Membrane Bioreactor to provide secondary and tertiary treatment
- Ultraviolet Disinfection
- Solids return to the sanitary sewer
- An enclosing building for the treatment process train
- Power, instrumentation, controls
- Process chemical storage and feed
- A recycled water storage tank sized for 80% of plant capacity
- A recycled water pump station
- An allowance for landscaping

Equipment costs are based on vendor quotes for a range of flows. The building is estimated at $200 per square foot and the storage tank is estimated at $1 per gallon.

Raw costs have been escalated to account for planning, design, construction inspection, site work and installation and appropriate sales tax.

The costs presented do not include land acquisition.

7.3.2 Assumptions for the Centralized Water Recycling Facility:

The cost curve presented for the Central Water Recycling Facility includes the following items:

- A granular media direct filtration unit
- Ultraviolet Disinfection
- Power, instrumentation, controls
- Process chemical storage and feed
- A recycled water storage tank sized for 80% of the filter capacity
- A recycled water pump station
- An allowance for modest landscaping

Equipment costs are based on vendor quotes for a range of flows. The storage tank is estimated at $1 per gallon.

Raw costs have been escalated to account for planning, design, construction inspection, site work and installation and appropriate sales tax.

The costs presented do not include land acquisition. It is assumed that land is available at the central facility. The costs also do not include salt removal for those plants in which the total dissolved solids of the effluent are too high to be used for the identified water needs. In those cases, a salt removal process such as reverse osmosis would need to be added to the recycled water facility.

7.3.3 Assumptions for Distribution Piping Extension

The cost curve presented for the distribution piping facility assumes pipe diameter varies with flow rate, as shown in Table 8. The curve is a step curve.

Table 8 Pipeline Size Assumptions

Facility Size (mgd)	Pipeline Size Assumption
0 – 0.25 mgd	4-inch
0.26 – 0.5 mgd	6-inch
0.51 – 0.75 mgd	8-inch
0.76 – 1 mgd	10-inch

Costs are based recent bid prices for pipeline installation as well as "Current Construction Costs 2003" from Saylor Publications for PVC pipe constructed along paved roads in an urban setting. They include allowances for planning, design, construction inspection, site work and installation.

The costs presented do not include land acquisition. It is assumed that land is available within a public right-of-way.

7.3.4 On-site Retrofit of Customer's Water Service

There is cost and time involved in converting a customer's irrigation services from potable to recycled water. These costs are not included in the cost curves presented in Section 7, but should be considered when making an overall evaluation of the feasibility of recycled water.

This section documents the efforts of Marin Municipal Water District in making such conversions, and is indicative of the effort that can be required.

"Time and effort to convert a site is independent of the size of the site. It frequently requires as much time and effort to convert a small site as a large one. Tasks involved in this effort include the following:

- Initial customer contact and check of records.
- Initial site visit and plumbing system inspection.
- Develop plan and scope of work to separate potable and non-potable systems.
- Deliver plan and scope to customer and assist with selection of contractor to perform work on customers' side of meter (system separation, backflow prevention device, expansion tank, and irrigation system modifications to satisfy "no overspray and no run-off" regulatory requirements.
- Place work order to have recycled water meter set.
- Inspect contractor work on customers' piping.
- Perform cross connection shut-down test to verify separation of potable and non-potable systems. Perform final tie-in upon successful test.
- Finalize drawings and records to as-built

Estimated Costs to water agency:

- Staff time 40 hrs @ $50/hr = $2000 per site
- Install 1-inch recycled water meter and service connection = $1,750

Estimated Cost to customer:

- Install 1-inch RP device on potable line, testing, and expansion tank = $1,500

Regulatory Requirements for Dual-Plumbed Sites

- For "dual-plumbed" sites, CA DHS regulations require inspections annually and cross connection tests once every 4 years. "Dual-plumbed" sites consist of irrigation at individual residences and buildings that use recycled water for toilet flushing.
- Annual inspections require 2 hours to schedule and perform: 3 hrs @$50/hr = $150 per site.
- Cross connection testing and follow-up report to CA DHS requires an additional 4 hrs @ $50/hr = $200 every 4 years."[10]

7.3.5 Application of the Cost Curves:

The cost curves can be used to arrive at order-of magnitude capital estimates using the following for formulas:

For the Satellite Facility = **Cost/MGD (from Figure 7) x MGD proposed**
+ (Cost/Ft of Pipe (from Figure 9) x Feet Required by Project

[10] Communication from Bob Castle, Marin Municipal Water District

For the Central Facility Expansion= Cost/MGD (from Figure 8) x MGD proposed + (Cost/Ft of Pipe (from Figure 9) x Feet Required by Project

7.4 Operational Cost Curves

The operational cost curves presented above were developed to allow for comparative O&M estimates rather than total O&M estimates. The operational cost curves reflect the difference in energy costs between pumping from a centralized facility to remote area rather the pumping from the satellite facility directly into the recycled water distribution system. For this order-of-magnitude estimate, the assumption is that the treatment process costs (manpower, chemicals, sampling and process power) are roughly equivalent at the satellite and the centralized facility. Note that interagency agreements between the water and the wastewater agency are needed for ownership and operation of the recycled water plant. A state certified wastewater operator is needed for operation of the recycled water plant. If the water agency rather than the wastewater agency operates the satellite plant, the inter-agency agreement should include provisions to provide certified wastewater operators on a part-time basis. Otherwise the water agency will need to cross-certify a water plant operator or hire a contract operator.

Distribution system delivery pressure assumed to be 70 psi. Headloss is assumed to be 5-feet per 1000-feet of pipeline. For calculating pump motor horsepower it is necessary to assume a distribution pipeline length. The satellite facility is assumed to be located no more that 0.5 miles from its service area. The central facility is assumed to be 5 miles from its service area.

Electricity is estimated to cost $0.15/kWh.

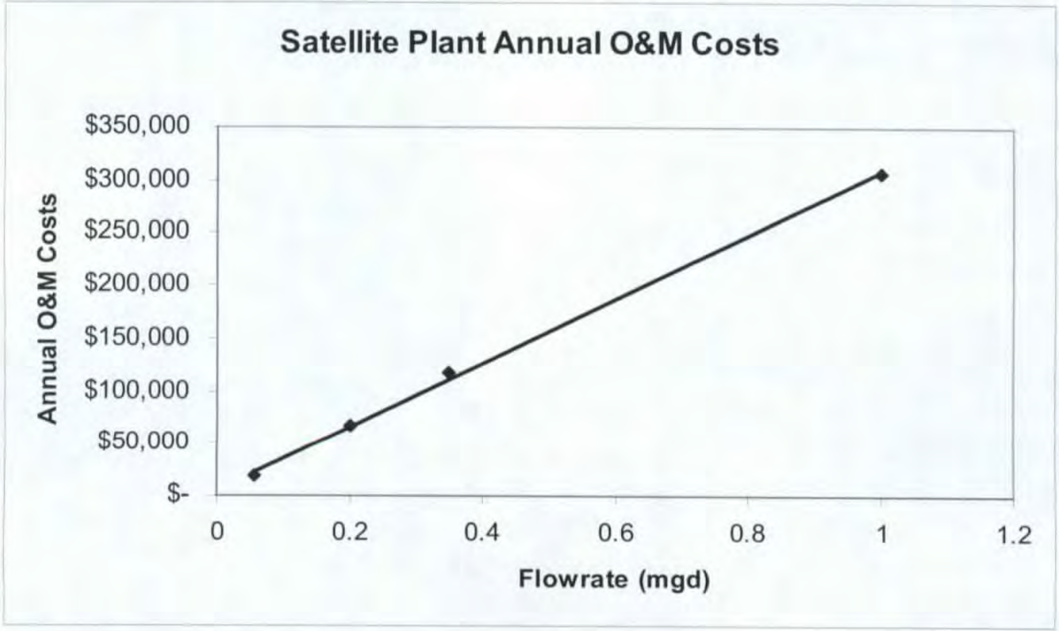


Figure 15 Satellite Plant Annual O&M Costs

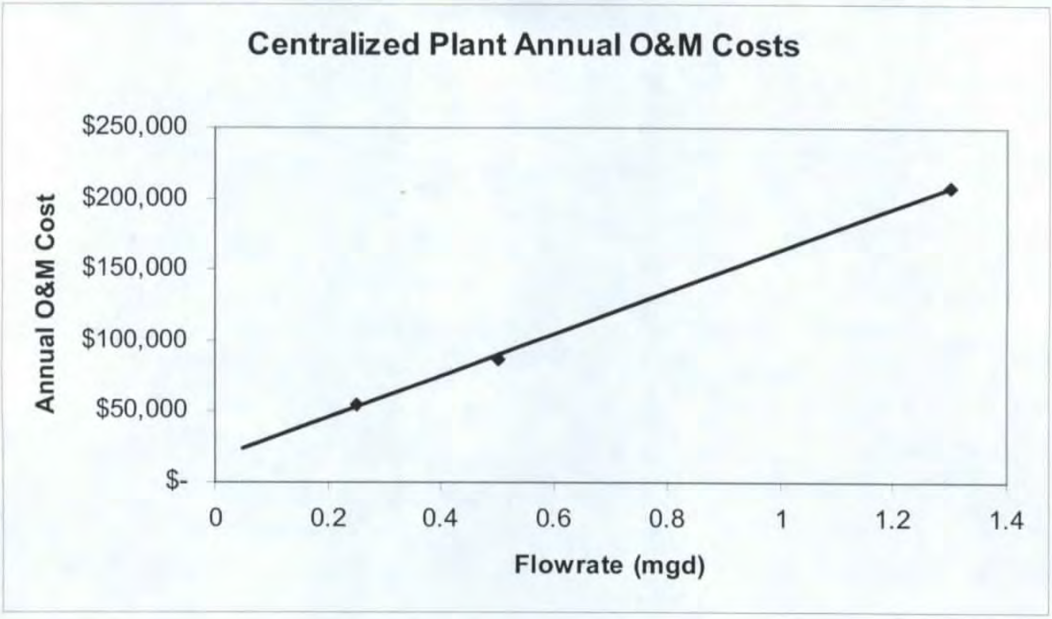


Figure 16 Centralized Plant Annual O&M Costs

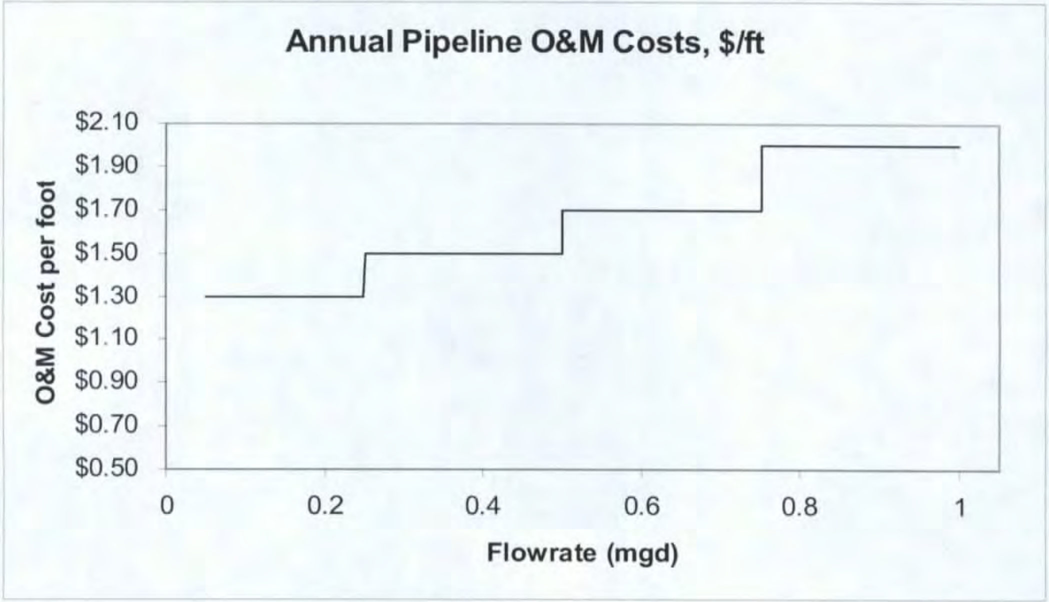


Figure 17 Pipeline Annual O&M Costs, $/ft

As a result of this analysis, it can generally be assumed that satellite facilities become economically feasible if they are approximately four miles away from the central plant. Otherwise central treatment and distribution are more feasible.

7.5 Economic Evaluation Techniques

As indicated in Figure 2 (The Decision Process Flow Chart), the screening process associated with evaluating the costs of a satellite recycled water facility as a water supply includes two cost comparisons. First a satellite water recycling facility is compared to extending service from a central water recycling facility and then the more cost effective recycled water source is compared to developing the necessary increment of potable water infrastructure.

The Department of Water Resources, which is providing funding assistance for this study, has developed tables intended to assist in the economic comparison of various alternative projects. These tables are included in Appendix B. Appendix B also provides guidance on using the cost information presented in Section 7 to complete the tables for the Satellite versus Central Recycling system.

Appendix A
Cost Estimating Templates

Quantity	Unit	Unit Cost	Subtotal	Sales Tax 8.25%	Subtotal	Tech. Allowance 82.5%	Subtotal	Imp. Allowance 35.0%	Total Cap. Cost	Annual O&M Cost	Ammortized Cost per AF (30 years @ 6%)	O
0.056												
1	LS	$ 5,000	$ 5,000									
56,000	GAL	$ 12.07	$ 676,000									
2,000	SF	$ 200	$ 400,000									
44,800	GAL	$ 0.80	$ 36,000									
1	LS	$ 21,000	$ 21,000									
1	LS	$ 10,000	$ 10,000									
			$ 1,148,000	$ 45,000	$ 1,193,000	$ 984,000	$ 2,177,000	$ 762,000	$ 2,939,000	$ 19,000.00	$ 7,100.00	$

Quantity	Unit	Unit Cost	Subtotal	Sales Tax 8.25%	Subtotal	Tech. Allowance 82.5%	Subtotal	Imp. Allowance 35.0%	Total Cap. Cost	Annual O&M Cost	Ammortized Cost per AF (30 years @ 6%)	O
0.200												
1	LS	$ 11,000	$ 11,000									
200,000	GAL	$ 3.93	$ 786,000									
3,500	SF	$ 200	$ 700,000									
160,000	GAL	$ 0.80	$ 128,000									
1	LS	$ 52,000	$ 52,000									
1	LS	$ 10,000	$ 10,000									
			$ 1,687,000	$ 52,000	$ 1,739,000	$ 1,435,000	$ 3,174,000	$ 1,111,000	$ 4,285,000	$ 67,000.00	$ 3,100.00	$

Quantity	Unit	Unit Cost	Subtotal	Sales Tax 8.25%	Subtotal	Tech. Allowance 82.5%	Subtotal	Imp. Allowance 35.0%	Total Cap. Cost	Annual O&M Cost	Ammortized Cost per AF (30 years @ 6%)	O
0.350												
1	LS	$ 11,000	$ 11,000									
350,000	GAL	$ 3.45	$ 1,208,000									
5,000	SF	$ 200	$ 1,000,000									
280,000	GAL	$ 0.80	$ 224,000									
1	LS	$ 77,000	$ 77,000									
1	LS	$ 10,000	$ 10,000									
			$ 2,530,000	$ 80,000	$ 2,610,000	$ 2,153,000	$ 4,763,000	$ 1,667,000	$ 6,430,000	$ 118,000.00	$ 2,600.00	$

Quantity	Unit	Unit Cost	Subtotal	Sales Tax 8.25%	Subtotal	Tech. Allowance 82.5%	Subtotal	Imp. Allowance 35.0%	Total Cap. Cost	Annual O&M Cost	Ammortized Cost per AF (30 years @ 6%)	O
1.000												
1	LS	$ 27,000	$ 27,000									
1,000,000	GAL	$ 2.73	$ 2,734,000									
8,300	SF	$ 200	$ 1,660,000									
800,000	GAL	$ 0.80	$ 640,000									
1	LS	$ 113,000	$ 113,000									
1	LS	$ 10,000	$ 10,000									
			$ 5,184,000	$ 180,000	$ 5,364,000	$ 4,425,000	$ 9,789,000	$ 3,426,000	$ 13,215,000	$ 307,000.00	$ 1,800.00	$

Quantity	Unit	Unit Cost	Subtotal	Sales Tax 8.25%	Subtotal	Tech. Allowance 82.5%	Subtotal	Imp. Allowance 35.0%	Total Cap. Cost	Annual O&M Cost	Ammortized Cost per AF (30 years @ 6%)	O[illegible]
0.250												
1	LS	$ 11,000.00	$ 11,000									
250,000	GAL	$ 1.76	$ 440,000									
360	SF	$ 200.00	$ 72,000									
200,000	GAL	$ 0.80	$ 160,000									
1	LS	$ 77,000.00	$ 77,000									
1	LS	$ 5,000.00	$ 5,000									
			$ 765,000	$ 22,000	$ 787,000	$ 649,000	$ 1,436,000	$ 503,000	$ 1,939,000	$ 55,000.00	$ 1,500.00	$

Quantity	Unit	Unit Cost	Subtotal	Sales Tax 8.25%	Subtotal	Tech. Allowance 82.5%	Subtotal	Imp. Allowance 35.0%	Total Cap. Cost	Annual O&M Cost	Ammortized Cost per AF (30 years @ 6%)	O[illegible]
0.500												
1	LS	$ 11,000.00	$ 11,000									
500,000	GAL	$ 1.12	$ 559,000									
360	SF	$ 200.00	$ 72,000									
400,000	GAL	$ 0.80	$ 320,000									
1	LS	$ 113,000.00	$ 113,000									
1	LS	$ 5,000.00	$ 5,000									
			$ 1,080,000	$ 28,000	$ 1,108,000	$ 914,000	$ 2,022,000	$ 708,000	$ 2,730,000	$ 87,000.00	$ 800.00	$

Quantity	Unit	Unit Cost	Subtotal	Sales Tax 8.25%	Subtotal	Tech. Allowance 82.5%	Subtotal	Imp. Allowance 35.0%	Total Cap. Cost	Annual O&M Cost	Ammortized Cost per AF (30 years @ 6%)	O[illegible]
1.300												
1	LS	$ 27,000.00	$ 27,000									
1,300,000	GAL	$ 0.64	$ 832,000									
420	SF	$ 200.00	$ 84,000									
1,040,000	GAL	$ 0.80	$ 832,000									
1	LS	$ 178,000.00	$ 178,000									
1	LS	$ 5,000.00	$ 5,000									
			$ 1,958,000	$ 41,000	$ 1,999,000	$ 1,649,000	$ 3,648,000	$ 1,277,000	$ 4,925,000	$ 208,000.00	$ 500.00	$

Appendix B
DWR Economic Tables

The Department of Water Resources, which is providing funding assistance for this study, has developed tables intended to assist in the economic comparison of various alternative projects. These tables are included in Appendix B. Appendix B also provides guidance on using the cost information presented in Section 7 to complete the tables for the Satellite versus Central Recycling system.

1. Satellite versus Centralized Recycling Systems

This comparison is completed first in order to identify the most cost effective recycling alternative.

Table 1 Project Performance: enter the demand proposed to be met by recycled water. This information is ultimately used to calculate the cost of new water supply and is often utilized by State and Federal funding agencies to evaluate projects.

Table 2 Capital Costs: this table is completed for the proposed Satellite Facility. Local agencies have the opportunity to enter land costs (Row 1). Other project costs are included in the Capital Cost pulled from the Cost Curve above and include a contingency. The table allows a local agency to include appropriate overhead, legal and site specific costs. These should also be included for the Centralized Facility.

Table 3 Operations & Maintenance Costs: this table is also completed for the proposed Satellite Facility. Annual Operations & Maintenance can be pulled from the Cost Curve. The table allows a local agency to include appropriate administration and other site specific costs. These same costs should also be included for the Centralized Facility. The table calculations allow an agency to discount the stream of annual costs (over 50 years) and arrive at a net present worth for this stream of expenditures.

Table 4 Total Cost Summary: This table utilizes the capital cost and the net present worth of the operational costs to calculate a total net present cost of the project.

Table 5a Avoided Costs of Current Supply Sources: This table should not be used when comparing the two recycled water sources. It can be used in the next section which compares the preferred recycled water source to a potable source.

Table 5b Avoided Costs of Future Supply Sources: This table should be completed for the Centralized Water Recycling facility. Base Capital and Operational Costs can be pulled from the Cost Curves. A local agency should remember to add land costs (if appropriate) and other overhead and site specific costs in order to develop a fair comparison with the Satellite Recycling Facility budgets developed in Tables 2 and 3.

Table 5c Water Sales Revenue: In general, this table should not be used when comparing the two recycled water sources because the two sources of water should be equally "vendible". (i.e. the local agency is likely to apply the same pricing structure to recycled water regardless of whether it is produced at the central or satellite facility).

Table 5d Total Water Supply Benefits: This table uses information generated in Tables 5a through 5c to calculate the net present benefits of the project.

Table 6 Benefit/Cost Ratio: This table compares Benefits to Costs. In theory, a Benefit/Cost Ratio of greater than 1 indicates that the satellite source is the preferable source of recycled water. Remembering that the costs curves utilize order-of-magnitude estimating techniques, an agency may wish to consider a "band of accuracy" in the B/C ratios where a ratio of less than 0.7 clearly favors centralized recycling; a ratio of greater than 1.5 clearly favors a satellite facility and ratios between 0.7 and 1.5 indicate that the two facilities have a comparable magnitude of cost. Within this accuracy band, other non-economic factors could be used to make a decision. These factors might include neighborhood sensitivity, a policy preference to have new development areas locally manage their resource demands or a policy preference to increase overall system reliability through decentralization.

2. Recycled Water versus Potable/Raw Water

Once the preferred recycled water source is selected, it can be compared against the other available water sources available to an agency. Essentially the same tables are used, but more factors can influence the completion of Tables 5a, 5b and 5c.

Tables 1 through 4: These tables can be completed exactly as described above, using the appropriate cost curves for the preferred recycled water source and adding appropriate local allowances for land, agency overhead and other site specific costs.

Table 5a Avoided Costs of Current Supply Sources: If the recycled water source will not only meet new demands but offset a portion of the current demand, this benefit should be accounted for. In general the current cost of supplying water should include the cost to produce the water and deliver it to the service area in question. These costs can generally be derived from water rates (wholesale or retail) and local capacity or connection fees. In accounting for these avoided costs, agencies should be careful to recognize that the proposed recycled water system includes increments of storage and distribution system capacity, that "free-up" and equivalent capacity in the potable water system. This means even if the recycled water supply is replacing a current source (it's only meeting new demand), it may still be "returning" distribution and storage capacity to the potable water system. The value of this returned capacity should be credited as a benefit. Some agencies may also be able to resell the potable water connection fee if a customer converts to recycled water use. That is an example of a site-specific factor that is not included in the DWR tables.

It should be noted here that the DWR tables do not account for avoided costs associated with wastewater treatment. If, for example, a wastewater agency must limit the mass of metals discharged, this could be accomplished by a recycled water program in lieu of treatment plant upgrades. The avoided cost of additional wastewater treatment then becomes a monetary benefit for the recycled water program. This benefit is very site-specific and agencies using the DWR tables to evaluate cost-effectiveness should include avoided costs of wastewater treatment if appropriate for their area.

Table 5b Avoided Costs of Future Supply Sources: Typically the satellite water recycling facility analysis is undertaken because an agency needs to develop a new water supply source. Table 5b should be completed with the best possible information on the cost of developing and operating this new source.

If, as can be the case in California, the new or expanded water source is viewed as valuable for environmental or recreational reasons, cover the costs of these values in Table 5b. Resource agencies and environmental groups have begun to develop this economic data and sources include the following:

- National Park Service, Rivers Trails and Conservation Assistance Program, "Economic Impacts of Protecting Rivers, Trails and Greenway Corridors", Washington D.C.
- Dolcino, Chiara and Anderson Stephen, "River Valuation Bibliography", privately published (703) 836-6149.
- US Fish & Wildlife Service, Ecology Research Center, "An Annotated Bibliography of Economic Literature on Instream Flow", Fort Collins, CO.

If, as can also be the case in California, the new or expanded water source *isn't obviously* available, cover the costs of constrained land and water use patterns in Table 5b. This technique is relatively common in agricultural economics, where land fallowing is included in economic analysis. In more urbanized settings, land trusts and open space districts may have current data on the costs of development rights purchased through conservation easements. Also, local agency economic development departments and chambers of commerce may also have data on the contributions of various types of development to the local economy.

Table 5c Water Sales Revenue: In this analysis, water sales revenue should be accounted for because the pricing system for recycled water is often different from the pricing for potable water. Some agencies do have a policy of paying users to accept recycled water (this is not recommended when high quality tertiary water is the recycled water product). However, if this is the case, the entry to Table 5c would be a negative number.

Table 5d Total Water Supply Benefits: This table uses information generated in Tables 5a through 5c to calculate the net present benefits of the project.

Table 6 Benefit/Cost Ratio: This table compares Benefits to Costs. In theory, a Benefit/Cost Ratio of greater than 1 indicates that the recycled water source is the preferable source of water. However, remembering that the costs curves utilize order-of-magnitude estimating techniques, an agency may wish to consider a “band of accuracy” in the B/C ratios where ratios between 0.7 and 1.5 are considered to represent water sources with comparable order of magnitude costs. Again, other non-economic factors could be used to make a decision. These factors might include neighborhood sensitivity, a policy preference in favor of recycling or a policy preference to preserve the highest qualities of water for the highest use (which may include environmental water).

Table 1
Project Performance

(A)	Average Annual Increase in Delivery (AF) 1	

1 Row (A) is the demand that could be met by recycled water

Table 2
Capital Costs

	A	B	C	D	E	F
				Contingency Costs		
	Capital Cost Category	Cost	Replacement Costs (Discounted)1	Percent	Dollars ((B+C)xD)	Subtotal (B+C+E)
1	Land Purchase/Easement				$0	$0
2	Planning/Design/Engineering			inc	$0	$0
3	Materials Costs			inc	$0	$0
4	Labor Costs			inc	$0	$0
5	Equipment Purchases/Rentals			inc	$0	$0
6	Environmental Mitigation/Enhancement			inc	$0	$0
7	Construction Administration/Overhead			inc	$0	$0
8	Subtotal Project Costs					$0
9	Agency Overhead Costs				$0	$0
10	Project Legal/License Fees				$0	$0
11	Other				$0	$0
12	Grand Total (8 thru 11)	$0				$0

1 Divide any future replacement cost by 1.06Y where Y is the number of years into the future that the replacement cost will occur.

Table 3
Annual Operations and Maintenance Costs

A	B	C	D	E	F
Annual Administration	Annual Operations	Annual Maintenance	Annual Other	Total Annual O & M Costs (A+…+F)	Total Discounted O&M Costs (E x 15.7)
				$0	$0

2 Total value of O&M costs over a 50-year period with discount rate of six percent

Table 4
Total Cost Summary

A	B	C
Capital and Replacement Costs1	Discounted O&M Costs2	Total Discounted Project Costs (A+B)
$0	$0	$0

1From Table 2, column (F) row (12)

2From Table 3, column (F)

Table G-5

Project Water Supply Benefits (Parts a and b)

Table 5a
Avoided Costs of Current Supply Sources

	B	C	D
Supply Sources1	Cost of Water ($/AF)	Annual Displaced Supply (AF)	Annual Avoided Costs ($) (B X C)
Totals		0	$0

1 Enter in order from most to least expensive source per unit of water.

Table 5b
Avoided Costs of Future Supply Sources

A	B	C	D	E	F	G	H	I	J
Future Supply Sources2	Total Capital Costs ($)	Capital Recovery Factor3	Annual Capital Costs ($), BxC	Annual O&M Costs ($)	Total Annual Costs ($), D+E	Annual Supply (AF)	Annual Costs ($/AF), F/G	Annual Displaced Supply (AF)	Annual Avoided Costs ($), HxI
							#DIV/0!	0	#DIV/0!
		0.0634	$0				#DIV/0!	0	#DIV/0!
							#DIV/0!	0	#DIV/0!
		0.0634	$0				#DIV/0!	0	#DIV/0!
		0.0634	$0				#DIV/0!	0	#DIV/0!
									$0
Total									#DIV/0!

2 Enter in order from most to least expensive source per unit of water.

3Six percent discount rate; 50 years.

Table G-5
Project Water Supply Benefits (Continued) (Parts c and d)

Table 5c
Water Sales Revenue (Vendibility)

A	B	C	D	E	F	G	H
Parties Purchasing Project Supplies	Annual Amount of Water to be Sold (AF)	Projected Selling Price ($/AF)	Gross Annual Expected Sales Revenue ($) (BxC)	Other Costs ($)	Net Annual Expected Sales Revenue ($) (D-E)	Optional Fee ($) [1]	Annual Expected Total Revenue ($) (F+G)
			0		$0		$0
			0		$0		$0
			0		$0		$0
			0		$0		$0
			0		$0		$0
Total	0						$0

1 Option fees are sometimes paid by a contracting agency to a selling agency to maintain the right of the contracting agency to buy water whenever needed. Although the water may not be purchased every year, the fee is usually paid every year.

Table 5d
Total Water Supply Benefits

A	Annual Avoided Costs of Current Supply Sources ($). (from 5a, column D total)	$0
B	Annual Avoided Costs of Future Supply Sources ($). (from 5b, column J total)	#DIV/0!
C	Annual Expected Water Sales Revenue ($). (from 5C, column H total)	$0
D	Annual costs of water shortages ($)[2].	
E	Total Annual Water Supply Benefit ($). (A+B+C+D)	#DIV/0!
F	Total Discounted Water Supply Benefits ($). (Ex15.7)[3]	#DIV/0!

2 Annual costs of shortages as an alternative to the project must be fully documented.

3 Discounted water supply benefits for 50-year period with discounted rate of 6%.

Table 6
Benefit/Cost Ratio

A	Total Discounted Water Supply Benefits1 ($)	#DIV/0!
B	Total Discounted Project Costs 2 ($)	$0
C	Benefit/Cost Ratio (A/B)	#DIV/0!

1 From Table 5d, Row F.

2 From Table 4, Column C.

Table 7
Unit Cost of Water Produced

A	Total Discounted Project Cost1 ($)	$0
B	Annualized Project Costs ($), row A/15.7	$0
C	Average Annual Project Yield2 (AF)	0
D	Cost per Acre Foot ($/AF), row B/row C	#DIV/0!

1 From Table 4, Column C.

2 From Table 1.

Appendix C
Alternative Technologies

GREAT CIRCLE WATER

Product Overview

Patented Point of Need Water Recycling

Contact: Ken Wooller, CEO
3 Reserva Lane
Tiburon CA 94920
Phone: (415) 435-3832
E-mail: kwooller@greatcirclewater.com

About the Company

Great Circle Water, Inc. (GCW) is an early-stage company that has developed patented equipment and process technologies for production of distributed recycled water for non-potable uses. GCW equipment will extract source water from nearby sewers and purify this water for local use. Initial markets addressed are irrigation for golf courses, office parks, athletic fields, agriculture and freeway landscaping. The products are currently being developed and tested on site at the wastewater treatment plant of the Dublin San Ramon Services District in Pleasanton, CA. GCW expects to sell products with Title 22 certification by mid 2004.

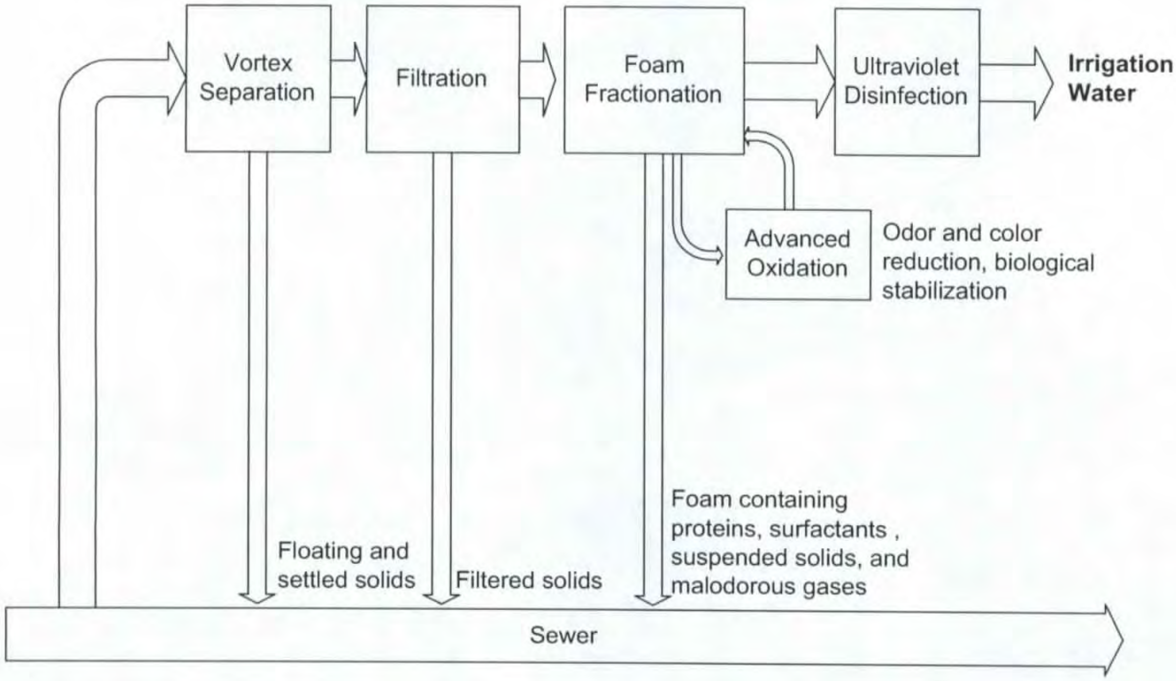
Technology / Product

GCW systems will produce water that is consistently low in odor and suspended solids, thoroughly disinfected, but with nutrient levels suitable for irrigation uses. Product installations will be odorless, quiet, automatic, and very compact, allowing them to be unobtrusively sited near residences and in populated areas. The processes used are all modular and easily scaled, allowing a wide range of capacities to be served, from less than 50,000 to over 500,000 gallons per day. The physical processes used are highly consistent and reliable, lending themselves to completely automatic, fail-safe operation, with remote monitoring. By virtue of their non-biological approach and associated short retention times, the installations can be turned on and off as needed, providing the amount of water required, when it is required. The only regular supply consumed by the process is electricity

Figure 1 presents a schematic diagram of the initial GCW product, and a list of associated benefits. The stages of treatment combine, in a unique and synergistic way, known processes and products that have proven themselves in other applications. Vortex separation in combination with fine filtration and foam fractionation removes settleable floatable and suspended solids. These treatments are followed by a combination of advanced oxidation and ultraviolet radiation which remove odor, biologically stabilize the water, and thoroughly disinfect it. Ultraviolet radiation is well recognized as being extremely effective in inactivating both bacteria and viruses, more so than commonly-used chlorine disinfectants, which also present handling hazards and create carcinogenic byproducts.

The process recovers 85% of the influent as irrigation water, returning the remainder with solids residuals to the sewer. That portion returned to the sewer is finely ground by the GCW equipment into a form that is more easily transported by the sewer and more readily treated at the central plant. COD/BOD returned to vegetation and soils as nutrients is diverted from the central treatment plant, thereby effectively reducing energy and chemical consumption at the plant, while also reducing sludge generation, and pollutant discharges into surface and ground waters.

The process encompasses much less volume and uses a much smaller footprint than conventional biological processes offering the same treatment capacity. Operation can be initiated and terminated quickly and frequently. The process is also very simple to regulate and monitor, unlike biological processes.



- Low cost
- Small footprint
- Low energy use
- Rapid startup/shutdown
- No process chemicals or supplies
- Reliable, consistent performance
- Good process and effluent esthetics
- Water meets Title 22 disinfection requirements
- Automatic, fail-safe operation; remote monitoring
- Off-the-shelf components and proven processes

Figure 1 GCW Process for Irrigation Use

Product Benefits

Benefits of the product are detailed below:

Low cost

The installed user cost of a 100K gallon per day system, excluding the associated shelter and the sewer system interconnection (which are both very site-specific), is projected at under $300,000. Operating costs are projected to be less than $1.50 per 1000 gallons, including all charges for: energy, operational and service labor, supplies, replacement parts , and off-site monitoring. These capital and operating costs taken together yield a life cycle cost for delivered water that is significantly lower than that of prevailing water recycling approaches.

Small footprint

A 50k gallon per day installation has a footprint of less than 170 sq. ft. Such an installation can fit into an unobtrusive utility building the size of a two-car garage. Larger installations will be even more space efficient. This compact installation is the result of the low retention time of the process, which is about 30 minutes, and which compares with hydraulic retention times of 8 to 16 hours for conventional biological plants.

Low energy use

Electrical energy consumption for delivered water from the GCW process is significantly lower than that for prevailing irrigation water sources, as can be seen below:

Source of Water	Energy Use (kWh/1000 gal
Great Circle Water	4.5 -6.7
Central treatment with Pipeline Distribution	6.3–7.1
Central Treatment with Groundwater Injection	6.5-8.0
Desalination of Sea Water	9.6-17.3
California State Water Project to Los Angeles	9.2

Rapid startup/shutdown

The system starts up in about 45 minutes, and shuts down in less than 15. These intervals are dramatically lower than those for biological systems, which require weeks to reach stability, and must be operated continuously to maintain proper performance. The ability to turn on and off quickly allows the GCW system to provide just the right amount of irrigation water when it is needed. The control of irrigation volumes assures balance with the ecosystem, and avoids the potential for runoff or groundwater pollution.

No process chemicals or supplies

Aside from cleaning chemicals that are used infrequently, the process requires only electricity. This minimizes the logistical needs, costs and hazards of operation.

Reliable, consistent performance
The physical process stages used are robust and inherently stable. Process throughput is essentially constant. Solids residuals are isolated and returned to the sewer.

Good process and effluent esthetics
The low retention time of the process, the injection of abundant amounts of oxygen, and the use of enclosed tanks all assure no generation of odors. Irrigation water produced is consistently free of visible suspended solids and has minimal odor.

Water meets Title 22 disinfection requirements
Preliminary tests show that the process produces an effluent containing less than 2.2e. coli MPN per 100 ml, thereby meeting the State of California Title 22 disinfection requirements for the most restrictive irrigation uses. With ultraviolet disinfection such as is used by the GCW process, such a low coliform count also assures substantial deactivation/kill of all waterborne viruses.

Automatic, fail-safe operation; remote monitoring
The process is inherently simple and self-regulating; controls are used only for input flow balancing, system monitoring, alarming and failure diagnosis. A variety of sensors – including pressure, flow, level, voltage, current, suspended solids, and temperature – allow the process to be thoroughly monitored and supervised by ssoftware-based industrial controls. Fail-safety is assured by the basic processes employed, combined with failure detection software, and a quick shutdown strategy, wherein throughput is terminated and all tanks are drained back to the sewer. Treatment sites will be monitored remotely via internet-based links using PCs with password-enabled web access.

Off-the-shelf components and proven processes
All stages of treatment use proven processes and designs, and involve primarily off-the-shelf components.

Comparative Performance

There are no known suppliers of packaged distributed "Point Of Need" water recycling systems. The biological processes likely to be used by potential competitors are expensive, bulky, maintenance-intensive, odor-prone, and unreliable. Valid comparisons are therefore with current alternative sources of new water for irrigation use: upgraded central treatment plants with newly constructed recycled water distribution pipelines or groundwater injection facilities, and new seawater desalination systems. Table 1 compares GCW Products with both existing and prospective competitors, using various attributes as bases for comparison.

● ◍ ○
Excellent ◄──► Poor

		Installed Capital Cost	Operating Cost	Siting Flexibility	Space Requirements	Implementation Time	Political Acceptibility	Modular Expandability	Oversight Requirements	Consumption of Supplies	Process Reliability	Title 22 Compliance	Energy Consumption	Esthetic Desirability
	Great Circle Water	●	●	●	●	●	●	●	●	●	●	●	●	●
Existing Competitors	Central treatment - distribution	○	●	○	●	○	○	○	●	○	○	●	◍	○
	Central treatment - groundwater inj.	◍	○	○	●	○	○	○	●	○	○	●	○	○
	Desalination of sea water	◍	◍	◍	●	○	◍	●	●	●	●	●	○	●
Potential Competitors	Membrane Bioreactor System	◍	○	◍	◍	◍	●	◍	◍	◍	◍	●	○	◍
	Fixed Film Biofilter System	◍	◍	○	○	◍	●	○	◍	◍	○	◍	◍	◍

Table 1 Comparative Attributes of Irrigation Water Sources

Compared with the current large-scale centralized approaches, GCW installations avoid the huge capital costs, long timelines, and negative environmental impacts associated with major pipeline construction projects. In terms of operating costs, the GCW process uses significantly less energy than systems using membranes for treatment of wastewater and systems using either membranes or vapor recovery for desalination of seawater . As a satellite system, it eliminates needless energy costs for pumping of water to and from distant treatment plants.

Product Development, Demonstration and Testing

GCW is developing and testing its product with the benefit of a testing/demonstration site at the Dublin San Ramon Services District wastewater treatment plant in Pleasanton, California. The District has been very supportive in this endeavor, being a leading agency in pursuing and promoting water recycling. The test site is an excellent location for such development work, containing a shelter-enclosed prototype, and a trailer lab with test equipment for measurement of most critical water quality parameters. The prototype has a treatment capacity of 50,000 gallons per day, which is the building block module for installations of all sizes. The site continues to be used for testing and evaluation of design refinements.

The commercial GCW product is now being engineered under contract by Pipeline Systems Inc. (www.pipesys.com). PSI is a leading full service control system integrator with extensive experience and strong capabilities in process and factory automation. Their previous projects have included aquariums, and municipal water and wastewater systems.

Concurrent with commercial product development, GCW will subject an upgraded version of its prototype to four months of formal testing at the DSRSD test site for the purpose of obtaining Title 22 certification. Title 22 is the State of California code governing use of recycled water for non-potable applications, and has become a defacto international standard. The certification process requires that a municipal agency make a formal request for such certification to the State of California Department of Health Services, which administers the Code. The Dublin San Ramon Services District has agreed to serve as this municipal agency sponsor. The formal tests and submittals are being planned and will be implemented with the assistance of an independent consulting firm, Carollo Engineers (www.carollo.com), Carollo Engineers is a respected, highly qualified environmental engineering firm specializing in the planning, design, and construction management of water and wastewater facilities.

Great Circle Water, Inc expects to install a certified beta version of its water recycling system product by the second quarter of 2004. GCW is currently investigating preferred sites for this purpose in the San Francisco Bay Area; it also has a prospective municipal customer in Colorado, which seeks to install a beta site in its Colorado jurisdiction.

AQUATIC ROOT ZONE-INTEGRATED FIXED-FILM ACTIVATED SLUDGE LIVING MACHINE™ SYSTEMS

Aquatic Root Zone – Integrated Fixed-Film Activated Sludge (ARZ-IFAS) Living Machine™ systems are biological nutrient removal (BNR) treatment systems that use plants as a key treatment component. This Living Machine™ technology has been extensively evaluated by the US EPA[1,2].

A distinguishing feature of the Living Machine™ systems is the designed use of plants and the associated root zone of the grazing organisms. Plant roots grow directly into aerated wastewater from racks fixed at the water surface of the treatment basin. Biofilms growing on plant roots and biosolids retained on plant roots are key treatment mechanisms. A diverse and abundant community of invertebrate organisms thrives in the plant roots by grazing on biofilms and retained biosolids.

Living Machine™ systems are both environmentally and ecologically engineered. Ecological engineering is manifested in the careful selection of plant species known to thrive and produce long roots in wastewater. The communities of invertebrate grazing organisms, scientifically termed *detritivores*, are also deliberately introduced into Living Machine ™ systems. The detritivore ecology in the plant root zone is a fundamental feature of traditional Living Machine™ systems and the family of technologies developed by Living Machines, Inc. The beauty of the plants emerging from the treatment basin is, in a sense, a bonus to human aesthetics for plant roots and associated ecology that do hard treatment work. Only negligible treatment appears to be done by uptake of nutrients into plants.

Most components of Living Machines™ systems are familiar to wastewater treatment professionals. These treatment components include headworks, anaerobic/anoxic reactors, pumps, blowers, air diffusers, programmable logic controllers, activated sludge, clarifiers, post-clarifier filtration, and disinfection systems.

ARZ-IFAS Living Machine™ Treatment Process

ARZ-IFAS Living Machine™ treatment process is comprised of a series of separate steps. Not all of the individual treatment steps listed below will be needed for a given application. All applications will employ aerated treatment basins covered with plants.

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[1] **US EPA**. 2001. The "*Living Machine*" Wastewater Treatment Technology: An Evaluation of Performance and System Cost. Municipal Technology Branch Office Of Water U.S. Environmental Protection Agency Washington, DC. In press.

[2] **Austin, David. Meyer, Jerry. Fluck, Steve. von Rohr, James R**. 2000. *Final Report on the South Burlington, Vermont Advanced Ecologically Engineered System (AEES) for Wastewater Treatment*. Unpublished report to US EPA.

Headworks

Wastewater arrives at the Living Machine™ treatment system headworks. "Headworks" is a general term for the first part of a wastewater treatment facility to receive wastewater. Types of headworks vary with the size of the treatment system and site considerations. The purpose of headworks is remove large debris and grit that are not treatable in the wastewater treatment system. Headworks may also contain advanced screening of wastewater that is more of a pretreatment step than a mere rough debris and grit removal.

Headworks can produce foul odors emanating from untreated wastewater. Control of these odors is essential if a wastewater treatment plant is located next to residences or business. Fortunately, odor control technology is highly effective with a careful selection of odor scrubbing technology which is site and scale dependent.

After the headworks, wastewater proceeds to initial treatment steps. These steps vary with the size of the treatment system and type of wastewater. In some instances, influent may arrive essentially debris-free, thereby simplifying or eliminating the need for traditional headworks.

Anaerobic Reactor

For debris-free, domestic effluent under flows of approximately 20,000 gpd, primary tanks can be used as passive anaerobic reactors that are a cost effective primary treatment system (in order to avoid confusion between a septic tank and a septic system, LMI prefers to use the term primary tank). Typically, headworks are not needed for these applications. Gases from anaerobic reactors are vented through odor control systems that scrub out hydrogen sulfide gas and offensive trace organics. These passive anaerobic pretreatment systems remove grit, floatable waste, and most grease and oil, and some BOD.

Anoxic Reactor

The purpose of the anoxic reactor is to denitrify effluent. Wastewater is extracted prior to the inlet of the clarifier and is pumped to the anoxic reactor. Nitrate in the recycled wastewater combines with raw or pretreated wastewater and then is converted to atmospheric nitrogen by bacterial metabolism. Reactor biomass is comprised of recycled activated sludge (RAS) from the clarifier and biofilm attached to a buoyant carrier media.

The anoxic reactor is mixed and intermittently aerated to prevent anaerobic conditions while promoting the growth of floc-forming and denitrifying microorganisms. These microorganisms will remove a significant portion of the incoming BOD and convert nitrate to nitrogen gas (denitrification). The anoxic reactor environment is between anaerobic and fully aerobic in terms of the oxygen content in the wastewater. There is effectively no free oxygen (O_2) in the wastewater; oxygen is present in bound forms of nitrates, sulfates and other compounds. The anoxic state is maintained by controlled aeration. An oxidation-reduction potential (ORP) probe in the reactor controls aeration to maintain ORP conditions inside the reactor within the anoxic design range. A constant recycle of process water from the last aerated reactor to the anoxic reactor returns nitrate for conversion to nitrogen gas.

Covered Aerobic Reactor

The Covered Aerobic Reactor (CAR) follows the anoxic reactor and is the first step in the fully aerobic portion of the Living Machine™ treatment process. The purpose of this reactor is to remove a large fraction of the BOD in the effluent from the anoxic reactor, and to strip odoriferous gases from the wastewater. Some conversion of organic and ammonia nitrogen to nitrate (nitrification) occurs in this reactor. The Covered Aerobic reactor is aerated with fine bubble diffuser(s) to provide oxygen required for treatment and mix the contents. Reactor biomass is comprised of RAS and biofilm attached to a buoyant carrier media.

Odor Control

To control odors at both the anoxic reactor and the covered aerobic reactors, planted biofilters consisting of approximately 2 feet of compost material and inert media, are situated directly over each reactor. The biofilters are planted with vegetation primarily to ensure that the biofilter is kept at an appropriate moisture content. Alternatively, in larger reactors, a floating cover can collect gases and vent them to an odor scrubbing system.

Hydroponic Reactors

The Hydroponic Reactors follow the Covered Aerobic reactor. These reactors reduce the BOD to less than 10 mg/L which allows for almost complete nitrification of ammonia-nitrogen to concentrations of less than 1 mg/L. The Hydroponic Reactors are aerated with fine bubble diffusers, which provide the oxygen required for microbial metabolism and keep the tank contents mixed. Reactor biomass is comprised of RAS and biofilm attached to plant roots.

The surface of the Hydroponic Reactors is covered with vegetation supported on racks. The roots of the vegetation provide surfaces for the growth of attached microbial populations that assist in the wastewater treatment. The vegetation serves as habitat for invertebrate detritivores that consume microbial biomass. The grazing reduces the sludge volume generated and prevents excessive biofilm growth. Also, the vegetation and racks reduce the surface turbulence in the reactor, which reduces the formation of aerosols and volatilization of odor compounds.

Clarifier

The Clarifier follows the Hydroponic Reactors and is the next treatment step in the Living Machine™ system. The purpose of the Clarifier is to separate the microbial solids from the treated wastewater stream using gravity settling. Some of the settled microbial solids (biosolids) are returned to the anoxic reactor to provide active microbial populations for the treatment process. Settled biosolids that are not recycled are removed from the clarifier and handled as described below.

Post-Clarifier Filtration

Effluent from the clarifier is usually very clear. However, the settling characteristics of biosolids may undergo transient changes that degrade clarifier performance. Disinfection performance can be degraded by these undesirable changes in clarifier performance. Standard engineering practice to ensure effective disinfection and high-quality effluent is to place some form of filtration system between the clarifier and the disinfection system. For high quality reuse applications, filtration is typically mandated by prescriptive regulatory standards.

Post-Clarifier Filtration – Polishing Wetland

For sites that have sufficient space, the post-clarifier filtration step can be effectively accomplished with a planted vertical flow polishing filter or wetland. Effluent from the clarifier is dosed on the wetland surface to flow down through plant roots and media to a bottom drain system. Biosolids not captured in the clarifier are strained out of water by plant roots and media and consumed by detritivores in the wetland. Periodic draining of the wetland prevents long-term formation of anaerobic conditions. Effluent from the bottom drain is very clear and suitable for disinfection. These polishing wetlands are compact in comparison to standard treatment wetlands and will operate outdoors even in severe winters.

Other Post-Clarifier Filtration Options

For sites that have limited space, a textile filtration system will produce effluent of superb clarity with simple operation. The Fuzzy Filter ™ (Schreiber Corporation) and the Aquadisc Filter ™ (Aqua-Aerobics Systems, Inc.) are two examples of modern textile filter technology that can be used in Living Machine™ Treatment systems. Conventional filtration technologies, such as rapid sand filtration, may be satisfactory.

Disinfection

Effluent from the clarifier flows to a disinfection system. Living Machines, Inc. strongly advises against the use of free-chlorine or chloramine based disinfection because they create toxic byproducts.

Ultraviolet (UV) disinfection relies on ultraviolet radiation to render bacteria and viruses non-infective by disrupting their DNA and/or RNA. The UV disinfection leaves no residual disinfectant and requires effluent with low turbidity and little color to be effective.

Living Machines, Inc., through its sister company, Water Technologies, Ltd., also offers the Curoxin™ chlorine dioxide disinfection system. Long recognized in the drinking water industry as a powerful disinfectant that produces no harmful byproducts in disinfected water, chlorine dioxide is becoming an increasingly attractive disinfection option for wastewater. The Curoxin™ system used to manufacture the chlorine dioxide on site is proprietary to Iasis, Ltd., the parent company of Living Machines, Inc.

Filtrate Disposal

Automated filter cleaning processes produce a filtrate side stream that requires further processing. Filtrate can be recycled to the front of the system for continued digestion or composted in an on-site reed bed or disposed of off-site. The volume and frequency of filtrate disposal and method of processing depends on the type of filtration employed and quantity of feed water.

Biosolids Disposal

The optimal means for the disposal of waste biosolids depends almost entirely on site-specific considerations such as, Living Machine™ system size, and local regulations. For small systems under 20,000 gpd, hauling waste biosolids off site by a sludge or septic hauler may be cost effective. Larger systems will typically require more sophisticated methods. In some instances, aerobic stabilization followed by biosolids composting in reed beds is a highly desirable and cost effective solution. Because of the variables involved, optimal biosolids disposal options determined on a case-by-case basis.

Plant Composting

Plants grow at a high rate with ample water, nutrients, and sun. Periodic mowing of plants is necessary to reduce plant biomass and to maintain the overall health of the plant community. Manual mowing/cutting and composting of plant biomass is cost effective for systems of approximately 100,000 gpd or less. The design details for larger treatment systems typically include mechanically assisted mowing and composting.

Applications

Living Machines, Inc. has designed Living Machine™ treatment systems for domestic and institutional sewage and industrial food waste. Our market focus is domestic sewage, however high-strength food processing wastewater projects can be ideal Living Machine™ applications. Domestic wastewater projects have included resorts, boarding schools, visitor centers, museums, botanical gardens, and municipal applications. All of these applications have required close proximity of wastewater treatment to areas receiving heavy foot traffic. Aesthetics and odor control have been key design elements of all these applications in addition to high effluent standards.

Treatment Levels

Treatment levels are usually dictated by discharge requirements. Treatment to higher levels may be desirable in many cases to expand re-use options, give greater safety margins, and reduce maintenance. Maximum Living Machine™ system treatment levels for domestic wastewater are summarized in Table 2-1. This maximum level of treatment is suitable for advanced reuse applications such as spray irrigation, where allowed by regulatioins, and discharge to sensitive surface waters. Maximum treatment effluent values are suitable for reverse osmosis feed water.

Table 2-1. Maximum Treatment Levels – Root Zone-IFAS Living Machine™ Systems

Parameter	Best attainable effluent standard	Note
BOD_5	≤5 mg/L	
Total nitrogen	≤10 mg/L	
Ammonia	≤1 mg/L	
Phosphorous	40% removal	Increased phosphorous removal will require additional chemical/physical unit processes.
TSS	≤5 mg/L	Typically requires post clarifier filtration
Turbidity	2 ntu	Requires post clarifier filtration
Fecal coliforms	< 2.2 cfu/100ml	Requires post clarifier filtration and disinfection.

A lower level of treatment is commonly sufficient to meet discharge requirements and is summarized in Table 2-2.

Table 2-2. Common treatment levels – Root Zone-IFAS Living Machine™ Systems

Parameter	Effluent standard	Note
BOD_5	10 mg/L	
Total nitrogen	15 mg/L	
Ammonia	3 mg/L	
Phosphorous	40% removal	Increased phosphorous removal will require additional chemical/physical unit processes.
TSS	10 mg/L	With post-clarifier wetland.
Turbidity	15 ntu	With post-clarifier wetland.
Fecal coliforms	100 cfu/100ml	Disinfection.

IMPORTANCE OF PLANTS IN LIVING MACHINE™ SYSTEMS

The impact of plants on wastewater treatment is directly proportional to their root penetration and density. Roots must deeply penetrate wastewater to affect treatment. Long, dense masses of roots significantly affect treatment. Short roots do not. Many plants will thrive with roots in wastewater, but only a small subset of those plants will produce the roots that make them useful for treatment. Careful, exclusive selection of plants known to produce long, dense root masses is a key element of Living Machines, Inc. designs.

Plants in Hydroponic Treatment

In hydroponic reactor systems, such as ARZ-IFAS Living Machines™ systems, plants installed on racks at the water surface send roots into wastewater. After years of research on hundreds of plant species, Living Machines, Inc. has determined that a reliable depth of penetration for dense root mats is approximately two feet. Greater depths of penetration do occur, but two feet is a safe design standard.

All hydroponic reactors systems designed by Living Machines, Inc. are restricted to a select list of plants. Criteria for selection of plants go beyond depth of root penetration. Hardiness in the wastewater environment, resistance to pests, and suitability for the site environment are other key selection concerns. Investigation of other species continues.

Depth of root penetration into wastewater must be considered in proportion to the depth of the treatment basin. The consensus among experts[3] who have studied water hyacinth wastewater treatment systems is that roots must densely penetrate approximately 20-30% of the wastewater column to significantly affect treatment. Living Machines, Inc. concurs with the experts. The same criterion applies to all hydroponic treatment systems. With a two foot-deep root mass 30% penetration therefore requires that a hydroponic treatment basin be no more than six feet deep.

Wastewater must circulate or pass through the root mass for plants to contribute to treatment. Aeration or hydraulic mixing creates the circulation patterns necessary to pass wastewater though plant roots. Flow may also be directed through the root mass via a surface collection system in each treatment basin.

The role of plant roots in hydroponic treatment appears to have three main elements: retention of suspended biosolids, substrate for biofilm growth, and creation of a habitat for large populations of invertebrate organisms that graze on bacterial biomass.

Retention of biosolids is an important treatment mechanism in ARZ-IFAS[4] Living Machine™ systems. The effect of biosolids retention is to stabilize treatment by retarding biosolids washout and to reduce yield. Reduction of yield is a consequence of grazing of biosolids by invertebrates and endogenous respiration of retained bacteria biomass. Retention of biofilms on plant roots sloughed from carrier media in upstream reactors is a treatment mechanism currently under evaluation.

Biofilms grow on submerged plant roots. These biofilms do play a key treatment role in water

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[3] Oral communication from Robert Bastian, US EPA Office of Water Management; George Tchobanoglous, Professor Emeritus, Department of Civil and Environmental Engineering, University of California-Davis; Sherwood Reed, US Army Corps of Engineers (retired).

[4] **Austin, David**. 2001. Parallel Performance Comparison Between Aquatic Root Zone - and Textile Medium - Integrated Fixed-film Activated Sludge (IFAS) Wastewater Treatment Systems. Proceedings Water Environment Federation Technical Conference 2001, Atlanta, Georgia.

hyacinth treatment systems[5]. Undoubtedly, biofilms growing on plant roots play a significant treatment role in Living Machine™ systems.
The root zone in water hyacinth treatment systems is known to host a diverse microbial community[6]. The same is true for Living Machine™ systems. Grazing of bacterial biomass is an important mechanism to achieve low yield (mass effluent VSS / mass influent BOD_5) in water hyacinth treatment systems[7] that can produce tertiary or near tertiary quality VSS effluent concentrations[8]. Selection of Living Machine™ hydroponic system plants with large, dense root masses and placing them in shallow reactors both maximizes habitat for grazing organisms and their access to bacteria biomass produced in wastewater.

Plants in Wetland Treatment

Decades of experience with wastewater treatment wetlands have provided a long list of plants suitable for this application. Because treatment wetlands are usually outdoors, use of native plant species is often desirable.

The role of plants in wastewater treatment wetlands is controversial. Results from studies comparing vegetated and unvegetated horizontal, subsurface flow gravel beds indicate that plants do not significantly impact treatment[9,10]even though there is strong evidence that the presence of roots significantly affects the composition of microbial populations[11]. In horizontal subsurface flow wetlands, roots tend to grow little below the permanently wetted media surface, and tend to create a dead zone through which little wastewater flows[12]. Obviously, roots cannot affect treatment if not effectively in contact with wastewater.

The design of horizontal subsurface flow wetlands is largely incompatible with deep penetration of roots into the wastewater treatment column. Plants need only send down roots a short distance to obtain abundant water and nutrients. As in hydroponic reactors, few plants will send down long roots under such conditions. Part of the lack of root penetration may also be attributed to dense gravel media that is not easily penetrated by roots adapted to growing in

[5] **Tchobanoglous, George. Maiski, Frank. Thompson, Ken. Chadwick, Tomas.** 1989. *Evolution and Performance of City of San Diego Pilot-scale Aquatic Wastewater Treatment System Using Water Hyacinths.* Research Journal Water Pollution Control Federation, November/December 1989.
[6] **Reed, Sherwood. Crites, Ron. Middlebrooks, E**. 1995. *Natural Systems for Waste Management and Treatment*, 2nd Ed. Chapt. 5. McGraw-Hill.
[7] **Crites, Ron. Tchobanoglous, George**. 1998. *Small and Decentralized Wastewater Treatment Systems*. McGraw Hill.
[8] **Western Consortium for Public Health (WCPH). EOA, Inc.** 1996. *Total Resource Recovery Project, Final Report.* City of San Diego Water Utilities Department.
[9] **US EPA**. September 2000. *Constructed Wetland Treatment of Municipal Wastewaters.* EPA/625/R-99/010.
[10] **Watson, J. Danzig, A**. 1993. Pilot-Scale Nitrification Studies Using Vertical-Flow and Shallow Horizontal-Flow Constructed Wetland Cells, in *Constructed Wetland for Water Quality Improvement*. G. Morshiri, Ed. Pp. 301-313. Lewis Publishers.
[11] **Hatano, K. Trettin, C. House, H. Wollum, G**. 1993. Microbial Populations and Decomposition in Three Subsurface Flow Constructed Wetlands, in *Constructed Wetland for Water Quality Improvement*, G. Morshiri, Ed. Pp. 541-548. Lewis Publishers.
[12] **US EPA**. September 2000. *Constructed Wetland Treatment of Municipal Wastewaters.* EPA/625/R-99/010.

muck.

Living Machines Inc.'s vertical flow wetland designs maximize the contribution of plant roots to treatment. Dosing wastewater on top of the root mat forces wastewater to pass through the root mass. Formation of a thick mat of interwoven roots is typical of wetland perennial species. Additionally, the media specified is a combination lightweight ceramic aggregate and plastic that is easily penetrated by plant roots, allowing for much deeper root penetration.

Plants in natural wetlands sustain communities of grazing organisms that consume bacterial and algal biomass. The same is true for surface flow wetlands. Horizontal subsurface flow wetlands, however, provide essentially no habitat for invertebrate grazer communities. Either the plant thatch is too dry, or the subsurface wetted zone does not have enough oxygen to support any higher aquatic invertebrates, such as rotifers, amphipods, copepods, and beneficial insect larvae.

Most obligate wetland plants do pump oxygen to their roots. However, mass flux of oxygen to the roots is too small to support more than plant physiology and a thin film of microaerophilic bacteria. Microaerophilic bacteria oxidize anaerobic compounds, such as H_2S, that are toxic to plants. Pumping of air to plant roots is an energy cost to plants. In highly reducing wetland soils, plant growth is stunted by the need for plants to expend excess energy to oxidize plant roots. There is not sufficient oxygen to support higher organisms that are associated with roots in soils with positive dissolved oxygen concentrations.

The vertical flow wetland designs by Living Machines, Inc. support a community of higher aquatic invertebrates. In Tidal Flow Wetland designs the plant thatch and root zone is either moist or flooded. In small re-circulating vertical flow wetlands the plant root zone stays moist and aerobic. Both maintain aerobic zones that will sustain higher aquatic organisms[13]. The action of these grazing organisms keeps the wetland surface from accumulating excessive bacterial biomass that can clog the wetland surface. Without the ecosystem created and sustained by plants a vertically loaded gravel bed will quickly clog at higher application rates.

Distinguishing between the treatment role of plants and media may be difficult for some parameters in vertical flow wetlands. Without doubt, the biofilms on wetland media play a primary role in wastewater treatment. Maximization of plant root growth and communities of associated grazing organisms optimizes the contribution of both media and plants to wastewater treatment.

[13] Insect disease vector larvae, such as mosquitoes or horseflies, however, are excluded from these treatment systems either by lack of habitat or predation.

OVERTIME

ACCRUE PAYMENT

SONOMA COUNTY WATER AGENCY

PAYROLL TIME REPORT FOR BI-WEEKLY PAY PERIOD ENDING 03/28/05

TIME_SHEET_PRINT ver 1.0 06/95

Printed 03/17/05 09:38

Premiums: 1. HAZARDOUS DUTY CLASS I 2. HAZARDOUS DUTY CLASS II 3. HVY EQUIP/WA MW II 4. WA OP/MECH PAY 5. HVY EQUIP/WA MW II 6. HEAVY TRUCK/DAILY 7. PHONE CALL 8. CALL BACK/2 HR MIN (SEIU) 9. CALL BACK/3 HR MIN (LOC 39)

DESCRIPTION	PROJECT NUMBER	TASK	SHIFT=1,3,4	PREMIUMS	HOURS WORKED & LEAVE HOURS TAKEN – WEEK 1 TUE	WED	THU	FRI	SAT	SUN	MON	TOTAL	OT TOTAL	WEEK 2 TUE	WED	THU	FRI	SAT	SUN	MON	TOTAL	OT TOTAL	BI-WEEK TOTAL
PUBLIC INFORMATION GENERAL OVERHEAD	3280	01			1.5	1.0	1.0					3.5											3.5
KAWANA SPRINGS TANK #2-RR/COTATI PROJECT DESIGN	3847	01			1.0	2.0						3.0											3.0
VICTORIA DR/CORBY AVE COLLECTION SYSTEM DESIGN	3629	01			1.0	0.5	1.0					2.5											2.5
ORGANIZATIONAL EXCELLENCE PROGRAM CAL EXCELLENCE PROGRAM	3960	03			1.5	1.0	1.0					3.5											3.5
ENGINEERING OVERHEAD ENGINEERING OVERHEAD-GENERAL	0114	01			1.0	1.0						2.0											2.0
FIRST ST W STORM DRAIN CONDUIT EXT SCWA ACTIVITY	3956	01				0.5						0.5											0.5
ENGINEERING OVERHEAD ENG OVHD-TRAINING/SEMINARS	0114	03				2.0						2.0											2.0
WATER TRANSMISSION SYSTEM-ENGR SERVICES WATER SUPPLY STUDIES/REPORTS/P	0617	01				0.5	1.0					1.5											1.5
KENMORE LANE COLLECTION SYSTEM DESIGN (WASTEWATER)	3628	01					1.0					1.0											1.0
TOTAL WORK HOURS					6.0	8.5	5.0					19.5											19.5
TOTAL LEAVE HOURS																							
TOTAL PAYROLL HOURS					6.0	8.5	5.0					19.5											19.5

HASH TOTALS	
WORK ORDERS	231463
EMP. NUMBER	21303

EMPLOYEE CERTIFICATION: I HEREBY CERTIFY THAT THE TIME REPORTED ON THIS FORM IS A TRUE & CORRECT RECORD OF MY TIME FOR THE PERIOD INDICATED. ADDITIONALY, I HEREBY AFFIRM THAT I WAS ELIGIBLE FOR ANY LEAVE REPORTED UNDER THE APPLICABLE PERSONNEL RULES AND REGULATIONS.

SIGNATURE

SUPERVISORS CERTIFICATION OF HOURS WORKED.

SUPERVISORS INITIAL

EMPLOYEE NAME: FLUGUM, P.

EMPLOYEE NUMBER: 2367PF

SHEET NO. 1

LAST SHEET

Technical Memorandum No. 2

Subject: Marin Municipal Water District Service Area Analysis

Prepared For: North Bay Watershed Association – Integrated Water Resources Committee

Prepared By: Raines, Melton & Carella, Inc.

Date: May 18, 2004

Contents

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Section 1 Introduction and Purpose

This Technical Memorandum is part of a feasibility study of satellite recycled water treatment as part of a regional water recycling analysis for the North Bay Watershed Association. The general analysis techniques, developed in Technical Memorandum #1 "Draft General Process and Distribution System Overview" dated May 2004 will be applied to the Marin Municipal Water District's (MMWD's) service area. The general analysis techniques and analyses described in Technical Memorandum #1 (hereinafter referred to as the General Criteria) are used to identify a range of candidate satellite treatment plant sites and compare the feasibility of these satellite systems to a centralized recycling system.

Section 2 Study Area Characteristics

2.1 General Hydrologic Overview

The MMWD Service Area, illustrated in Figure 1, generally includes eastern Marin County from the Golden Gate Bridge to approximately the urban limits of the City of Novato. The most prominent geologic feature in the study area is Mt. Tamalpias. Groundwater resources are not significant.

Water Supply: MMWD actively manages surface water resources from 50,000 acres of local watershed lands in the Mt. Tamalpias and West Marin basins. The MMWD drinking water supply from Mt. Tamalpias and West Marin within MMWD's watershed is excellent.[1]

Wastewater Discharge Issues: The San Francisco Bay Regional Water Quality Control Board has identified the majority of streams lower in the watershed, outside of the MMWD drinking water supply, as impaired for diazinon. This is generally the result of storm water runoff and storm drain discharges within the urbanized portions of the study area.[2] The study area drains to San Pablo Bay, Richardson's Bay and San Francisco Bay. These waters are listed for multiple contaminants including pesticides, exotic species, dioxin and furan compounds, mercury, nickel, selenium and PCBs[3]..

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[1] Urban Water Supply Management Plan, Marin Municipal Water District, February 18, 2003.
[2] Phase 1 Executive Summary, North Bay Watershed Stewardship Plan. RMC, October 2003.
[3] Phase 1 Executive Summary, North Bay Watershed Stewardship Plan. RMC, October 2003.

Figure 1 MMWD Service Area

2.2 Land Use & Population Trends

The MMWD service area and Marin County is, in general, slow-growing as a result of both growth management policies and active land conservation efforts. Much of the County's western coast is held as a National Seashore; upland watershed resources are held by MMWD; in the eastern portion of the County there are a number of bayside parks and open space holdings. The County expects population to grow from approximately 230,000 people to 250,000 (an increase of 10%) as it moves to buildout. However, commercial and industrial square footage is expected to double as the County seeks to improve its jobs-to-housing balance.[4]

Growth will be concentrated within the existing urban areas. While the County is expected to grow by 10%, the population in MMWD's service area is closer to build-out, and is anticipated to grow by 7.5%.

2.3 Water Supply

MMWD's water supply is composed of local stored surface water (approximately 80,000 acre-feet annual average), imported water from Sonoma County Water Agency (approximately 8,000 acre-feet annual average) and recycled water produced in the northern part of its service area (approximately 800 acre-feet on annual average). MMWD also has an extensive water conservation program that has

[4] Marin Countywide Plan, Community Development Element, September 1999 amendments.

achieved a 25% reduction in demand through various measures.[5] The local surface water supply, in particular, is highly variable and MMWD experienced prolonged droughts in the late 1970s and early 1990s. In addition, Sonoma County Water Agency is currently engaged in a complex Endangered Species Act negotiation for its Russian River supply and has entered into a "Temporary Impairment Agreement" with its wholesale customers. MMWD's Urban Water Management Plan acknowledged a potential water supply deficit of 1,650 acre-feet annually in 2000 at current demands[6]. MMWD analyzed the feasibility of constructing a desalination plant along San Francisco Bay in the early 1990's. Because of improvements to membrane system efficiency and the potentially high variability in its source water supply, MMWD is revisiting this analysis and has begun scoping an environmental document. The desalinated water supply is estimated to cost $1,525 per acre-foot per year in current dollars.[7]

2.4 Wastewater Disposal

The MMWD Service area includes 14 wastewater agencies. Five of these agencies shown in bold face maintain treatment facilities, including two Title 22 tertiary water recycling facilities; eight of these agencies maintain only collection systems and 1 maintains a collection system and a water recycling facility that does not meet current Title 22 standards for filtration or disinfection. This water recycling facility, operated by Richardson Bay Sanitary District was "grandfathered" to allow it to continue its urban irrigation practice, and can not be expanded to serve additional users. Treated effluent is generally disposed of by outfall to San Pablo or San Francisco Bay. Shallow water discharges to San Pablo Bay are limited to the wet weather season, creating the need for some land-based disposal at the Las Gallinas Valley Sanitary District in the northern part of the service area. Table 1 below provides a summary of the wastewater agencies, listed from south to north.

[5] Urban Water Supply Management Plan, Marin Municipal Water District, February 18, 2003, page 6.
[6] Urban Water Supply Management Plan, page 29. "Deficit means that MMWD is relying more heavily on local surface water supplies which may not be sustainable under drought conditions."
[7] Seawater Desalination as Possible Alternative component of Integrated Water Resources for MMWD, June 2001, Bahman Sheikh in association with Parsons

Table 1 Summary of Wastewater Agencies

Agency	Facilities Maintained	Tributary To	Average Dry Weather Flow	Recycling Capacity	Other Disposal Methods
Sausalito Marin City Sanitary District (SMCSD) [1]	Collection & Treatment Facilities	N.A.	1.40 mgd	0	**San Francisco Bay Outfall**
Tamalpias CSD	Collection Facilities	SMCSD & SASM	0.36 mgd	0	N.A.
Sewerage Agency of Southern Marin (SASM) [2]	Treatment & Recycling Facilities	N.A.	2.90 mgd	0.18 mgd	**San Francisco Bay Outfall**
Richardson Bay Sanitary District	Collection & Recycling Facilities	SASM	not available	0.07 mgd	N.A.
Homestead Valley Sanitary District	Collection Facilities	SASM	0.18 mgd	0	N.A.
Alto Sanitary District	Collection Facilities	SASM	0.08 mgd	0	N.A.
Almonte Sanitary District	Collection Facilities	SASM	0.14 mgd	0	N.A.
City of Mill Valley	Collection Facilities	SASM		0	N.A.
Sanitary District No. 5	Collection & Treatment Facilities	N.A.	0.76 mgd	0	**San Francisco Bay Outfall**
Central Marin Sanitation Agency (CMSA) [1]	Treatment Facilities	N.A.	8-10 mgd	0	**San Francisco Bay Outfall**
Sanitary District No. 1	Collection Facilities	CMSA	3.00 mgd	0	N.A.
Sanitary District No. 2	Collection Facilities	CMSA	0.81 mgd	0	N.A.
San Rafael Sanitation District	Collection Facilities	CMSA	4.40 mgd	0	N.A.
Las Gallinas Valley Sanitary District (LGVSD)	Treatment & Collection Facilities	N.A.	2.20 mgd	2.0 mgd	**Shallow Water Discharge (Miller Creek), Land Application**

[1] TDS of effluent is too high to be used for landscape irrigation
[2] TDS of effluent is marginal for landscape irrigation
N.A. stands for Not Applicable

Section 3 Market Assessment Methodology

3.1 Relationship to Previous Studies

In the 1976-77 drought, MMWD began providing recycled water in its service area from a pilot facility. In 1981, MMWD brought online a 1 mgd recycled water facility, using effluent from the Las Gallinas Valley Sanitary District (LGVSD). This facility was expanded to 2 mgd in 1989. Since that time, MMWD has actively explored additional water recycling opportunities and the recycled water market within this service area is well understood. Recent market analyses completed within the service area include:

- <u>The Recycled Water Expansion Feasibility Study,</u> prepared by Marin Municipal Water District in January, 2000. This study explored additional development of recycled water from both the LGVSD and the Central Marin Sanitation Agency (CSMA).

- Review of Water Recycling and Gray Water, prepared by Bahman Sheik, Ph.D, P.E. with Parsons in April of 2001. This study reviewed the results of the Recycled Water Expansion Feasibility Study and introduced the concept of Satellite Water Recycling Facilities.
- North Bay Regional Water Recycling Feasibility Study, prepared by RMC in November of 2002. This study explored providing regional tertiary treatment for all five wastewater dischargers in the MMWD service area along with facilities that serve the City of Novato, the City of Petaluma and the Sonoma Valley Sanitation District.
- The SMCSD/Ft. Baker Recycled Water Feasibility Study, currently in draft by RMC. This study focuses specifically on the recycled water market at Ft. Baker at the Southern end of the MMWD Service Area.

Figure 2 illustrates the geographic area reviewed in each of the previous market analyses, as well as the service areas reviewed by this study.

This study, which focuses specifically on the feasibility of satellite facilities, included an analysis of the tributary collection systems in the MMWD service area in order to match wastewater flows with water demands. The analysis focuses on discrete clusters of users located some distance from the central wastewater treatment plant and begins by identifying a distant large water user and then identifying a nearby "sewershed" with adequate flow to serve the user.

3.2 Regulatory Context

All of the market analyses indicate that MMWD's urban recycled water market will require Title 22 Disinfected Tertiary Recycled Water. Additional treatment to manage high salt content in the secondary effluent is considered in specific areas and is described in the Alternative Analysis section, below.

MMWD currently operates its recycled water facilities under permit from the San Francisco Bay Regional Water Quality Control Board (Region 2). Region 2 has implemented a General Water Recycling Permit. Public agencies may apply for coverage under the General Permit by filing a Notice of Intent together with an Engineer's Report prepared in accordance with Title 22.

MMWD has a Recycled Water Mandatory Use Ordinance in place within its service area, assuring that available recycled water will be beneficially used. The Ordinance serves as evidence of potential user notification.

3.3 Water Demand and Costs

Water demand within the MMWD service area was quantified using MMWD's user database. This database includes information on each users "entitlement", which is the total capacity that user has purchased in the system. This analysis focuses primarily on irrigation demand and, as appropriate, the entitlement data has been reviewed with respect to water use records. As noted above, MMWD anticipates that cost of future water supply through desalination will be $1,525 acre-foot.

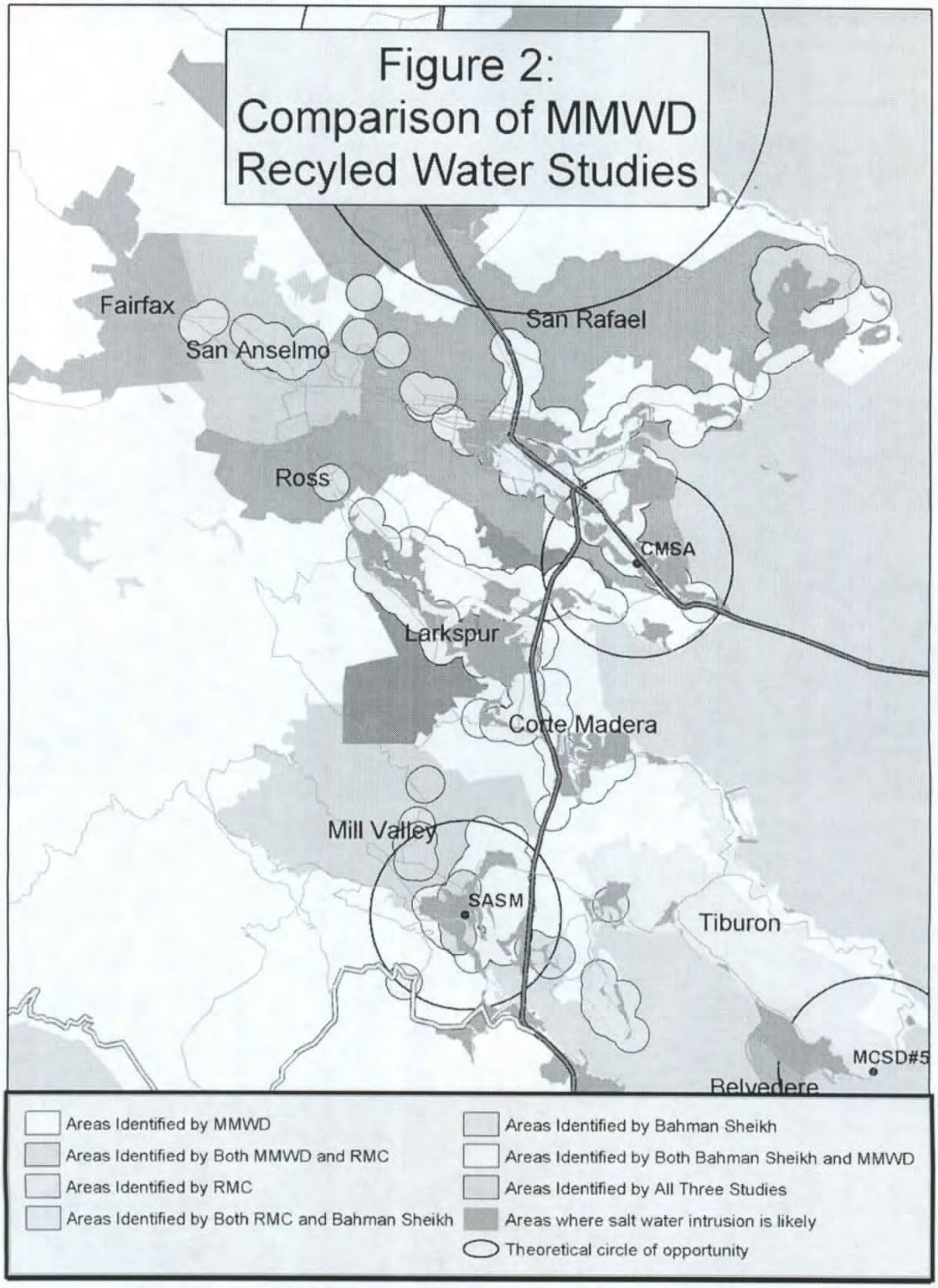

Figure 2 Comparison of MMWD Recycled Water Studies

Section 4 Alternatives Analyzed

4.1 No Project

Under the No Project Alternative, recycled water service is not expanded in the MMWD service area. MMWD would be limited to meeting approximately 2 mgd of its total demand with recycled water.[8] Future water supply will be provided by a desalination plant. Future water costs are $1,525 per acre foot in 2003 dollars. The No Project Alternative also does not provide any wastewater disposal benefits. All five dischargers would continue to meet their disposal needs through land application and/or outfalls to San Pablo and San Francisco Bays resulting in approximately 14 to 16 million gallons per day of discharge under average conditions.[9]

4.2 Assumptions Common to all Recycled Water Alternatives

All alternatives developed are located within the MMWD service area, although in different sanitary sewer service areas. Some common assumptions were made in order to produce a uniform analysis. These assumptions relate to:

- interpretation of water demand data;
- present and future water needs;
- quality (salinity), reliability and timing of water use;
- distance from the central wastewater treatment plant;
- availability of adequate sanitary sewer flow; and
- capital and operational costs.

4.2.1 Interpretation of Water Demand Data

In support of this study, MMWD provided water use data for all of its water customers. The most important data sets used for this study were called entitlement and estimated use. The entitlement is the amount of water that has been agreed upon for MMWD to supply to each user. It depends on each user's assumed water demand. The estimated use is an average of each customers actual metered water use which can vary significantly from entitlement.

These data sets were used in combination to estimate the costs of providing satellite recycled water treatment. The entitlement data was used first to help identify the large "anchor users" that may indicate a cluster of recycled water users that could feasibly be served by a satellite plant. In most cases, this entitlement data (provided in the unit of acre-feet per year) for an identified cluster was used to size the plant since it is important to have the capability to provide the quantity of water that has been promised to each user.

In many cases the estimated use data indicated that the anchor users were not in fact consuming the full amount of their entitlement. If any of the alternatives were to proceed forward into predesign, additional investigation would be needed to determine the best basis for process sizing, i.e. entitlement versus actual usage.

The cost per delivered acre-foot (or $/AF) is shown based on both the entitlement and the actual usage.

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[8] The Las Gallinas Water Recycling Facility has a capacity of 2 mgd.

[9] Marin Municipal Water District 2000 Urban Water Management Plan, February 18, 2003, pages 11 and 12

4.2.2 Present and Future Water Needs

As noted above, the MMWD service area is slow-growing and contains stable land uses. Each alternative developed is "anchored" on an existing urban irrigation use. Present and future water demands are estimated based on each individual's water entitlement from MMWD, as well as average annual water use, as provided by MMWD. Because of MMWD's mandatory use ordinance, it is assumed that recycled water use can begin as soon as the water is available.

The proposed water recycling facilities are sized to provide for the demand of the average day of the peak month of water use. It has been assumed that the peak monthly demand is approximately 18% of the total annual water demand, as shown in Figure 3. To determine the size of the plant, the total annual demand is multiplied by 18% to determine the total demand during the peak month. It is then divided by 30, to determine the average daily demand during the peak month. The plant is sized to provide for this demand.

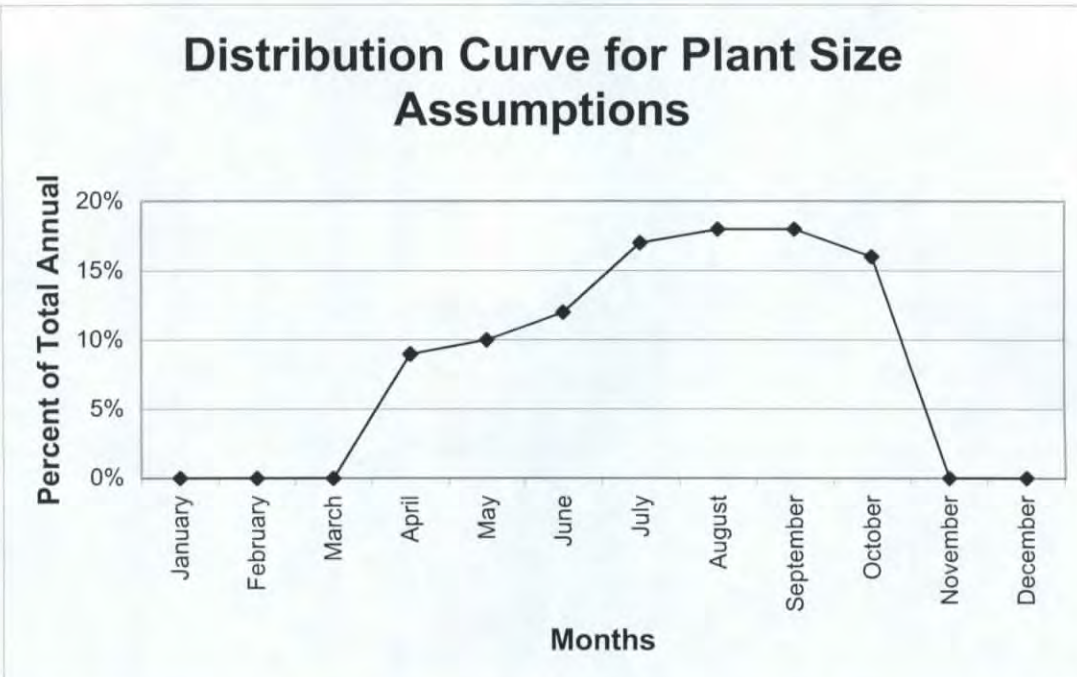

Figure 3 Distribution Curve for Plant Size Assumptions

4.2.3 Water Quality, Reliability and Delivery Timing

In accordance with the General Criteria outlined in Technical Memorandum #1, this analysis is based on supplying Disinfected Tertiary Recycled Water to the recycled water users. In addition, because most users are irrigation users, the study assumes that salt concentrations will be a limiting constituent in areas where the ground elevation is below 10 feet.[10] This analysis uses two methods of salt concentration management when recycled water facilities and/or their sewersheds are located below

[10] Data from SASM and the Central Marin Sanitation Agency Salt Water Reduction Study (CDM, 1993) both associate salt water infiltration with a 6-foot tide. This study assumes that sanitary sewers will have minimum depth of 4-feet, yielding potential saltwater intrusion problems in portions of sewer service area at elevation 10 or under.

this 10-foot elevation. These include adding reverse osmosis to the treatment process and blending with potable water to reduce concentrations.

In addition to the extra cost, the introduction of reverse osmosis to the centralized wastewater treatment plant takes away from the wastewater agencies' incentive to participate in recycling. In general, producing recycled water results lowers the mass of contaminants in a wastewater treatment plant's discharge. Reverse osmosis removes this benefit.

In accordance with the General Criteria, this analysis assumes that a potable water backup supply is available to provide adequate reliability to the user. In addition, and in accordance with the General Criteria, this study assumes that the satellite treatment plant includes a storage tank to manage potential discrepancies between wastewater flow and irrigation demand.

4.2.4 Distance from the Central Treatment Plant

The General Criteria suggested that users located outside a 4-mile distance from the central treatment plant might be cost-effectively served by a satellite water recycling facility. This analysis acknowledges that pipeline can rarely be placed on a straight radial alignment and uses a 2.5 mile radius to approximate a 4 mile distance along an alignment. This radius is reduced to approximately 1 mile if reverse osmosis treatment is required to improve the water quality from the central plant. This initial assumption has helped to focus the study on a reasonable range of customers to review.

4.2.5 Sanitary Sewer Flow

While all of the sewerage agencies located within the MMWD service area provided detailed mapping to assist in this analysis, none of the agencies had available flow data from their collection systems. Flow measurement was performed only at the treatment plant, not out in the collections system. Estimating sanitary sewer flow is an important part of satellite plant feasibility because, many times, the location and/or size of the plant is determined by how much wastewater is available at the site.

There were two methods used to estimate dry weather sewer flow. The first is an estimate based on water records. MMWD estimates that 40% of its annual water delivery goes to outdoor use.[11] It is estimated that another 5% goes to consumptive uses. Therefore, it was estimated that the sewer main will carry 55% of the average annual water use. The other way of estimating sewer flow was to use land use production assumptions outlined in Technical Memorandum #1. Marin County averages 2.25 people per residence.[12] This average was multiplied by the number of residential service connections in each area's sewershed and then by 75 gpd/person. In all cases, the latter estimating method proved more conservative (resulted in a lower estimated flow), so it was chosen as the method to estimate sewer flow.

4.2.6 Capital and Operational Costs

The General Criteria in Technical Memorandum #1 include cost curves for both satellite treatment facilities and central plant upgrades. These curves were used to develop the cost analysis for each alternative evaluated. The cost per acre foot calculation includes capital cost annualized over 30 years at an interest rate of 6% plus the annual O&M cost divided by the annual yield of the plant in acre feet. For more information on cost development, see Technical Memorandum #1.

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[11] Personal Communication, Bob Castle, Water Quality Manager, Marin Municipal Water District.
[12] Marin Countywide Plan, Community Development Element, January 1994 with amendments as of September 1999

4.3 Sausalito Marin City Sanitation District (SMCSD) Service Area

4.3.1 Summary Market Analysis

The SMCSD Service Area includes the cities of Sausalito and Mill Valley, Tamalpais Valley, Muir Woods and Marin Headlands. Much of this service area is in public-trust holdings, primarily by the National Parks Service. Water use in the service area is modest. Review of water use records and personal conversations with utility system managers indicate that the primary new water demand is on Fort Baker, in the Marin Headlands, which is redeveloping for civilian use.

A Feasibility Study for siting a satellite plant at Fort Baker is currently underway by the National Park Service. The following summarizes that analysis. Analyses performed for the National Park Service indicates a potential demand of 98,700 gallons per day, or 55.4 AFY, as outlined in Table 2, below.

Table 2 Potential Water Demands at Fort Baker

Potential Recycled Water Use	Average Demand (AFY)
Fort Baker Irrigation	
Parade Grounds	29.3
Water Front Meadow	9.2
Other Landscape Restoration	8.5
Coast Guard Headquarters	1.7
Proposed Fort Baker Plan	
Toilet Flushing	4.0
Commercial Laundry	2.7
Totals	55.4

Demands from the National Park Service Fort Baker Feasibility Study, RMC April 2004

4.3.2 Sizing of Treatment Facilities

The National Parks Service is redeveloping Fort Baker with a goal of demonstrating sustainable development. To this end, they are working to match the recycled water use with the volume of wastewater generated on the facility. The Fort Baker Redevelopment is anticipated to generate 56,000 gpd of raw wastewater. Water recycling facilities will be sized for this influent flow. Landscaping design and irrigation practices will be modified to use only the volume of recycled water available.

4.3.3 Location of Treatment Facilities

The satellite facilities are proposed to be located on an abandoned building pad east of the Bay Area Discovery Museum. This is approximately 360 feet from the main irrigation use and approximately 3800 feet from SMCSD's main treatment facilities.

4.3.4 Salt Water Intrusion

The lower portions of SMCSD's service area are subject to salt water intrusion. Influent sampling confirms the need to utilize RO treatment on the effluent from the central plant. However, the sewershed on Fort Baker is not subject to salt water intrusion.

4.3.5 Comparative Cost Analysis

The preliminary analysis for the Fort Baker facility includes a capital cost of $5,200,000 for a central plant upgrade and $4,000,000 for a satellite treatment facility. Operational costs are estimated at $48,000 and $44,000 per year respectively. This corresponds to a satellite plant cost of $9,980/AF.

4.3.6 Implementation Considerations

The central SMCSD treatment facility is built essentially on a platform on the waterfront of San Francisco Bay. There is no space on the platform for additional treatment equipment necessary to provide Title 22 effluent suitable for irrigation or for the reverse osmosis process required for salt removal. The central site is surrounded by sensitive land uses and the nearest location to site additional treatment facilities is literally on Fort Baker. These fundamental site constraints, combined with NPS's stated desire to develop in a sustainable manner favor the satellite facility.

4.4 Sewerage Agency of Southern Marin (SASM) Service Area

4.4.1 Summary Market Analysis

The SASM Service Area includes the City of Mill Valley. In the analysis for siting a satellite plant, nine water users, including the Mill Valley Golf Course, were identified as possible candidates for satellite treatment. As with the satellite analysis in the other service areas, this alternative was compared with the alternative of building recycled water facilities at the central plant (which, in this case, would include reverse osmosis) and building a distribution system to serve this area.

Mill Valley Golf Course has wells that currently supplement the potable water they purchase from MMWD. This accounts for their relatively small entitlement (30 AF/yr) in comparison to other 9-hole golf courses. It is expected that if recycled water became available, the golf course would continue to irrigate with a combination of well water and purchased water.

Table 3 provides a listing of users and entitlements and their associated recycled water demand data. Figure 4 illustrates the location of the candidate users. The satellite users are located in the Buenavista/East Blithedale sewershed, approximately 2 miles from the central treatment plant.

Table 3 Water Demands in SASM Service Area

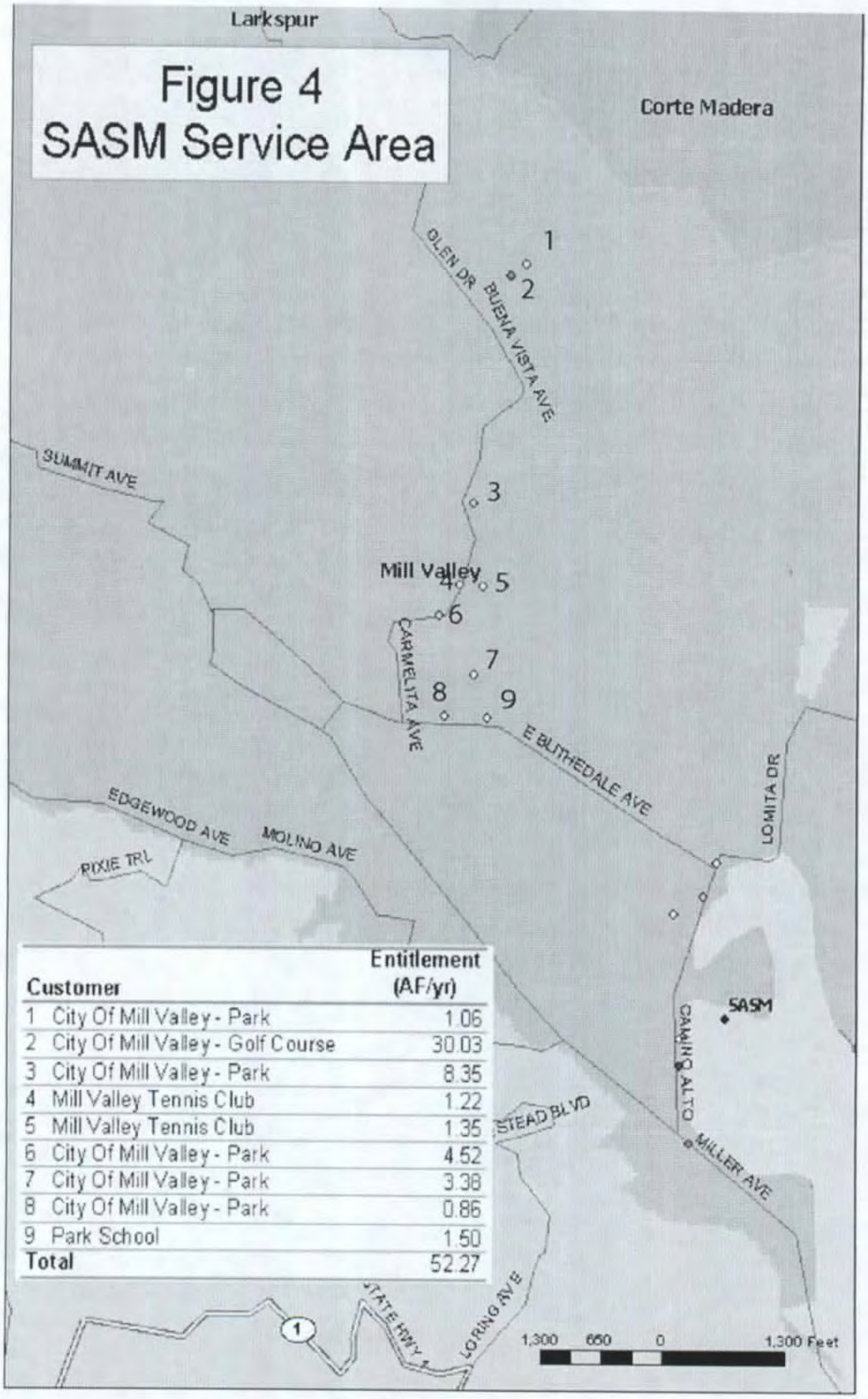
Customer	Entitlement (AF/yr)	Average Use (AF/yr)
Park School	1.50	0.41
Mill Valley Tennis Club	1.22	0.25
City Of Mill Valley - Park	8.35	8.35
City Of Mill Valley - Park	0.86	0.76
Mill Valley Tennis Club	1.35	0.84
City Of Mill Valley - Park	4.52	4.52
City Of Mill Valley - Park	3.38	3.38
City Of Mill Valley - Golf Course	30.03	30.03
City Of Mill Valley - Park	1.06	1.06
Total	**52.27**	**49.60**

4.4.2 Sizing of Treatment Facilities

Based on an entitlement of 52.27 AFY, the satellite service area demand can be met by a recycling facility with a capacity of 101,000 gallons per day, which is sufficient to meet the demand of the average day of the peak month. Note that for this service area, the average use of the customers was approximately 95% of the users' entitlements

4.4.3 Location of Treatment Facilities

The Buenavista/East Blithedale sewershed is a relatively small sewershed with less than 150 residential connections. In order to develop enough flow in the trunk sewer to support the recycled water demand, the satellite recycling facility needs to intercept flow near the intersection of East Blithedale and Camino Alto. This is approximately 8,000 feet from the Mill Valley Golf Course, the largest user in the satellite service area. It is approximately 2,500 feet from SASM's treatment plant.



Customer	Entitlement (AF/yr)
1 City Of Mill Valley - Park	1.06
2 City Of Mill Valley - Golf Course	30.03
3 City Of Mill Valley - Park	8.35
4 Mill Valley Tennis Club	1.22
5 Mill Valley Tennis Club	1.35
6 City Of Mill Valley - Park	4.52
7 City Of Mill Valley - Park	3.38
8 City Of Mill Valley - Park	0.86
9 Park School	1.50
Total	52.27

Figure 4 SASM Service Area

4.4.4 Salt Water Intrusion

The SASM service area includes low lying areas where salty groundwater infiltrates into the collection system. SASM currently blends potable water with their recycled water during certain tide cycles in order to deliver recycled water of acceptable quality.

4.4.5 Comparative Cost Analysis

This study develops two alternative cost scenarios for the SASM area. These include: (1) a 101,000 gpd Satellite Facility at the intersection of East Blithedale and Camino Alto; (2) a 101,000 gpd upgrade to the SASM facilities including reverse osmosis treatment for salt management. Table 4 presents these costs estimates. The calculation of $/AF is calculated using both the total acre-feet of water from the entitlement data as well as the estimated use data.

Table 4 Comparative Cost Analysis for SASM Area

	Alternative	Capital Cost	Annual O&M	Unit Cost $/AF (based on Entitlement)	Unit Cost $/AF (based on Estimated Usage)
1	101,000 gpd Satellite Facility	$3,820,000	$41,000	$6,140	$6,470
2	101,000 gpd upgrade to SASM (inc. RO)	$3,430,000	$228,000	$9,660	$9,910

4.4.6 Implementation Considerations

The satellite alternative is the most cost effective. The delivered water cost of $6,140/AF based on entitlement or $6,470/AF based on estimated usage are, respectively approximately $4,615/AF and $4,945/AF more than the next increment of potable water supply.

4.5 Richardson Bay Sanitary District (RBSD) Service Area

4.5.1 Summary Market Analysis

The RBSD Service Area includes Strawberry Peninsula and portions of the Tiburon Peninsula. Flows from RBSD are pumped to SASM for treatment and disposal. RBSD maintains a small effluent polishing plant that treats SASM's secondary effluent for irrigation use.

The was no anchor user or candidate cluster of users identified for satellite treatment in the RBSD Service Area so this area was determined to be infeasible for satellite treatment.

4.6 San Rafael Sanitation District

4.6.1 Summary Market Analysis

The most feasible location for a satellite plant in San Rafael is in the Peacock Gap area. There are 19 irrigation users in the Peacock Gap area that could be served with recycled water. The largest irrigation in the area is the Peacock Gap Golf Course. In total, the users in the area have a total entitlement of 248 acre-feet per year. The irrigation users are listed in Table 5 and their locations are shown in Figure 5.

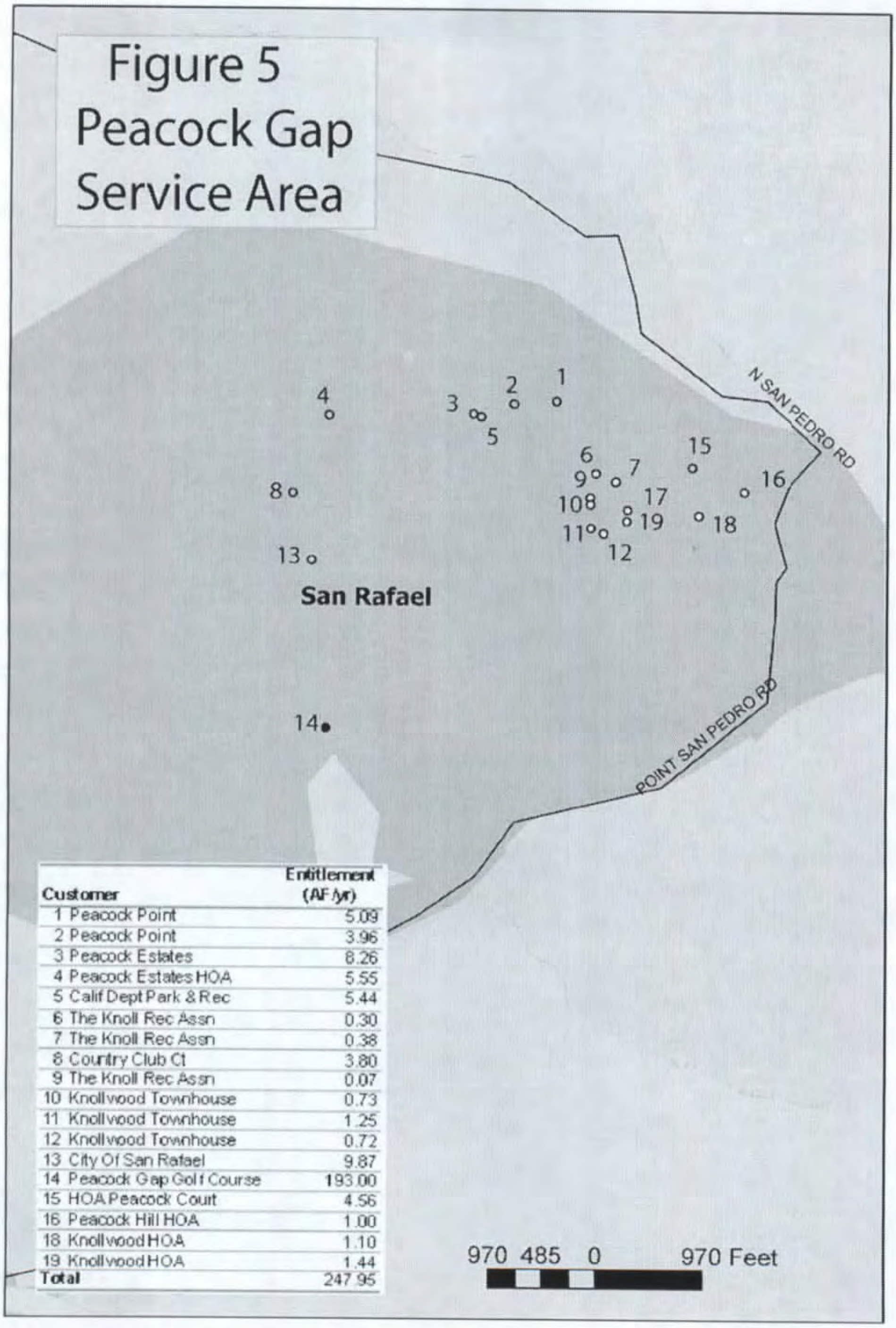
Table 5 Water Use in the Peacock Gap Area

Customer	Entitlement (AF/yr)	Average Use (AF/yr)
Peacock Gap Golf Course	193.00	114.00
Peacock Hill HOA	1.00	0.44
City Of San Rafael	1.43	1.43
The Knoll Rec Assn	0.07	0.07
Knollwood Townhouse	0.73	0.15
Knollwood Townhouse	1.25	0.25
Knollwood Townhouse	0.72	0.30
Knollwood HOA	1.10	0.31
Knollwood HOA	1.44	0.38
The Knoll Rec Assn	0.30	0.26
The Knoll Rec Assn	0.38	0.38
Calif Dept Park & Rec	5.44	1.47
Peacock Estates HOA	5.55	5.55
Peacock Estates	8.26	8.26
City Of San Rafael	9.87	9.87
Peacock Point	3.96	3.96
Peacock Point	5.09	5.09
HOA Peacock Court	4.56	4.56
Country Club Ct	3.80	3.80
Total	**247.95**	**160.53**

4.6.2 Sizing of Treatment Facilities

The satellite service area entitlement demand can be met with 480,000 gallons per day of irrigation water. However, the sewer main along Pt. San Pedro Road doesn't carry enough flow to supply a satellite plant of that size. A location was chosen in the sewershed that will supply enough wastewater for a 220,000 gpd plant. The recycled at this plant will be blended with potable water in order to serve all of the users listed above.

For this service area, the average use of the customers was approximately 65% of the users' entitlements. This disparity is mostly due to the fact that its anchor user (Peacock Gap Golf Course) only currently uses 60% of its entitlement. The total of all of the users' entitlements was used to determine the recycled water demand in the area.



Customer	Entitlement (AF/yr)
1 Peacock Point	5.09
2 Peacock Point	3.96
3 Peacock Estates	8.26
4 Peacock Estates HOA	5.55
5 Calif Dept Park & Rec	5.44
6 The Knoll Rec Assn	0.30
7 The Knoll Rec Assn	0.38
8 Country Club Ct	3.80
9 The Knoll Rec Assn	0.07
10 Knollwood Townhouse	0.73
11 Knollwood Townhouse	1.25
12 Knollwood Townhouse	0.72
13 City Of San Rafael	9.87
14 Peacock Gap Golf Course	193.00
15 HOA Peacock Court	4.56
16 Peacock Hill HOA	1.00
18 Knollwood HOA	1.10
19 Knollwood HOA	1.44
Total	247.95

Figure 5 Peacock Gap Service Area

4.6.3 Location of Treatment Facilities

The Peacock Gap area has a very small sewershed. The wastewater must be intercepted at Pt. San Pedro Rd. at Main Dr., a location approximately 4,200 feet away from Peacock Gap Golf Course, the area's anchor user. This location is approximately 20,000 feet from CMSA, the closest wastewater treatment plant. A distribution system of approximately 4,200 feet of pipe will be needed to serve the identified irrigation users.

4.6.4 Salt Water Intrusion

Much of the Peacock Gap area resides below the 10-foot elevation. It is expected that the wastewater in the sewer main will have a high salt content. Since the satellite plant will be creating less than half of the irrigation demand, it can be blended with potable water. In this case, the satellite plant won't require any additional unit processes to manage the salinity. This blending will create enough water to meet the recycled water demand at a tolerable salinity level.

4.6.5 Comparative Cost Analysis

This study compared the cost of a 220,000 gpd satellite facility with the cost of adding 480,000 gpd recycled water facilities including reverse osmosis to CMSA and building a distribution system to serve these irrigation users. The satellite plant is sized according to the flow available in the nearby sewer main, while the central plant is sized to meet the total entitlement demand in the Peacock Gap area. The costs of these alternatives are presented in Table 6. Siting a satellite treatment plant along Pt. San Pedro Road and blending its effluent with potable water was the most cost effective alternative.

The calculation of $/AF is calculated using both the total acre-feet of water from the entitlement data as well as the estimated use data. The cost of any blending water that may be required is not included in this calculation, so this represents the cost of the new water supply created by the recycled water facilities. For this area, the unit cost for satellite treatment is the same for both entitlement and estimated usage because the capacity of the plant provides less annual acre feet of water than both estimates for water use.

Table 6 Comparative Cost Analysis for Peacock Gap Area

	Alternative	Capital Cost	Annual O&M	Unit Cost $/AF (based on Entitlement)	Unit Cost $/AF (based on Estimated Usage)
1	220,000 gpd Satellite Facility	$4,590,000	$57,000	$3,420	$3,420
2	480,000 gpd upgrade to CMSA (inc. RO)	$13,160,000	$1,048,000	$7,624	$8,840

Note: The unit costs for the satellite facility are based on total water generated by the plant, which is less than both the entitlement and estimated usage. This results in the same unit cost for both categories.

4.6.6 Implementation Considerations

The assumptions of sewer flow and wastewater quality were made based on land use and topography, not by flow monitoring or testing. These assumptions should be verified before considering the construction of a satellite plant. The delivered water cost of $3,420/AF is approximately $1,895/AF more than the next increment of potable water supply through desalination.

4.7 Ross Valley Sanitary District

4.7.1 Summary Market Analysis

The Ross Valley Sanitary District (Sanitary District #1) serves the areas of Bon Air, Fairfax, Greenbrae, Larkspur, Kentfield, Kent Woodlands, Murray Park, Ross, San Anselmo, Sleepy Hollow and Oak Manor. The large recycled water candidates are clustered around Sir Francis Drake Blvd. in San Anselmo. There are 13 identified irrigation users along Sir Francis Drake Blvd. that could be potentially served by a satellite treatment plant. In addition to these users, Mt. Tam Cemetery is a large water user that is close enough to the Sir Francis Drake users to be included in this cluster. The candidate users are listed in Table 7 and their location is shown in Figure 6.

Table 7 Water Use in the Sir Francis Drake Area of San Anselmo

Customer	Entitlement (AF/yr)	Average Use (AF/yr)
Town Of San Anselmo	1.62	0.53
Union HS Dist Tamalpais	0.02	0.02
Union HS Dist Tamalpais	1.18	0.17
Town Of San Anselmo	0.29	0.29
Tamalpais Union HS Dist	44.93	16.10
Union HS Dist Tamalpais	0.36	0.65
Town Of San Anselmo	9.18	9.18
Sunny Hills Children's Service	9.23	6.06
Ross Valley	4.65	0.49
Donald M Arntz	7.35	1.22
San Anselmo	1.49	0.39
San Anselmo	1.32	1.32
Redhill Fastbreak 76	0.63	0.38
Mt Tam Cemetery	33.51	33.51
Total	**115.76**	**70.31**

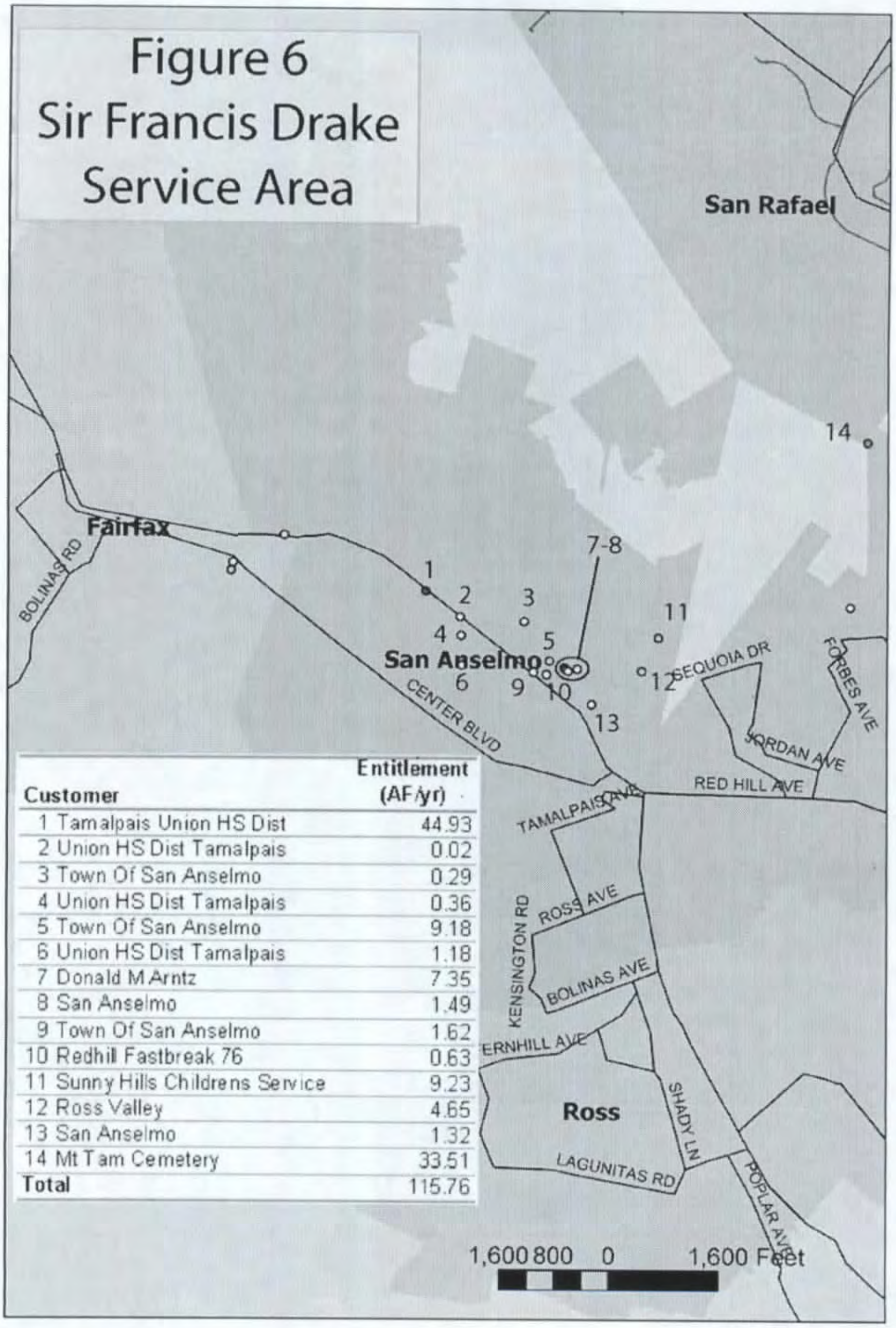
4.7.2 Sizing of Treatment Facilities

Many users in this service area, most notably, Sir Francis Drake High School, use significantly less water than their entitlement. The estimated water usage is only 60% of the entitlement. Even though the satellite plant is sized for the full entitlement, if this alternative were to advance to predesign, a closer evaluation of the correct sizing criteria would be warranted.

The entitlement demands could be supplied by a 224,000 gpd satellite plant.

4.7.3 Location of Treatment Facilities

The best location for the wastewater diversion for the satellite plant is the sewer main on Center Blvd. at Sycamore Ave. As this sewer main contains flows from all of the town of Fairfax, there is plenty of raw wastewater to supply the satellite plant. This location is approximately 24,000 feet from CMSA, the wastewater treatment plant that serves the area. A distribution system of approximately 3,400 feet of pipe would be required from the satellite plant to serve all of these water users.



Customer	Entitlement (AF/yr)
1 Tamalpais Union HS Dist	44.93
2 Union HS Dist Tamalpais	0.02
3 Town Of San Anselmo	0.29
4 Union HS Dist Tamalpais	0.36
5 Town Of San Anselmo	9.18
6 Union HS Dist Tamalpais	1.18
7 Donald M Arntz	7.35
8 San Anselmo	1.49
9 Town Of San Anselmo	1.62
10 Redhill Fastbreak 76	0.63
11 Sunny Hills Childrens Service	9.23
12 Ross Valley	4.65
13 San Anselmo	1.32
14 Mt Tam Cemetery	33.51
Total	115.76

Figure 6 Sir Francis Drake Service Area

4.7.4 Salt Water Intrusion

The entirety of this sewershed is located above the elevation of concern for salt water intrusion.

4.7.5 Comparative Cost Analysis

This study compared the cost of a 224,000 gpd satellite facility with the cost of adding recycled water facilities to CMSA and building a distribution system to serve these water users. Reverse osmosis is assumed to be required at CMSA to manage the salinity. The costs of these alternatives are presented in Table 8. The satellite plant and distribution system was the most cost effective alternative.

Table 8 Comparative Cost Analysis for Sir Francis Drake Area

	Alternative	Capital Cost	Annual O&M	Unit Cost $/AF (based on Entitlement)	Unit Cost $/AF (based on Estimated Usage)
1	224,000 gpd Satellite Facility	$4,770,000	$71,000	$3,600	$5,950
2	224,000 gpd upgrade to CMSA (inc. RO)	$8,550,000	$514,000	$9,370	$12,290

4.7.6 Implementation Considerations

The assumptions of sewer flow and wastewater quality were made based on land use and topography, not by flow monitoring or testing. These assumptions should be verified before considering the construction of a satellite plant. The delivered water cost of $3,600/AF based on entitlement or $5,950/AF based on estimated usage are, respectively approximately $2,075/AF and $4,425AF more than the next increment of potable water supply through desalination.

4.8 Las Gallinas Valley Sanitary District

4.8.1 Summary Market Analysis

MMWD has a recycled water facility adjacent to the Las Gallinas facility with an extensive recycled water distribution system. The analysis in this study identified the Hamilton Fields area of Novato as an area that may feasibly be served by the Las Gallinas recycled water system. The capacity of the existing MMWD 2-mgd recycled water plant is already fully utilized serving current peak summery day demands so expansion of the recycled water facility would be required to serve the Hamilton Fields area. Since this area is in the North Marin Water District service area, it will be discussed in TM #4.

Section 5 Results of Site Visits

The RMC project team conducted a "windshield tour" with Ken Feil of MMWD of the two satellite plants with the lowest cost, the Sir Frances Drake/Mt. Tam Cemetery area, and the Peacock Gap area to determine the feasibility of siting a satellite plant.

5.1 Sir Francis Drake/Mt. Tam Cemetery

There is a large area of land behind the Redhill Shopping Center that may feasibly be used to house a satellite treatment plant and associated storage. Currently there are some ball fields and a preschool in the general area, with many square feet of available, unused land. It is about 2,000 feet from the location of the sewer diversion (the large sewer main in the area goes down Center Blvd), so a small pump station would be required to divert the flow to the location of the plant and another pipe would be required to convey sludge back to the collection system. Another possibility for siting the plant would be to purchase some unused land along the south end of Mt. Tam Cemetery, this *would also require* pumping from the sewer diversion location. The locations are shown in Figure 7.

One of the largest obstacles to constructing a satellite plant in the area would be serving Mt. Tam Cemetery. The Cemetery's current service connection to MMWD is at its northernmost (and highest elevation) point, furthest from the proposed plant. It is anticipated that the recycled water pipeline that serves the cemetery would have to go all the way to the cemetery's current service connection in order to minimize affect on the existing irrigation system.

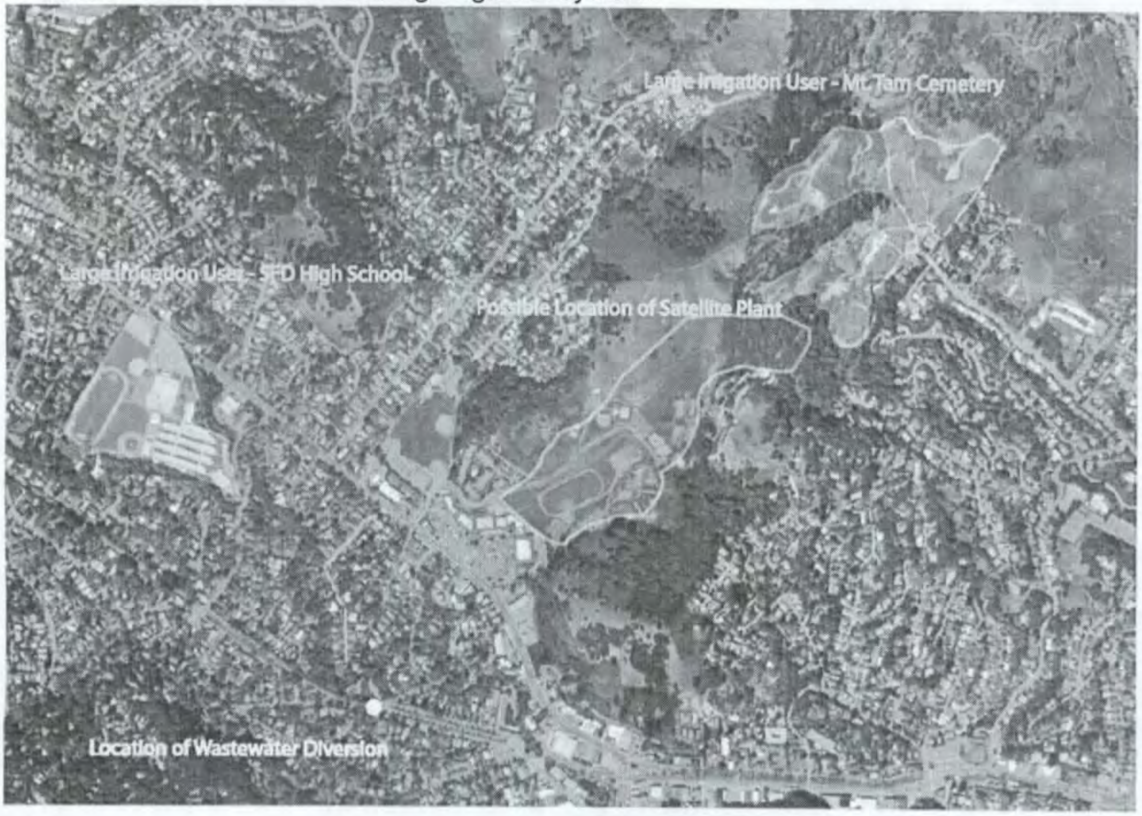


Figure 7 Proposed Location – Sir Francis Drake/Mt Tam Cemetery

5.2 Peacock Gap

The most feasible location for siting a satellite plant in Peacock Gap is the location of the old brick factory off of Pt. San Pedro Rd. This location, while thousands of feet away from both the location of the wastewater diversion and the location of the recycled water users, seems to be the closest area of less-developed, flat land that could house the satellite plant and associated storage. Again, a small pump station would be required for pumping the wastewater from the point of diversion to the satellite plant and another pipe would be required to convey sludge back to the collection system. The location of the proposed facilities is shown in figure 8.

Figure 8 Proposed Location – Peacock Gap

Section 6 Conclusions & Recommendations

The General Criteria in TM #1 suggested that a 4-mile distance from the central plant could result in a cost effective satellite plant as compared to a centralized recycling facility. This local analysis used a 2.5-mile radius to locate potential customers over 4 miles distant from the central plant. A 1-mile radius was used when reverse osmosis was required at the central plant. This proved to be a reasonable method to approximate the actual length of pipeline in public roads.

The customer clusters considered included:

- The Mill Valley Golf Course in the City of Mill Valley's collection system, ultimately tributary to SASM.
- Irrigation at the Peacock Gap Golf Course in the City of San Rafael's collection system, ultimately tributary to CMSA.
- Irrigation along Sir Francis Drake Blvd. in San Anselmo and Mt Tam Cemetery in San Rafael, ultimately tributary to CMSA.

In all three cases the satellite facility was more cost effective than providing recycled water from a centralized facility. The Mill Valley Golf Course case is discussed below.

Satellite water recycling facilities are also under consideration at Fort Baker in the Sausalito-Marin City Sanitary District. That study effort was reviewed but not independently verified as part of this effort.

Because the satellite facilities are most cost-effective at the "edge" of a service area, available sewer flows can be limiting.

The Mill Valley Golf Course irrigation site is relatively close to SASM's central plant. The demand presented by the golf course requires a reasonably-sized sewershed in order to collect adequate flow. This combination of circumstances resulted in a wastewater collection point in very close proximity to the central plant. In this case, pipeline costs resulted in very high satellite plant costs. In other areas, particularly the Peacock Gap area, the full customer demand cannot be served from available, reliable wastewater flows in the sewershed.

Blending with potable water is less expensive than reverse osmosis as a way to manage potential salt effects in recycled water.

Currently, SASM blends potable water with recycled water to reduce salt loading. Expanding this practice within the SASM service area to serve the customers identified in this study is more cost-effective than adding reverse osmosis to expand recycled water service in Mill Valley. However, both alternatives are more expensive than the next increment of potable water supply through desalination.

Generally, while moving to the edge of the water and sewer service area provides some relief from known salt water intrusion problems, there is less available data on wastewater quality. SASM indicates that their need for blending begins when tide elevations reach 6.0. A review of the collection system elevations in the Peacock Gap area suggest that portions of this collection system may be affected by tides. If a recycled water project was implemented, blending with potable water, ideally through an air-gap at a Golf Course pond, could provide more potentially available supply and mitigate salt effects.

This study shows higher costs for satellite treatment than did previous studies

The Review of Water Recycling and Gray Water study done for MMWD in April 2001 by Bahman Sheikh in association with Parsons, showed much more favorable costs and demands for satellite treatment and delivery of recycled water than . Based on the detailed cost estimates provided in Appendix A of the report, the following reasons for these disparities are proposed:

- In the 2001 report, recycled water demands seem to be based on land use assumptions as opposed to actual entitlement and water use data. This resulted in larger proposed satellite plants. These plants would have a smaller unit cost due to economies of scale.
- The 2001 report included many large water users that have been determined in this analysis to be more cost effectively served by central recycled water treatment.
- The 2001 report did not include allowances for the satellite plant needing a pump station and force main to divert wastewater to the satellite plant. The analysis for this TM included situations in which the raw wastewater will need to be pumped large distances to feed the satellite plant.
- The 2001 report did not include cost allowances for architectural treatments that would be needed in an urban setting.
- It has been three years since the former report was written, and construction costs have gone up considerably in that amount of time.

The satellite treatment facilities have higher unit costs than the next increment of potable water as a stand-alone water supply.

Table 9, below, outlines the estimated cost per acre-foot of water from each of the clusters under study and compares these to the estimated cost per acre-foot of water from MMWD's proposed desalination plant.

Table 9 Overall Cost Comparison

Satellite Location	**Unit Cost $/AF (based on Entitlement)**	**Unit Cost $/AF (based on Estimated Usage)**
Mill Valley Golf Course	$6,140	$6,470
Peacock Gap	$3,420	$3,420
Sir Francis Drake – San Anselmo	$3,600	$5,950
Potable Service	**$/AF**	**$/AF**
Desalination – next increment of water supply	$1,525	$1,525

Based on evaluation of recycled water as a new water supply, satellite treatment plants do not appear to be a cost-effective alternative to the new desalination supply proposed by MMWD. Further study of satellite plants as an alternative water supply within the MMWD service area is therefore not recommended.

If other driving forces for expansion of the recycled water supply emerge in the future, such as a need to reduce wastewater discharge due to new regulations, further studies should include the following:

- Verification of water demands and available wastewater flow within the sewershed
- Environmental documentation
- Refinement of costs including land acquisition, engineering studies and design
- Financing plan
- Development of inter-agency agreements for operation and maintenance of the facilities

Technical Memorandum No. 3

RMC
Raines, Melton & Carella, Inc.
Consulting Engineers/Project Managers

Subject:	Sonoma Valley Analysis
Prepared For:	North Bay Watershed Association – Integrated Water Resources Committee
Prepared By:	Raines, Melton & Carella, Inc.
Date:	January 28, 2005

Section 1 Introduction and Purpose

This Technical Memorandum is part of a feasibility study of satellite recycled water treatment prepared as part of a regional water recycling analysis for the North Bay Watershed Association. The general analysis techniques, developed in Technical Memorandum #1 "General Process and Distribution System Overview" (hereinafter referred to as the General Criteria) dated May 2004 will be applied to the Sonoma Valley County Sanitation District's (SVCSD's) service area. The general analysis techniques and analyses are used to identify a range of candidate satellite treatment plant sites and compare the feasibility of these satellite systems to a centralized recycling system.

The Sonoma Valley is located within the CalFed Solution Area. Projects within this Solution Area are expected to have priority for funding under Proposition 50.[1] This service area analysis is generally consistent with the State Water Resources Control Board Water Recycling Funding Guidelines.

Section 2 Study Area Characteristics

2.1 General Hydrologic Overview

The SVCSD service area generally includes southeast Sonoma County, east of the Sonoma Mountains and west of the Napa County line. The long narrow service area generally follows Sonoma Creek, a tributary to San Pablo Bay. The service area is located on an alluvial plain and groundwater resources are available. Groundwater resources are used by agricultural interests in the Sonoma Valley and provide a portion of the municipal supply.

The study area drains to San Pablo Bay via Sonoma Creek. The San Francisco Bay Regional Water Quality Control Board (Region 2) has listed Sonoma Creek as impaired for pathogens, nutrients and sediment.[2] San Pablo Bay is listed as impaired for multiple contaminants including pesticides, exotic species, dioxin and furan compounds, mercury, nickel, selenium and PCBs[3]. Improving water quality in the San Francisco Bay Delta System is the focus of the CalFed program and efforts by many local agencies and nonprofit groups.

2.2 Land Use & Population Trends

The Sonoma Valley is slow-growing as a result of both growth management policies and active land conservation efforts. The City of Sonoma has approved urban growth boundary and Sonoma County actively acquires development rights in rural portions of the County through its Open Space District.

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[1] Personal Communication, Diana Robles, Chief Office of Water Recycling, State Water Resources Control Board.

[2] http://www.swrcb.ca.gov/rwqcb2/tmdlmain.htm

[3] Phase 1 Executive Summary, North Bay Watershed Stewardship Plan. RMC, October 2003.

Valley of the Moon Water District (VOMWD) anticipates its service population will grow from 20,580 to 22,801 by the year 2020 (an increase of 0.5% per year).[4] The City of Sonoma anticipates its service population will grow from 9,282 to 13,482 by the year 2020 (an increase of approximately 2% per year).[5]

2.3 Water Supply

There are two retail water suppliers in the area of study; Valley of the Moon Water District and the City of Sonoma. Both retail water suppliers purchase wholesale water from the Sonoma County Water Agency (Agency). The retail water suppliers and the Agency have a contractual relationship defined in the "Eleventh Amended Agreement for Water Supply" dated 2001. This wholesale water is delivered through the Sonoma Aqueduct.

The Agency's primary water supply comes from underflow of the Russian River, which is in a separate watershed from the SVCSD Service Area. The Agency also has three groundwater wells in Santa Rosa. Russian River water supply is of high quality.

The Agency estimates its reliable groundwater supply at 3,025 acre-feet/year and its reliable Russian River water supply at 123,830 acre-feet/year in 2020.[6] Valley of the Moon Water District is contractually entitled to 3,200 acre-feet/year from the Agency's system. The City of Sonoma is contractually entitled to 3,000 acre-feet/year from the Agency's system.[7]

Table 1 Summary of Water Supply

Agency	Entitlement from SCWA
Valley of the Moon Water Agency	3,200 AF/Year
City of Sonoma	3,000 AF/Year

The Agency is developing the Water Supply, Transmission, and Reliability Project (Water Project) that is intended to provide a safe, economical, and reliable water supply to its retail water contractors to meet their current and defined future needs. The Water Project will include upgrades to the Agency's transmission system including a proposed parallel aqueduct to the Sonoma Valley.

2.4 Wastewater Disposal

Wastewater collection, treatment, reclamation and disposal are provided by the SVCSD. The Agency provides day to day operational and maintenance oversight for SVCSD. The SVCSD service area extends from the unincorporated communities of Glen Ellen in the north to Schellville in the south. The wastewater collection system consists of approximately 188 miles of pipeline and two lift stations that convey wastewater to SVCSD's secondary treatment plant (treatment facility) located in the southern portion of Sonoma Valley. As currently operated, effluent from the treatment facility is discharged to Schell Slough, from November through April, and is used for agricultural irrigation and wetlands enhancement during the remainder of the year. These discharges to waters of the United States are regulated under a National Pollutant Discharge Elimination System (NPDES) permit administered by the Region 2 RWQCB.

In 2002,[8] the SVCSD served approximately 16,452 equivalent single-family dwelling units with an average dry weather flow of approximately 2.5 million gallons per day (MGD). The permitted average

[4] Urban Water Management Plan 2000, Sonoma County Water Agency.
[5] Urban Water Management Plan 2000, Sonoma County Water Agency.
[6] Urban Water Management Plan 2000, Sonoma County Water Agency, Table 3-1.
[7] Urban Water Management Plan 2000, Sonoma County Water Agency, Tables 3-6 and 3-7.
[8] 2002 is the latest SVCSD service information available.

dry weather flow is 3.0 MGD. The treatment facility has the capacity to treat up to 16.0 MGD and discharge a peak wet weather flow of approximately 11.0 to 12.0 MGD depending on discharge conditions. Excess flow is stored in the influent equalization basins for deferred treatment.

Currently, the SVCSD has approximately 635 acre-feet of recycled water storage. This existing storage is located in the southeast area of Sonoma Valley and is comprised of four storage reservoirs: R1, R2, R3, and R4. R1 and R2 supply water to R3 and to a wetland restoration project (Management Units). R3 provides water to the reclamation users (vineyard, pasturelands, and dairies) and provides pressure for the reclamation system. R4 provides additional storage and water to Ringstrom Bay, to reclamation users (vineyards, pasturelands, dairies), and provides pressure in the reclamation system.

Construction to upgrade SVCSD treatment facility to tertiary treatment level is scheduled to begin in the summer of 2005. Construction is anticipated to be completed in the fall of 2006. Table 2 provides a summary of the Wastewater Treatment System.

Table 2 Summary of Wastewater Treatment System

Agency	Facilities Maintained	Permitted Average Dry Weather Flow	Recycling Capacity	Disposal Methods
Sonoma Valley County Sanitation District (SVCSD)	Collection system, Treatment, Storage & Recycling Facilities	3.0 MGD	2.5 MGD	Schell Slough Discharge, Agricultural Reclamation, Wetland Restoration

Section 3 Market Assessment Methodology

3.1 Regulatory Context

This market analysis assumes that the recycled water market in the Sonoma Valley will require Title 22 Disinfected Tertiary Recycled Water. Additional treatment to manage high salt content is not needed.

An urban water recycling operation would operate under permit from Region 2. Region 2 has implemented a General Water Recycling Permit; public agencies may apply for coverage under the General Permit by filing a Notice of Intent together with an Engineer's Report prepared in accordance with Title 22. The General Permit does not restrict the delivery of recycled water, applied at agronomic rates.

3.2 Water Demand and Costs

Water demand within the service area was quantified using historic use records, where available. For irrigation users that are not current water customers (vineyards and golf courses that use well water for irrigation) water use was estimated using the land use estimations outlined in the General Criteria as shown in Table 3. The acreages were estimated using parcel maps and spatial land use data from the Sonoma County GIS.

Table 3 Land Use Based Demand Factors

Land Use	Demand Rate (AF/acre/year)
Vineyards	0.5
Irrigated Agriculture	2.0
Irrigated Pasture	2.5
Golf Courses	3.5
Urban Irrigation	3.0
Commercial/Industrial Process	1.7
Toilet Flushing	1.5 gal/flush

3.3 Identifying Candidate Locations

The strategy for determining candidate locations for satellite treatment was to find a large anchor water user in the vicinity of a sewer main with enough flow to provide for the satellite plant. As previously stated, the anchor user must also be far enough away from the central wastewater treatment plant that it is more economically served by a satellite plant than the central plant. This distance was preliminarily set at 2.5 miles.

Applying this strategy to Sonoma Valley resulted in a focus on the Boyes Hot Springs area. The irrigation users in the area were discussed in two separate sets of analysis. The first analysis estimates the cost of supplying only the current VOMWD customers with recycled water. The second estimates the cost of supplying all of the major users in the area, including those that are currently using private wells.

Section 4 Alternatives Analyzed

4.1 No Project

Under the No Project Alternative, recycled water service is not expanded in the Sonoma Valley. Future water supply will be provided by expansion of the Sonoma Valley aqueduct system and from increased reliance on groundwater. The No Project Alternative also does not provide any wastewater disposal benefits. The SVCSD would continue to meet a portion of its disposal needs through discharge to Schell Slough, a tributary of San Pablo Bay resulting in up to 12 million gallons per day of discharge under wet weather conditions.

4.2 Assumptions for the Recycled Water Analysis

Some common assumptions are used in order to produce a uniform analysis throughout the Sonoma Valley study area. These assumptions relate to present and future water needs; quality, reliability and timing of water use; distance from the central wastewater treatment plant; availability of adequate sanitary sewer flow; and capital and operational costs.

4.2.1 Present and Future Water Needs

As noted above, the Sonoma Valley is slow-growing, with stable land uses. Each alternative developed is "anchored" on an existing urban irrigation use. Present and future water demands are estimated based on historic use pattern. When the analysis includes providing recycled water to an agricultural operation currently using ground water, the assumed water demand was determined based on the criteria in Table 3.

The proposed water recycling facilities are sized to provide for the demand of the average day of the peak month of water use. Figure 1 shows a typical distribution of the annual recycled water demand for Northern California irrigation uses. It has been assumed that the peak monthly demand is approximately 18% of the total annual water demand. To determine the size of the plant, the total annual demand is multiplied by 18% to determine the total demand during the peak month. It is then divided by 30, to determine the average daily demand during the peak month. The plant is sized to provide for this demand.

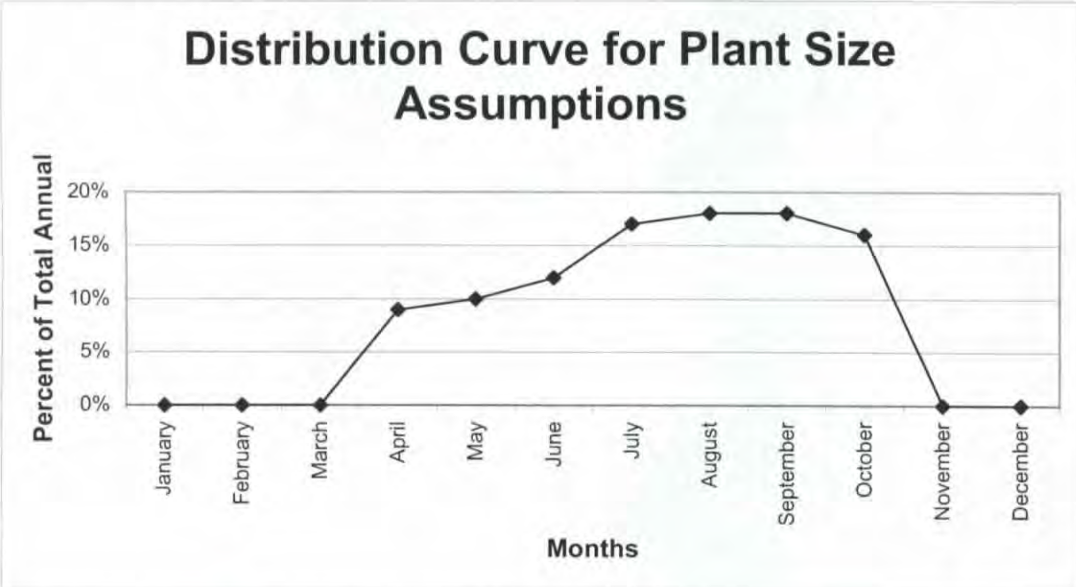

Figure 1 Distribution Curve for Plant Size Assumptions

4.2.2 Water Quality, Reliability and Delivery Timing

In accordance with the General Criteria, this analysis assumes that a potable water backup supply is available to provide adequate reliability to the user. In addition, and in accordance with the General Criteria, this study assumes that the satellite treatment plant includes a storage tank to manage potential discrepancies between wastewater flow and irrigation demand.

4.2.3 Distance from the Central Treatment Plant

The General Criteria suggested that users located outside a 4-mile distance from the central treatment plant might be cost-effectively served by a satellite water recycling facility. This analysis acknowledges that pipeline can rarely be placed on a radial alignment and uses a 2.5 mile radius to approximate a 4 mile distance along an alignment. This initial assumption has helped to focus the study on a reasonable range of customers to review.

4.2.4 Sanitary Sewer Flow

SVCSD has an active program that uses flow meters to record volume of flow in its collection system. This flow monitoring data has been used as the basis for determining wastewater flow in the sewersheds tributary to proposed satellite facilities.

4.2.5 Capital and Operational Costs

The General Criteria in Technical Memorandum #1 include cost curves for both satellite treatment facilities and central plant upgrades. These curves were used to develop the cost analysis for each alternative evaluated. The cost per acre foot calculation includes capital cost annualized over 30 years at an interest rate of 6% plus the annual O&M cost divided by the annual yield of the plant in acre feet. For more information on cost development, see Technical Memorandum #1.

4.3 Boyes Hot Springs Area – Current Water Customers Only

4.3.1 Summary Market Analysis

The Boyes Hot Springs Area is located just north of the City of Sonoma and approximately 7 miles north of the SVCSD treatment facilities. The water customers in the area purchase water from VOMWD. There are 6 large irrigation users that are current VOMWD customers in the Boyes Hot Springs Area. Their total estimated use is 75.39 acre-feet per year. Figure 2 illustrates the location of the irrigation users. Table 4 provides a listing of the users and their annual demand.

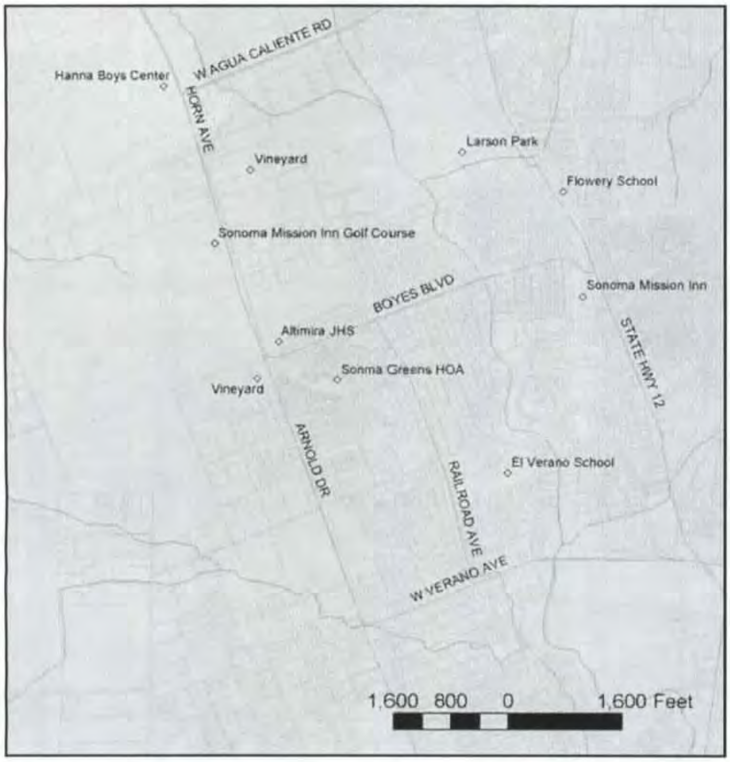

Figure 2 Location of Water Users

Table 4 Large VOMWD Customers in the Boyes Hot Springs Area

User Site(s)	Entitlement (AF/yr)
Larson Park	6.73
Sonoma Greens HOA	17.26
Flowery School	0.36
Altimira JHS	11.09
Hanna Boys Center	31.34
Sonoma Mission Inn	8.61
Total	**75.39**

4.3.2 Sizing of Treatment Facilities

Based on the sizing criteria discussed in section 4.2.1, this satellite service area demand can be met by a recycling facility with a capacity of 150,000 gallons per day.

4.3.3 Location of Treatment Facilities

The Boyes Hot Springs service area is located just west of Sonoma Creek. SVCSD's major trunk sewer is located just east of Sonoma Creek. According to modeled flow data provided by SCWA, the daily dry weather flow in the sewer is approximately 1.13 mgd where it crosses through Maxwell Park. Therefore, the trunk sewer has more than adequate flow to support the recycled water demand in the area. Wastewater is proposed to be diverted just south of Vailetti Drive.

4.3.4 Comparative Cost Analysis

This alternative compares: (1) the cost of building a 150,000 gpd satellite facility south of Vailetti Drive and east of Sonoma Creek to (2) the cost of a 150,000 gpd upgrade to the SVCSD facilities. The evaluation includes the cost of a creek crossing (assumed to be constructed with trenchless methods) in the satellite analysis because the main trunk sewer and the irrigation users are located on opposite sides of Sonoma Creek. Table 5 presents these costs estimates. The cost estimates are based on the cost estimating techniques outlined in Technical Memorandum No. 1 of this study.

The satellite facility is more cost effective than central treatment and distribution.

Table 5 Comparative Cost Analysis for Boyes Hot Springs Current Water Customers

Alternative	Capital Cost	Annual O&M	Total $/AF
150,000 gpd Satellite Facility	$5,490,000	$53,000	$5,881
150,000 gpd Upgrade to SVCSD	$5,950,000	$93,000	$6,891

4.4 Boyes Hot Springs Area – Current Customers and Private Well Users

4.4.1 Summary Market Analysis

This alternative expands the Boyes Hot Springs recycled water market to include The Sonoma Mission Inn Golf Course and two vineyards that utilize groundwater for irrigation purposes. Recycled water demand increases to approximately 380 acre-feet annually. These users are located in the same vicinity as the water users described above and are also illustrated on Figure 2. Table 6 provides a listing of the expanded user group and their demands.

Table 6 Large Water Users in the Boyes Hot Springs Area

User Sites	Entitlement (AF/yr)
Larson Park	6.73
Sonoma Greens HOA	17.26
Flowery School	0.36
Altimira JHS	11.09
Hanna Boys Center	31.34
Sonoma Mission Inn	8.61
Sonoma Mission Inn Golf Course	266.00
Vineyard	20.00
Vineyard	6.40
Total	**367.79**

4.4.2 Sizing of Treatment Facilities

The satellite service area demand can be met by a recycling facility with a capacity of 720,000 gallons per day.

4.4.3 Location of Treatment Facilities

Wastewater is proposed to be diverted south of Vailetti Drive, just as described for the analysis of current water customers.

4.4.4 Comparative Cost Analysis

This alternative compares: (1) the cost of building a 720,000 gpd satellite facility south of Vailetti Drive and east of Sonoma Creek to (2) the cost of a 720,000 gpd upgrade to the SVCSD facilities. The evaluation includes the cost of a creek crossing (assumed to be constructed with trenchless methods) in the satellite analysis because the main trunk sewer and the irrigation users are located on opposite sides of Sonoma Creek. Table 7 presents these costs estimates. In this case, the central plant expansion is slightly more cost effective. The overall cost of delivered water is approximately one-half of the cost projected for the current water customers alternative described above. This is a result of economies of scale associated with the larger recycled water market.

Table 7 Comparative Cost Analysis for Boyes Hot Springs Users

Alternative	Capital Cost	Annual O&M	Total $/AF
720,000 gpd Satellite Facility	$11,020,000	$171,000	$2,609
720,000 gpd Upgrade to SVCSD	$8,610,000	$212,000	$2,249

Section 5 Conclusions & Recommendations

The SVCSD Service area has relatively limited opportunities for urban water recycling. Large irrigation users that utilize the water system to meet their needs are concentrated in the Boyes Hot Springs Area.

The recycled water market expands when groundwater users are included in the analysis. The combination of current water customers and groundwater users in the Boyes Hot Springs area results in a relatively cost-effective water recycling project that appears to be best served by expansion of the SVCSD's central facilities. Because the local water purveyors are considering expanded use of groundwater resources to meet their future needs, a recycled water program that allows offset groundwater to be dedicated to meeting overall basin demands is attractive from water resources management perspective.

The overall cost of recycled water facilities is high. SVCSD does receive some benefits because beneficial reuse reduces the overall hydraulic and pollutant loading associated with its surface water discharge. In addition, outside grant funding can reduce the cost of delivering recycled water.

CEQA documentation and ongoing funding coordination are critical to implementation. The current Water Recycling Grant program administered by the State Water Resources Control Board (SWRCB) requires environmental documentation as a condition of eligibility for the currently available construction funding. As Proposition 50 is implemented, both the SWRCB and the Department of Water Resources will be in a position to make grant funding for available water recycling projects. Preliminary information indicates that projects will be received most favorably if they are located within the CalFed solution area and if they are included with some form of an integrated regional water management plan.

Technical Memorandum No. 4

RMC
Raines, Melton & Carella, Inc.
Consulting Engineers Project Managers

Subject:	Novato Service Area Analysis
Prepared For:	North Bay Watershed Association – Integrated Water Resources Committee
Prepared By:	Kim Hackett and Marilyn Bailey
Date:	June 24, 2004

Section 1 Introduction and Purpose

This Technical Memorandum is part of a feasibility study of satellite recycled water treatment prepared as part of a regional water recycling analysis for the North Bay Watershed Association. The general analysis techniques, developed in Technical Memorandum #1 "Draft General Process and Distribution System Overview" dated May 2004 will be applied to the North Marin Water District's (NMWD's) service area. The general analysis techniques described in Technical Memorandum #1 (hereinafter referred to as the General Criteria) are used to identify a range of candidate satellite treatment plant sites and compare the feasibility of these satellite systems to a centralized recycling system.

Section 2 Study Area Characteristics

2.1 Study Area

The study area includes a suburban population of approximately 56,000 people situated in and about the City of Novato which is located in a warm inland coastal valley of Marin County. The study area includes approximately 75 square miles and is comprised primarily of single-family residential units on lots under one acre in size. Commercial land-use is concentrated in pockets along Highway 101, along Redwood Boulevard, downtown along Grant Avenue, in the Industrial Park south of Highway 37, and in small clusters and convenience centers. There are no major industries within the study area. The 1996 Novato General Plan estimated that at buildout (year 2025) a total of 5,465 new dwelling units, or approximately 14,600 new residents, and a total of 7.6 million square feet of commercial, industrial, and office buildings will be added to the study area.

2.2 Water Supply

Water service is provided by NMWD. In addition to the City of Novato, the NMWD service area also includes several small improvement districts in the West Marin area near the coast. There are two sources of water supply:

- <u>Russian River Water</u> - The NMWD purchases approximately 80% of its supply from Sonoma County Water Agency (SCWA). The SCWA water is collected 60 to 80 feet below the gravel beds adjacent to the Russian River.
- <u>Stafford Treatment Plant</u> - About 20% of Novato's water supply originates from local surface water at Stafford Lake. Stafford Treatment Plant is typically operated in the late spring through early fall to supplement the NMWD's purchased water supply. The amount of Stafford water used during the year depends on the storage levels attained with the previous winter's rainfall.

The current annual water demand is 10,969 acre feet per year (AFY). The forecasted annual demand is 14,152 AFY with conservation or 15,356 AFY without conservation. Future water demand is expected to be met with a combination of Stafford Lake supplies and Sonoma County Water Agency Russian River supplies.[1]

2.3 Wastewater Treatment and Disposal

Wastewater collection, treatment, and disposal services for the study area are provided by Novato Sanitary District (NSD). NSD operates two wastewater treatment plants. The Novato Treatment Plant treats an average dry weather flow of 3.6 mgd and serves the northern two thirds of Novato. The Ignacio Treatment Plant treats an average dry weather flow of 1.6 mgd and serves the southern third. Each treatment plant provides primary and secondary treatment plus ammonia removal and filtration.

During the winter months the treated water flows to San Pablo Bay via an outfall pipe. During the summer months the treated water is recycled and used to irrigate 820 acres of pastures and to operate a fifteen acre wildlife pond adjacent to Highway 37. The District reclaims an average of over 40% of the average annual dry weather flow.

A tertiary recycled water facility, jointly sponsored by NSD and NMWD, is currently being designed. When completed in approximately 2006, the facility will provide 0.5 mgd of tertiary disinfected recycled water for irrigation of the Stone Tree golf course.

Section 3 Market Assessment Methodology

3.1 Relationship to Previous Studies

Recent market analyses completed within the service area include:

- North Marin Water District and Novato Sanitary District Recycled Water Master Plan, prepared by Nute Engineering, dated April 2003. This study identified potential irrigation water customers in the City of Novato and estimated the costs of providing recycled water to these customers.
- North Bay Regional Water Recycling Feasibility Study, prepared by RMC in November of 2002. This study explored providing regional tertiary treatment for the NMWD service area along with facilities that serve the Marin Municipal Water District service area, the City of Petaluma and the Sonoma Valley Sanitation District service area.

This technical memorandum, which focuses specifically on the feasibility of satellite treatment facilities, included an analysis of the tributary collection systems in the NMWD/NSD service area in order to match wastewater flows with water demands. The analysis focuses on discrete clusters of users located some distance from the central wastewater treatment plant and begins by identifying a distant large water user and then identifying a nearby "sewershed" with adequate flow to serve the user.

3.2 Regulatory Context

All of the previous market analyses indicate that NMWD's urban recycled water market will require Title 22 Disinfected Tertiary Recycled Water.

NSD is in San Francisco Bay Regional Water Quality Control Board (Region 2). Region 2 has implemented a General Water Recycling Permit. Public agencies may apply for coverage under the General Permit by filing a Notice of Intent together with an Engineer's Report prepared in accordance with Title 22.

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[1] Letter from NMWD to Sonoma County Water Agency subject: "Coordinating Activities *Regarding Russian River* Water Supply Diversions", December 11, 2003

3.3 Water Demand

Recycled water demand within the NMWD service area was quantified using the demand tables outlined in the April 2003 Recycled Water Master Plan, prepared by Nute Engineering. The irrigation demand of each site identified in the Master Plan is given as total acre-feet/year, average day of peak month, peak day, and peak hour demand.

The analysis done for the NBWA Satellite Project assumes that the satellite recycled water facility will be designed to meet the demand of the average day of the peak month of irrigation demand. This number was determined in the Recycled Water Master Plan by assuming that 20% of total annual demand is delivered in the peak month of the year.

Section 4 Alternatives Analyzed

4.1 Assumptions Common to all Recycled Water Alternatives

The alternatives developed are located within the Novato service area. Some common assumptions were made in order to produce a uniform analysis. These assumptions relate to:

- Present and future water needs;
- Reliability and timing of water use;
- Distance from the central wastewater treatment plant;
- Availability of adequate sanitary sewer flow;
- Capital and operational costs; and
- Value of potable water.

4.1.1 Present and Future Water Needs

The irrigation water demand was based on both current and future irrigation customers identified in the Recycled Water Master Plan. This analysis assumes that the satellite plant will be sized to meet the demand of the average day of the peak month of irrigation demand. To determine average day of peak month flow, the total annual demand is multiplied by 20% to determine the total demand during the peak month. It is then divided by 30, to determine the average daily demand during the peak month. The plant is sized to provide for this demand.

4.1.2 Water Reliability and Delivery Timing

In accordance with the General Criteria, this analysis assumes that a potable water backup supply is available to provide adequate reliability to the user. In addition, and in accordance with the General Criteria, this study assumes that the satellite treatment plant includes a storage tank to manage potential discrepancies between the wastewater flow and irrigation demand curves.

4.1.3 Distance from the Central Treatment Plant

The General Criteria suggested that users located outside a 4-mile distance from the central treatment plant might be cost-effectively served by a satellite water recycling facility. This analysis acknowledges that pipeline can rarely be placed on a straight radial alignment and uses a 2.5 mile radius to approximate a 4 mile distance along an alignment. This initial assumption has helped to focus the study on a reasonable range of customers to review.

4.1.4 Sanitary Sewer Flow

NSD provided detailed sewer mapping to assist in this analysis along with anecdotal information on flowrate in several of its sanitary sewer pump stations. This information assisted in estimating flowrate in the district's sewer mains. Estimating sanitary sewer flow is an important part of satellite plant feasibility because, many times, the location and/or size of the satellite plant is determined by how much wastewater is available at the site.

The sewer mapping was used in conjunction with land use assumptions to estimate sewer flow at the sewer diversion locations. Novato Sanitary District assumes a flowrate of 85 gpd of wastewater per capita, and 2.67 persons per household[2]. Therefore, it can be estimated that 227 gpd of wastewater is produced per residential lot in the sewershed.

4.1.5 Capital and Operational Costs

The General Criteria in Technical Memorandum #1 include cost curves for both satellite treatment facilities and central plant upgrades. These curves were used to develop the cost analysis for each alternative evaluated. The cost per acre foot calculation includes capital cost annualized over 30 years at an interest rate of 6% plus the annual O&M cost divided by the annual yield of the plant in acre feet. For more information on cost development, see Technical Memorandum #1.

4.1.6 Value of Potable Water

Each potential satellite plant frees up potable water sources for use in other areas. For this analysis, the cost of recycled water is compared to the value of the quantity of water that becomes available due to recycled water use. For simplicity, it is assumed that the potable water will serve single family residences, and the value of the water is the amount that equivalent dwelling units would pay for the new water.

Table 1 shows the current NMWD charges for single family water customers under 60' in elevation with a 5/8" meter. A single family residence uses about 636 gpd on the average day of the peak month of water usage.

Table 1 Current NMWD Potable Water Charges[3]

Initial Charges for Service	Cost	Rates for Domestic, Commercial and Industrial Users, Novato Service Area	Cost
Meter Charge	$40	Minimum Service Charge	$9 bimonthly
Service Line Charge	$2,000		
Reimbursement Fund Charge	$272	Water Quantity Rate	$1.23/ 100 ft^3
Facilities Reserve Charge	$6,400		
Total Initial Charges	$8,712		

4.2 Locations of Alternatives Analyzed

Based on irrigation water demand, estimated sewer flow and distance from central wastewater plant, three locations were identified as satellite treatment candidates. The cluster of water users identified in West Novato includes San Marin High School and the future San Andreas School; the cluster in North Novato includes the irrigation demand of Fireman's Fund Insurance Company; and the cluster in the Hamilton Area, which includes the U.S. Coast Guard Installation. These areas are shown in Figure 1.

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[2] *Novato Sanitary District Strategic Plan*, Larry Walker and Associates, September 2001
[3] North Marin Water District Regulations, Regulation 1 and Regulation 54

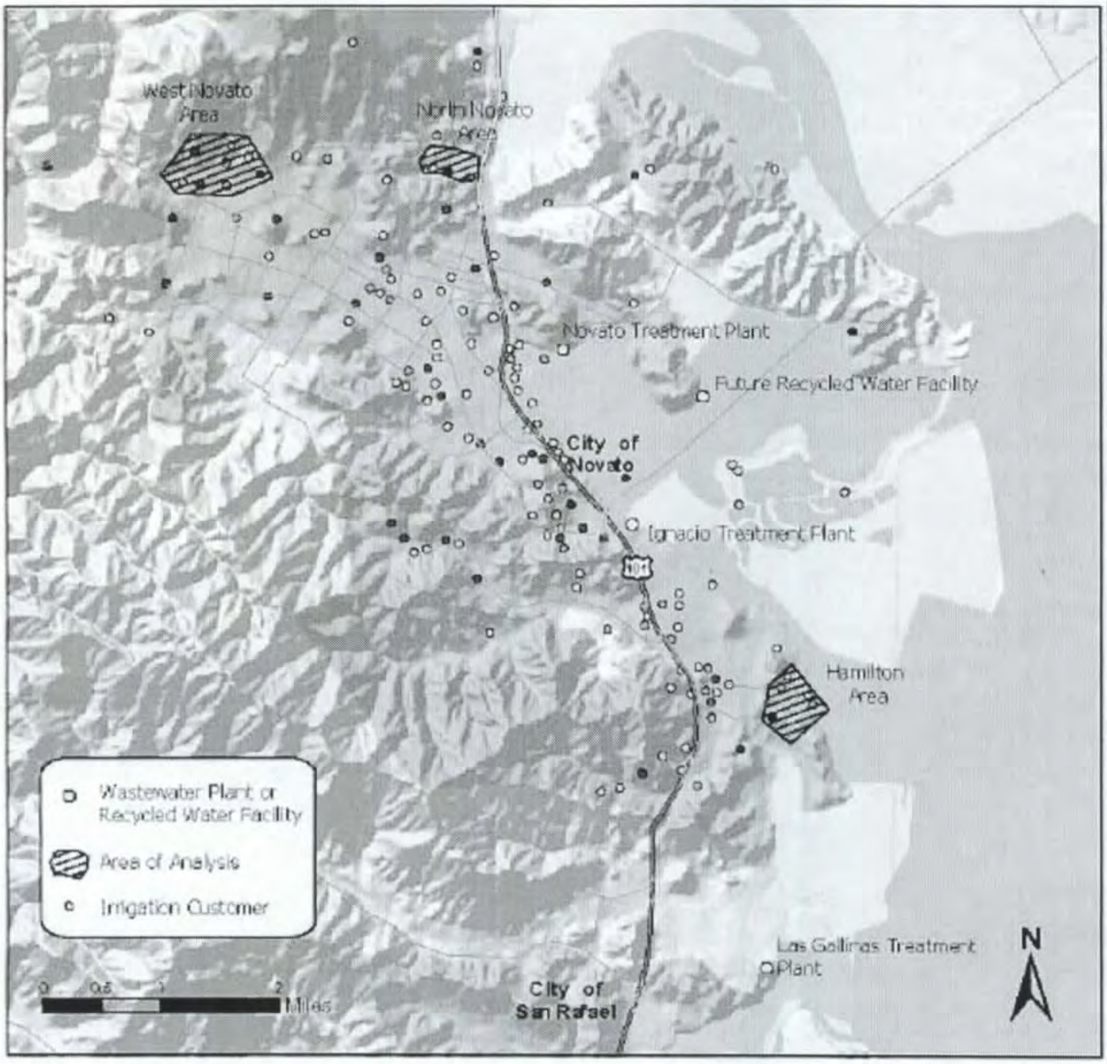

Figure 1 Overview of Areas of Analysis

4.3 West Novato Area

4.3.1 Summary Market Analysis

There are several irrigation customers in the West Novato. The Recycled Water Master Plan identified five potential recycled water customers in West Novato that could be served by a satellite treatment plant. They are listed in Table 2 below, and are shown on Figure 2. The anchor users in the area are San Marin High school and the future San Andreas School. The total recycled water demand for these users is 105 acre-feet per year.

Table 2 Irrigation Water Use in the West Novato Area

User Site(s)	AF/yr
San Andreas School (assumed future flow)	70
Center – 143 San Marin	4
Novato United School District – 15 San Marin	17
Novato United School District – 45 San Marin	9
Novato United School District – 15 San Marin	5
Total	**105**

4.3.2 Sizing of Treatment Facilities

Based on the assumed annual irrigation water consumption curve of 20% of annual flow occurring in the peak month, 105 acre-feet per year of demand is equivalent to a demand of 230,000 gallons per day for the average day of the peak month of irrigation season. This corresponds to a 230,000 gpd satellite treatment plant.

4.3.3 Location of Sanitary Sewer Diversion

Based on land use assumptions of 227 gallons per day per lot, there is more than the required flow to meet the recycled water demand in the sewer main at San Andreas Dr. and San Carlos Way.

The location of sewer diversion is approximately 20,000 ft from the Novato Treatment Plant. The Novato Treatment plant was chosen for comparison for several reasons. It is assumed that the district's Recycled Water Facility will be running at capacity. Since new recycled facilities would be required, it makes more sense to provide them at the Novato Treatment Plant, which is closer to these demands, rather than from the Recycled Water Facility.

Figure 2 Location of Satellite Plant and Irrigation Users in West Novato

4.3.4 Cost Comparison

For feasibility analysis, the capital and O&M cost of siting a recycled water satellite plant in West Novato was compared to adding the equivalent capacity and transmission system to the Novato Treatment Plant. These two costs are also compared to the value of the water saved by replacement with potable water. The costs are shown in Table 3 below.

Table 3 Comparative Cost Analysis for West Novato Area

Alternative	Capital Cost	Annual O&M	Total $/AF
230,000 gpd Satellite Facility	$4,580,000	$60,000	$3,290
230,000 gpd Upgrade to Novato Treatment Plant	$5,680,000	$97,000	$4,197

The capital cost of the satellite facility corresponds to a $3.8 million satellite plant plus a $0.8 million distribution system. The capital cost of central treatment at the recycled water facility is much smaller for treatment, but much larger for distribution. It corresponds to $1.6 million for treatment and $4.0 million for distribution which includes the cost for crossing Highway 101.

The 230,000 gpd recycled water facility will free up potable water equivalent to 362 dwelling units (230,000 gpd / 636 gpd per dwelling unit). Table 1 shows that each new single family residence has upfront fees of $8,712 when connecting to the water service and then pays $1.23/100 ft^3 of water used. The total value of the potable water freed up by reclaimed water is the upfront fees times the number of equivalent dwelling units plus the volume of water times the unit cost to the consumer. The calculation is shown below:

Value from upfront fees = $8,712 x 362 = $3,153,744

Annualized at 30 years at 6% = $3,153,744 x .07265 = **$229,119/yr**

Value from unit cost = 105 AF/yr x $1.23/100 cu. ft. x 43,560 = **$56,258/yr**

Value on $/AF basis = ($229,119/yr + $56,258/yr)/105 AF/yr = **$2,720/AF**

4.3.5 Implementation Considerations:

The satellite alternative is more cost effective than central treatment and transmission. However, both of these alternatives are more costly than the current potable water costs. Therefore, from a water supply standpoint, it is more feasible to continue providing potable water to these customers.

4.4 North Novato Area

The Recycled Water Master Plan identified a very large water user in North Novato that is relatively close to the Novato Treatment Plant, but a large enough user that it merits analysis of its own satellite plant. This user is Fireman's Fund Insurance Company, which according to the Recycled Water Master Plan, has 99 AF/yr of irrigation water demand. This demand is listed in Table 4 and shown in Figure 3.

Table 4 Irrigation Water Use in the West Novato Area

User Site(s)	AF/yr
Fireman's Fund	96
Fireman's Fund (second and third meter)	3
Total	**99**

4.4.1 Sizing of Treatment Facilities

Based on the assumed annual irrigation water consumption curve, 99 acre-feet per year of demand is equivalent to a demand of 210,000 gallons per day for the average day of the peak month of irrigation season. This corresponds to a 210,000 gpd satellite treatment plant.

4.4.2 Location of Sanitary Sewer Diversion

The wastewater will be diverted from the sanitary sewer main that goes down San Marin Dr. in front of the Fireman's Fund campus. It is approximately 11,000 feet from the Novato Treatment Plant.

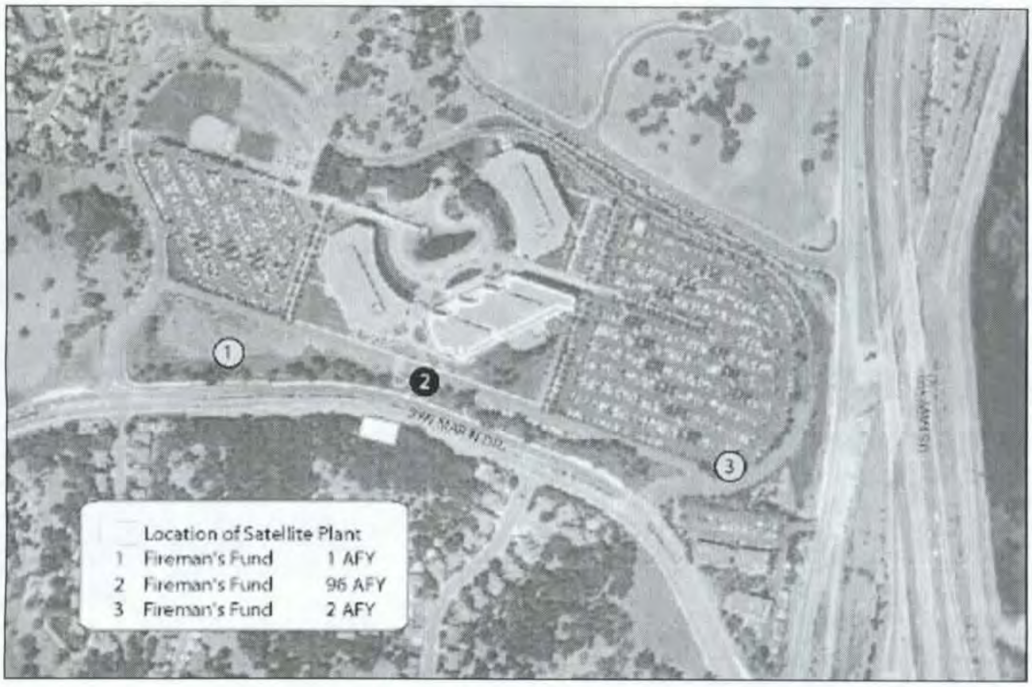

Figure 3 Location of Satellite Plant and Irrigation Users in North Novato

4.4.3 Cost Comparison

The cost of providing recycled water to the irrigation users was evaluated in two ways. The cost of siting a satellite treatment plant on San Marin Drive was compared with the cost of adding tertiary and distribution facilities to the Novato Treatment Plant. The comparative costs are shown in Table 5 below.

Table 5 Comparative Cost Analysis for North Novato

Alternative	Capital Cost	Annual O&M	Total $/AF
210,000 gpd Satellite Facility	$3,390,000	$45,000	$2,680
210,000 gpd Upgrade to Novato Treatment Plant	$3,170,000	$64,000	$2,670

The capital cost of the satellite facility corresponds to a $3.3 million satellite plant plus a $50,000 distribution system. The capital cost of central treatment at the Novato Treatment Plant is much smaller for treatment, but much larger for distribution, corresponding to a $1.6 million tertiary facility and a $1.6 million distribution system.

The 210,000 gpd recycled water facility will free up water equivalent to 330 dwelling units. The calculation of the value of the potable water follows the same methodology as Section 4.3.4.

Value from upfront fees = $8,712 x 330 = $2,874,960

Annualized at 30 years at 6% = $2,874,960x .07265 = **$208,866/yr**

Value from unit cost = 99 AF/yr x $1.23/100 cu. ft. x 43,560 = **$53,043/yr**

Value on $/AF basis = ($208,866/yr + $53,043/yr)/99 AF/yr = **$2,650/AF**

4.4.4 Implementation Considerations

Based on the recycled water cost analysis developed in the General Criteria, the satellite alternative and the central treatment alternative cost almost exactly the same on a $/AF basis. They are also in the same range as the value of potable water that they would replace. A more detailed recycled water demand and cost analysis would further determine which is the lowest cost water supply option.

4.5 Hamilton Field Area

4.5.1 Summary Market Analysis

The Hamilton Field area is another high water demand area that is attractive from a satellite treatment standpoint. The Recycled Water Master Plan identified six users in the area, listed in Table 6 and shown on Figure 4. The largest potential recycled water customer in the area is the Coast Guard installation.

Table 6 Irrigation Water Use in Hamilton Field Area

User Site(s)	AF/yr
Hamilton Park HOA - 59 Holliday	6
Hamilton Marin - 676 Hangar	9
Hamilton Park HOA - 1 Gann Way	4
City of Novato - 551 Hangar	4
Coast Guard - Palm Dr.	105
Total	**128**

4.5.2 Sizing of Treatment Facilities

There is a total of 128 acre-feet of demand in the area, which corresponds to a recycled water treatment installation of 270,000 gpd. Based on a discussion with Novato Sanitary District Staff, there is 1 mgd of dry weather flow in the nearby Hamilton pump station. Therefore, there is sufficient flow to meet the demands of a satellite treatment plant in the area.

4.5.3 Location of Sanitary Sewer Diversion

The satellite plant could be located adjacent to the Hamilton Pump Station on Hamilton Parkway. It is approximately 4000 feet from the demands.

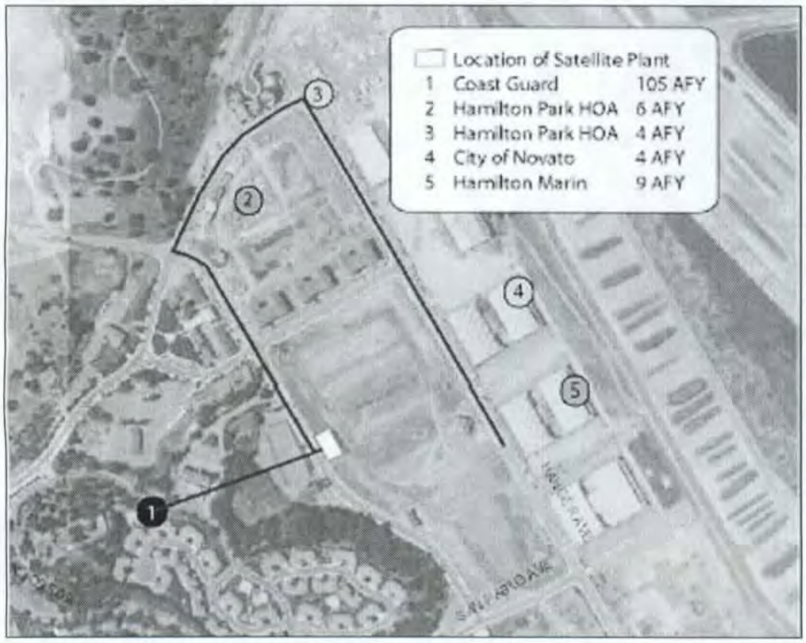

Figure 4 Location of Satellite Plant and Irrigation Users in Hamilton Field Area

4.5.4 Cost Comparison

For this alternative, the cost of satellite treatment is compared to the cost of central treatment at three different treatment plants. The three plants are the future NMWD/NSD Recycled Water Facility located north of Highway 37 at the NSD Effluent Storage ponds, Novato Sanitation District's Ignacio Treatment Plant, and the Las Gallinas Wastewater Treatment Plant. The recycled water demands are respectively

23,000 feet, 12,000 feet, and 15,000 feet from these potential centralized treatment sites. The locations of these plants are shown on Figure 1.

The costs are shown in Table 7 below.

Table 7 Comparative Cost Analysis for Hamilton Field

Alternative	Capital Cost	Annual O&M	Total $/AF
270,000 gpd Satellite Facility	$4,760,000	$63,000	$2,920
270,000 gpd Upgrade to RWF	$5,150,000	$95,000	$3,300
270,000 gpd Upgrade to Ignacio	$3,490,000	$76,000	$2,330
270,000 gpd Upgrade to Las Gallinas	$3,920,000	$82,000	$2,590

The capital cost of the satellite facility corresponds to a $4.1 million satellite plant plus a $0.6 million distribution system. The capital cost of central treatment is much smaller for treatment, but much larger for distribution. The capital cost of the centralized Title 22 facilities is $1.7 million with the remaining of the capital costs going to the distribution system. The capital costs for the distribution systems from the Recycled Water Facility, Ignacio Treatment Plant, and Las Gallinas Plant are $3.5 million, $1.8 million, and $2.2 million, respectively.

The 270,000 gpd recycled water facility will free up water equivalent to 424 dwelling units. The calculation of the value of the potable water follows the same methodology as Section 4.3.4.

Value from upfront fees = $8,712 x 330 = $3,693,888

Annualized at 30 years at 6% = $3,693,888 x .07265 = **$268,360/yr**

Value from unit cost = 128 AF/yr x $1.23/100 cu. ft. x 43,560 = **$68,581/yr**

Value on $/AF basis = ($268,360/yr + $68,581/yr)/128 AF/yr = **$2,630/AF**

4.5.5 Implementation Considerations

Table 7 shows that satellite treatment costs less than centralized treatment at the Recycled Water Facility, but costs more than recycled water treatment at the Ignacio and Las Gallinas plants. The costs shown, however, are based on cost curves with assumptions that may not necessarily apply to all of the treatment plant options. For example, the Ignacio treatment plant's effluent would probably need a pretreatment step before tertiary treatment in order to meet Title 22 requirements. This extra process step is not included in the cost curve assumptions. In addition, the Ignacio treatment plant may be taken out of service in the future depending on results of an ongoing NSD wastewater treatment facility plan. There may be some extra costs associated with treating and delivering recycled water from the Las Gallinas Plant. Las Gallinas's recycled water facilities are currently operated by Marin Municipal Water District. The costs shown in Table 7 only consider the cost of adding tertiary capacity to the plant, not the additional administrative costs that may come with developing and maintaining agreements with other agencies.

Section 5 Conclusions and Recommendations

The customer clusters considered included:

- Irrigation customers in West Novato, including San Marin High School and future use at the San Andreas School.
- The Fireman's Fund Insurance Company campus on San Marin Drive in North Novato.
- The Hamilton Field area, including the US Coast Guard Facility.

For the West Novato case, the satellite plant was more cost-effective than providing recycled water from a centralized facility. For the Hamilton Field area, the most cost-effective recycled water alternatives were to provide recycled water from a centralized facility at either the Las Gallinas or Ignacio treatment plants. However, in both cases, the satellite treatment facilities have higher unit costs than potable water as a stand-alone water supply.

For the North Novato area, the cost of providing recycled water was virtually the same for satellite treatment and central treatment, and was only slightly higher than the value of potable water. In this case, a more detailed cost estimate would determine which option is the most cost effective.

Table 8, below, outlines the estimated cost per acre-foot of water for satellite treatment from all three of the clusters under study and compares these to the estimated cost per acre-foot of potable water.

Table 8 Overall Cost Comparison

Satellite Location	Unit Cost for Satellite Treatment $/AF	Value of Potable Water Replaced $/AF
West Novato	$3,290	$2,720
North Novato	$2,680	$2,650
Hamilton Field	$2,920	$2,630

Based on evaluation of recycled water as a new water supply, satellite treatment plants do not appear to be a cost-effective alternative in the West Novato and Hamilton Field areas strictly from a water supply viewpoint. In the North Novato Area, satellite treatment may be cost-effective as a new water supply. If other driving forces for expansion of the recycled water supply emerge in the future, such as a need to reduce wastewater discharge due to new regulations, further studies should include the following:

- Verification of water demands and available wastewater flow within the sewershed
- Environmental documentation
- Refinement of costs including land acquisition, engineering studies and design
- Financing plan
- Development of inter-agency agreements for operation and maintenance of the facilities

Technical Memorandum No. 5

RMC
Raines, Melton & Carella, Inc.

Subject: Napa Silverado Service Area Analysis

Prepared For: North Bay Watershed Association – Integrated Water Resources Committee

Prepared By: Kim Hackett and Marilyn Bailey

Date: September 24, 2004

Section 1 Introduction and Purpose

This Technical Memorandum is part of a feasibility study of satellite recycled water treatment prepared as part of a regional water recycling analysis for the North Bay Watershed Association. The general analysis techniques and analyses described in Technical Memorandum #1 "Draft General Process and Distribution System Overview", dated May 2004, (hereinafter referred to as the General Criteria) are used to identify a range of candidate satellite treatment plant sites and compare the feasibility of these satellite systems to a centralized recycling system. These techniques will be applied to the Silverado Area of Napa.

Section 2 Study Area Characteristics

2.1 Study Area

The study area is the Silverado area of the City of Napa (City), which includes the Silverado Country Club and Resort as well as Silverado Highlands, a community of luxury homes. The Silverado Country Club includes two 18-hole golf courses, tennis courts and a spa as well as guest condominiums and meeting facilities.

2.2 Water Supply

Water service within the City of Napa is provided by the City public works department. The City also provides water to certain unincorporated areas outside of the City boundaries, including the Silverado Highlands Community. There are three sources of water supply[1]:

- Lake Hennessey – Lake Hennessey is the City's primary water supply source between the months of May and October. The reservoir was created by the Conn Dam, built in 1946, and stores approximately 31,000 acre-feet of water. Water from Lake Hennessey is treated at the Hennessey Treatment Plant.
- Milliken Reservoir – The Milliken Dam was built on the Napa River in 1923, creating Milliken Reservoir. Currently, Milliken Reservoir is used as a secondary water supply during the months of March and October. This water supply is treated at the Milliken Water Treatment Plant.
- State Water Project – Napa receives water from the State Water Project through the North Bay Aqueduct. This source is the City's lead water supply between October and April, and is treated at the Jameson Treatment Plant.

The Silverado Country Club and Resort uses groundwater for its irrigation demands.

[1] Comprehensive Water Service Study: Draft Determinations, LAFCO of Napa County, October 9, 2003.

2.3 Wastewater Treatment and Disposal

Wastewater collection, treatment, and disposal services for the study area are provided by Napa Sanitary District (NSD). NSD operates the Soscol Water Recycling Facility which collects and treats wastewater from the City of Napa as well as unincorporated areas of Napa County.

During the winter months the treated water is discharged into the Napa River. During the summer months discharge in the Napa River is prohibited. Between May 1 and October 31, the water is treated in the plant's tertiary treatment facilities and recycled. The current and future customers for the recycled water include nearby golf courses, parks and business parks.

Section 3 Market Assessment Methodology

3.1 Relationship to Current Recycled Water Supply

This technical memorandum, which focuses specifically on the feasibility of satellite treatment facilities, analyzes recycled water feasibility differently than traditional market assessments. The traditional method for identifying potential recycled water customers is to locate large irrigation or process water customers that are in the vicinity of the central wastewater treatment facility. The analysis for satellite treatment focuses on users located some distance from the central wastewater treatment plant and begins by identifying a distant large water user and then identifying a nearby "sewershed" with adequate flow to serve the user.

The City and NSD have an agreement that recognizes the City as the sole purveyor of water, but defines a portion of the service area in which NSD is allowed to provide recycled water. NSD sells the recycled water to large users close to its Soscol Water Recycling Facility and reimburses the City for loss of revenue from its water customers[2]. It is assumed that the construction of a satellite plant would require an amendment to this agreement that would expand the service area for recycled water delivery.

3.2 Regulatory Context

It is assumed that all of Napa's urban recycled water market, including the Silverado area, will require Title 22 Disinfected Tertiary Recycled Water.

NSD is in San Francisco Bay Regional Water Quality Control Board (Region 2). Region 2 has implemented a General Water Recycling Permit. Public agencies may apply for coverage under the General Permit by filing a Notice of Intent together with an Engineer's Report prepared in accordance with Title 22.

3.3 Water Demand and Sanitary Sewer Flow

The water demand for the Silverado Area was estimated using the land use estimations outlined in the General Criteria as shown in Table 1. The acreages were estimated using parcel maps and spatial land use data from the Napa County Geographic Information Systems Database.

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[2] Agreement Between City of Napa and Napa Sanitation District for Sale of Recycled Water Within City of Napa Water Service Area, dated August 4, 1998.

Table 1 Land Use Based Demand Factors

Land Use	Demand Rate (AF/acre/year)
Vineyards	0.5
Irrigated Agriculture	2.0
Irrigated Pasture	2.5
Golf Courses	3.5
Urban Irrigation	3.0
Commercial/Industrial Process	1.7
Toilet Flushing	1.5 gal/flush

In accordance with the General Criteria, the satellite treatment analysis assumes that a potable water backup supply is available to provide adequate reliability to the user. In addition, and in accordance with the General Criteria, this study assumes that the satellite treatment plant includes a storage tank to manage potential discrepancies between wastewater flow and irrigation demand.

The General Criteria suggested that users located outside a 4-mile distance from the central treatment plant might be cost-effectively served by a satellite water recycling facility. This analysis acknowledges that pipeline can rarely be placed on a straight radial alignment and uses a 2.5 mile radius to approximate a 4 mile distance along an alignment. This initial assumption preliminarily identified the Silverado area as a location in which satellite recycled water production might be more cost effective than centralized production.

The proposed water recycling facilities are sized to provide for the demand of the average day of the peak month of water use. It has been assumed that the peak monthly demand is approximately 18% of the total annual water demand, as shown in Figure 1. To determine the size of the plant, the total annual demand is multiplied by 18% to determine the total demand during the peak month. It is then divided by 30, to determine the average daily demand during the peak month. The plant is sized to provide for this demand.

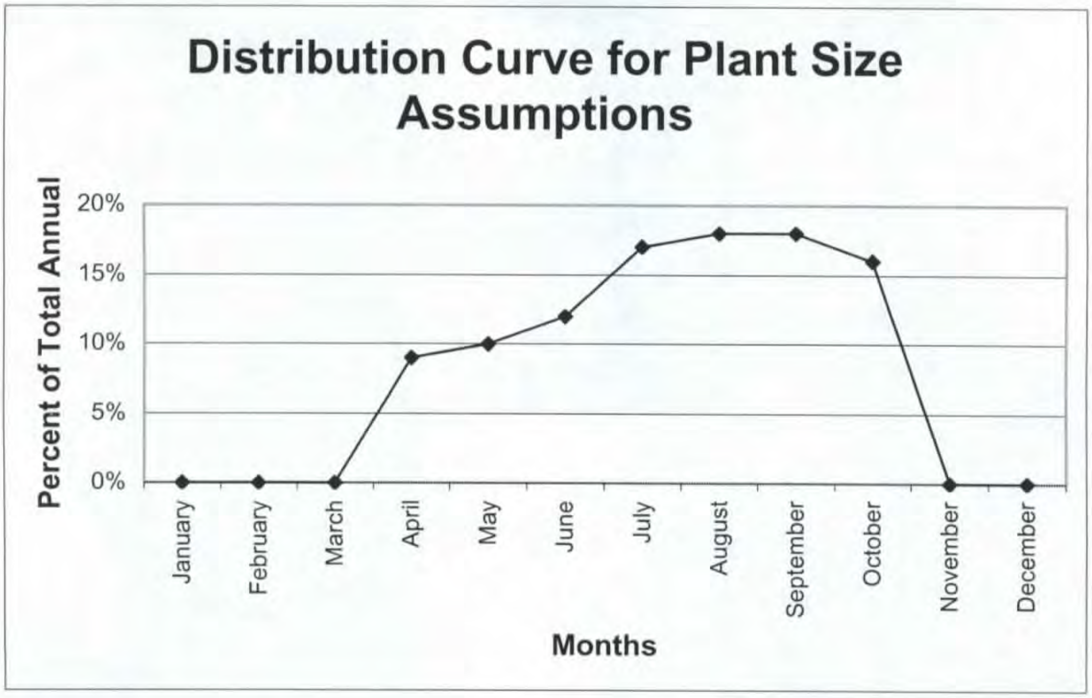

Figure 1 Distribution Curve for Plant Size Assumptions

For satellite treatment plant sizing, the other consideration to be examined is the amount of wastewater available to be treated in the area. NSD provided detailed sewer mapping in AutoCAD format to assist in the analysis of raw wastewater supply for the satellite plant. This mapping was used to locate the best location for the sewer diversion. In addition, the District provided flow data from an inflow and infiltration study done by Geotivity. This data was helpful for estimating the dry weather flow in the sewer at the point of diversion, and by extension, the maximum potential size of the satellite plant.

3.4 Cost Assumptions

The NBWA Satellite Plant analysis includes comparison of the cost of satellite treatment to the cost of treatment at the central plant. Satellite treatment can be a cost effective recycled water alternative at locations miles away from the central plant because of high distribution system costs from the central plant. The costs of satellite and centralized recycled water treatment are also compared to the cost of potable water.

The General Criteria in Technical Memorandum #1 include cost curves for both satellite treatment facilities and central plant upgrades. These curves were used to develop the cost analysis for each alternative evaluated. The cost per acre foot calculation includes capital cost annualized over 30 years at an interest rate of 6% plus the annual O&M cost divided by the annual yield of the plant in acre feet. For more information on cost development, see Technical Memorandum #1.

When looking at recycled water as a water supply, it is useful to compare its cost to the cost of potable water for the current customers. The Silverado Country Club uses well water for so its cost of irrigation water is negligible. For the water users that are City of Napa customers, the cost of water is $3.23/thousand gallons.

Section 4 Alternatives Analyzed

4.1 Silverado Area

4.1.1 Summary Market Analysis

There are several irrigation water users in the Silverado area, most notably, the Silverado Country Club and Resort. The users were identified using parcel maps and land use information from the Napa County GIS system. They are shown in Figure 2. According to the land use information, the two largest water users in the Silverado Area are the Silverado Country Club golf courses, and the common use areas of the surrounding condominiums. The Silverado Country Club covers approximately 272 acres. Assuming 90% of the area is golf course turf and a land use factor of 3.5 AF/acre/year, the annual water demand of the Country Club golf courses is approximately 860 AF/yr. The condominium common areas cover approximately 111 acres. Assuming 80% of the area is irrigable turf and a land use factor of 3 AF/acre/year, the annual water demand of the common areas is approximately 270 AF/yr.

Figure 2 Irrigation Land Use in Silverado Area

4.1.2 Sizing of Treatment Facilities

Based on the estimated irrigation demand curve, the total demand of the golf courses and condominium common areas could be met with a recycled water facility with a capacity of 2.2 mgd. However, there is not enough capacity in the sewer collection system in the Silverado area to meet this demand. Based on the sewer flow data provided by NSD, the sewer main that carries flow from the Silverado Area has only 150,000 gpd of dry weather flow. Therefore, a satellite plant in the area would be sized based on the raw wastewater available, and it would only serve a fraction of the total demand.

4.1.3 Location of Sanitary Sewer Diversion

The raw wastewater for the satellite treatment plant would be diverted from the sewer main that conveys the collected wastewater from the Silverado Area to the rest of the NSD collection system. This sewer main roughly follows an alignment roughly 300 ft to the east of Milliken Creek. The diversion would be at the location where this sewer main crosses Hedgeside Ave.

The location of sewer diversion is approximately 40,000 ft from the Soscol Treatment Plant.

4.1.4 Cost Comparison

For feasibility analysis, the capital and O&M cost of siting a recycled water satellite plant at Hedgeside Avenue was compared to adding the equivalent capacity and transmission system to the Soscol Treatment Plant. These two costs are also compared to the value of the water saved by replacement with potable water. The costs are shown in Table 2 below.

Table 2 Comparative Cost Analysis for West Novato Area

Alternative	Capital Cost	Annual O&M	Total $/AF
150,000 gpd Satellite Facility	$3,940,000	$46,000	$4,300
150,000 gpd Upgrade to Soscol RWF	$7,780,000	$111,000	$8,670

The capital cost of the satellite facility corresponds to a $3.1 million satellite plant plus a $0.8 million distribution system. The capital cost of central treatment at the recycled water facility is only $1.5 million for treatment, but is $6.3 million for distribution due to the distance from the plant. However, it is likely that NSD would not limit itself to 150,000 gpd if providing recycled water produced at the centralized treatment plant. It is expected that the cost per acre foot of providing for all 2.2 mgd of irrigation demand from the Soscol facility would be significantly lower due to economies of scale. Based on extrapolation of the cost curves described in the General Criteria, treatment and distribution to supply the entire demand in the Silverado Country Club Area from the Soscol treatment plant would cost approximately $1,670 per acre foot.

The City of Napa water customers currently pay $3.23/thousand gallons for water. This is equivalent to approximately $1,050/af.

Section 5 Conclusions and Recommendations

A satellite treatment plant on Hedgeside Ave. would only provide for a fraction (7%) of the irrigation demand in the area due to the limited volume of wastewater available in the collection system. The satellite plant would also have a higher unit cost as compared to other sources of water for the area. The cost in $/AF each alternative is shown in Table 3.

Table 3 Overall Cost Comparison

Water Source	Unit Cost $/AF
150,000 gpd satellite recycled water plant	$4,300
150,000 gpd recycled water supply from Soscol	$8,670
2.2 mgd recycled water supply from Soscol	$1,670
Potable water provided by City of Napa	$1,050

Since a satellite treatment plant would be limited in size and have a relatively high unit cost, it is not a feasible water supply alternative for serving the Silverado Country Club area. If other driving forces for satellite treatment emerge in the future, further studies should include the following:

- Verification of water demands and available wastewater flow within the sewershed
- Environmental documentation
- Refinement of costs including land acquisition, engineering studies and design
- Financing plan
- Development of inter-agency agreements for operation and maintenance of the facilities