NORTH COAST RESOURCE PARTNERSHIP

2014 IRWM Drought Project Grant Application

ATTACHMENT 3:

Project Justification Appendix

Integrated Regional Water Management Program
Applicant: Humboldt County

North Coast Resource Partnership 2014 IRWM Drought Project Grant

Attachment 3. Project Justification Appendix

Supporting Documentation

1. Recycled Water Master Plan (2012)
2. Moisture Sensor Agricultural Irrigation Design Manual
3. Electrical Interface for Water Sensors
4. Soil Moisture Monitoring: Low-Cost Tools and Methods
5. NRCS Conservation Practice Standard: Irrigation Water Management
6. Mendocino County Crop Report
7. Project maps

City of Ukiah

Recycled Water Master Plan

DRAFT REPORT • February 2012

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City of Ukiah

RECYCLED WATER MASTER PLAN

DRAFT

February 2012

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City of Ukiah

RECYCLED WATER MASTER PLAN

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LIST OF ABBREVIATIONS

AACE	Association for the Advancement of Cost Estimating
af	Acre Feet
ac	Acre
AFY	Acre Feet per Year
ENR	Engineering News Record
ft	Feet
ft/kft	Feet per Thousand Feet
ft/sec	Feet per Second
gpm	Gallons per Minute
GW	Groundwater
M	million
Max	Maximum
MG	Million Gallons
mgd	Million Gallons per Day
Min	Minimum
Mod	Moderate
psi	Pounds per Square Inch
RRFCD	Russian River Flood Control District
SWRCB	State Water Resources Control Board
UUSD	Ukiah Unified School District
WWTP	Wastewater Treatment Plant

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(UCCEMC, 2008) University of California Cooperative Extension. *Irrigated Agriculture Water Needs and Management in the Mendocino County Portion of the Russian River Watershed.* Prepared for the Mendocino County Water Agency. July 2008.

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Chapter 1

STUDY AREA CHARACTERISTICS

1.1 INTRODUCTION

The City of Ukiah (City) contracted with Carollo Engineers to provide engineering services to develop the City's first Recycled Water Master Plan (RWMP). The purpose of the RWMP is to determine the feasibility of constructing a recycled water system to replace/augment existing water supplies in Ukiah Valley. Recycled water use within the Valley would offset existing and future water demands for irrigation and frost protection of agricultural land, and in doing so, would support the local agricultural industry. It would also offset urban irrigation demands, ease storage limitations at the Ukiah Wastewater Treatment Plant (UWWTP) and reduce treated wastewater discharges to the Russian River.

The City of Ukiah (City), as shown in Figure 1.1, is located in Mendocino County in the northern coastal region of California. The City is situated in the Ukiah Valley approximately 60 miles north of Santa Rosa, 20 miles south of Willits, and 5 miles south-west of Lake Mendocino, and is surrounded by coastal ranges in southern Mendocino County. The Valley is bordered on the west by the Mendocino Range and on the east by the Mayacamas Mountains. Elevations in the nearby mountains reach over 1,800 feet above mean sea level (MSL), while elevations in the Valley range from about 560 feet above MSL in the south near El Robles Ranch to 670 feet above MSL in the north near Calpella. Interstate Highway 101 runs north to south through the City along its eastern boundary and the Russian River flows from north to south through the Ukiah area. Ukiah is the county seat for Mendocino County.

Originally part of a Mexican Land Grant, the City began its history as a Valley settlement in 1856. Due to the City's moderate climate and productive soil, lumber production became a major industry by the end of the 1940s. Agriculture is currently the largest industry in Ukiah and the rest of Mendocino County (www.cityofukiah.com). Ukiah is home to wineries, grape vineyards, pear orchards, and wood production plants, in addition to up-and-coming non-agricultural manufacturers.

1.1.1 IMPETUS FOR RECYCLED WATER USE

Surface waters, namely the Russian River (River) and Lake Mendocino, and groundwater are the major water resources that sustain the people and industries of Ukiah area. The City and several other water service providers in the area use a combination of these water supplies to support the urban demands within their service area boundaries. Agricultural entities also draw groundwater and surface water to both irrigate their crops and protect them from frost and heat events. Over the years, these water resources have become

Legend

- City/Community
- Major Roads
- Water Body
- Recycled Water Master Plan Study Area
- County Boundary

N

0 7.5 15 Miles

Figure 1.1
LOCATION MAP
RECYCLED WATER MASTER PLAN
CITY OF UKIAH

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increasingly taxed to meet urban and agricultural demands as well as in-stream flow requirements for endangered species. As a result, the need to procure alternative water supplies, including recycled water, has increased.

Environmental groups have increasingly studied how river and groundwater diversions have negatively affected the species of the Russian River stream system and have requested increased regulation of these diversions. In 2009, The National Oceanic Atmospheric Administration's National Marine Fisheries Service (NOAA Fisheries) presented the State Water Board with information that water withdrawn from the Russian River for frost protection of agricultural crops poses a threat to federally threatened and endangered salmonids in the Russian River watershed. They documented two episodes of fish stranding mortality that occurred in April 2008, one on Felta Creek in Sonoma County and the second on the mainstream of the Russian River near Hopland in Mendocino County (Draft EIR Russian River Frost Protection Regulation, 2007). NOAA Fisheries requested the State Board take regulatory action immediately to regulate diversions for frost protection to prevent salmonid mortality. The State Board is currently considering regulatory action that would deem any diversions for frost protection from March 15 through May 15 unreasonable, unless approved by the State Water Board through the completion of an extensive Water Demand Management Program (WDMP). In February 2012, the Courts granted a stay of the State Board regulations that declare frost protection diversions unreasonable in Mendocino and Sonoma Counties.

Faced with this future regulatory consideration, farmers in the Ukiah area are looking for alternative water supplies to sustain their agricultural practices. In addition to this, during dry years water service providers in the surrounding area are limited on the amount of water they can withdraw from the River and Lake Mendocino. Developing recycled water supplies in the Ukiah Valley and surrounding area would increase the overall water supply and its reliability under a range of hydrologic conditions.

The recycled water supply that is being considered under this study is the treated wastewater effluent of the UWWTP. While water users are being limited by the water they can take out of the River, the City is limited on the treated effluent they can put in the River. The City must comply with increasingly stringent discharge requirements that regulate both the volume and quality of the water that can be discharged to the Russian River. As a result, when discharging to the River, the City currently discharges very high quality effluent that meets recycled water needs. Limited on the volume and time at which treated effluent can be discharged, the City could benefit from additional disposal alternatives including delivery of recycled water to irrigation customers.

This report includes the City's plan for implementing recycled water use in the City of Ukiah and surrounding area. This report follows the July 2008 State Water Resources Control Board Water Recycling Funding Program Guidelines. These guidelines can be found on the Board's website at the following website:

http://www.waterboards.ca.gov/water_issues/programs/water_recycling_policy/docs/final_wrfpguidelines071508.pdf.

1.2 VISIONING WORKSHOP

The City of Ukiah held a visioning workshop on February 28, 2011 early in the master planning process to ensure the RWMP aligned with the goals and values of the City and other potentially affected interests. To ensure the master plan addressed both local and regional issues and provided local and regional benefits, the City of Ukiah invited City engineering, planning, management, and operations staff, water service providers in the surrounding area from Redwood Valley to Willow County Water District, and agricultural entities to partake in the visioning workshop. Attendees included representatives from the following entities:

- City of Ukiah
- Ukiah Valley Sanitation District
- Mendocino County Russian River Flood Control and Water Conservation Improvement District
- Mendocino County Farm Bureau
- Millview Water District
- Rogina Water District
- Willow Water District
- Redwood Valley Water District

The group discussed values and challenges pertaining to the RWMP and identified several goals and objectives. Some of the identified goals and objectives included:

- Implementing a recycled water program that is safe and meets the needs of the City and surrounding communities, including local agricultural businesses.
- Reducing withdrawals from the Russian River and Lake Mendocino surface waters.
- Implementing a program that is financially viable and minimizes costs to ratepayers.

It was agreed during the workshop that implementing recycled water anywhere within Ukiah Valley and the surrounding area would improve the regional water supply from Redwood Valley to Hopland. The attendees also identified major water uses located near the recycled water source – the UWWTP.

1.3 STUDY AREA

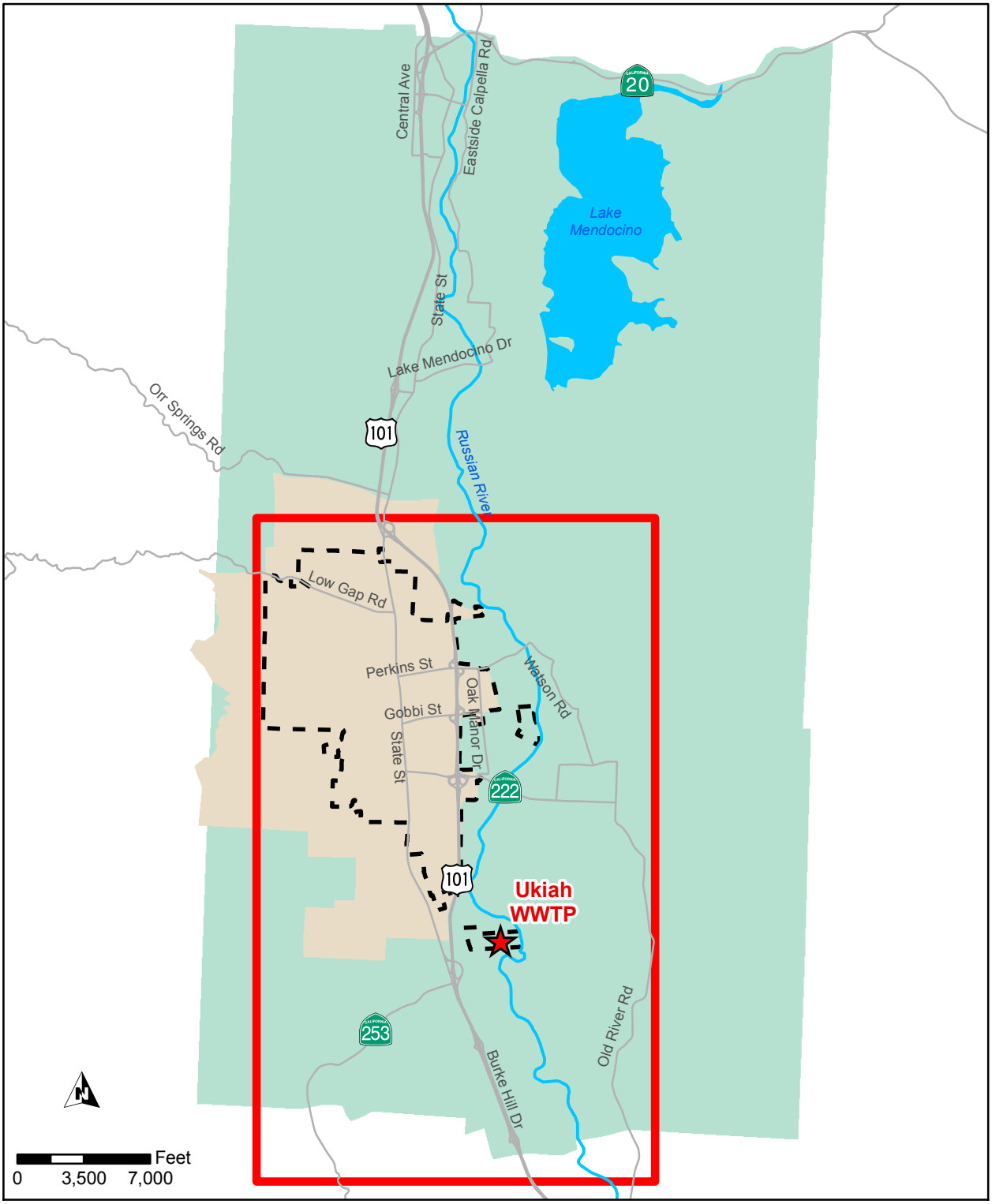
As described above, at the onset of the recycled water master planning effort, the City considered the water needs within the entire Ukiah Valley and surrounding areas. Understanding that implementing recycled water anywhere in the Valley would have regional benefits and that minimizing project costs was a major objective, the City narrowed the focus of the master planning effort to the area surrounding the UWWTP. A major cost of recycled water programs can be the infrastructure associated with distributing the water to recycled water customers. The closer the customers are to the source, less distribution is needed, which leads to a more cost effective program.

Through the visioning workshop and preliminary GIS analysis, the City identified major water users within a reasonable distance of the UWWTP and determined a study area that included those users. Figure 1.2 illustrates the RWMP Study Area. For reference, the figure also illustrates the City limits, the City Sphere of Influence (SOI), and the City Planning Area (General Plan).

The City's General Plan, adopted in December 1995 and revised in 2004, identifies boundaries associated with two planning areas: the incorporated area within the City limits and the unincorporated area, which is a combination of the Sphere of Influence (SOI) and an additional planning area. The City limits include the land currently within the City of Ukiah. The City's SOI represents the land limits to which the City may extend its services and project its growth over the next 20 years. The SOI must be adopted by the Local Agency Formation Commission (LAFCo) if the City wants to consider annexing land area. For comprehensive policy planning, the City's General Plan also incorporates an additional planning area, which encompasses the surrounding Ukiah Valley and includes the City of Ukiah. The planning area encompasses land area which is unlikely to be annexed by the City within the next 20 years, including rural communities Calpella, Talmage, and the Forks, and the North State Complex – a central point of business and commerce for portions of the unincorporated County (City General Plan).

1.4 HYDROLOGIC FEATURES

The City of Ukiah and the surrounding area are located in the Ukiah Valley groundwater basin (Basin). For planning purposes, the Department of Water Resources (DWR) has subdivided the State of California into ten separate hydrologic regions, corresponding to the State's major drainage basins. The Ukiah Valley groundwater basin (Number 1-52 as described in DWR Bulletin 118) is located in southeastern Mendocino County and is the largest basin along the Russian River. The Basin is approximately 22 miles long and 5 miles wide, and underlies Ukiah Valley and Redwood Valley, an area over sixty square miles. The groundwater is hydraulically connected to and interacts with surface water flows.



Legend

- Major Streets
- Major Water Way
- Major Water Body
- Recycled Water Master Plan Study Area
- City Limits
- Sphere of Influence
- General Plan Planning Area

Figure 1.2
RECYCLED WATER MASTER PLAN STUDY AREA
RECYCLED WATER MASTER PLAN
CITY OF UKIAH

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Major surface waters in the Ukiah area include the Russian River and Lake Mendocino. The River flows from North to South through the Ukiah Valley. Lake Mendocino is a large reservoir located northeast of the City of Ukiah. The Lake was formed in 1958 with the construction of Coyote Dam. In addition to these hydrologic features, there are a number of minor streams and creeks that flow through the Ukiah area. In the past, the City has managed surface runoff by channelizing creeks passing through the downtown area. For many years, the pear orchards and vineyards along the river have served as de facto detention basis and floodwater storage areas for the City's and County's urbanized land uses (City General Plan) Figure 1.3 illustrates the hydrologic features in the Ukiah area.

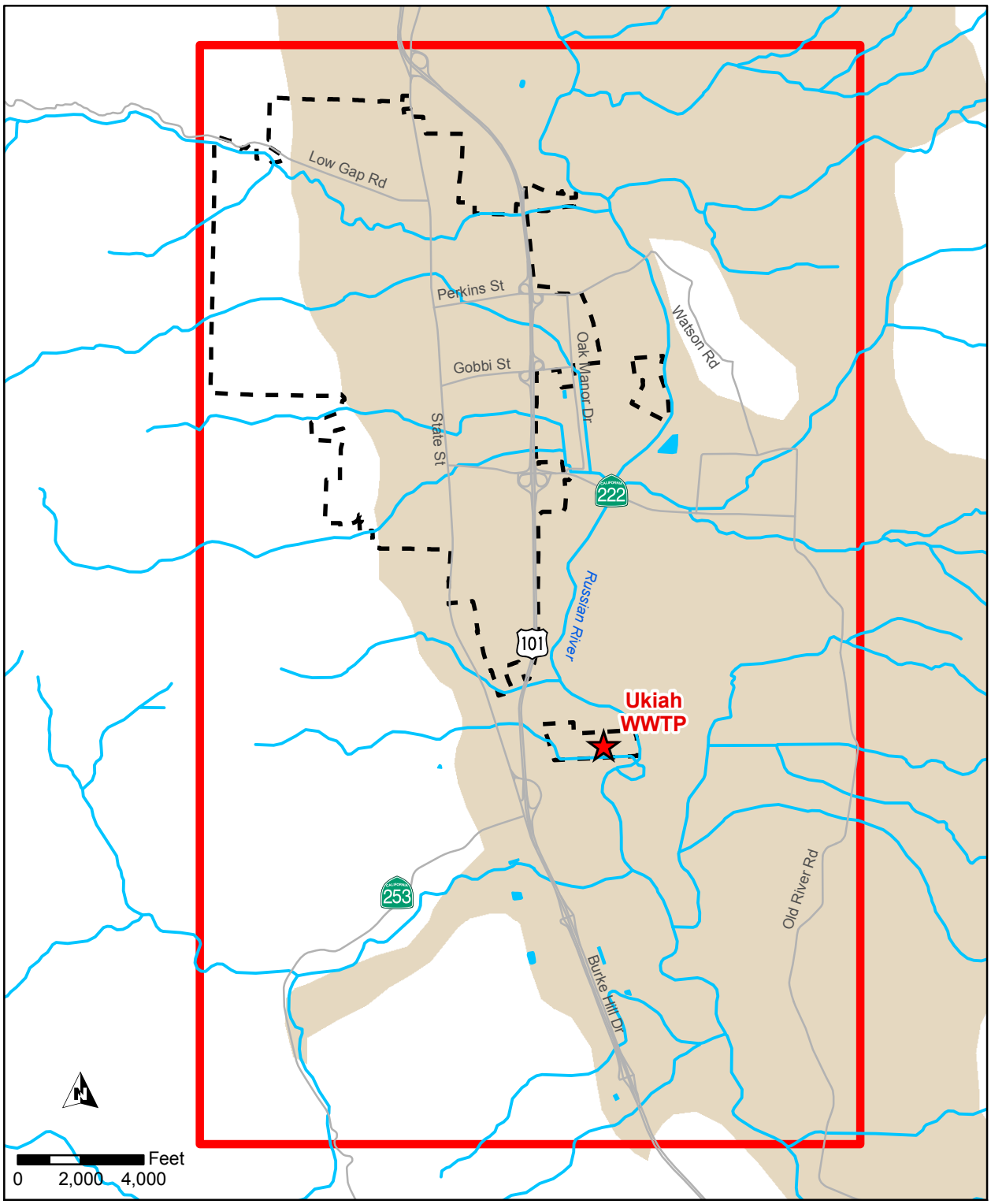
1.5 LAND USE AND POPULATION

Land use within the City of Ukiah is predominantly residential, rural residential, and commercial, while land use in the remaining portions of the RWMP Study Area is predominantly agricultural and rural residential with some industrial areas. Figure 1.4 illustrates the land use within the RWMP Study Area. A majority of the agricultural land is grape vineyards and pear orchards. Residential land use is generally located west of the Russian River (City of Ukiah General Plan, 2004).

The UWWTP is the primary source of recycled water considered under this plan. The wastewater supply conveyed to the UWWTP, that is ultimately available for recycled water reuse, is directly impacted by the population served by the UWWTP – the City of Ukiah. The incorporated City of Ukiah has a population of approximately 15,612 as of January 1, 2010[1], and represents approximately 18 percent of Mendocino County. The median annual growth rate between 1995 and 2010 was approximately 0.4 percent, although the City experienced a net decrease from its 2003 population of 15,942. The City population increased by 0.1 percent between 2009 and 2010.

Population projections, shown in Table 1.1 were included in the City's 2010 Urban Water Management Plan and were used to forecast water requirements for the City. Historical population statistics shown on Figure 1.5 are from California Department of Finance (DOF) estimates. These population projections pertain to the population served by the City's water distribution system. The SOI defined in the General Plan represents the ultimate limits to which the City will extend its water services over the next 20 years. The most recent population projection for the City of Ukiah was included in the 2010 Mendocino County General Plan, in which the annual population growth for the City is estimated at one percent through 2020. Based on this most recent estimate by the County, recent periods of slow growth, population decline, future annexation plans, and that build out is expected to occur by 2015; the annual population was projected in the Urban Water Management Plan to increase by 1 percent between 2015 and 2035. A population increase will result in increased wastewater supplies available for recycled water reuse.

[1] California Department of Finance.



Legend

- Major Streets
- Water Way
- Water Body
- Recycled Water Master Plan Study Area
- Ukiah Valley Groundwater Basin
- City Limits

Figure 1.3
HYDROLOGIC FEATURES
RECYCLED WATER MASTER PLAN
CITY OF UKIAH

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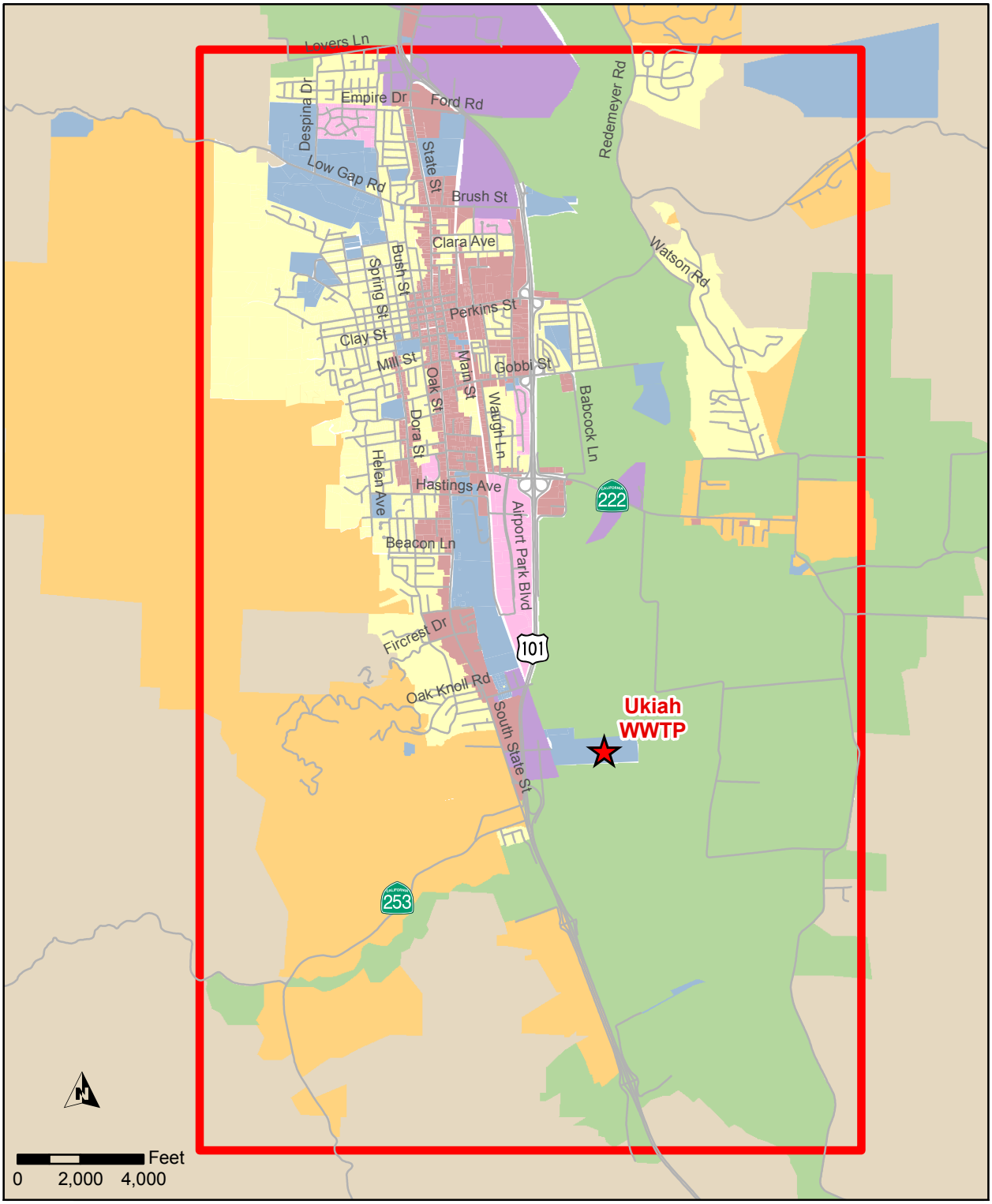

Legend

- Streets
- Recycled Water Master Plan Study Area

Land Use

- Agriculture
- Commercial
- Industrial
- Planned Development
- Public Facilities
- Rangeland
- Residential
- Rural Residential

Figure 1.4
LAND USE
RECYCLED WATER MASTER PLAN
CITY OF UKIAH

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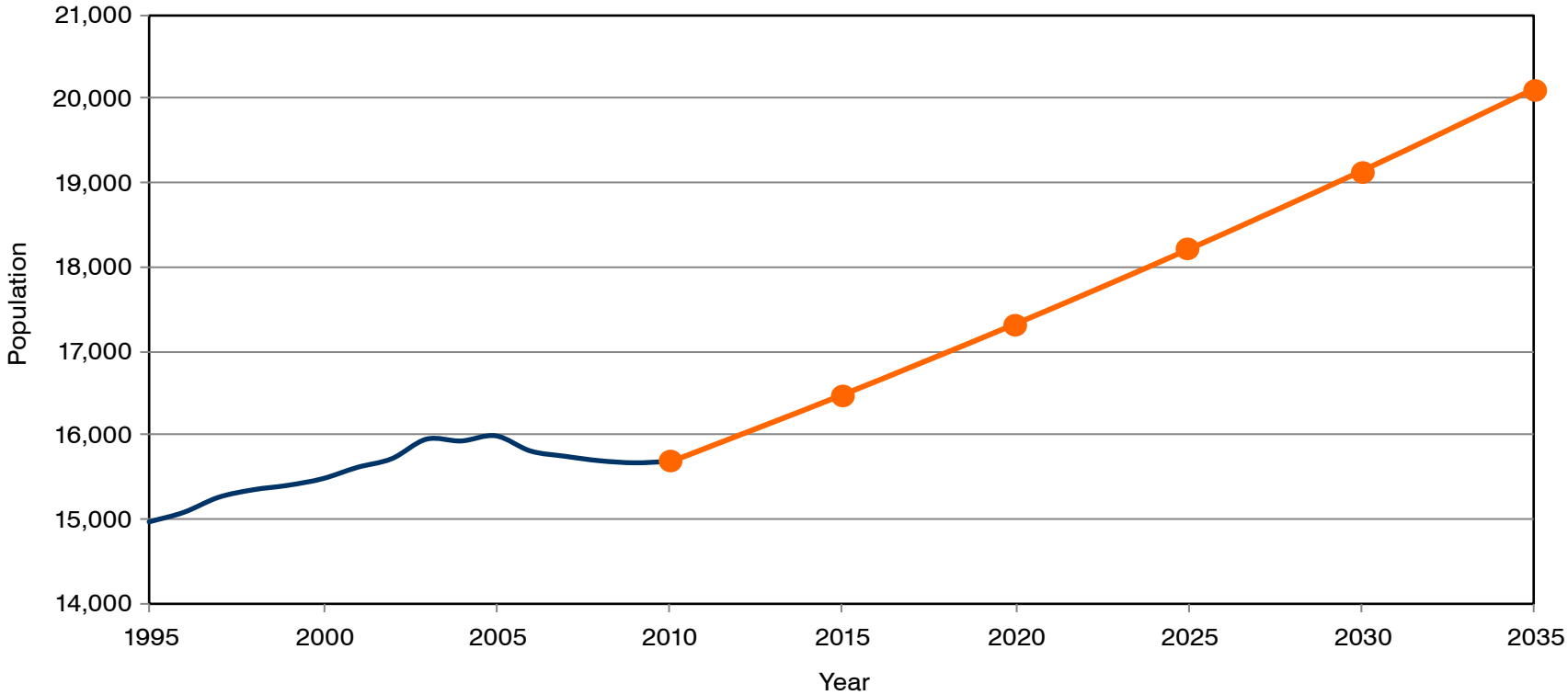

LEGEND
Historical Population(1)
Projected Population(2)

Notes:
(1) Source: California Department of Finance
(2) Source: 2010 Mendocino County General Plan

Figure 1.5
HISTORICAL AND PROJECTED POPULATION
RECYCLED WATER MASTER PLAN
CITY OF UKIAH

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Table 1.1 Current and Projected Population
Recycled Water Master Plan
City of Ukiah

Years	2010	2015	2020	2025	2030	2035	Data Source
Service Area Population[1]	15,682	16,482	17,323	18,206	19,135	20,111	Source[2]

Notes:
(1) Service area population is defined as the population served by the water distribution system.
(2) Projected estimates based on expected population growth from the Mendocino County General Plan, adopted March 2010. An annual growth rate of one percent was used.

WATER SUPPLY CHARACTERISTICS AND FACILITIES

2.1 WATER SOURCES

A combination of water supplies are used to meet the needs of the Ukiah Valley area, namely groundwater, surface water from the underflow of the Russian River, and project water available from the Mendocino County Russian River Flood Control and Water Conservation Improvement District.

2.1.1 Overview of Water Sources

The Ukiah Valley area includes four major watersheds: Ukiah Valley, Redwood Valley, Potter Valley, and Hopland Valley. These watersheds are shown in Figure 2.1.

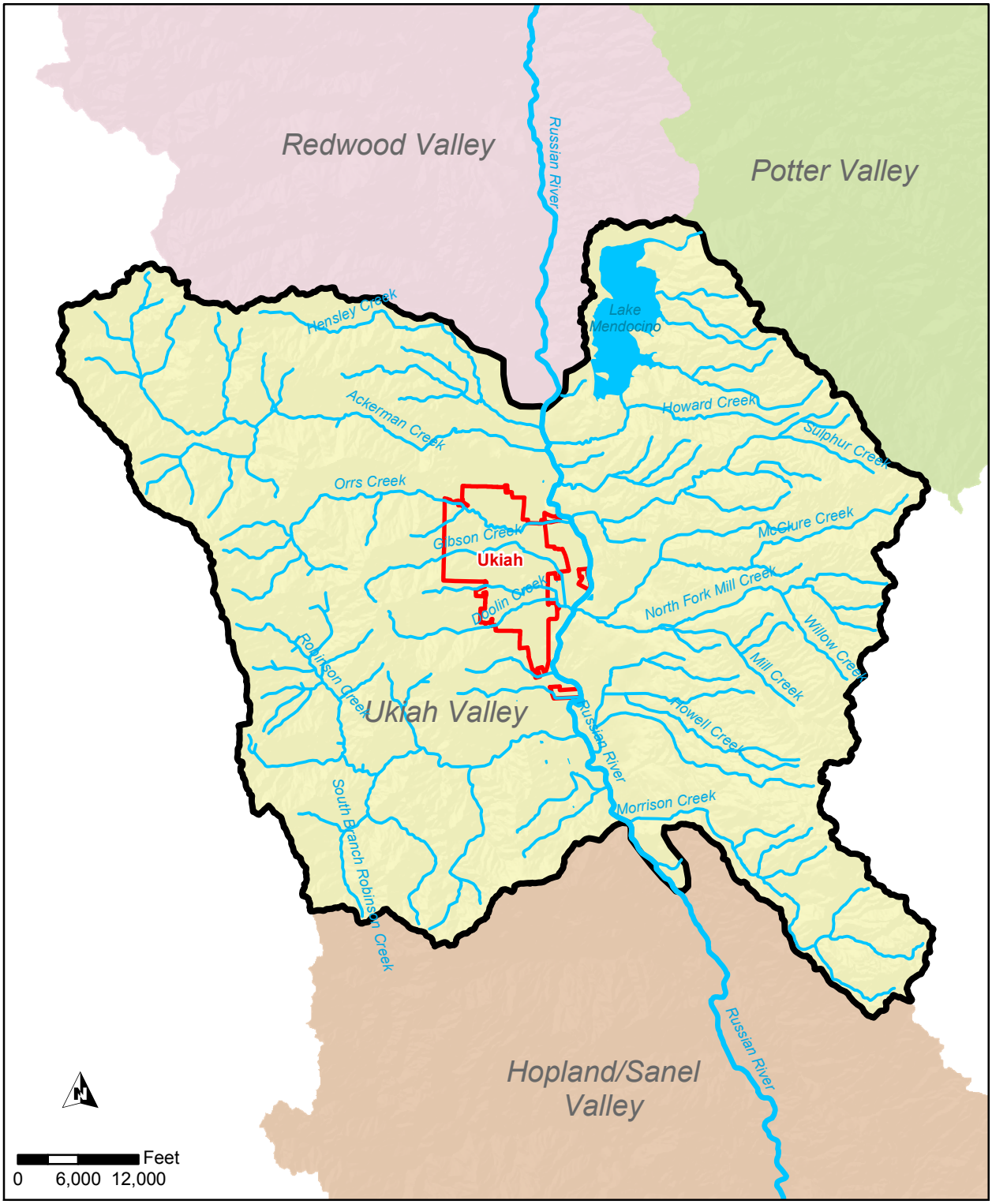
2.1.2 Surface Water

Surface water sources in the Ukiah Valley and surrounding areas (including Redwood Potter, and Hopland Valleys) include the Russian River, the Potter Valley Hydroelectric Project (PVP), and Lake Mendocino. These three sources are the Ukiah area's primary water supply and provide significant recharge of the Ukiah Valley Groundwater Basin (Mendocino County Water Supply Assessment, 2010).

Historically, the Russian River has had high flows in the winter and spring and low or no flows in the summer and fall; however, the construction of the Coyote Dam and Lake Mendocino in 1959 transformed the Russian River into a perennial surface water which has supported agricultural and urban development in Ukiah Valley.

The Potter Valley Hydroelectric Project began operating in 1912 and includes two water impoundments along the Upper Eel River and a diversion tunnel and powerhouse located along the East Fork of the Russian River. Waters from the project are ultimately discharged to the East Fork which runs through Potter Valley and to Lake Mendocino. The PVP has turned the East Fork into a perennial stream, which has allowed agricultural and urban development in Potter Valley.

Lake Mendocino and Coyote Valley Dam is a federal facility that was constructed by the United States Army Corps of Engineers (USACE) in 1959. It is located along the East Fork of the Russian River about three miles north of Ukiah. Lake Mendocino is the Valley's primary water storage facility providing storage for flood control, municipal and industrial water supplies, recreation, and power generation. Lake Mendocino has a maximum storage capacity of 122,000 acre-feet (af), of which 50,000 af is reserved for flood control purposes. The remaining portion is potentially available for water supply storage (Mendocino County Water Supply Assessment, 2010).



Legend

- Waterway
- Water Body
- City Limits

Watersheds

- Ukiah Valley
- Potter Valley
- Redwood Valley
- Hopland/Sanel Valley

Figure 2.1
UKIAH VALLEY AND NEIGHBORING WATERSHEDS
RECYCLED WATER MASTER PLAN
CITY OF UKIAH

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2.1.3 Groundwater

In addition to surface water, groundwater is a major water source for municipal and industrial use. As mentioned in Chapter 1, the Ukiah Valley Groundwater Basin (Number 1-52 as described in DWR Bulletin 118) is located in southeastern Mendocino County and is the largest basin along the Russian River. The Basin is approximately 22 miles long and 5 miles wide, and underlies Ukiah Valley and Redwood Valley. This basin is not adjudicated.

The United States Geological Survey (USGS) published a Water Resources Investigation Report 85-4258 in 1986 on the Groundwater Resources in Mendocino County, California (USGS Investigative Report). Storage capacities and groundwater elevations within the Basin were evaluated in the USGS Investigative Report. USGS concluded that groundwater wells in the Basin, monitored over a 30-year period, show no prominent long-term declines. In addition, hydrograph analysis indicates that the Basin is recharged fully each year except when precipitation falls below 60 percent of normal.

DWR Bulletin 118 suggests that groundwater in storage is approximately 90,000 af in the upper 100 feet of the most productive area of the Ukiah Valley, and an additional 45,000 af within the margins of the Ukiah Valley. Therefore, the volume of water available from pumping from the upper 100 feet of the most productive portion of the aquifer is estimated at 90,000 af. Groundwater is hydraulically connected to and interacts with surface flows.

2.2 WHOLESALE AND RETAIL ENTITIES

Water service providers in the Ukiah Valley include:

- Mendocino County Russian River Flood Control and Water Conservation Improvement District (RRFC)
- Calpella County Water District
- Millview County Water District
- The City of Ukiah
- Rogina Water Company
- Willow County Water District
- Redwood Valley County Water District
- Hopland Public Utility District

The service area of each of these entities is illustrated on Figure 2.2.

Property owners without access to the City or one of the district systems obtain water from individual wells or springs (Mendocino County Water Supply Assessment, 2010).

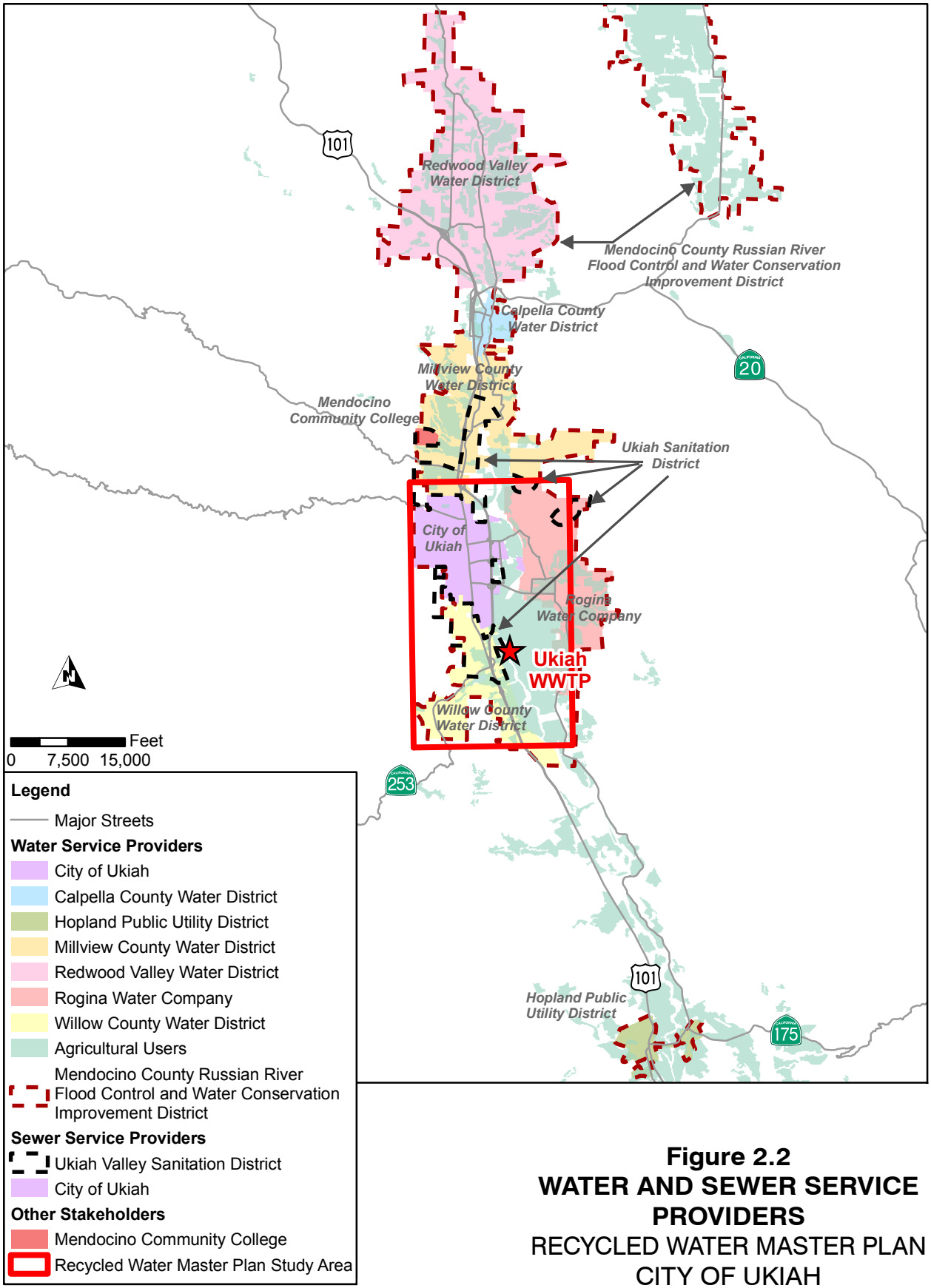


Figure 2.2
WATER AND SEWER SERVICE PROVIDERS
RECYCLED WATER MASTER PLAN
CITY OF UKIAH

uk711f11-8660.ai

2.2.1 RRFC

The RRFC is a wholesale water provider of water to Mendocino County for domestic, municipal, irrigation, and recreational purposes. The RRFC holds Water Right Permit 12947B for storage and use of up to 8,000 af per year. This water supply includes water stored in Lake Mendocino and water directly diverted from the East Fork of the Russian River. The water is sold to public water systems for urban use and to private agricultural entities for irrigation and frost protection. Of the 8,000 af provided each year, only 500 af has yet to be contracted to public water systems and entities. Water that is not contracted is currently sold to Redwood Valley County Water District for municipal and agricultural use.

2.2.2 The City of Ukiah

The City of Ukiah is the largest public water service provider in the Ukiah Valley, providing roughly half of Ukiah Valley's public water supply (Mendocino County Water Supply Assessment, 2010). The City's water supply sources include groundwater, surface water from the underflow of the Russian River, and project water available from the RRFC. During dry periods, when surface and underflows are insufficient the City can purchase up to 800 af of water annually from the RRFC per Water Right Permit 12947B.

2.2.3 Other Water Service Providers

The other water surface providers listed above use a combination of the following water supplies:

- Surface water diverted from the Russian River
- Surface water diverted from Lake Mendocino
- Groundwater
- Water supply contracts with the RRFC

2.3 WATER RIGHTS

Both public and individual agricultural entities have water rights to divert surface water from the Russian River. Appropriate water rights to Lake Mendocino were established on January 28, 1949 and from that point forward, appropriate water rights to Russian River drainage were grouped into three major categories: Pre-1949 rights, Lake Mendocino Rights and Post-1949 rights (Mendocino County Water Supply Assessment, 2010).

2.3.1 Pre-1949 Water Rights

Pre-1949 water rights include approximately 8,000 af that is primarily comprised of direct diversions from the Russian River. These rights are subject to the availability of stream flows during authorized diversion seasons, i.e., water right holders only have water supply if there is stream flow.

Many agricultural entities in the upper Valley have Pre-1949 rights and rely on these rights to supply irrigation and frost protection waters to their crops.

2.3.2 Lake Mendocino Water Rights

Lake Mendocino rights allow for substantial storage of water in Lake Mendocino to accommodate water needs during dry periods. Consequently, there are times when all, or nearly all, of the Russian River flow is attributed to Lake Mendocino releases and the water rights associated with Lake Mendocino. These rights allow diversions from Lake Mendocino even in times when little or no water is legally available to Pre-1949 water right holders. As a result, these water rights make Lake Mendocino an essential water supply source during dry and critically dry years.

2.3.3 Post-1949 Water Rights

Post-1949 rights are junior to Pre-1949 and Lake Mendocino rights. Consequently, during extended or critically dry periods, Russian River flows may be to low to legally exercise these rights.

2.3.4 Water Rights of Public Water Providers

The RRFC has Pre-1949 rights; the City of Ukiah has a combination of Pre-1949 and Post-1949 rights; and the Millview County Water District and Willow County Water District have Post-1949 water rights (Russian River Division of Water Rights 2005).

2.3.5 Legislation and Water Rights

Water availability for all users in Mendocino County is an increasingly contentious and acute issue. Regulations and policies are being implemented In part to reduce impacts to instream habitat, including critical habitat for chinook salmon and steelhead trout in the Russian River. The California State Water Resources Control Board required water purveyors in the Russian River to reduce their water use by 15%. In addition to this, the state passed Assembly Bill 2121 (AB2121) in 2004, which added Water Code section 1259.4 and required the SWRCB to implement guidelines to maintain instream flows in northern California Coastal streams (Mendocino Irrigated Agricultural Water Needs and Management, 2008).

There is concern that the Russian River waters are fully allocated, with no water remaining for future water rights applicants. As a result, agricultural applications for water rights are

being delayed by the SWRCB, in some cases, for over a decade (Mendocino Irrigated Agricultural Water Needs and Management, 2008).

In addition to the lack of water available for future water rights, existing water rights may be further regulated. AB2121 may prohibit Russian River underflow diversions. While this does not impact water rights holders located along the main stem of the Russian River, this will impact water rights holders located along the tributaries of the River.

As discussed in Chapter 1, the National Oceanic and Atmospheric Administration's National Marine Fishers Service has requested the SWRCB address concerns that water diversions from the Russian River stream system for purposes of frost protection of crops will cause significant salmonid mortality. In response to this, the SWRCB is proposing regulation that would provide that diversions from the Russian River stream system for purposes of frost protection from March 15 through May 15 are unreasonable, unless they are in accordance with a Water Demand Management Program (WDMP) approved by the State Water Board. In order to be approved the WDMP would be required to include: (1) an inventory of the frost diversion systems within the area subject to the WDMP, (2) a stream stage monitoring program, (3) an assessment of the potential risk of stranding mortality [of salmonids] due to frost diversion, (4) identification and implementation of necessary corrective actions, and (5) an annual reporting program. The SWRCB is scheduled to hold a public hearing to receive comments and to consider adopting a proposed Russian River frost protection regulation on September 20, 2011.

If the regulation is adopted, agricultural entities may lose the right to divert water from the Russian River for frost protection from March 15 – May 15. While frost season typically occurs from March through May, this regulation could be detrimental to the Ukiah Valley agricultural industry if additional water supplies are not secured for frost protection. (Mendocino Irrigated Agricultural Water Needs and Management, 2008) (SWRCB Notice of Proposed Frost Protection Regulation Hearing, 2011)

2.4 BENEFITS OF RECYCLED WATER USE

Implementation of recycled water in the Ukiah Valley area could provide several regional water resource benefits. Not only could it be used for frost protection to sustain the local agricultural industry, it could also be used for agricultural irrigation and urban irrigation. Any amount of recycled water reuse in the area will decrease water that is diverted from the Russian River and Lake Mendocino. In making more water available in these surface waters, water service providers, including those with junior water rights, will have a more reliable water supply over a wider range of hydrologic conditions.

2.5 CITY OF UKIAH WATER FACILITIES

The City's water supply facilities include five active wells and a Ranney Collector. Table 2.1 below provides a summary of the water supply sources, including description of the type of supply source for each facility.

Table 2.1 Water Supply Sources[1]
Recycled Water Master Plan
City of Ukiah

Facility	Type of Supply	Current Status	Production Capacity (GPM)
Ranney Collector[2]	Surface water	Active	3,194
Well #3	Groundwater influenced by surface water	Active	600
Well #4	Groundwater	Active	799
Well #5	Groundwater influenced by surface water	Active	300
Well #7	Groundwater	Active	799
Well #8	Groundwater	Active	694
		Total Active Well Capacity (GPM)	**6,386**
		Total Active Well Capacity (AFY)	**10,308**

Notes:
(1) Source: City staff records.
(2) The Ranney Collector can only be used during the dry season when surface water turbidity is low.

The City's surface water is obtained from the Ranney Collector and Wells 3 and 5, which draw water from an alluvial zone along the Russian River. Water taken from these sources is considered under the influence of surface water by the California Department of Public Health (DPH). Accordingly, water diverted from the Ranney Collector and Wells 3 and 5 is classified as surface water. The City also draws groundwater from Wells 4, 7, and 8.

2.6 AGRICULTURAL WATER FACILITIES

Agricultural farmers within the area maintain their own onsite pumping and distribution systems to supply water to their crops. Depending on their access and water rights, they rely on water from the Russian River and its tributaries as well as groundwater. Some farmers maintain onsite storage ponds. With this storage, farmers are able to divert flows during low demand seasons when river flows are high (e.g., the winter) and store the water for future use during high demand seasons when river diversions are more restricted (e.g., frost season).

Farmers typically have two types of distribution systems: one for irrigation, and a second for frost protection. The irrigation system usually includes a small, electric pump(s) that distributes water to one irrigation block at a time and rotates through each irrigation block. The frost protection system usually includes a lager pump(s) that distributes water to the entire lot at one time.

2.7 GROUNDWATER MANAGEMENT, RECHARGE AND OVERDRAFT PROBLEMS

2.7.1 Groundwater Management Plan

A groundwater management plan has not been prepared for the City, Ukiah Valley, or Mendocino County. In the future, the City may consider coordination with other agencies within the Basin to develop a more comprehensive groundwater management plan.

2.7.2 Groundwater Levels and Historical Trends

In general, the Basin experiences seasonal and year-to-year variation in groundwater elevations due to relative rainfall and pumping, as described in Bulletin 118 and the USGS Investigative Report. However, these variations tend to be small and water levels, in general, recover.

Groundwater elevations fluctuate seasonally, being the highest level in March or April at the end of the wet season and lowest in October at the end of the dry season. Seasonal fluctuations range on the order of about 5 to 20 feet. Long-term measurements are taken and recorded from several wells within the Ukiah Valley.

The USGS Investigative Report found that, from the available hydrographs of the Basin, none of the hydrographs show prominent long-term declines. In fact, water levels measured during the 1980s are similar to those measured during the 1960s and 1970s.

DWR Bulletin 118 concurs with this assessment. According to Bulletin 118, groundwater levels in the Basin have remained relatively stable in the past 30 years. As expected, there is increased drawdown during summer months and less recovery in winter months when the area experiences drought conditions. Post-drought groundwater conditions rebound to approximately the same levels as pre-drought conditions.

Based on historical information available for the Basin, groundwater supplies are expected to adequately meet existing and future demands.

2.7.3 Groundwater Overdraft

The current and historical groundwater trends for this Basin indicate that there is no long-term decline in water levels that suggest water shortage or overdraft. The Basin is not considered to be in a state of overdraft by DWR, and is not projected to be in a state of overdraft in the near future.

2.8 WATER USE TRENDS

Table 2.2 summarizes the City's current and projected water supply sources, excluding potential, future recycled water sources. As shown in the table, the City's water supply is not expected to increase in the future.

Table 2.2 Water Supplies - Current and Projected[1]
Recycled Water Master Plan
City of Ukiah

Water Supply Sources		Projected Water Supply (AFY)					
Water purchased from:	**Wholesale Supplied Volume**	**2010**	**2015**	**2020**	**2025**	**2030**	**2035**
Project Water (Mendocino County Russian River Flood Control and Water Conservation Improvement District)	Yes	800	800	800	800	800	800
Supplier-produced groundwater[2]	No	3,705	3,705	3,705	3,705	3,705	3,705
Supplier-produced surface water[3]	No	14,480	14,480	14,480	14,480	14,480	14,480
Supplier-produced surface water (pre-1914 Rights)	No	2,027	2,027	2,027	2,027	2,027	2,027
Transfers In	No	0	0	0	0	0	0
Exchanges In	No	0	0	0	0	0	0
Desalinated Water	No	0	0	0	0	0	0
Total		**21,012**	**21,012**	**21,012**	**21,012**	**21,012**	**21,012**

Notes:
(1) Excluding potential, future recycled water sources.
(2) Based on groundwater pumping capacities provided by the City.
(3) Permit 12952 (Application 15704) authorizes diversion of 20 CFS, with no annual limit. Therefore, the City's potential water right is reported above.

2.9 WATER COSTS

Current water costs are summarized in Table 2.3.

Table 2.3 Current Water Costs Recycled Water Master Plan City of Ukiah	
Water Source	**Cost**
City of Ukiah Potable Water[(1)]	$963/acre-foot ($2.21/unit)
Water Purchased from RRFC	$47/acre-foot
Notes: (1) Based on July 2011 water rates (see table in appendix).	

2.10 QUALITY OF WATER SUPPLIES

As reported in the 2010 Urban Water Management Plan, water quality issues are not anticipated to have significant impact on water supply reliability. Unforeseen future occurrences of chemical contamination or the lowering of maximum contaminant levels (MCLs) for naturally-occurring constituents can be mitigated with proper treatment. If water quality becomes an issue for water supply reliability in the future, the City will evaluate the need for upgrades to its current treatment system or construction of a new water treatment facility.

The City continually takes the necessary steps to comply with existing and future groundwater quality regulations and to continue to provide reliable water service to its residents.

2.11 PLANS FOR NEW FACILITIES OR ADDITIONAL WATER SOURCES

There are no current plans in the Ukiah Valley for new water facilities or additional water sources. As discussed in the Urban Water Management Plan, the City's firm water supply capacity is approximately 43 percent higher than the maximum projected demand through 2035. The total current supply capacity is 65 percent higher than projected 2035 demands. Therefore, the City has no planned projects to increase its water supply production capacity. Maintenance and well replacement projects may be performed on an as-needed basis.

WASTEWATER CHARACTERISTICS AND FACILITIES

3.1 WASTEWATER ENTITIES

There are several wastewater entities in the Ukiah Valley; however this study focuses on two wastewater entities – The City of Ukiah and the Ukiah Valley Sanitation District (UVSD) – because these two entities collect the wastewater flows that can potentially be used to provide recycled water to the Valley. The City of Ukiah and the UVSD provide sewerage collection and treatment services for a population of about 20,000 residential, commercial, and industrial customers.

3.2 WASTEWATER COLLECTION SYSTEM FACILITIES

The City collection system receives wastewater from about 82 percent of the City's service area and serves about 75 percent of the City's population. The UVSD serves the remaining portion of the City's service area and about 25 percent of the City's population, as well as an additional 5,000 residential customers from the urban areas surrounding the City. Both collection systems convey the collected wastewater to the Ukiah Wastewater Treatment Plant (UWWTP).

3.3 WASTEWATER TREATMENT FACILITIES

The Ukiah Wastewater Treatment Plant (UWWTP) is owned and operated by the City. The UWWTP includes primary, secondary, and tertiary treatment facilities, as well as solids handling facilities. The tertiary treatment facilities are referred to as the Advanced Wastewater Treatment (AWT) System. Table 3.1 summarizes the treatment capacity of the UWWTP and Table 3.2 summarizes the major components of the UWWTP facilities.

Table 3.1 Treatment Capacity of UWWTP
Recycled Water Master Plan
City of Ukiah

Design Flow Criterion	Units	Secondary Treatment	AWT System[1] (Tertiary Treatment)
Average Dry Weather Flow (ADWF)	mgd	3.01	N/A[2]
Average Wet Weather Flow (AWWF)	mgd	6.89	4
Peak Wet Weather Flow (PWWF)	mgd	24.5	8

Notes:
(1) The Advanced Wastewater Treatment (AWT) Facility produces effluent that meets Title 22 recycled water requirements.
(2) The AWT system is not operated during dry weather flows.

Table 3.2 Major Components of UWWTP Facilities Recycled Water Master Plan City of Ukiah		
Primary and Secondary Treatment Facilities	**AWT System (Tertiary Treatment Facilities)**	**Solids Handling Facilities**
• Influent pump station • Bar screen facility and grit removal system • Primary clarifiers • Trickling filter pump station and trickling filters • Solids contact tanks • Secondary clarifiers • Chlorine disinfection system • Effluent pump station	• AWT pump station • Coagulation system • Tertiary multimedia filters and backwash pump station • Chlorine contact basins • Dechlorination system	• Dissolved air flotation thickeners • Anaerobic digesters • Belt filter press for dewatering

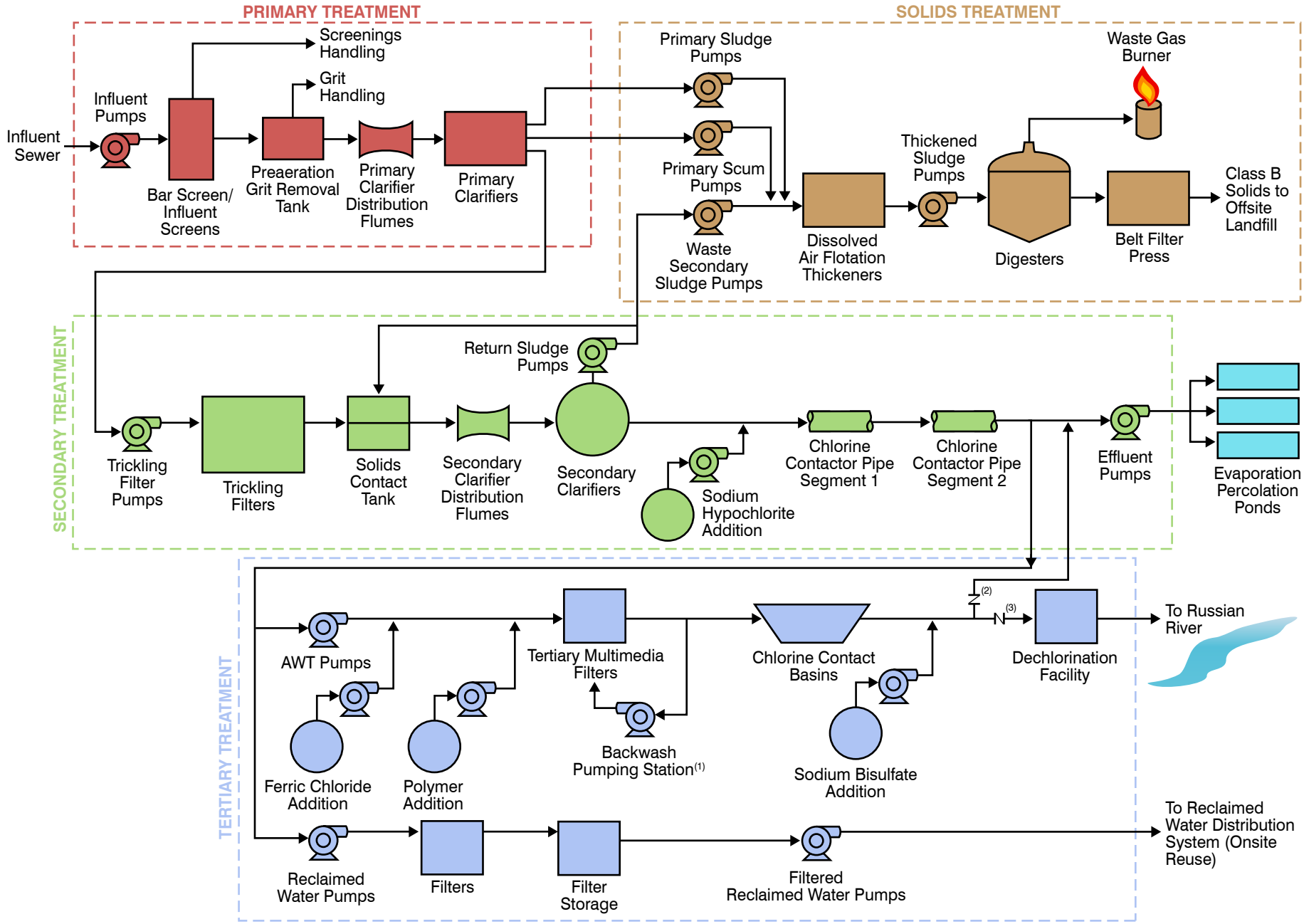
3.3.1 Treatment Process Description

A process flow diagram of the existing liquid and solids handling facilities is presented in Figure 3.1.

The UWWTP produces disinfected secondary effluent which is discharged to three percolation/evaporation ponds, and disinfected, dechlorinated tertiary effluent that is discharged to the Russian River. As shown in Figure 3.2, raw wastewater enters the plant through two gravity influent lines: one 42-inch influent line enters from the north, and one 18” influent line enters from the west. Wastewater entering the facility is pumped to influent screens and manually cleaned bar screens which remove large solids from the effluent. It then flows through a pre-aeration grit removal tank which removes grit and other solids from the flow. Screenings and grit slurry from the bar screens and grit tank are washed and discharged offsite.

The primary wastewater treatment process facilities include four primary clarifiers where additional solids settle from the effluent. Two primary sludge and two scum pumps pump sludge and scum to two dissolved air flotation thickeners for solids treatment, while four trickling filter pumps pump the clarified primary effluent to the trickling filters.

Secondary treatment is achieved with a fixed film biological treatment process followed by an activated sludge process. Primary effluent is pumped to the top of two trickling filters where it subsequently falls by gravity through the trickling filter media. A biofilm on the



Primary Treatment
Solids Treatment
Secondary Treatment
Tertiary Treatment

Notes:
(1) Includes backwash pumps and surface wash pump.
(2) Valve normally closed.
(3) Valve normally open.

Figure 3.1
UKIAH WWTP TREATMENT PROCESS SCHEMATIC
RECYCLED WATER MASTER PLAN
CITY OF UKIAH

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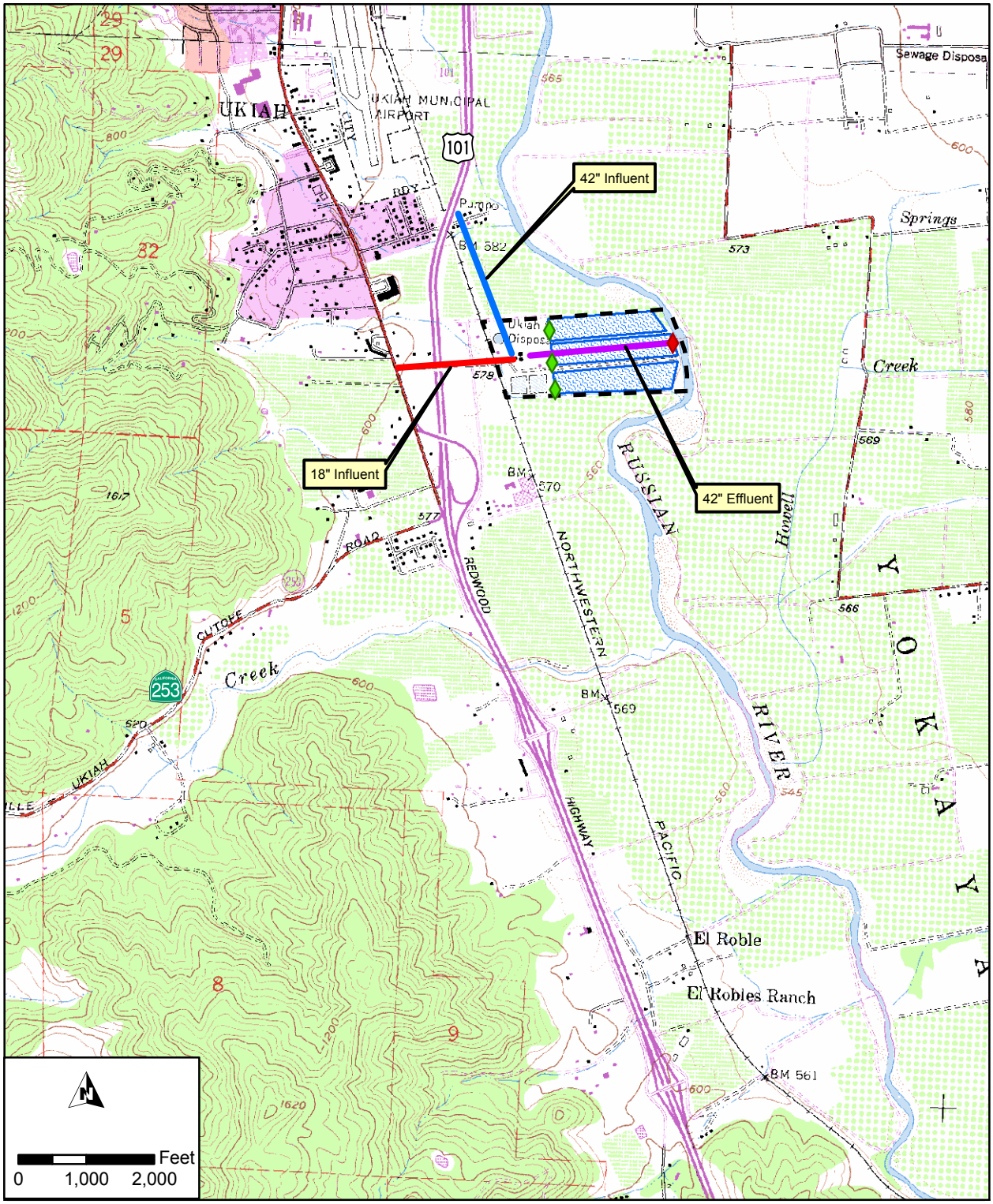

Legend

Pipelines

- 18" Influent
- 42" Effluent
- 42" Influent

- Discharge Point 001 - Russian River
- Discharge Point 002 - Percolation/Evaporation Ponds
- Ukiah WWTP

Figure 3.2
UKIAH WWTP OVERVIEW
RECYCLED WATER MASTER PLAN
CITY OF UKIAH

uk711f12-8660.ai

surface of the media removes organic compounds from the primary effluent through absorption and adsorption. As the biofilm layer thickens, it sloughs off and passes with the trickling filter effluent to two aerated solids contact tanks. In the tanks, the flow undergoes further biological treatment through an activated sludge process. Effluent from the solids contact tanks then flows to two circular secondary clarifiers where solids settle from the effluent. Four pumps pump recycled activated sludge from the secondary clarifiers to the solids contact tank. A portion of the recycled activated sludge is wasted and pumped by waste secondary sludge pumps to the dissolved air flotation thickeners for further solids treatment.

Following secondary treatment, the effluent is chlorinated. The chlorine disinfection facilities include two chlorine contactor pipes and a sodium hypochlorite addition system. The effluent pump station, which includes two pumps, then pumps the disinfected secondary effluent to three evaporation/percolation storage ponds where the effluent ultimately evaporates or percolates through the bottom of the ponds. The City can discharge up to 4 million gallons per day (mgd) to the ponds which have a combined storage capacity of 115 million gallons (MG). To maximize percolation, the bottom of one pond per summer is alternately ripped to increase the ponds permeability.

A portion of the disinfected, secondary treated effluent undergoes additional filtration and is stored in storage units for various onsite reuse including: landscape irrigation, process washdown, and spray water. Approximately 300 – 325 af is reused onsite per year.

When the UWWTP is discharging effluent to the Russian River, all flows that are discharged to the river undergo tertiary treatment immediately following secondary treatment. Disinfected, secondary flows are pumped by three advanced water treatment pumps from the recycled water pump station to the Advanced Water Treatment System (AWT). Ferric chloride and polymer are added to the effluent as it is pumped to four tertiary, multimedia filters. Effluent from the filters then flows to two chlorine contact basins for disinfection. A sodium bisulfite feed pump dechlorinates the tertiary disinfected effluent as it flows by gravity to the Russian River discharge point. If needed, the tertiary disinfected effluent can be routed to the three evaporation/percolation ponds. The tertiary treatment facilities are further described in Table 3.3.

The solids handling facilities include: two dissolved air flotation thickeners and various ancillary pumps and equipment, three thickened sludge pumps, two anaerobic digesters and ancillary equipment, and a belt filter press. The solids handling facilities produces Class B solids that are disposed of at a landfill.

3.3.2 History of Expansions

The original wastewater treatment facility was constructed in 1958 and provided secondary treatment at an average dry weather flow capacity of 2.5 mgd and a peak wet weather flow capacity of 10.5 mgd. At that time, all treated effluent was discharged to the Russian River.

Table 3.3 Tertiary Facilities Design Criteria Recycled Water Master Plan City of Ukiah		
Element	**Existing[1]**	**Future**
Applied Water Pumps		
Type	Vertical Turbine	
Number	3	TBD
Capacity, each	4 mgd	
Polymer Feed System		
Storage Tote Capacity	275 gallon	
Number	1	TBD
Polymer Feed Pump Capacity	4.5 gph	
Flocculation Basins		
Number of basins	4	
Design capacity, each	2 mgd	TBD
Detention time	~ 14 min at 2 mgd	
Tertiary Multimedia Filters		
Number of filters	4	
Area, each	25 ft 9 in x 12 ft	
Anthracite media depth	18 inches	TBD
Sand, garnet sand, and gravel media depth	26.5 inches	
Capacity, at 5 gpm/sq ft, each	2 mgd	
Chlorine Disinfection		
Number of basins	2	
Design capacity, each	8 mgd	
Detention time	90 minutes	
Dose[2]	~ 5 mg/L	TBD
Dechlorination		
Type	In-pipe	
Dose	X mg/L	TBD
Effluent/Recycled Water Pumps		
Type	Vertical Turbine	
Number	3	
Capacity, each	360 gpm at 230 TDH	
Firm Capacity	720 gpm at 230 TDH	TBD

Notes:

(1) Source: California Regional Water Quality Control Board Order No. R1-2006-0049, NPDES No. CA0022888.

(2) Chlorine is dosed as needed for coliform removal.

The UWWTP has been expanded and upgraded several times since then. In 1983, the facility was expanded to increase the treatment capacity to an average dry weather flow capacity of 2.8 mgd and a maximum wet weather capacity of 7 mgd. In 1986, the third percolation/evaporation pond was constructed to increase the treated effluent storage capacity, and in 1989 an effluent pump station was constructed to convey secondary treated effluent to the third pond. In 1989, the Regional Water Quality Control Board (RWQCB) required tertiary treatment of all river discharges and secondary treatment for all

discharges to the evaporation/percolation ponds. To meet this requirement, the plant was upgraded again in 1995. The project included the construction of the fourth secondary clarifier, a new solids handling facility, and the AWT system, as well as upgrades to the headworks.

The most recent upgrade to the facility occurred in 2009 to expand the facility to its current treatment capacity and to upgrade the AWT system to meet Title 22 tertiary recycled water standards. This upgrade included a new headworks facility, a new bar screen facility and grit removal system, conversion of the existing secondary clarifiers to primary clarifiers, a new trickling filter pump station and upgrades to the trickling filters, conversion of the existing primary clarifiers to solids contact tanks, modifications to the chlorine disinfection facilities, and other miscellaneous upgrades.

3.3.3 Future Expansions

Although no expansion projects are planned for the near term, the City is expected to grow and the UWWTP will need to be expanded to accommodate this growth. In 2003, the City developed 2025 Design Criteria for the City's wastewater treatment capacity and projected that the total wastewater flows of the service area would increase steadily over the next few decades. The total flow in 2025 was projected to be approximately 6,363 AFY, equivalent to an average annual flow of about 5.7 mgd.

3.3.4 Water Recycling Facilities

The UWWTP's AWT system produces disinfected, tertiary treated effluent that meets Title 22, Division 4, Chapter 3, California Code of Regulations (CCR) for recycled water. The AWT system is currently operated as needed during wet weather months (October through mid May) to treat flows in excess of that which can be stored in the onsite percolation/evaporation ponds. If operated at full capacity, the AWT could provide an average annual flow of 7 mgd given sufficient wastewater flows were available. Table 3.3 presents a summary of the tertiary treatment facilities design criteria.

3.4 EXISTING WASTEWATER QUALITY

The UWWTP's effluent discharges are regulated by a National Pollutant Discharge Elimination System (NPDES) permit – Order No. R1-2006-0049, NPDES No. CA0022888. The permit was adopted on September 20, 2006 and expires on November 9, 2011. Permit effluent limits are summarized in Table 3.4. A new permit is currently under negotiation and expected to be finalized in June 2012.

The UWWTP discharges disinfected secondary effluent to three percolation/evaporation ponds located at the UWWTP on a year-round basis, and discharges disinfected tertiary effluent to the Russian River as allowed during wet weather months. The UWWTP is only permitted to discharge disinfected tertiary wastewater to the Russian River from October 1

Table 3.4 Ukiah WWTP Effluent Limits in 2006 NPDES Permit[1]
Recycled Water Master Plan
City of Ukiah

Constituent	Units[2]	Effluent Limitations				
		Average Monthly	Average Weekly	Maximum Daily	Instantaneous Minimum	Instantaneous Maximum
Discharge Point 001 – Direct Discharge to Russian River[3][4][5]						
Biochemical Oxygen Demand (5 day at 20°C)[6]	mg/L	10	15	---	---	---
	lbs/day (wet weather)[7]	580	880	---	---	---
Total Suspended Solids	mg/L	10	15	---	---	---
	lbs/day (wet weather)[7]	580	880	---	---	---
pH	standard units	---	---	---	6.5	8.5
Nitrate (as N) [8]	mg/L	10	---	---	---	---
Copper[8]	µg/L	1.55	---	3.11	---	---
Dichlorobromomethane[8]	µg/L	0.56	---	1.1	---	---
Discharge Point 002 –Discharge to Evaporation/Percolation Ponds[9][10]						
Biochemical Oxygen Demand (5 day at 20°C)[6]	mg/L	30	45	60	---	---
Total Suspended Solids	mg/L	30	45	60	---	---
pH	standard units	---	---	---	6.0	9.0

Notes:

(1) Limits included in Waste Discharge Requirements Order No. R2-2006-0049, NPDES Permit No. CA0022888.

(2) Abbreviations: mg/L = milligrams per liter; µg/L = micrograms per liter.

(3) The advanced treated wastewater shall be adequately oxidized, filtered and disinfected as defined in Title 22, Division 4, Chapter 3, California Code of Regulations (CCR).

(4) The median coliform concentration shall not exceed a Most Probable Number (MPN) of 2.2 per 100 milliliters, using the bacteriological results of the last seven days for which analyses have been completed, nor shall the MPN exceed 23 per 100 milliliters in any sample.

(5) The effluent shall not contain detectable levels of total chlorine, any measureable settelable solids, or acute toxicity.

(6) The average monthly percent removal of BOD (5-day 20°C) shall not be less than 85 percent.

(7) Mass-based effluent limitations are based on the peak design flow of the AWT filters when the permit was issued (7.0 mgd).

(8) Limits presented are final effluent limits. Interim limits are: average monthly nitrate (as N) limit of 26.6, maximum daily copper limit of 30 µg/L, average monthly dichlorobromomethane limit of 0.68 µg/L, and maximum daily dichlorobromomethane limit of 1.1 µg/L. Interim copper and dichlorobromomethane limits were effective until May 18, 2010. Interim nitrate limitations shall be effective until September 20, 2011.

(9) The secondary treated wastewater shall be adequately oxidized and disinfected as defined in Title 22, Division 4, Chapter 3, CCR.

(10) The median coliform concentration shall not exceed a MPN of 23 per 100 milliliters, using the bacteriological results of the last seven days for which analyses have been completed, nor shall the MPN exceed 240 per 100 milliliters in any sample.

through May 14 at a discharge rate of up to one percent of the total Russian River flow. The Water Quality Control Plan for the North Coast Region (Basin Plan) prohibits the discharge of treated wastewater from the UWWTP from May 15 through September 30.

As mentioned above, the AWT system produces disinfected tertiary treated effluent suitable for recycled water use. This water is currently only produced during the river discharge season, October 1 through May 14.

3.5 ADDITIONAL FACILITIES NEEDED

No additional facilities are needed in the foreseeable future to comply with the existing waste discharge requirements.

3.6 PROBLEM CONSTITUENTS AND CONTROL MEASURES

There are no significant sources of industrial or problem constituents nor necessary control measures of such constituents at this time.

3.7 CURRENT AND PROJECTED WASTEWATER GENERATION

Table 3.5 includes the historical and projected wastewater flows collected and treated within the service area. Projected wastewater flows are based on actual wastewater flow data from 2001 – 2010 and population data and projections presented herein.

3.8 WASTEWATER FLOW VARIATIONS

Discharge of treated wastewater effluent is a critical component of the City's water balance. Wastewater flow and disposal varies seasonally, as depicted in Figures 3.3 and 3.4. During dry weather months, wastewater flows to the UWWTP are low enough that the full flow is stored in the percolation ponds. During these months, the AWT System is not in operation. During wet weather flows, the AWT System is operated to provide tertiary treatment of flows in excess of that which can be stored in the ponds. Flows in excess of that which can be stored in the ponds and that which can be discharged to the Russian River must be disposed of by other means including reuse of treated effluent onsite. The UWWTP currently reuses an average of about 0.3 mgd of treated effluent onsite (323 AFY). In recent wet years, the UWWTP has discharged the maximum flow that can be stored in the ponds and discharged to the river. As flows increase in the future, additional pond storages will be needed or an additional discharge alternative, such as distribution to recycled water customers, must be developed.

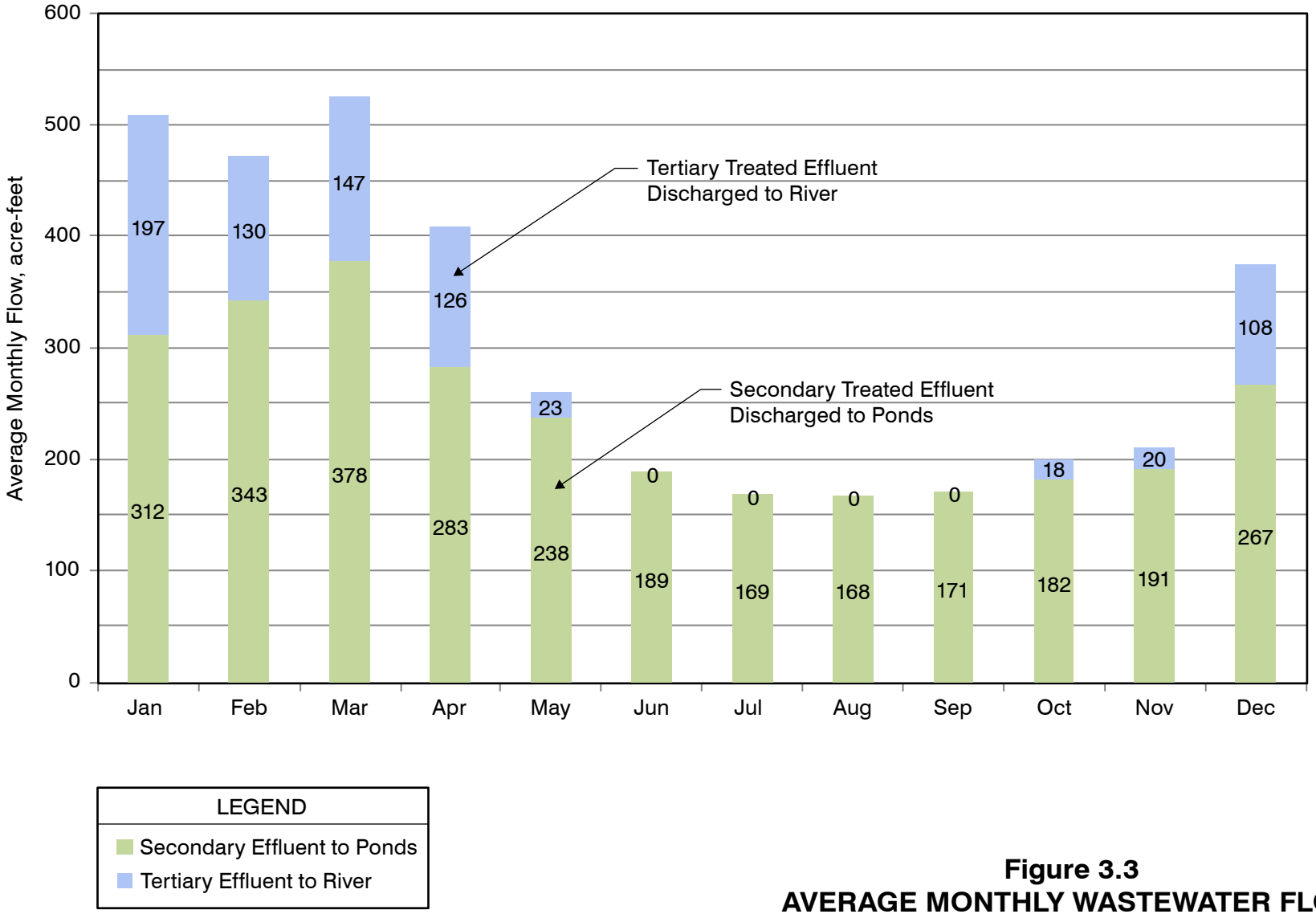

Figure 3.3
AVERAGE MONTHLY WASTEWATER FLOW IN ACRE-FEET FROM 2001 - 2011
RECYCLED WATER MASTER PLAN
CITY OF UKIAH

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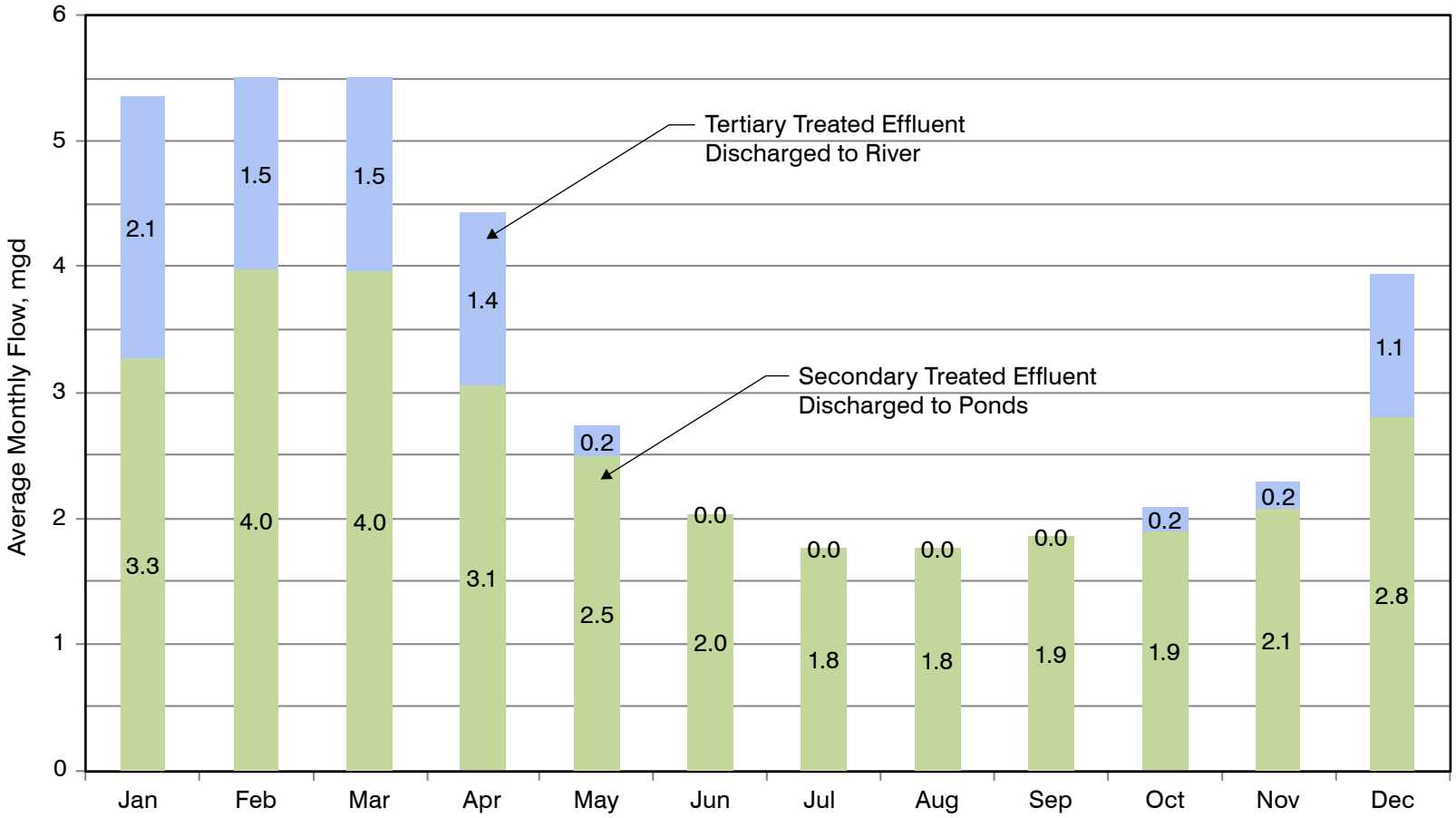

LEGEND
Secondary Effluent to Ponds
Tertiary Effluent to River

Figure 3.4
AVERAGE MONTHLY WASTEWATER FLOW
IN MGD FROM 2001 - 2011
RECYCLED WATER MASTER PLAN
CITY OF UKIAH

uk711f4-8660.ai

Table 3.5 Historical and Projected Wastewater Flows Recycled Water Master Plan City of Ukiah							
	Volume (AFY)						
Type of Wastewater	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**	**2035**
Wastewater Collected and Treated in Service Area	4,570	4,650	4,650	4,780	4,910	5,060	5,200

Notes:
(1) 2005 and 2010 wastewater flows based on actual plant data.
(2) Wastewater flow projections for 2015 – 2035 based on wastewater flows from 2001 – 2010 and population projections presented herein.

3.9 EXISTING RECYCLED WATER USERS

The City's only existing recycled water user is the UWWTP. The UWWTP reuses treated effluent produced at the UWWTP for on-site landscape irrigation, process water, and spray down.

3.10 RECYCLED WATER RIGHTS

Ukiah Valley water users do not have existing rights to use treated effluent after discharge.

TREATMENT REQUIREMENTS FOR DISCHARGE AND REUSE

4.1 TREATMENT REQUIREMENTS

The Ukiah wastewater treatment plant (UWWTP) produces tertiary treated water in the wet months when river discharge requirements can be met. Otherwise, the UWWTP produces secondary effluent and discharges the effluent to evaporation/percolation ponds. Tertiary treated recycled water is approved for all uses except for drinking or food preparation. This includes irrigation of all types including food crops and pastures for milking animals, commercial uses such as toilet/urinal flushing, process uses such as in cooling towers, supply for impoundments, and many more. The UWWTP's AWT system produces disinfected, tertiary treated effluent that meets Title 22, Division 4, Chapter 3, California Code of Regulations (CCR) for recycled water. The City is currently developing a RWMP to determine how this effluent can be put to its highest and best use to increase the reliability and maximize the capacity of the City's wastewater treatment facilities. Detailed analysis of the tertiary effluent water quality is underway to determine the various applications the recycled water could be used for, especially with respect to irrigation.

The AWT system is currently operated as needed during wet weather months (October through mid May) to treat flows in excess of that which can be stored in the onsite percolation/evaporation ponds.

The primary regulation governing recycled water use is the California Water Code Regulations, Title 22. The primary laws regulating water quality are the Clean Water Act (CWA) and the California Water Code. Under the CWA, the Environmental Protection Agency or a delegated State agency regulates the discharge of pollutants to waterways through the issuance of National Pollutant Discharge Elimination System (NPDES) permits. NPDES permits set limits on the amount of pollutants that can be discharged into the waters of the United States. The State Water Resources Control Board (SWRCB) is the state agency that has jurisdiction over water quality throughout California. Under the SWRCB, nine Regional Water Quality Control Boards (RWQCB's) have authority to exercise rulemaking and regulatory activities by water basins. The UWWTP is located in the North Coastal Region (Region 1) and is regulated by the North Coastal RWQCB. The SWRCB and the RWQCBs have regulatory authority along with the California Department of Public Health (DPH) over projects using recycled water. The roles of the SWRCB, RWQCB, and DPH are further discussed in the following paragraph.

The SWRCB establishes general policies governing the permitting of recycled water projects consistent with its role of protecting water quality and sustaining water supplies. The SWRCB also exercises general oversight over recycled water projects, including review of RWQCB permitting practices. The DPH is charged with protection of public health and drinking water supplies and with the development of uniform water recycling criteria

appropriate to particular uses of water. The RWQCB is charged with protection of surface and groundwater resources and with the issuance of permits that implement DPH recommendations.

4.2 WASTEWATER DISCHARGE REQUIREMENTS

As discussed in Chapter 3, the UWWTP's effluent discharges are regulated by a National Pollutant Discharge Elimination System (NPDES) permit – Order No. R1-2006-0049, NPDES No. CA0022888. The discharge limitations defined by this permit are described in further detail in Chapter 3, Section 3.4 of this report.

The UWWTP's Advanced Water Treatment system AWT produces disinfected, tertiary treated effluent that meets Title 22, Division 4, Chapter 3, California Code of Regulations (CCR) for recycled water. The AWT system is currently operated as needed during wet weather months (October through mid May) to treat flows in excess of that which can be stored in the onsite percolation/evaporation ponds. Although this effluent meets recycled water standards, it is not distributed to any recycled water users and is instead entirely discharged by gravity to the Russian River. Provided wastewater influent to the UWWTP was high enough, and recycled water demands were high enough, the AWT system could be operated on a daily basis to produce approximately 7.0 mgd of recycled water. However, during dry weather months the AWT can produce 4 mgd due to the limited flow volume.

A potential, future change to the current discharge requirements includes prohibition of all river discharges. The current permit allows discharge of disinfected, tertiary wastewater to the Russian River from October 1 through May 14 at a discharge rate of up to one percent of the total Russian River flow; river discharges from May 15 through September 30 are prohibited. If river discharges are prohibited year-round in the future, the City will need to determine alternative methods for disposing of its treated wastewater effluent. The City may need to construct additional pond storage or distribute treated effluent to recycled water customers.

4.3 WATER QUALITY-RELATED REQUIREMENTS

No water quality-related requirements are expected. Implementation of this project is anticipated to improve surface and groundwater water quality due to the reduced dependence on the groundwater basin.

4.4 SALT/NUTRIENT MANAGEMENT PLANS

Some groundwater basins in the state contain salts and nutrients that could threaten Basin Plan water quality objectives, whether the cause be natural soils/conditions, waste discharges, irrigation using surface or recycled water, or through groundwater. The State's recently adopted Recycled Water (RW) Policy requires that salt/nutrient management plans

for every basin in California be developed and adopted as Basin Plan Amendments by 2015. These Management Plans will be developed by local water and wastewater entities and stakeholders, and funded by the regulated community. Each salt and nutrient management plan shall include the following components:

- A basin-wide monitoring plan.
- A provision for annual monitoring of constituents of emerging concern (CECs).
- Water recycling use goals and objectives.
- Salt and nutrient source identification, basin assimilative capacity and loading estimates.
- Implementation measures to manage salt and nutrient loading in the basin.
- An antidegradation analysis.

After salt/nutrient management plans are developed, they will govern whether anti-degradation analyses are necessary for specific projects. While the plans are in the process of being drafted, antidegradation analyses will be required for recycling projects where the discharge will use more than 10 percent of the Basin's available assimilative capacity for one project, or 20 percent for multiple projects. It is assumed that this will not be the case in the City of Ukiah's area and therefore a salt/nutrient management plan will most likely not be needed. The RW program can proceed with permitting now, even though a salt/nutrient management plan has not been done. It is not the intent of the RW policy to hold up recycling projects to wait on those plans.

4.5 GENERAL USE GUIDELINES

4.5.1 Title 22 Use Area Requirements

Title 22 has two main requirements that could affect the potential users and will need to be considered on a case-by-case- basis during the design phase of the project. Per Title 22, no irrigation with disinfected tertiary recycled water shall take place within 50 feet of any domestic water supply well unless the well meets certain criteria such as:

- An annular seal.
- Well housing to prevent recycled water spray from contacting the wellhead.
- The owner approves of the elimination of the buffer zone, etc.

Also per Title 22, no impoundment of disinfected tertiary recycled water shall occur within 100 feet of any domestic water supply well. This will need to be considered during design where landowners have existing irrigation water storage on-site.

4.5.2 General Irrigation Use Guidelines

The successful long-term use of irrigation water depends more on rainfall, leaching, soil drainage, irrigation water management, salt tolerance of plants, and soil management practices than upon water quality itself. Figure 4.1 shows the typical monthly rainfall for the Ukiah Valley area, and since there is a considerable amount of rain it is assumed that salt build up would not be a problem with the use of the recycled water.

Since salinity problems may eventually develop from the use of any water, the following guidelines are given, should they be needed, to assist water users to better manage salinity in either agricultural or community-based irrigation:

- Irrigate more frequently to maintain an adequate soil water supply.
- Select plants that are tolerant of an existing or potential salinity level.
- Routinely use extra water to satisfy the leaching requirements.
- If possible, direct the spray pattern of sprinklers away from foliage. To reduce foliar absorption, try not to water during periods of high temperature and low humidity or during windy periods. Change time of irrigation to early morning, late afternoon, or night.
- Maintain good downward water percolation by using deep tillage or artificial drainage to prevent the development of a perched water table.
- Salinity may be easier to control under sprinkler and drip irrigation than under surface irrigation. However, sprinkler and drip irrigation may not be adapted to all qualities of water and all conditions of soil, climate, or plants.

General management/use guidelines are shown for landscape and crop irrigation based on the average constituent quantity. A wastewater sample of the UWWTP effluent was collected on May 23, 2011 and analyzed for typical irrigation constituents. These constituents and management/use guidelines compared to the UWWTP sample are summarized in Table 4.1. When comparing the information in Table 4.1 it can be seen that the Ukiah effluent is very high quality recycled water that is in the acceptable range for irrigation. It is recommended the City do additional water quality sampling at various times during the year to determine any seasonal variations in treated effluent quality.

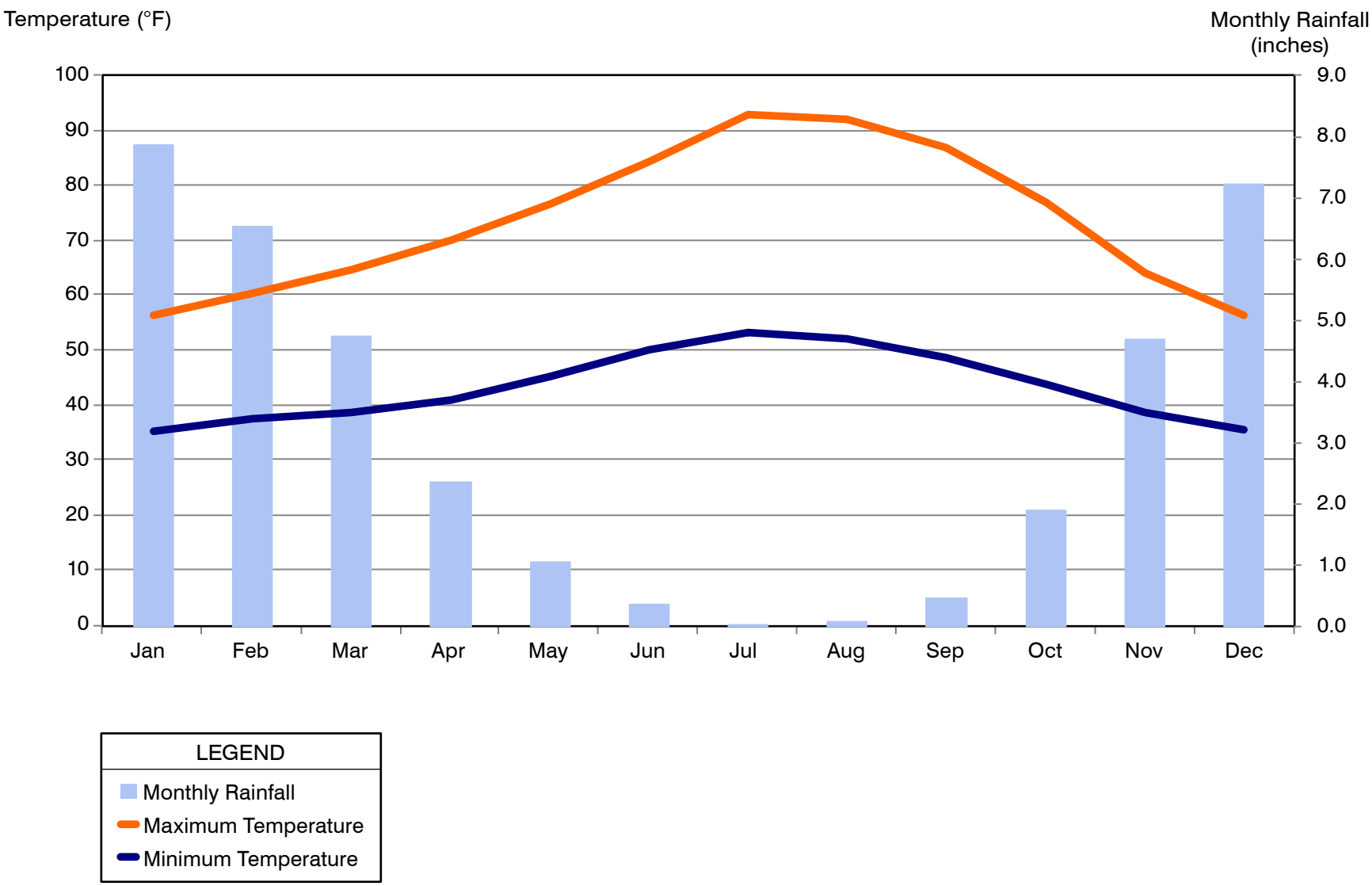

Figure 4.1
AVERAGE PRECIPITATION AND TEMPERATURE
RECYCLED WATER MASTER PLAN
CITY OF UKIAH

Source: Ukiah Station #049122 Data from the Western Regional Climate Center Precipitation Gauges, 1893-2010.

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Table 4.1 Comparison of City of Ukiah Water Quality with Established Guidelines for Interpretations of Water Quality for Irrigation
Recycled Water Master Plan
City of Ukiah

Parameter	Units	Established Criteria Degree of Use Restriction[1,2] None	Slight	Severe	Ukiah WWTP Effluent [3]
Salinity					
Electrical Conductance	ds/m	**<0.7**	0.7 - 3.0	>3.0	0.5
Total Dissolved Solids (TDS)	mg/L	**<450**	450 - 2000	>2000	250
Permeability					
aSAR = 0 - 3 and EC		>0.7	**0.7 - 0.2**	<0.2	(Based on
= 3 - 6 and EC		>1.2	1.2 - 0.3	<0.3	SAR = 1.6;
= 6 - 12 and EC		>1.9	1.9 - 0.5	<0.5	EC = 0.5)
= 12 - 20 and EC		>2.9	2.9 - 1.9	<1.9	
= 20 - 40 and EC		>5.0	5.0 - 2.9	<2.9	
Sodium					
Root Absorption	SAR	**<3**	3 - 9	>9	1.9
Foliar Absorption	mg/L	**<70**	>70		43
Chloride					
Root Absorption	mg/L	**<140**	140 - 355	>365	38
Foliar Absorption	mg/L	**<100**	>100		38
Boron	mg/L	**<0.7**	0.7 - 3.0	>3.0	0.2
pH[4]	–	**6.5 - 8.4 (normal range)**			6.5 - 7.5
Ammonia (NH_4)[4]	mg/L	(see combined N values below)			7.1
Nitrate (as NO_3)	mg/L	(see combined N values below)			9.3
Nitrate (as N)[4]	mg/L	(see combined N values below)			2.1
Total Kjeldahl Nitrogen (N)[5]	mg/L	<5	**5 - 30**	>30	12
Bicarbonate (HCO_3)[6]	mg/L	**<90**	90 - 500	>500	68

Notes:
(1) Adapted from University of California Committee of Consultants (1974) and Water Quality for Agriculture (Ayers and Westcot 1984).
(2) Definition of the "Degree of Use Restriction" terms:
None = Reclaimed water can be used similar to the best available irrigation water.
Slight = Some additional management will be required above that with the best available irrigation water in terms of leaching salts from the root zone and/or choice of plants.
Severe = Typically cannot be used due to limitations imposed by the specific parameters.
(3) The Ukiah WWTP effluent data is based on secondary effluent sampling done May 23, 2011, unless noted otherwise.
(4) pH, ammonia, and nitrate (as N) data are based on average effluent values measured at the Ukiah WWTP.
(5) Total Kjeldahl Nitrogen (TKN) is the sum of the ammonia nitrogen and organic nitrogen. Organic nitrogen is bound in living material. Ammonia and nitrate are inorganic forms of nitrogen.
(6) Presence of bicarbonate can result in unsightly foliar deposits.

RECYCLED WATER MARKET

This chapter summarizes the market identification and quantification process and the landscape irrigation requirements for the City of Ukiah and the surrounding Ukiah Valley area.

5.1 MARKET ASSESSMENT PROCEDURES

Over 30 potential recycled water customers were identified within the study area, many representing multiple parcels and several acres of land that could be served with recycled water. The customers were identified using multiple sources including:

- Previous reports.
- Discussions with City engineering and planning staff.
- GIS mapping.
- Discussions with various regulatory industrial agencies including the Mendocino County Russian River Flood Control and Water Conservation Improvement District and the Mendocino County Farm Bureau.
- A recycled water questionnaire.

The types of acceptable uses identified include urban irrigation (i.e. school yards, parks, cemeteries, golf courses, Home Owners Associations (HOAs)) and agricultural irrigation (i.e. vineyards, orchards and miscellaneous row crops).

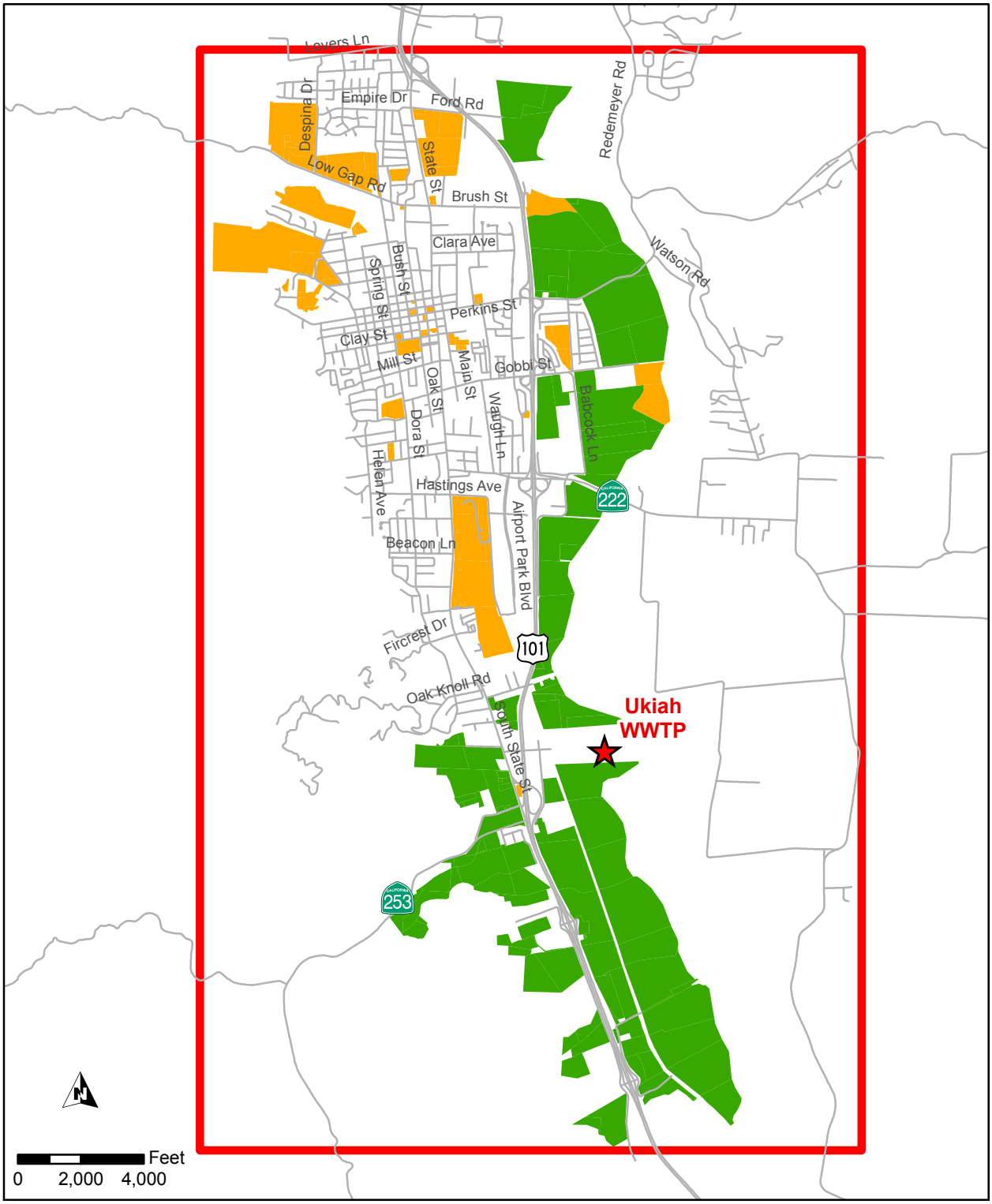
The potential recycled water use sites are shown on Figure 5.1 and listed in Appendix B.

5.1.1 Recycled Water Questionnaire

A recycled water questionnaire was delivered to approximately 20 key potential recycled water users in the area surrounding the wastewater treatment plant and the City to determine local interest in using recycled water and to assess current water use practices. These key potential recycled water users account for approximately 144 irrigable or agricultural parcels (about 1,180 acres) within the City of Ukiah and surrounding area. The questionnaire and summaries of the questionnaire responses are located in Appendix A.

The following information was requested on the questionnaires:

- Irrigation type (e.g. vines, orchard, grass/landscaping, pasture).
- Existing and planned additional irrigated acreage.
- Water source for irrigation and frost protection.



Legend

Streets

Recycled Water Master Plan Study Area

Potential Recycled Water Use Sites

Agricultural

Urban Landscaping

Figure 5.1
POTENTIAL RECYCLED WATER USE SITES
RECYCLED WATER MASTER PLAN
CITY OF UKIAH

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- Existing and planned storage for irrigation.
- Interest in using recycled water.
- Concerns and comments.

5.1.1.1 Questionnaire responses

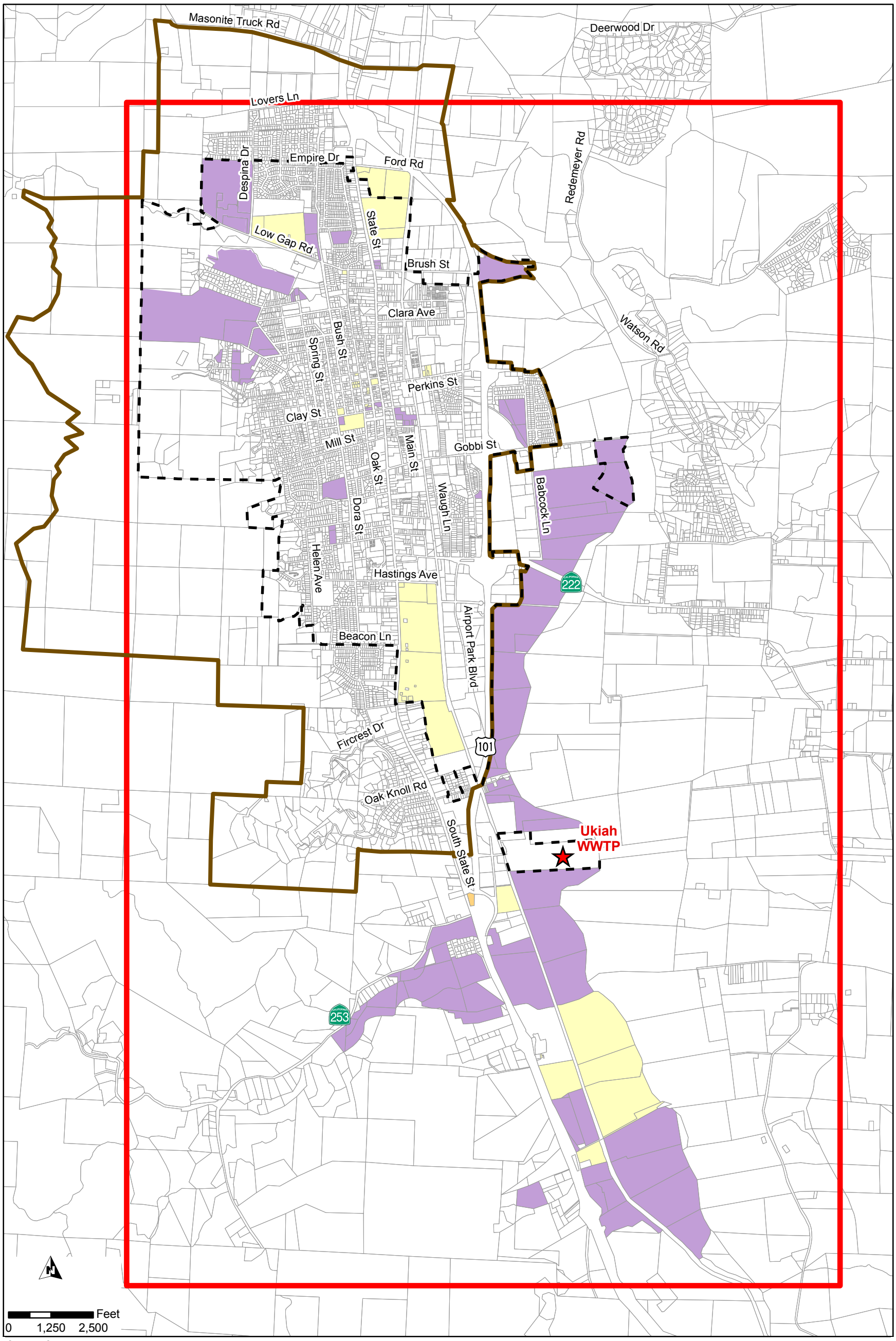
The questionnaire responses are illustrated in Figure 5.2 and summarized by irrigation type in Table 5.1. The Study Area is comprised of mostly vineyards and orchards, urban landscaping and some row crops and pasture irrigation. For properties where a questionnaire response was not received, GIS data was used to estimate irrigable acreage and type of irrigable acreage.

As can be surmised from Table 5.1, 80 percent of the questionnaires were returned, which represented over 66 percent of the parcels and 76 percent of the land area considered in the study. Of the questionnaires returned, owners and managers of 99 percent of the parcels were interested in using recycled water to meet their irrigation needs. These parcels account for 100 percent of the acreage reported in the returned questionnaires. Appendix A provides further analysis of the questionnaire responses.

5.1.1.2 Frequent Responses

Many of the questionnaire responses contained similar feedback and formed overall trends. The most frequent concerns/comments were:

- They are interested in using recycled water.
- How much will recycled water and a recycled water delivery system cost.
- How will the use of recycled water impact their water rights.
- Uncertainty about the recycled water quality (i.e. salts, nutrients).
- Pressure and daily/seasonal timing of supply (i.e.: main need is in spring for frost protection).
- Will recycled water use be compatible with fresh fruit and cannery markets, and wineries.
- Compatibility with organic certification requirements.
- Will a recycled water program be feasible based on recycled water programs implemented in the region (e.g., Sonoma).



Legend

- Interested in RW
- Not Interested in RW
- Did Not Respond
- Parcels
- Recycled Water Master Plan Study Area
- City Limits
- Sphere of Influence

Figure 5.2
RECYCLED WATER (RW)
QUESTIONNAIRE RESPONSES
RECYCLED WATER MASTER PLAN
CITY OF UKIAH

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Table 5.1 Summary of Questionnaire Responses by Irrigable Area
Recycled Water Master Plan
City of Ukiah

Irrigation Type	Questionnaires			Corresponding Number of Parcels			Corresponding Irrigable Acreage[1]			Percent of Respondents Interested in Using Recycled Water	
	Total Number Sent	Number Responded	% Responded	Total Number Sent	Number Responded	% Responded	Total Acres Sent	Acres Responded	% Responded	Parcels	Acreage
Agriculture	13	11	85%	60	52	87%	860	730	85%	100%	100%
Landscaping[2]	7	5	71%	84	43	51%	320	170	53%	98%	100%
Total	**20**	**16**	**80%**	**144**	**95**	**66%**	**1180**	**900**	**76%**	**99%**	**100%**

Notes:

(1) GIS data was use to approximate the parcels, irrigable acreage and type of irrigable acreage corresponding to land owners for which a questionnaire was not received.

(2) Landscaping includes grass, gardens and other non-agricultural irrigation.

5.2 MARKET QUANTIFICATION

The potential recycled water demand was quantified for each of the recycled water customer sites indentified through the market assessment based on irrigable acreage and crop type. To estimate the annual and peak water requirements of each site, the total irrigable acreage of each site was multiplied by assumed water use parameters (included in Table 5.2). The irrigable acreage and type of irrigable acreage of each site was determined using both GIS mapping and the questionnaire responses. Expected landscape irrigation demands were estimated using landscape irrigation requirements for the Ukiah Valley area based on evapotranspiration and rainfall data. Expected agricultural irrigation and frost protection demands were developed based on water use data included in regional agricultural publications and discussions with local agricultural and water agencies and industries.

Crop types for evaluated agricultural parcels within the study area are shown on Figure 5.3. The estimated annual water use and peak water use of the identified potential customers are summarized in Appendix B.

5.2.1 Agricultural Water Demands

Irrigation and frost protection are the two primary agricultural water demands in Ukiah Valley. Agricultural irrigation requirements are subject to numerous variables, including crop selection, irrigation method (i.e. flood, drip, etc), field rotation, planting season, planting date, and other farmer-specific factors.

In addition to meeting irrigation demands, farmers in the Ukiah Valley apply water to their crops to protect them from damage during frost events. During typical frost conditions, known as radiant frost conditions, heavier cold air settles in the lower parts of the landscape and can potentially damage crops grown in these areas. During adjective frost conditions, which occur infrequently, the entire Ukiah Valley is impacted regardless of elevation. While radiant frost conditions are more typical of the area, frost protection is typically implemented on crops that are in the lower parts of the landscape - below about 700 feet in elevation. (Mendocino Irrigated Agricultural Water Needs and Management, 2008)

Table 5.2 summarizes the parameters that were used to quantify agricultural water demands. Several discussions were held with local agricultural and water supply agencies and industries including Mendocino County Farm Bureau, Mendocino County Russian River Flood Control and Water Conservation Improvement District, and AG Unlimited, to determine agricultural water use parameters that were representative of most agricultural practices in the Ukiah Valley. In addition to this, several agricultural publications were referenced as sited in Table 5.2.

Table 5.2 Assumed Water Use Parameters
Recycled Water Master Plan
City of Ukiah

Water Use Parameter	Vineyard[1,2]	Orchard (Pears)[1,3]	PTL (Pasture)[4]	Row Crops[4]	Grass[5]
Frost Protection					
Frost Months	Mar – May	Apr – May	NA	NA	NA
Duration of Frost Season, months	3	3	NA	NA	NA
Average frost events per max month	2	2	NA	NA	NA
Frost event duration, days	3	3	NA	NA	NA
Frost event duration, hrs. per day	8	6.5	NA	NA	NA
Rate of application, gal/min/acre	55	65	NA	NA	NA
Max Month Frost Demand, af/acre/month	0.5	0.5	NA	NA	NA
Max Day Frost Demand, af/acre/day	0.08	0.08	NA	NA	NA
Average Total Demand During Frost Season	0.50	0.50	NA	NA	NA
Irrigation					
Irrigation Months	Jun – Oct	May - Sep	May – Sep	May – Sep	Apr – Oct
Duration of irrigation season, months	5	5	5	5	7
Avg. annual demand[1], af/acre/yr	0.75	2.0	2	2	2.03
Avg. monthly demand, af/acre/mo	0.15	0.45	0.40	0.40	0.29
Avg. daily demand, af/acre/day	0.02	0.22	0.01	0.01	0.01
Total Demand[5] (afy)	**1.3**	**2.5**	**2.0**	**2.0**	**2.0**

Notes:

(1) Vineyard and pear frost and irrigation requirements from local farmers and Lewis, David et.al., Irrigated Water Needs and Management in the Mendocino County Portion of the Russian River Watershed, July 2008, Tables 1, 2 and 9. http://ucanr.org/sites/Mendocino/files/17223.pdf

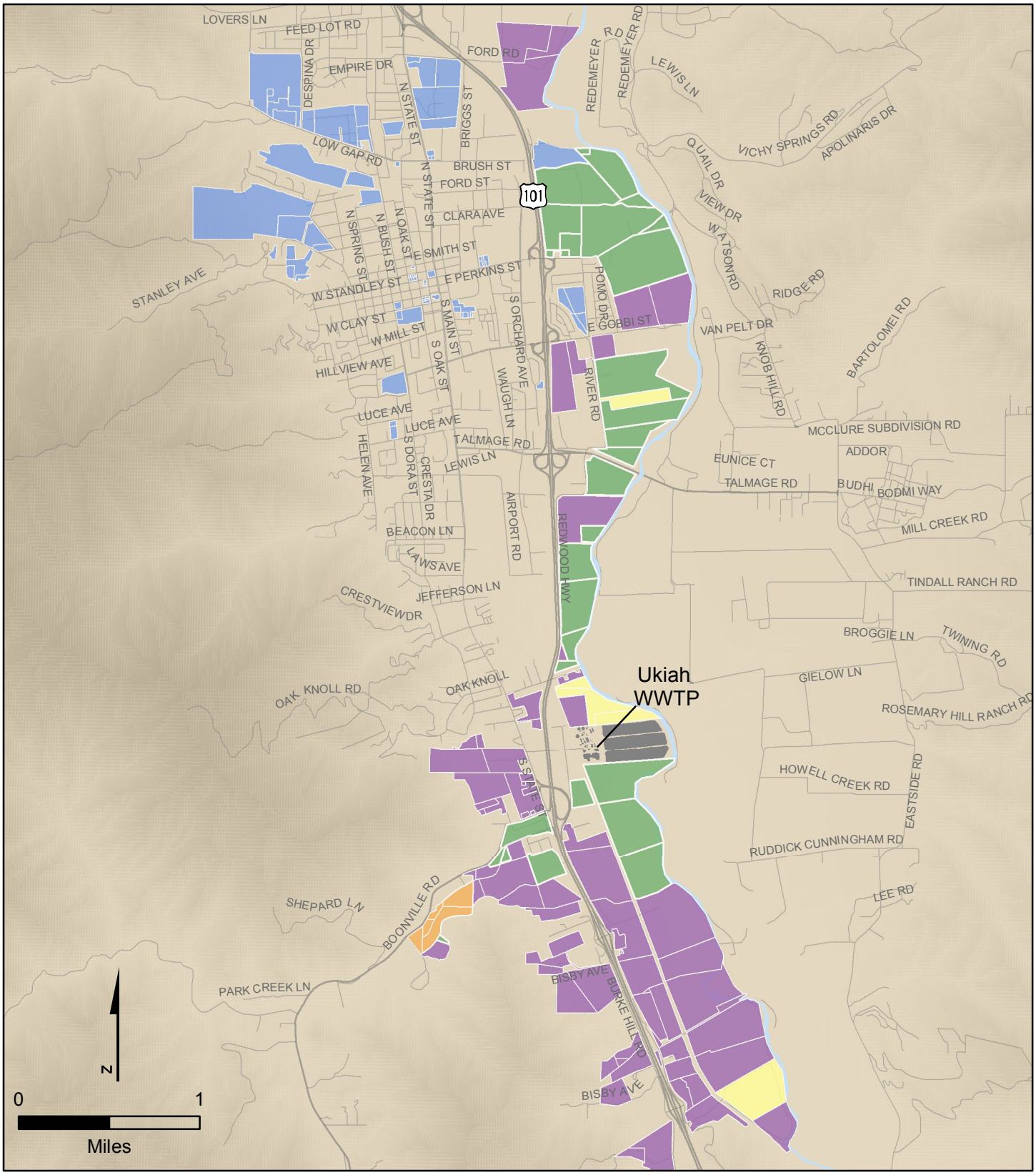
(2) Rate of application for frost protection of vineyards from Mendocino County Farm Bureau and Mendocino County Russian River Flood Control and Water Conservation Improvement District.

(3) Rate of application for frost protection of pears from UC Cooperative Extension, 2006 Sample Costs to Establish and Produce Pears, 2006, pg. 4. http://coststudies.ucdavis.edu/files/pearnc2006.pdf

(4) Pasture and row crop irrigation requirements from Lewis, David et. al., Irrigated Water Needs and Management in the Mendocino County Portion of the Russian River Watershed, July 2008, Tables 5. http://ucanr.org/sites/Mendocino/files/17223.pdf

(5) Grass irrigation requirement calculated using temperature, rainfall, and evapotranspiration data obtained from the Western Regional Climate Center and the Guide to Estimating Irrigation Water Needs of Landscape Plantings in California by the California Department of Water Resources.

(6) Annual water use for vineyards and pears from Mendocino County Farm Bureau and Mendocino County Russian River Flood Control and Water Conservation Improvement District and local agricultural industries.



Legend

- Other Row Crop Parcels
- Pasture Parcels
- Orchard Parcels
- Vineyard Parcels
- Potential Landscape Parcels
- WWTP Ponds and Buildings
- River
- Major Roads
- Local Streets

Proposed Pipeline by Diameter

- 12" and smaller
- 16" to 24"
- larger than 24"

Figure 5.3
AGRICULTURAL PARCELS BY CROP TYPE
RECYCLED WATER MASTER PLAN
CITY OF UKIAH

Fig_5_3-Ag_Parcels_by_Crop.mxd

5.2.2 Landscape Irrigation Requirements

In many cases, landscape irrigation customers use less water than necessary because of conservation practices and cost considerations. Conversely, some customers over-irrigate because of uneven sprinkler coverage or overly conservative watering practices. Therefore, expected landscape irrigation requirements for the Ukiah Valley area were calculated based on evapotranspiration and rainfall data. Calculated irrigation requirements, as defined below, were used to estimate irrigation use at the sites. Calculated irrigation requirements were also used to estimate peak month demand, peak day demand, and peak hour demand for distribution considerations.

The amount of irrigation required for the potential irrigation customers is directly dependent on precipitation quantities in the region. The amount of precipitation, evapotranspiration, and irrigation required for the potential irrigation customers are listed in Table 5.3. To calculate the amount of evapotranspiration occurring in the study area, the following formula was used:

$$ET_L = K_L * ET_o$$

Where: ET_L = Evapotranspiration of landscaped areas (in inches)

K_L = Landscaped area crop coefficient

ET_o = Reference evapotranspiration (in inches)

The reference Evapotranspiration was obtained from the California Irrigation Management Information System (CIMIS) Evapotranspiration zoning map. The City is located in Zone 8: Inland San Francisco Bay Area characterized as inland areas near San Francisco with some marine influence.

To calculate the landscape evapotranspiration, the landscaped area crop coefficient was estimated using information contained in the Guide to Estimating Irrigation Water Needs of Landscape Plantings in California by the California Department of Water Resources. The landscaped area crop coefficient is the product of an average species factor (k_s), density factor (k_d), and microclimate factor (k_{mc}). These were estimated to be 0.6, 1, and 1, respectively. The landscape coefficient was then multiplied by the reference evapotranspiration to determine the average landscape evapotranspiration for the study area.

Therefore, the net annual average landscape irrigation requirement in the study area is approximately 24.3 inches per year or 2.0 feet per year. The irrigation season is roughly April through October, a period of 214 days. Landscape irrigation demand peaks in the month of July at 6 inches, 25 percent of the annual total.

Table 5.3 Average Annual Landscape Irrigation Requirements
Recycled Water Master Plan
City of Ukiah

Month	Landscape Area Evapotranspiration[1] (Inches)	Average Rainfall[2] (Inches)	Net Irrigation Requirement[3] (Inches)	Percent of Annual Net Irrigation Requirement[4] (%)
January	0.74	4.75	0.0	0%
February	1.01	6.52	0.0	0%
March	2.05	4.75	0.0	0%
April	2.88	2.35	0.7	3%
May	3.72	1.05	3.6	15%
June	4.14	0.35	5.1	21%
July	4.46	0.04	6.0	25%
August	3.91	0.08	5.2	21%
September	3.06	0.46	3.5	14%
October	2.05	1.9	0.2	1%
November	1.08	4.69	0.0	0%
December	0.56	7.22	0.0	0%
Total	**29.65**	**34.16**	**24.3**	**100%**
			2.0 feet	

Notes:

(1) Evapotranspiration (ETL) = Reference Evapotranspiration (ETo) x Landscaped Crop Area Coefficient (KL). Reference evapotranspiration values obtained from the California Irrigation Management Information System Reference Evapotranspiration Zone Map and rates included in the Guide to Estimating Irrigation Water Needs of Landscape Plantings in California by the California Department of Water Resources (Guide). The City of Ukiah is located in Zone 8 (Inland San Francisco Bay Area). Landscaped crop coefficient (KL) = Average Species Factor (Ks) x Density Factor (Kd) x Microclimate Factor (Kmc). Ks, Kd, Kmc estimated using data in the Guide.

(2) Source: Ukiah Station #049122 Data from the Western Regional Climate Center Precipitation Gauges, 1893-2010.

(3) Net Irrigation Requirement = (Evapotranspiration - Rainfall)*1.15/0.85. Where 0.85 = 85% Irrigation Factor (Average Value from Carlos and Guitijens, University of Nevada) and 1.15 = 15% Leaching Fraction (Average value from Ayers and Westcot, "Water Quality for Agriculture", Food and Agriculture Organization of the United Nations).

(4) Current month net irrigation requirement divided by total net irrigation requirement.

5.2.3 Potential Customer Storage

As discussed in Section 5.1.1, several agricultural parcels have existing storage ponds or plans to construct storage ponds. Since frost protection is a significant demand, it is anticipated that storage at the site of potential customers will extend the potential coverage of frost protection supply from the Ukiah WWTP.

Agricultural parcels with storage ponds are presented in Figure 5.4. Whether a parcel has a storage pond was determined based on the results of the questionnaire and discussions with City and RRFCD staff. It should be noted that some of the responses on questionnaires did not seem feasible and were thus revised accordingly. While the sizing of individual storage ponds was considered the responsibility of the farmer and was not evaluated within this study, the aggregate size of the storage ponds were used to determine the potential seasonal storage available. This will be discussed in detail in Chapter 6.

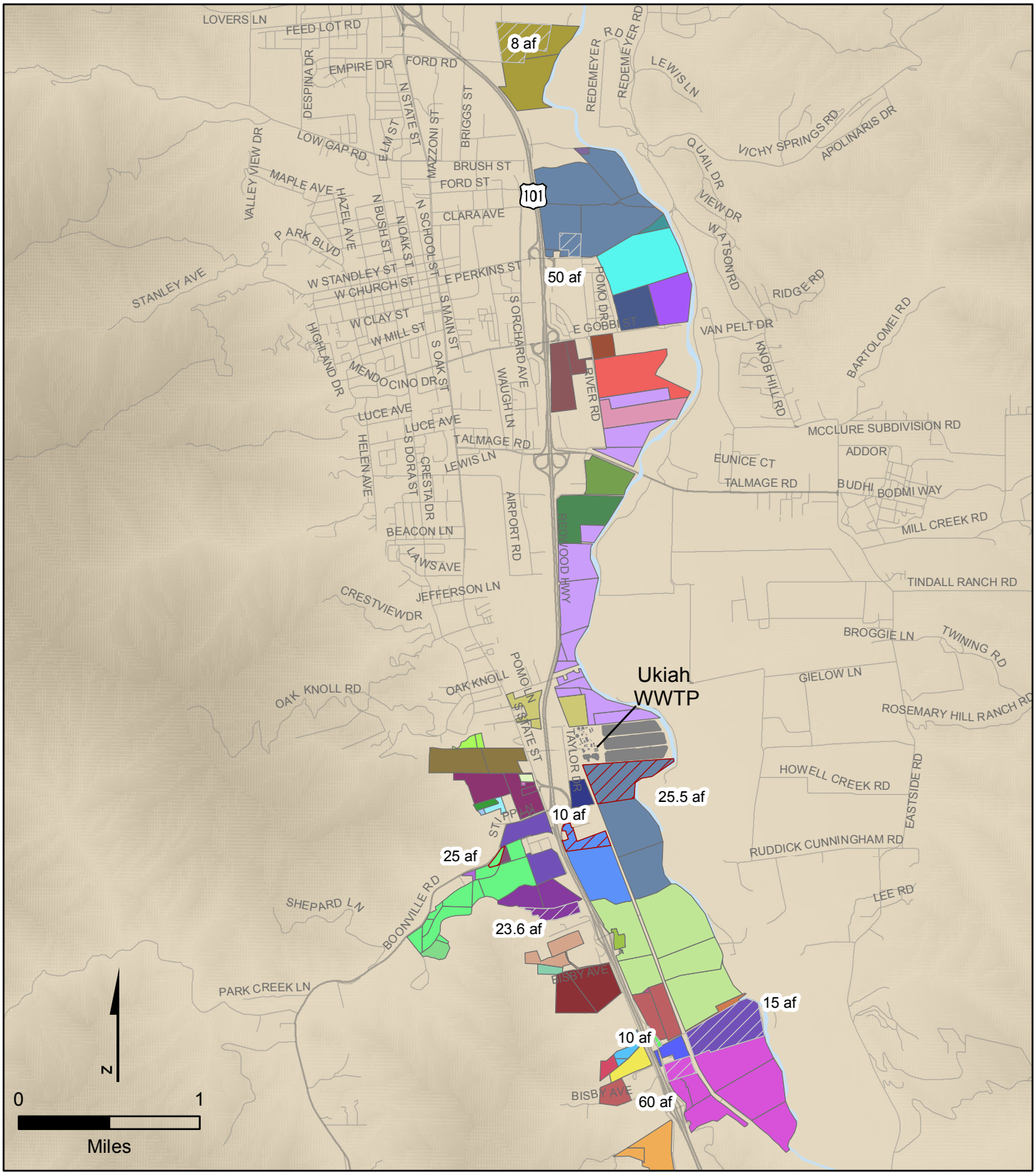
5.3 STAKEHOLDER OUTREACH

In addition to the mailing of questionnaires to larger and local possible users, two Stakeholder Workshops were held to inform the public of the project and obtain feedback. The Stakeholder Workshops were used to describe the project and the process, present recycled water alternatives, and obtain feedback. The workshops were held at key milestones during the planning process and had approximately 10 to 20 attendees at each. Besides the potential users, attendees from the City also participated.

The first Stakeholder Workshop was held on June 8, 2011 and presented a recycled water overview, project timeline, description of the master plan and its focus, discussion of expected irrigation water quality, brief review of funding options, and closed with the next steps in the process. Numerous questions were asked and as the meeting closed, the attendees were highly considering using the recycled water. The purpose of this meeting was to introduce the project to the attendees and describe the process being conducted.

Stakeholder Workshop No. 2 was held on October 6, 2011. The goals were to present the background information, schedule, and work-to-date, present the alternatives analyzed, review the recommended project and costs, review possible funding options, and again close with the next steps in the process. Five alternatives were presented along with their screening and ranking based on the criteria established at the Visioning Workshop at the beginning of the Plan. Based on input from the stakeholders, a six alternative was added that combined serving the agricultural interests as well as serving the large urban irrigation sites like the sports park and golf club.

A presentation to the City Council was conducted on December 7, 2011 to present the project status, the recommended alternative, and associated costs (capital and O&M).



Legend

- Parcels w/ Existing Storage Pond
- Parcels w/ Future Storage Pond
- Agricultural Parcels Colored by Grower or Owner Name (Adjacent parcels with the same color are likely able to share storage)
- WWTP Ponds and Buildings
- River
- Major Roads
- Local Streets

Figure 5.4
EXISTING AND PLANNED AGRICULTURAL STORAGE
RECYCLED WATER MASTER PLAN
CITY OF UKIAH

Fig_5_4-Existing_and_Planned_Agricultural_Storage.mxd

PROJECT ALTERNATIVE ANALYSIS

6.1 WATER RECYCLING ALTERNATIVES EVALUATED

A total of six alternatives were evaluated in this study. The alternatives were selected based on providing recycled water along different alignments and prioritization of different use types. The alternatives vary by area/acreage served, use types served, and storage configuration. Pipelines for each alternative was routed and sized in Innovyze's H_2OMap Water hydraulic modeling software.

First, Alternatives 1 through 3 (a total of 5 different alternatives) were preliminarily developed and presented to City staff and potential agricultural users at a workshop. Through input at the workshop, the alternatives were refined and Alternative 4 was developed to prioritize supplying recycled water to urban sites, including City parks, schools, and the golf course. A complete description of the alternatives follows. Planning level cost estimates for each alternative are presented and discussed following the alternative descriptions. Planning assumptions are discussed in more detail in Section 6.2.

6.1.1 Alternative 1

The Baseline Alternative, Alternative 1, was routed to the south and west to maximize use of the existing off-site storage while minimizing length and size of pipelines. It was considered as the minimum pipeline alternative that could be constructed while utilizing the full dry weather recycled water supply of 4 mgd. This alternative maximized supplying recycled water to meet frost protection demands. This alternative serves only agricultural needs.

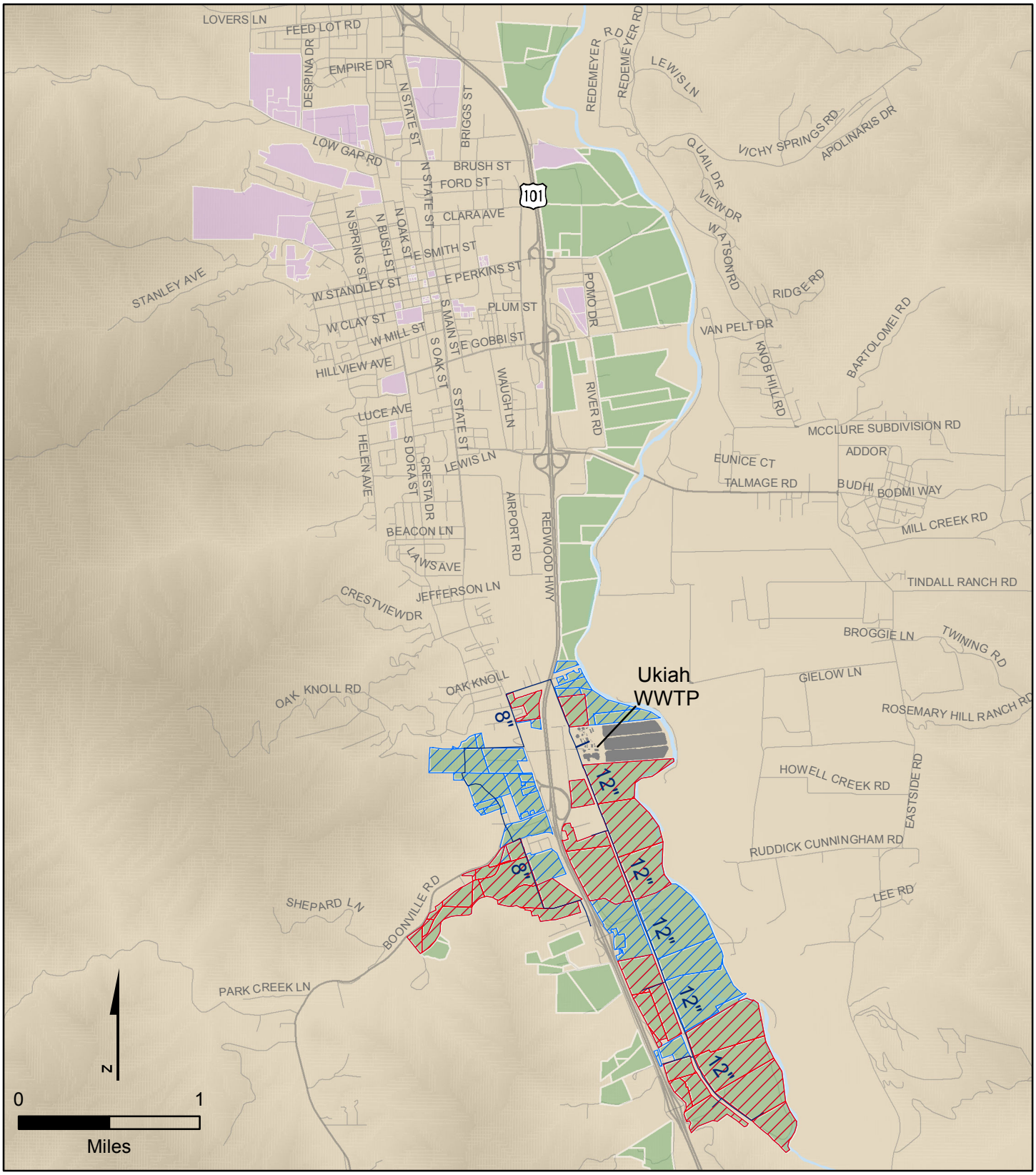
A total of 68 parcels covering 793 acres would be supplied with irrigation in this alternative with an irrigation demand of 830 AFY. About 483 acres representing 35 parcels (corresponding to about 10 farmers) would be supplied with frost protection water, with an estimated annual frost protection demand of 242 AFY. This alternative includes just under 6 miles of pipeline, with diameters ranging between 8 and 16 inches.

This alternative would utilize 5 farmer owned storage ponds, totaling 99 af in size. In addition, 19 parcels representing about 5 farmers not having ponds, covering 134 acre (ac) of land, are provided frost protection during frost events.

Figure 6.1 illustrates the pipeline routing and properties served by Alternative 1.

6.1.2 Alternative 1B

Alternative 1B follows a similar alignment to Alternative 1, but extends north to supply irrigation to additional parcels. This alternative prioritizes supplying agricultural parcels with recycled water for irrigation. This alternative serves only agricultural needs.



Legend

- Parcels Provided Frost Protection and Irrigation
- Parcels Provided Irrigation
- Potential Agriculture Parcels
- Potential Landscape Parcels
- WWTP Ponds and Buildings
- River
- Major Roads
- Local Streets

Proposed Pipeline by Diameter

- 12" and smaller
- 16" to 24"
- larger than 24"

Figure 6.1
ALTERNATIVE 1
RECYCLED WATER MASTER PLAN
CITY OF UKIAH

Fig_6_1-Alternative_1.mxd

A total of 75 parcels covering 915 acres, representing about 12 farmers, would be supplied with irrigation in this alternative with an irrigation demand of 1,027 AFY. Similar to Alternative 1, 483 acres would be supplied with frost protection water, with an estimated annual frost protection annual demand of 242 AFY.

This alternative includes just over 7 miles of pipeline, with diameters ranging between 8 and 16 inches. Similar to Alternative 1, this alternative would utilize 5 farmer based storage ponds, totaling 99 af in size. Figure 6.2 illustrates the pipeline routing and properties served by Alternative 1B.

6.1.3 Alternative 2

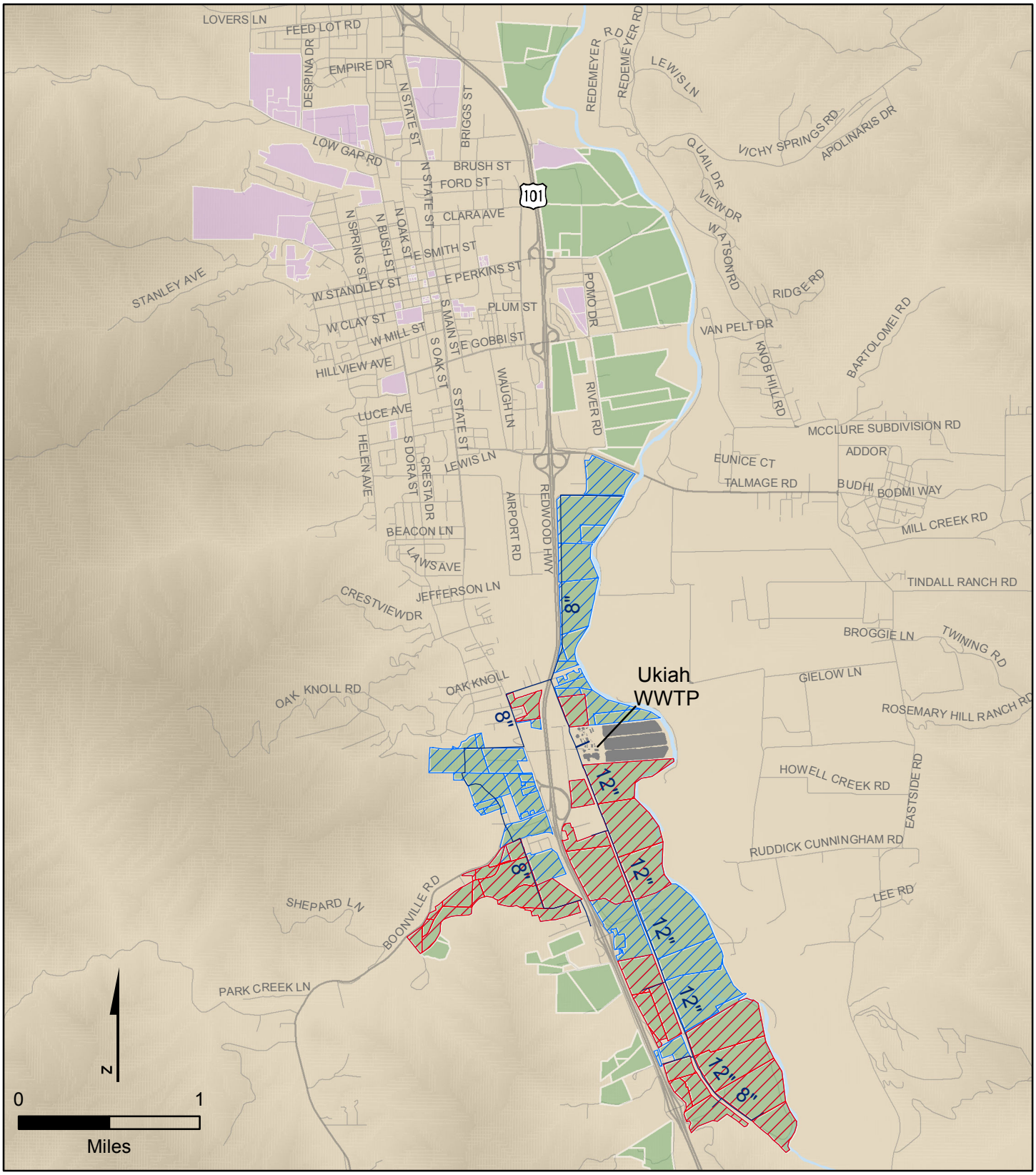
Alternative 2 investigates the feasibility of farmers constructing their own storage ponds with which to provide their own peaking for frost protection.

Based on discussions with Russian River Flood Control District (RRFCD), many farmers are considering adding storage due to the new possible State Board river withdrawal schedule, making this alternative likely. This would save the WWTP money in storage facilities, but would cost the farmers more and it would rely on the farmers being proactive in building storage facilities. This alternative serves only agricultural needs.

While Alternative 1 focused on supplying frost protection water to farmers with existing or planned storage ponds, Alternative 2 was developed to determine the effective maximum extent of acreage provided frost protection assuming farmers built a typical amount of storage.

The limiting factor for this alternative is the recharging of farmer ponds between frost events. Based on results of the questionnaire, a typical storage factor of 0.3 af/ac was applied to all the parcels to determine the minimum volume of storage each farmer would construct. The recycled water distribution system was sized assuming that the ponds could be refilled during the non-frost hours of each day during a frost protection event and over a period of seven days between frost events (as discussed in Chapter 5, frost events are assumed to last three days). Based on the assumptions discussed in Chapter 5, a single frost event (occurring over 3 days) will require between 0.23 and 0.24 af/ac of storage. In this scenario, recharge demands between frost events are calculated as 2,982 gallons per minute (gpm). A storage pond sized for 0.3 af/ac would include sufficient storage to make up for the difference between the recharge flows and the projected flow from the Ukiah WWTP.

A total of 35 parcels covering 494 acres, representing about 10 farmers, would be supplied with frost protection in this alternative with an estimated frost protection demand of 247 AFY. About 619 acres would be supplied with irrigation water, with an estimated annual annual irrigation demand of 699 AFY. This alternative includes about 4 miles of pipeline, with diameters ranging between 8 and 16 inches. Figure 6.3 illustrates the pipeline routing and properties served by Alternative 2.



Legend

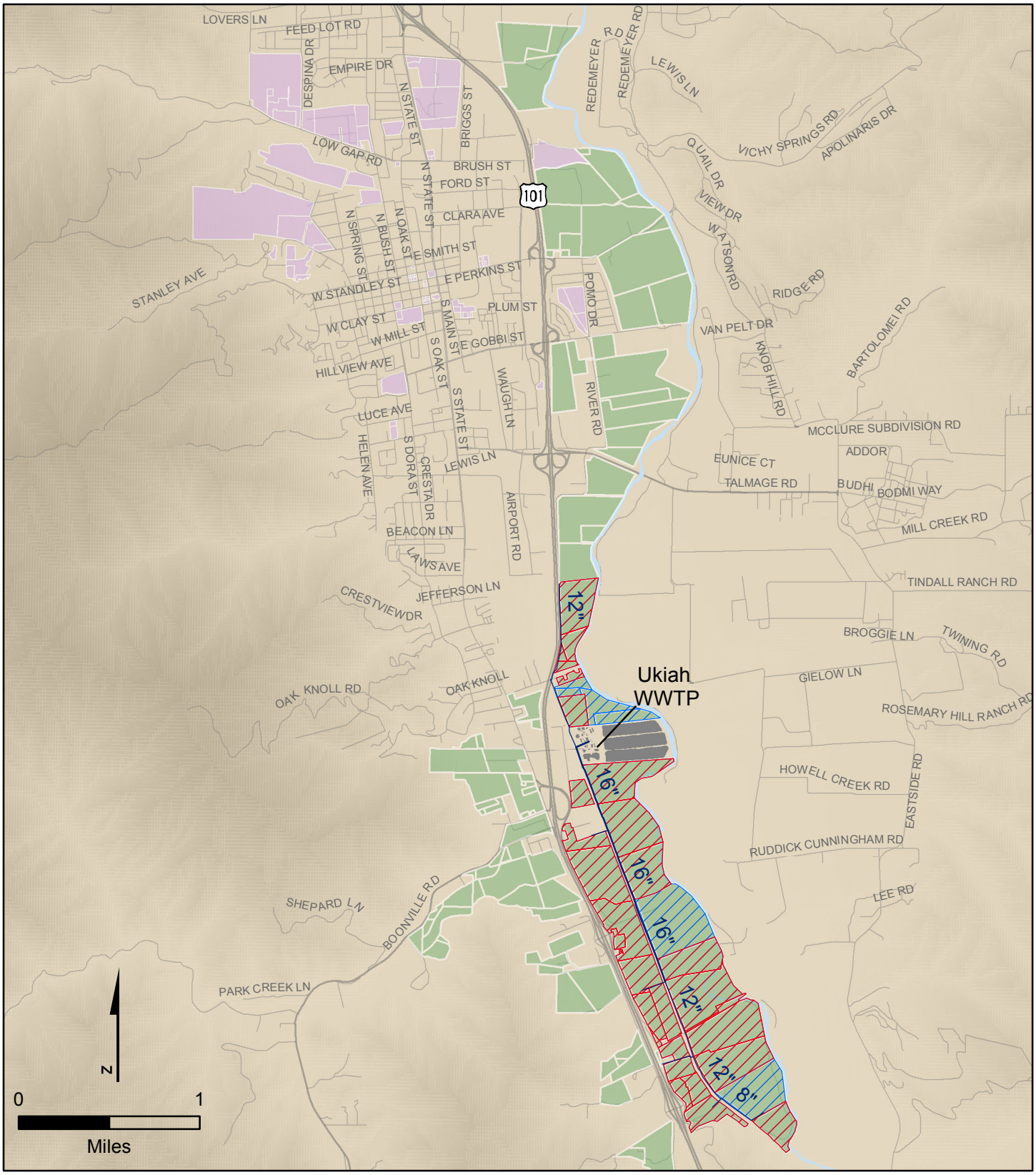
- Parcels Provided Frost Protection and Irrigation
- Parcels Provided Irrigation
- Potential Agriculture Parcels
- Potential Landscape Parcels
- WWTP Ponds and Buildings
- River
- Major Roads
- Local Streets

Proposed Pipeline by Diameter

- 12" and smaller
- 16" to 24"
- larger than 24"

Figure 6.2
ALTERNATIVE 1B
RECYCLED WATER MASTER PLAN
CITY OF UKIAH

Fig_6_2-Alternative_1B.mxd



Legend

- Parcels Provided Frost Protection and Irrigation
- Parcels Provided Irrigation
- Potential Agriculture Parcels
- Potential Landscape Parcels
- WWTP Ponds and Buildings
- River
- Major Roads
- Local Streets

Proposed Pipeline by Diameter

- 12" and smaller
- 16" to 24"
- larger than 24"

Figure 6.3
ALTERNATIVE 2
RECYCLED WATER MASTER PLAN
CITY OF UKIAH

Fig_6_3-Alternative_2.mxd

It should be noted that if the storage ponds were sized for the average annual frost protection demand of 0.5 af/ac (as discussed in Chapter 5) plus evaporation or other losses, and filled at the start of the frost season, the farmers could theoretically require no recharge during frost events. While it was assumed that this level of storage may be too large for most farmers, this strategy could potentially be used to provide frost protection to any farmers not supplied frost protection in any of the alternatives.

6.1.4 Alternative 3

Alternative 3 investigates the feasibility of supplying frost protection through centralized storage. In this alternative, a large centralized storage facility would be constructed at the WWTP. This reservoir would then feed the demands as needed to meet frost protection and some irrigation needs. This would allow instantaneous supply of demands much larger than the 4-mgd dry weather tertiary capacity. The main issue with this alternative is that the infrastructure required to convey instantaneous frost protection demands is very substantial.

A total of 54 parcels covering 891 acres would be supplied with irrigation in this alternative with an irrigation demand of 1,081 AFY. A total of 50 parcels, representing about 11 farmers and covering 837 acres would be supplied with frost protection water, with an estimated annual frost protection annual demand of 419 AFY.

The centralized storage at the Ukiah WWTP was assumed as a 200 af pond. Since this alternative includes centralized storage at the Ukiah WWTP, the infrastructure is sized to supply the full frost protection demand instantaneously to all farmers. Thus, this alternative includes about 6 miles of pipeline, with diameters ranging between 8 and 48 inches. Instantaneous demand supplied to farmers without storage during the frost event is estimated as 28,600 gpm, representing 489 acres of land provided frost protection. In addition, recycled water could be supplied between frost events to farmers with storage ponds. This would enable an additional instantaneous supply of about 20,200 gpm from farmer ponds, protecting another 348 acres. Accounting for the hours of frost protection required for each type of crop, the effective supply to the system from storage and the WWTP would be 21.8 mgd for each of the three days of a frost protection event.

As with Alternative 2, the limiting factor for this alternative regarding the number of parcels supplied with frost protection is the recharge time between frost events of both the centralized storage pond and the individual farmer ponds. While the limiting effect of this recharge time could be reduced by increasing the size of the storage, a larger storage pond was assumed not to be feasible within this study.

An additional benefit of this alternative is the large storage pond, in that the Ukiah WWTP could use the pond to increase its operational flexibility when discharge to the Russian River is limited.

This alternative would utilize 4 farmer owned storage ponds, totaling over 50 af in size (size for one is unknown). In addition, 35 parcels representing 7 farmers not having ponds, covering 489 acres of land, are provided frost protection during frost events.

Figure 6.4 illustrates the pipeline routing and properties served by Alternative 3. This alternative serves mainly agricultural needs and two small urban sites, Oak Manor Park and Oak Manor School.

6.1.5 Alternative 3B

Alternative 3B follows a similar alignment as Alternative 3, but extends the recycled water distributions system to supply irrigation to additional parcels. This alternative prioritizes supplying agricultural parcels with recycled water for irrigation. The benefits and issues are primarily the same for this alternative as with Alternative 3.

A total of 69 parcels representing about 11 farmers and 2 urban users covering a total of 1,210 acres would be supplied with irrigation in this alternative with an irrigation demand of 1,598 AFY. Substantially more irrigation water is available in this scenario as the centralized storage can be used for seasonal storage in the summer, when the Ukiah WWTP's capacity constrains the available irrigation water.

While slightly more acreage could be provided frost protection due to the additional existing or planned storage ponds that can be reached based on the irrigation driven pipeline alignment, the flow from the Ukiah WWTP is not sufficient to recharge the centralized storage pond in addition to the additional farmer storage ponds. Thus, the frost protection acreage and demand are the same as Alternative 3. This alternative includes over 8 miles of pipeline, with diameters ranging between 8 and 48 inches.

Figure 6.5 illustrates the pipeline routing and properties served by Alternative 3B. This alternative serves mainly agricultural needs and three small urban sites. When compared with Alternative 3B, an additional urban site, the Ukiah Sports Complex, can be supplied with recycled water since the pipeline extends further north in Alternative 3B.

6.1.6 Alternative 4

Alternative 4 was developed following input from the community at the second Stakeholder Workshop. This alternative is intended to supply a combined set of agricultural and urban landscape irrigation demands. The alignment is routed to the northeast, then extends west to supply urban landscape irrigation demands at several City parks and schools.

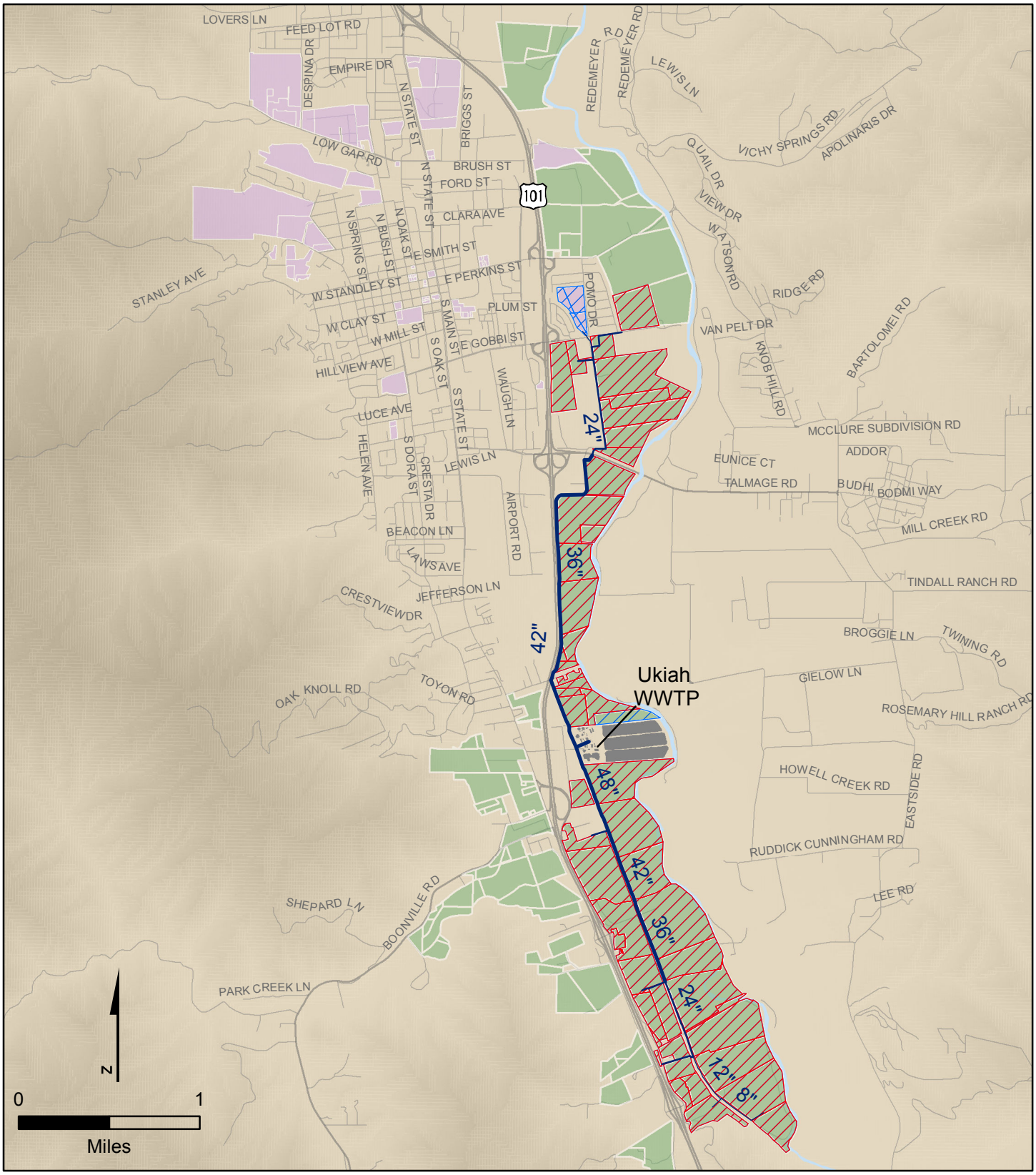
A total of 60 parcels covering 703 acres would be supplied with irrigation in this alternative with an irrigation demand of 1,234 AFY. About 284 acres would be supplied with frost protection water, with an estimated annual frost protection demand of 142 AFY. This alternative includes 9 miles of pipeline, with diameters ranging between 8 and 16 inches.

This alternative would utilize 2 farmer based storage ponds, totaling approximately 75 af in size. In addition, 9 parcels representing 3 farmers not having ponds, covering 50 acres of land, are provided frost protection during frost events.

Figure 6.6 illustrates the pipeline routing and properties served by Alternative 4.

Table 6.1 Alternative Parameter Summary
Recycled Water Master Plan
City of Ukiah

Parameter	Alternative 1	Alternative 1B	Alternative 2	Alternative 3	Alternative 3B	Alternative 4
Irrigation Demand (AFY)	830	1,027	699	1,081	1,598	1,234
Irrigated Area Served[1] (Acres)	793	915	619	891	1,210	703
Parcels Provided Irrigation (Number)	68	75	37	54	69	60
Frost Protection Demand (AFY)	242	242	247	419	419	142
Frost Protected Land (Acres)	483	483	494	837	837	284
Parcels Provided Frost Protection (Number)	35	35	35	50	50	17
Pipeline (Miles)	5.8	7.3	3.9	6.0	8.4	9.4
Diameter (Inches)	8 – 16	8 – 16	8 – 16	8 – 48	8 – 48	8 – 16
Pump Stations (Number)	1	1	1	1	1	1



Legend

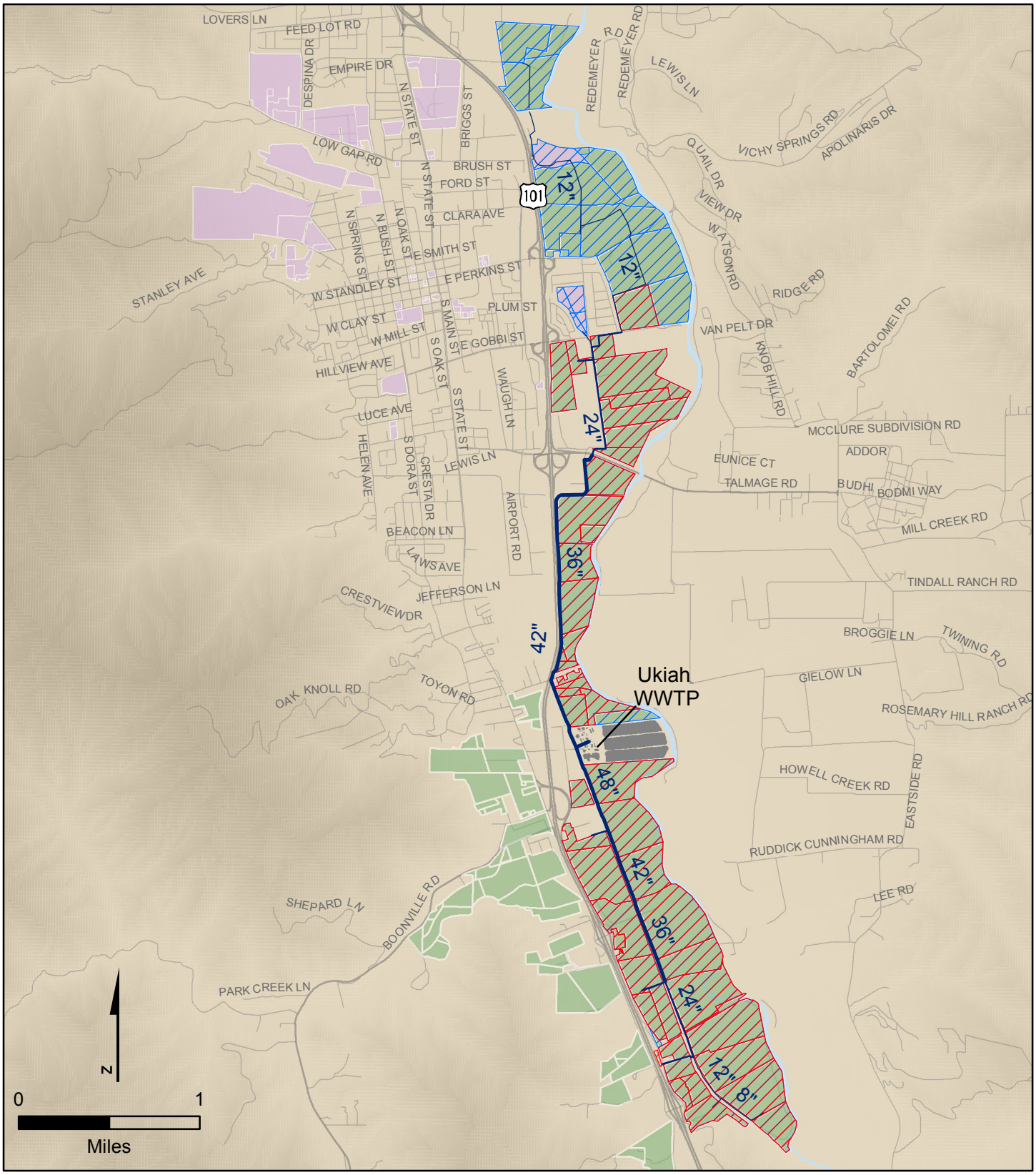
- Parcels Provided Frost Protection and Irrigation
- Parcels Provided Irrigation
- Potential Agriculture Parcels
- Potential Landscape Parcels
- WWTP Ponds and Buildings
- River
- Major Roads
- Local Streets

Proposed Pipeline by Diameter

- 12" and smaller
- 16" to 24"
- larger than 24"

Figure 6.4
ALTERNATIVE 3
RECYCLED WATER MASTER PLAN
CITY OF UKIAH

Fig_6_4-Alternative_3.mxd



Legend

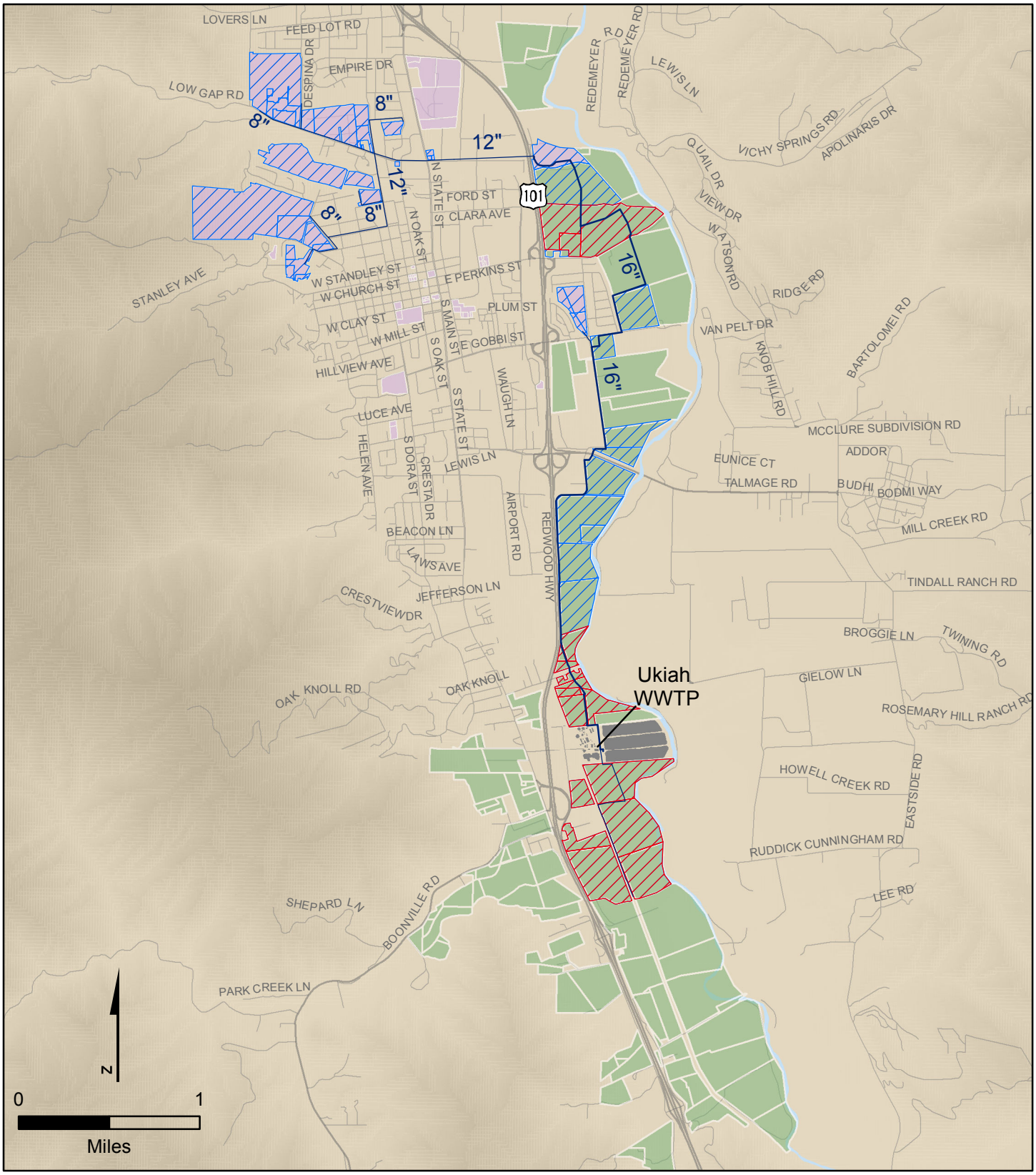
- Parcels Provided Frost Protection and Irrigation
- Parcels Provided Irrigation
- Potential Agriculture Parcels
- Potential Landscape Parcels
- WWTP Ponds and Buildings
- River
- Major Roads
- Local Streets

Proposed Pipeline by Diameter

- 12" and smaller
- 16" to 24"
- larger than 24"

Figure 6.5
ALTERNATIVE 3B
RECYCLED WATER MASTER PLAN
CITY OF UKIAH

Fig_6_5-Alternative_3B.mxd



Legend

- Parcels Provided Frost Protection and Irrigation
- Parcels Provided Irrigation
- Potential Agriculture Parcels
- Potential Landscape Parcels
- WWTP Ponds and Buildings
- River
- Major Roads
- Local Streets

Proposed Pipeline by Diameter

- 12" and smaller
- 16" to 24"
- larger than 24"

Figure 6.6
ALTERNATIVE 4
RECYCLED WATER MASTER PLAN
CITY OF UKIAH

Fig_6_6-Alternative_4.mxd

6.2 PLANNING LEVEL COST ESTIMATES

Planning level cost estimates were developed for each of the alternatives discussed above. Assumptions regarding costs are discussed, followed by a presentation of the costs for each alternative.

6.2.1 Assumptions

Several assumptions were used in the development of cost estimates. Scope and anticipated range of accuracy are discussed, followed by a discussion of the markups and contingencies and a presentation of the unit costs used in this study.

6.2.1.1 Scope and Accuracy Range

The cost estimating criteria presented herein develop a consistent methodology for comparing alternatives. This methodology allows for different alternatives to be evaluated on the same cost basis.

Cost estimates presented in this master plan are based on the Engineering and News Record (ENR) San Francisco cost index of 10,199 published in October 2011. Future adjustments of cost estimates presented in this report can be estimated by increasing the estimated capital cost by the ratio of the future ENR to 10,199.

The cost estimates presented in the CIP have been prepared for general master planning purposes and for guidance in project evaluation and implementation. The actual costs of a project will depend on actual labor and material costs, competitive market conditions, final project scope, implementation schedule, and other variable factors such as preliminary alignment generation, detailed utility surveys, and environmental and local considerations.

The Association for the Advancement of Cost Engineering (AACE) defines an order-of-magnitude estimate for master plan studies as an approximate estimate made without detailed engineering data. It is normally expected that an estimate of this type would be accurate within +100 percent to -50 percent. This section presents the assumptions used in developing order of magnitude cost estimates for recommended facilities.

The AACE International defines five different class estimate categories as summarized in Table 6.2.

The budgeting level estimates needed for planning purposes and CIPs are usually based on Class 5, and as such, the costs developed in this master plan shall be considered Class 5 estimates, unless noted otherwise. A definition of the Class 5 estimate is described below.

Table 6.2	Class Estimates Recycled Water Master Plan City of Ukiah		
		Accuracy Range	
Class	**Status of Design**	**Low Side**	**High Side**
5	N/A	-20% to -50%	+30% to +100%
4	1% to 5%	-15% to -30%	+20% to +50%
3	10% to 40%	-10% to -20%	+10% to +30%
2	30% to 70%	-5% to -15%	+5% to +20%
1	80% to 110%	-3% to -10%	+3% to +15%
5	Rough Order-of-Magnitude Planning Estimate		
4	Detailed Planning Level Estimate		
3	Project Budget Estimate		
2	Detailed Project Control Estimate		
1	Bid Check Estimate		

Note:
Percentages are based on the construction cost value and not on an incremental subtotal after each percentage category

Class 5. This estimate is considered as rough order-of-magnitude estimate. It is usually prepared based on limited information, where little more than proposed facility type, its location, and the capacity are known. Strategic planning purposes include, but are not limited to, market studies, assessment of viability, evaluation of alternate schemes, project screening, location, and evaluation of resource needs and budgeting, and long-range capital planning. Examples of estimating methods used would be cost/capacity curves and factors, scale-up factors, and parametric and modeling techniques. Little time is expended in the development of this estimate. The typical expected accuracy range for this class estimate is -20 to -50 percent on the low side and +30 to +100 percent on the high side.

All classes of cost estimates described, and any resulting conclusions on project financial or economic feasibility or funding requirements, are prepared for guidance in project evaluation and implementation. The final costs of the project, and resulting feasibility, will depend on actual labor and material costs, competitive market conditions, actual site conditions, final project scope, implementation schedule, continuity of personnel and engineering, and other variable factors. Therefore, the final project costs will vary from the estimate developed using the information in this master plan. Because of these factors, project feasibility, cost-benefit ratios, risks, and funding needs must be carefully reviewed prior to making specific financial decisions or establishing project budgets to help ensure proper project evaluation and adequate funding.

This evaluation is concerned only with estimates at the planning and conceptual phase of the projects for the City. Therefore, only Class 5 estimates have been developed. For the development of the project costs, a construction cost contingency, estimating contingency, and other markups will be applied consistent with Table 6.3. The markups are intended to account for costs of engineering, design, administration, and legal efforts associated with implementing the project. It should be noted that construction contingency, estimating contingency, and markups are applied incrementally; that is, the percentage for each component is applied to the previous subtotal.

Table 6.3 General Cost Estimating Assumptions
Recycled Water Master Plan
City of Ukiah

Description	Percent of Construction Cost[1]
Construction Cost	100.0%
Construction Cost Contingency	20.0%
Subtotal: Construction Cost + Construction Contingency	**120.0%**
Estimating Contingency	20.0%
Subtotal of Estimating Contingency	20.0%
Subtotal w/ Estimating Contingency[2]	**144.0%**
Engineering and Design	21.0%
Project Administration	5.0%
Legal	5.0%
Subtotal of Total Markups	31.0%
Total Project Cost	**188.6%**

Note:
(1) Percentages are based on the construction cost value and an incremental subtotal after each category for contingencies and total markup cost. Total Project Cost = Construction Cost x (1 + (Construction Cost Contingency x Estimating Contingency)) x (1 + Total Markups).
(2) Estimating Contingency multiplied by Subtotal of Construction Cost plus Construction Contingency.

6.2.1.2 Markups and Contingency

The cost estimates are based on current perceptions of conditions at the project locations. These estimates reflect Carollo's professional opinion of costs at this time and are subject to change as the project details are defined. Carollo has no control over variances in the cost of labor, materials, equipment, services provided by others, contractor's methods of determining prices, competitive bidding, or market conditions, practices, or bidding strategies. Carollo cannot, and does not, warrant or guarantee that proposals, bids, or actual construction costs will not vary for the costs presented as shown.

6.2.1.3 Unit Construction Costs

The construction cost estimates presented in this report are based on the unit construction costs listed in Table 6.4. Construction costs for recycled water system pipelines include pipe material, valves, appurtenances, excavation, installation, bedding material, backfill material, transport, and paving where applicable. The costs of acquiring easements for pipeline construction are not included in the estimates presented in this report.

For booster pumping stations (PS), unit costs are included based on the required horsepower assuming the project involves a new PS requiring new piping and all associated appurtenances. If a PS project only requires the replacement or addition of a pump to an existing PS, the unit costs will be evaluated on a per site basis at that time. Unit costs for PSs are estimated per horsepower of design size.

6.2.1.4 Excluded Costs

There are several other components that may be needed to support the development of major water supply facilities. Since most of these items are unique and project specific, they should be applied on a project-by-project basis. Therefore, no unit costs were included in Table 6.4 for the following items:

- **Land acquisition.** Cost for purchasing land or right of way are not included due to variability of real estate market conditions.
- **Power transmission lines.** The cost of these to support a major pumping or treatment is often on a shared cost basis with the power utility.
- **Maintenance roads.** If pipelines are installed in remote areas, maintenance roads are sometimes required to access the facilities.
- **Overall program management.** If the sheer magnitude of the capital cost program exceeds the capacity of City of Ukiah staff to manage all of the work, then the services of a program management team may be required.
- **Public information program.** Depending on the relative public acceptability of a major water facility or a group of facilities, there may be a need for a public information program, which could take many different shapes.
- **Customer retrofits.** Retrofit costs are associated with separating the customer's existing potable water system from a new recycled water system. An example would be a park where restroom and drinking fountain water supply pipes would need to be isolated from an existing irrigation system. Additional costs include posting signage, which identifies where recycled water is being used. Customer retrofits are one-time costs and are dependent upon the complexity of existing irrigation systems at each individual site. This cost estimate excludes cost of customer retrofits.

Table 6.4 Unit Construction Cost Recycled Water Master Plan City of Ukiah	
Category	**Unit Construction Cost**
Pipelines – Paved Streets	**$/lineal ft**
8-inch diameter	136
12-inch diameter	204
16-inch diameter	272
20-inch diameter	340
24-inch diameter	408
30-inch diameter	510
36-inch diameter	612
42-inch diameter	714
48-inch diameter	816
54-inch diameter	918
60-inch diameter	1,020
72-inch diameter	1,224
Pipelines – Unpaved Easements (Agricultural Land, Site Piping)	**$/lineal ft**
8-inch diameter	109
12-inch diameter	163
16-inch diameter	218
20-inch diameter	272
24-inch diameter	326
30-inch diameter	408
36-inch diameter	490
42-inch diameter	571
48-inch diameter	653
54-inch diameter	734
60-inch diameter	816
72-inch diameter	979
Special Pipeline Construction	**Markup (%) or $/lineal ft**
Jack and Bore	$1,200 /lineal ft
Booster Pumping Stations – New Construction	**$/hp**
Less than 100 hp	9,800
100 to 500 hp	7,400
500 to 3,000 hp	6,400
3,000 to 5,000 hp	3,100
Greater than 5,000 hp	3,000
Storage	**$/gallon**
Pond	$0.10
Steel Tank	$0.70

- **Foundation requirements.** Foundation reinforcement or support requirements are very site specific with regard to necessary method and type, and a geotechnical study is typically needed to determine such requirements. These costs, therefore, have not been included in any of the unit cost curves.
- **Other costs.** These costs may be necessary on some projects and could include environmental mitigation and permitting costs; special legal, administrative, or financial assistance; easements or rights-of-way and land acquisition costs; and expediting costs, such as separate material procurement contracts. These *other* costs typically range from 5 to 15 percent of construction cost.

6.2.2 Cost Estimates for Alternatives

Preliminary capital cost estimates for each of the alternatives discussed in Section 6.1 were developed for relative comparison between the alternatives. Components included in the cost estimates for each alternative include pipelines, storage provided by the City, and pump stations. The sizing of the components is presented in Table 6.5.

Table 6.5 Summary of Project Components
Recycled Water Master Plan
City of Ukiah

Alternative	Irrigation Acreage	Frost Protection Acreage	Pipeline Length (mi.)	Pump Station (hp)	Storage Pond(1) (MG)
1	793	483	5.8	150	0.65
1B	915	483	7.3	150	0.65
2	619	494	3.9	75	1.60
3	891	837	6.0	1,400	200.00
3B	1,210	837	8.4	1,400	200.00
4	703	284	9.4	400	1.60

Note:

(1) Costs for farmer provided storage were not included in this analysis. While all alternatives utilize farmer provided storage, Alternative 2 relies the most heavily on farmer provided storage. Based on discussions during the Stakeholder Workshops, farmers may be able to construct frost protection storage ponds more economically than the unit costs used within this study. However, it is important to recognize this unseen cost. For Alternative 2, based on the unit costs used in this study of $0.10 per gallon, the estimated project cost for the 58.8 af of farmer provided storage would be $3.6 M.

Preliminary cost estimates for capital costs for each alternative are presented in Table 6.6. Cost estimates do not account for operations and maintenance costs. Some operations and maintenance costs will be included in the financial analysis of the recommended alternative in Chapter 8.

Table 6.6	Preliminary Cost Estimates Recycled Water Master Plan City of Ukiah			
Alternative	**Capital Cost ($M)**	**Annual Demand[1] (AFY)**	**Annual Cost[2] ($ per year)**	**Estimated Unit Cost[1] ($ per AF)**
1	$10.3	1,071	$680,000	$635
1B	$12.3	1,268	$810,000	$639
2	$8.0	946	$530,000	$560
3	$58.4	1,499	$3,800,000	$2,535
3B	$67.0	2,017	$4,360,000	$2,162
4	$25.3	1,376	$1,650,000	$1,199

Notes:
(1) Annual demand is based on the combined demand of landscape irrigation, agricultural irrigation, and frost protection. It should be noted that the value associated with the frost protection demand is whether or not frost protection is provided rather than the quantity of actual demand.
(2) Amortization assumes interest rate of 6% and 30-year payback period.

Capital costs were amortized to compare the relative advantages on a unit cost basis assuming an interest rate of 6 percent and a payback period of 30 years. It should be noted that, although the frost protection demand is included in the annual demands used to develop the unit costs, the unit costs do not reflect the value of frost protection, as whether or not frost protection is provided is much more critical than the actual quantity of frost protection demand supplied.

As shown in Table 6.6, Alternative 2 is the least costly, on both a capital and unit cost basis. However, the cost to the individual farmers of on-site storage is not included in this estimate. Alternative 1 and 1B are the next least expensive on both a capital and unit cost basis. The additional pipeline length included in Alternative 1B is offset by the increase in demand, making the two alternatives comparable on a unit cost basis. Alternative 3 and 3B are predicted to be the most expensive, with unit costs exceeding $2,000 per af. Estimated costs for Alternative 4 fall between the centralized storage costs and the lower cost alternatives. Detailed cost estimates are included in Appendix C.

6.3 PLANNING AND DESIGN ASSUMPTIONS

The alternatives for the City's recycled water system are planned based on the project flows and planning and design criteria defined in this chapter. The developed criteria addressed the recycled water system capacity, pipe roughness, maximum velocity, minimum velocity, maximum headloss, and demand factors.

Demand factors and other customer specific factors were discussed in detail in Chapter 5, and will only be summarized here.

The planning and design criteria are presented in Table 6.7. A discussion of several of these criteria follows.

Table 6.7 Planning and Design Criteria
Recycled Water Master Plan
City of Ukiah

Description	Criteria
Delivery Pressure – Agricultural Irrigation	20 psi
Delivery Pressure – Landscape Irrigation	40 psi
Minimum System Pressure	5 psi
Maximum Pipeline Velocity(1)	5 ft/sec
Maximum Pipeline Headloss (Diameter <= 12-inches)	10 ft/1,000 ft (ft/kft)
Maximum Pipeline Headloss (Diameter > 12-inches)	3 ft/kft(2)
Pipeline Roughness (C Factor)	130
Seasonal Peaking for Irrigation	1.00
Agricultural Irrigation Schedule	Continuous
Landscaping Irrigation Schedule	6 pm to 5 am (Continuous)
Customers with Storage Frost Protection Schedule	Recharge for 16 hours a day for 3 days, then continuous for 7 days
Customers without Storage Frost Protection Schedule	8 hours a day for 3 days

Notes:
(1) A higher pipeline velocity criteria of 10 ft/sec was used to accommodate the significant frost protection demands. A pipeline velocity criteria of 5 ft/sec was used for irrigation scenarios.
(2) Under frost protection scenarios, headloss of up to 5 ft/kft was considered acceptable in pipelines over 12-inches in diameter.

6.3.1 Supply Availability

As discussed in Chapter 3, the projected wastewater available for use as recycled water is projected to grow by about 550 AFY over the next 25 years. The wastewater flow varies seasonally, with minimum flows occurring during the summer months. Since the minimum flow coincides with peak irrigation demands (due to evapotranspiration, as discussed in Chapter 5), the irrigation demands supplied by the recycled water system will be limited by the available flow during summer months. Table 6.8 presents projected available supplies for both average annual and August conditions.

Table 6.8	Projected Wastewater Flow Recycled Water Master Plan City of Ukiah				
	Average Annual Wastewater Flow		Projected August Flow[1]	Ukiah WWTP Demand	Available Recycled Water Supply[2]
Year	(AFY)	(mgd)	(mgd)	(mgd)	(mgd)
2010	4,650	4.15	1.99	0.14	1.85
2015	4,650	4.15	2.25	0.16	2.09
2020	4,780	4.27	2.31	0.16	2.15
2025	4,910	4.39	2.38	0.17	2.21
2030	5,060	4.51	2.45	0.17	2.28
2035	5,200	4.65	2.52	0.18	2.34

Notes:

(1) Predicted minimum monthly flow based on the month of August, the minimum month for the period 2001 through 2010. Average seasonal flow pattern for August when compared with average flows was 0.54. Actual flow for the month of September 2010, the minimum flow month for 2010, was 1.99 mgd.

(2) During month of August (predicted to have the minimum available wastewater flow).

As discussed in Chapter 3, the Ukiah WWTP is the only existing recycled water user. Based on discussions with City staff, annual usage by the Ukiah WWTP is estimated at 323 AFY or about 0.3 mgd. Assuming the demand of the treatment plant varies according to the plant flow, the projected August flow is included in Table 6.8 and deducted from the plant flow in order to calculate the available supply.

As shown in Table 6.8, estimated available supply is projected to increase from 1.85 mgd to 2.34 mgd by 2035. The alternatives developed in this chapter will be constrained by this available recycled water supply.

6.3.2 Alignments

Routing of pipelines was assumed through agricultural land and along the railroad easement to minimize the cost associated with laying pipeline in paved streets. Pipelines routed within agricultural land were aligned to farmers' access paths from aerial photographs.

6.3.3 Seasonal Demand Variation

While irrigation is expected to vary by season, based on discussions with City staff, the farm bureau, and the RRFCD, irrigation demands are assumed to be relatively flat seasonally. This is believed to be partially due to the limited number of months for which irrigation is used. As discussed in Chapter 5, vineyards are typically irrigated between June

and October and Orchards are typically irrigated between May and September. When compared to irrigation occurring year round, the seasonal peaking during this irrigation season may appear relatively flat. Thus, a seasonal peaking factor of 1.0 will be used for development of the alternatives in this chapter. However, irrigation will be assumed to occur for only a limited number of months out of the year.

6.3.4 Daily Demand Variation

Based on discussions with City staff, the farm bureau, and the RRFCD, irrigation demands for agricultural crops vary significantly by crop type and individual farmer. It was noted that farmers would most likely be accustom to irrigating for a few days continuously every couple weeks. For the purposes of developing alternatives, the assumption was made that agricultural irrigation would be continuous and relatively flat, with no hourly fluctuation.

Demands for urban landscape irrigation are assumed to occur between 6 p.m. and 5 a.m. It is assumed that demand will be evenly distributed over this period. It should be noted that if irrigation is concentrated simultaneously within a couple hours, the sizing of the distribution system would need to be increased. This can be averted by staggering the scheduling of irrigation timers, especially those within the City's control, such as those for City parks. Based on discussions with City staff, potential urban landscape irrigation users, such as the golf course, do not have on-site storage capabilities, and thus could not accept water during daytime hours (golf courses often can use on-site ponds to accept irrigation water during off-peak hours, reducing the required sizing of the recycled water distribution system).

6.3.5 Frost Protection Demands

As discussed in Section 6.1, the limiting factor for many of the alternatives is the plant flow and corresponding recharge time for replenishing storage, whether farmer provided storage or centralized storage. As discussed in Chapter 5, typical frost event durations are estimated as three days, with two frost events occurring during a typical peak month of the frost season. It is assumed that the two frost events occurring during a typical month occur at least one week apart, allowing time for the plant to recharge the applicable storage. While some frost events in a worst case scenario are anticipated to occur for more than three consecutive days, or occur less than a week apart, sizing of the storage for such events is anticipated to be prohibitively expensive or reach too few farmers to be justified.

6.4 NO PROJECT ALTERNATIVE

Since this project has multiple beneficiaries, the effect of a "No-Project" Alternative is discussed separately for each. The beneficiaries for the various alternatives in this study include the wastewater users (since Ukiah WWTP is restricted from discharging to the Russian River during specific times), agricultural farmers (for frost protection and irrigation), and landscape irrigation users (as a lower cost alternative to potable water).

For the wastewater users, a “No-Project” Alternative would necessitate the Ukiah WWTP to build additional percolation ponds to accommodate effluent flow during periods in which discharge is restricted.

For agricultural farmers, based on recent developments regarding restrictions on use of water from the Russian River for frost protection, without recycled water as an alternative source for water for frost protection demands, agricultural parcels in the area may not be provided frost protection using water. The farmers are outside of the City service area to receive potable water supplied by the City, and the City currently has no plans to expand their service area in order to serve them. And it is highly unlikely any of the other water purveyors in the area have additional supplies to serve the farmers. It is anticipated that potable or groundwater sources for frost protection water would be economically unfeasible. While not evaluated within the scope of this study, without water for frost protection, agricultural farmers may be forced to utilize alternative methods of frost protection, such as heaters or wind machines (Snyder, 2001), which may not be economically viable or feasible due to the type of frost situations the Valley is accustomed to. Effects of the “No-Project” Alternative on farmer irrigation use is assumed to be minimal.

For landscape irrigation uses, effects of the “No-Project” Alternative include continuing to use potable water for landscape irrigation at potable water rates. It is not anticipated that the City will face shortages of water supplies within the planning horizon of this study.

6.5 COMPARISON OF ALTERNATIVES

The six alternatives were compared on their technical and non-technical merits.

Screening criteria were developed at the Visioning Workshop held at the beginning of the master planning process. Both quantitative and qualitative criteria were used to compare and rank the alternatives. A summary of the criteria is show in Table 6.9.

The quantitative parameters were straightforward in their ranking. As shown in Table 6.10, Alternatives 1B and 4 rank best in the quantitative scoring, while Alternative 3 ranks worst.

Table 6.11 presents the comparison of alternatives on a qualitative basis, with the associated scoring results in Table 6.12. For the qualitative parameters, a description was provided and then a general ranking of minimum, moderate, or maximum was provided depending on how the alternative met the criteria relative to the other alternatives. A discussion of the specific qualitative rankings and scores follows.

A matrix showing the quantitative scoring was developed and is presented in Table 6.10.

As shown in Table 6.12, Alternatives 1 and 1B have the lowest qualitative scores, while Alternatives 3B and 4 have the highest qualitative scores. Overall scores are presented in Table 6.13.

Table 6.9 Screening Criteria
Recycled Water Master Plan
City of Ukiah

Criteria	Definition	Quantitative Measure	Qualitative Measure
Cost	Planning-level estimate of capital cost	$ and $/af	-
Water Offsets	Reduction in water use: - Potable* - River/groundwater*	AFY	-
System Flexibility	Variety and quantity of benefits and uses	Ac (irrigation) and Ac (frost)	-
Implementation Considerations	Political will, project phasing, and timing	-	Description
Public Acceptance	Public support of project (aesthetics and social benefits)	-	Description
Funding	State and Federal funding	-	Description
Environmental Considerations	Improves environment, CEQA requirements	-	Description
Regulatory Implications	Meets regulatory requirements	-	Description

Table 6.10 Quantitative Scoring
Recycled Water Master Plan
City of Ukiah

	System Flexibility		Water Offsets		Costs		
Alternative	Irrigated Area	Frost Protected Area	Potable	River or GW	Capital	Unit	Overall Quantitative Score
1	1.7	2.1	5.0	2.3	0.8	1.2	13.0
1B	1.2	2.1	5.0	1.8	0.9	1.2	12.0
2	2.4	2.1	5.0	2.6	0.6	1.1	14.0
3	1.3	0.0	4.5	1.3	4.4	5.0	16.0
3B	0.0	0.0	4.0	0.0	5.0	4.3	13.0
4	2.1	3.3	0.0	2.0	1.9	2.4	12.0

Note:
(1) Scores are weighted based on the relative quantities for each criteria. A score of 0 meets the criteria best of the alternatives, while a score of 5 meets the criteria worst out of the alternatives.

Table 6.11 Qualitative Comparison
Recycled Water Master Plan
City of Ukiah

Alternative	Difficulty of Implementation	Public Acceptance	Funding	Environmental Considerations	Regulatory Impacts
1	Min	Max	Mod	Min	Min
1B	Min-Mod	Max	Mod	Min	Min
2	Max	Max	Max	Mod	Mod
3	Mod	Max	Min	Max	Mod
3B	Mod	Max	Min	Max	Mod
4	Mod-Max	Max	Mod	Min	Mod

Note:
(1) Assessment based on discussion above. Min = minimal, Mod = moderate, Max = maximal.

Table 6.12 Qualitative Scoring
Recycled Water Master Plan
City of Ukiah

Alternative	Ease of Implementation	Public Acceptance	Funding	Environmental Considerations	Regulatory Impacts	Overall Score
1	1	1	3	1	1	**7**
1B	2	1	3	1	1	**8**
2	5	1	1	3	5	**15**
3	3	1	5	5	3	**17**
3B	3	1	5	5	3	**17**
4	4	1	3	1	3	**12**

Table 6.13 Total Scoring
Recycled Water Master Plan
City of Ukiah

Alternative	Quantitative Score	Qualitative Score	Overall Score	Rank
1	14	7	21	1
1B	13	8	21	1
2	14	15	29	4
3	17	17	34	6
3B	14	17	31	5
4	12	12	24	2

6.5.1 Difficulty of Implementation

Difficulty of implementation accounts for difficulty of design and construction, as well as effort required to coordinate construction and implementation between parties.

Alternative 1 was ranked minimal, meaning that relative to the other alternatives, Alternative 1 represents the least effort with implementation, due to its smaller footprint. Alternative 1B requires slightly more effort to implement, due to increased length of pipeline. Alternatives 3 and 3B were ranked as moderate difficulty to implement, since these projects would require extensive design and construction. Difficulty of implementation was scored moderate to maximal for Alternative 4, due to construction considerations in the urban areas and coordination between agricultural and landscape irrigation. Alternative 2 was considered to have the least ease of implementation due to the necessity of individual farmers constructing their own individual storage.

6.5.2 Public Acceptance

Since each of the alternatives assists with providing a point of discharge while the wastewater discharge limitations are in effect and helps to preserve agricultural character of the City and Valley, all alternatives were scored maximal.

6.5.3 Funding

Assessment of funding was based on the anticipated ease of obtaining funding for the alternative. Alternative 2 was considered to have the least difficulty with funding, as some grants are available to individual farmers for construction of ponds. Alternatives 3 and 3B are ranked minimal since they have the greatest cost, and are anticipated to have the greatest difficulty with financing out of the alternatives.

6.5.4 Environmental Considerations

Alternatives 1 and 1B are anticipated to encounter the least environmental issues when compared to the other alternatives. Alternatives 3 and 3B include construction of a 200 af pond, with associated environmental considerations, and were thus ranked maximal.

6.5.5 Regulatory Impacts

Because of their smaller footprint, Alternatives 1 and 1B are anticipated to have the least difficulty with regulatory impacts out of the alternatives. The remaining alternatives are anticipated to have fairly similar regulatory impacts.

6.5.6 Qualitative Scoring

Based on the qualitative issues described, scores were assigned to each alternative, as presented in Table 6.12.

6.5.7 Overall Scoring

The combined scoring, incorporating both the quantitative and qualitative scores, is presented in Table 6.13. As shown in Table 6.13, Alternatives 1 and 1B rank the best out of the alternatives, while Alternatives 3 and 3B ranked the least favorable. Alternative 4 ranked just after Alternatives 1 and 1B.

6.5.8 Recommended Alternative

The preferred alternative was selected using the screening and ranking outcome as a basis, but also considered relative importance of each criteria. During the ranking process, each criteria was considered to be equal and hold the same level of importance as the others. This however, was not the case when a bigger picture view was considered, such as the importance of off setting potable water demands. Alternatives 1 and 1B met most of the screening criteria the best, but did not contain any potable water offsets. Alternative 2 had the most implementation concerns and regulatory concerns as its success relies on the farmers developing storage. Alternatives 3 and 3B were the least desirable with the highest costs, highest operations and maintenance due to the large pump station required, and very minimal potable water offsets. Alternative 4 had a relatively higher cost since it serves the most users, and also has the most potential for potable water offsets. Therefore, based on the ranking process and discussions with City staff, Alternative 4 was selected as the preferred alternative.

RECOMMENDED FACILITIES PROJECT PLAN

7.1 RECOMMENDED ALTERNATIVE

After reviewing the draft outcome of the projects screening and ranking, discussions with City staff, and a presentation to the City Council, it was decided to select Alternative 4 as the recommended recycled water project alternative for the City. This alternative is presented in Figure 7.1. This alternative combines agricultural frost protection and irrigation usage with urban landscape irrigation. The recycled water would be pumped from Ukiah Wastewater Treatment Plant (WWTP) to those landowners with storage, and would also be available up to the WWTP and pump station capacity to those landowners without storage facilities. Optimization in this analysis will be focused on further development of alternative details and phasing of the recommended alternative. This alternative is recommended because it provides a greater number of benefits, including the option for eventual urban landscape irrigation, at a lower cost than many of the other alternatives.

7.1.1 Preliminary Design

The design conditions and criteria for the recommended alternative are summarized in Table 7.1. The pipeline routing and potential customers and parcels served are discussed in the sections that follow.

7.1.1.1 Planning and Evaluation Criteria

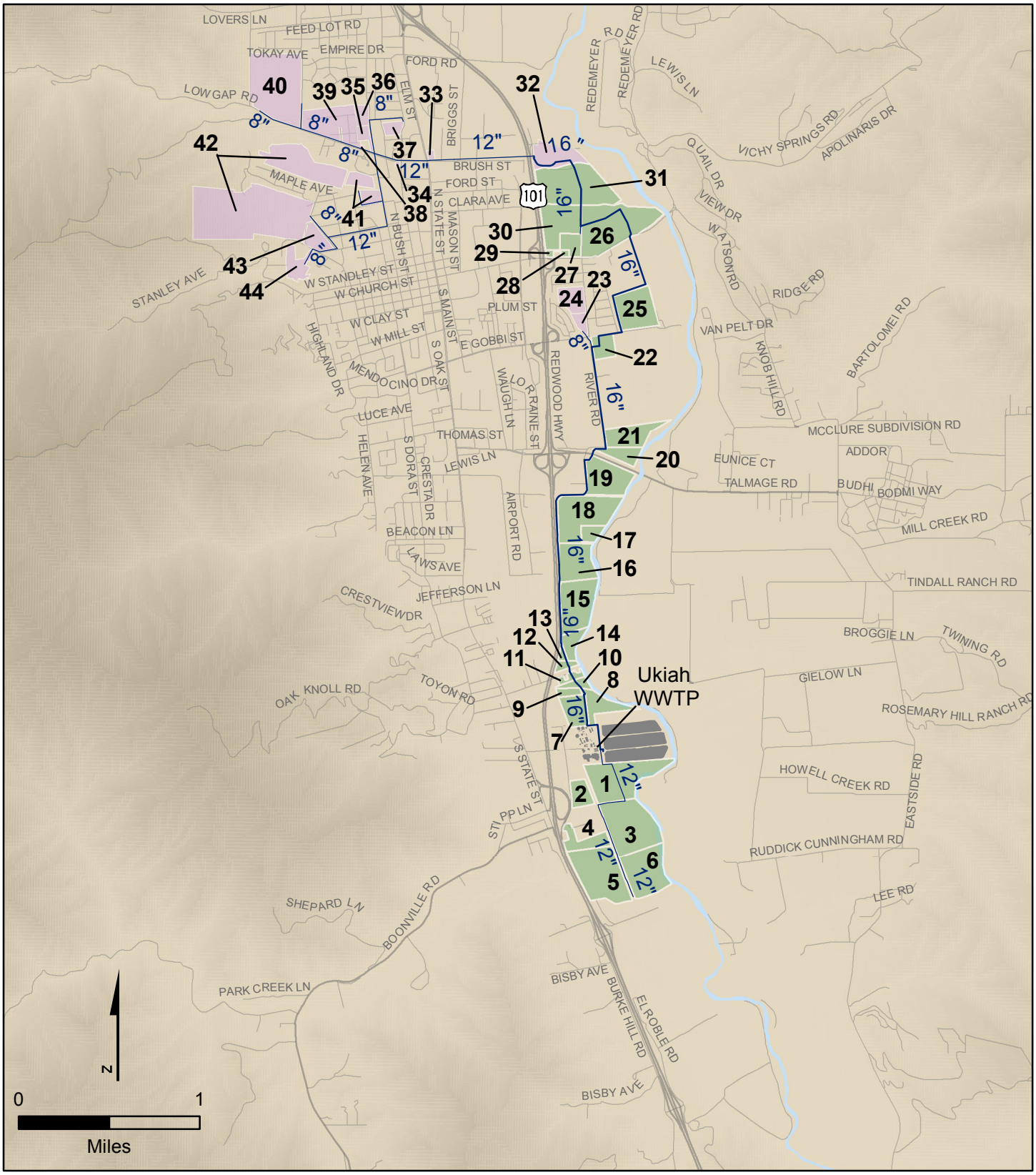
Planning and evaluation criteria were used to develop the preliminary design in the following sections. This criteria is listed in Table 7.1. In addition, the criteria discussed in Chapter 6 was used to develop demands.

Several of the criteria listed in Table 7.1 represent conservative planning assumptions. During more detailed design, and as the commitment of potential customers becomes more certain, these planning and evaluation criteria may be further refined.

As in the preliminary alternatives analysis, it is assumed that the individual potential customers are responsible for their customer laterals. It is also assumed that the farmer's are individually responsible for sizing of their frost protection ponds and pumping and pipelines from their ponds.

7.1.1.2 Pipeline Route

The proposed recycled water system includes 9.4 miles of recycled water pipelines ranging between 8 and 16-inches in diameter. The preliminary pipeline alignment for the recommended alternative is presented in Figure 7.1. In order to reduce construction costs, the pipeline is planned to be constructed partially within the right-of-way of some of the agricultural land that it provides frost protection to. Major transmission pipelines are routed



Legend

Proposed Pipeline by Diameter

- 12" and smaller
- 16" to 24"
- larger than 24"

- WWTP Ponds and Buildings
- Landscape Parcels
- Agricultural Parcels
- River
- Major Roads
- Local Streets

Figure 7.1
RECOMMENDED ALTERNATIVE
RECYCLED WATER MASTER PLAN
CITY OF UKIAH

Fig_7_1-Recommended_Alternative.mxd

Table 7.1 Planning and Evaluation Criteria Recycled Water Master Plan City of Ukiah	
Description	**Criteria**
Delivery Pressure – Agricultural Irrigation	20 psi
Delivery Pressure – Landscape Irrigation	40 psi
Minimum System Pressure	5 psi
Maximum Pipeline Velocity(1)	5 ft/sec
Maximum Pipeline Headloss (Diameter <= 12-inches)	10 ft/kft(1)
Maximum Pipeline Headloss (Diameter > 12-inches)	3 ft/kft(2)
Pipeline Roughness (C Factor)	130
Storage	5 af (1.6 MG) at Ukiah WWTP
Seasonal Peaking for Agricultural Irrigation	1.00
Seasonal Peaking for Landscape Irrigation	1.73
Agricultural Irrigation Schedule	Continuous
Landscaping Irrigation Schedule	6 pm to 5 am (Continuous)
Customers with Storage Frost Protection Schedule	Recharge for 16 hours a day for 3 days, then continuous for 7 days
Customers without Storage Frost Protection Schedule	8 hours a day for 3 days

Notes:
(1) A higher pipeline velocity criteria of 10 ft/sec was used to accommodate the significant frost protection demands. A pipeline velocity criteria of 5 ft/sec was used for irrigation scenarios.
(2) Under frost protection scenarios, headloss of up to 5 ft/kft was considered acceptable in pipelines over 12-inches in diameter.

north through the east part of the City along Hastings Road and through agricultural right of way. Assuming the optional urban landscape irrigation would be developed, Highway 101 would be crossed using trenchless construction techniques at Brush Street to serve urban landscape irrigation demands on the west side of the City.

A previous recycled water study evaluated the feasibility of a recycled water pipeline installed through the City downtown along State Street. At the time of that study, other utilities were being constructed along the State Street alignment, minimizing the disruption and cost associated with constructing a recycled water pipeline along that alignment. However, that route focused on offsetting urban irrigation, and did not maximize agricultural uses. The alignment shown in Figure 7.1 is routed to the east of the City to maximize the potential for agricultural benefit AND minimize costs associated with construction through the developed downtown area.

A summary of the pipeline lengths associated with the alignment shown in Figure 7.1 are presented in Table 7.2.

Table 7.2 Pipeline Length
Recycled Water Master Plan
City of Ukiah

Type of Alignment[1]	Diameter (in)	Length (ft)
Agricultural Land / Site Piping	16	14,500
Agricultural Land / Site Piping	12	6,000
Paved Public Street	16	9,600
Paved Public Street	12	8,600
Paved Public Street	8	10,900
	Total	**49,600**

Note:
(1) Laterals to individual agricultural parcels are assumed to be the responsibility of the farmer or landowner and are not included in the lengths presented here.

As shown in Table 7.2, a total of approximately 49,600 feet, or 9.4 miles, of pipeline is included in the alignment shown in Figure 7.1.

7.1.1.3 Potential Users

There are two categories of potential users, agricultural and landscape irrigation. Based on discussions with City staff, it is anticipated that the City will pursue a phased approach to implement the recommended recycled water system. Total estimated demand by phase and type is presented in Table 7.3. Table 7.4 lists the agricultural users by irrigable area, annual irrigation and frost protection demands, and instantaneous demand. Table 7.5 lists landscape irrigation demands by parcel, and includes the estimated instantaneous irrigation demand, annual irrigation demand, and name. The Map IDs in Table 7.4 and Table 7.5 correspond to Figure 7.2.

Table 7.3 Annual Demand Summary
Recycled Water Master Plan
City of Ukiah

	Estimated Annual Demand (afy)				
	Irrigation				
Phase	Agricultural	Urban Landscape	Frost Protection	Total for Phase	Cumulative Total
1	309.2	0.0	94.6	403.8	403.8
2	210.4	0.0	4.8	215.1	618.9
3	311.8	22.2	42.3	376.3	995.2
4	0.0	380.6	0.0	380.6	1,375.8
Total	**831.4**	**402.8**	**141.7**	**1,375.8**	

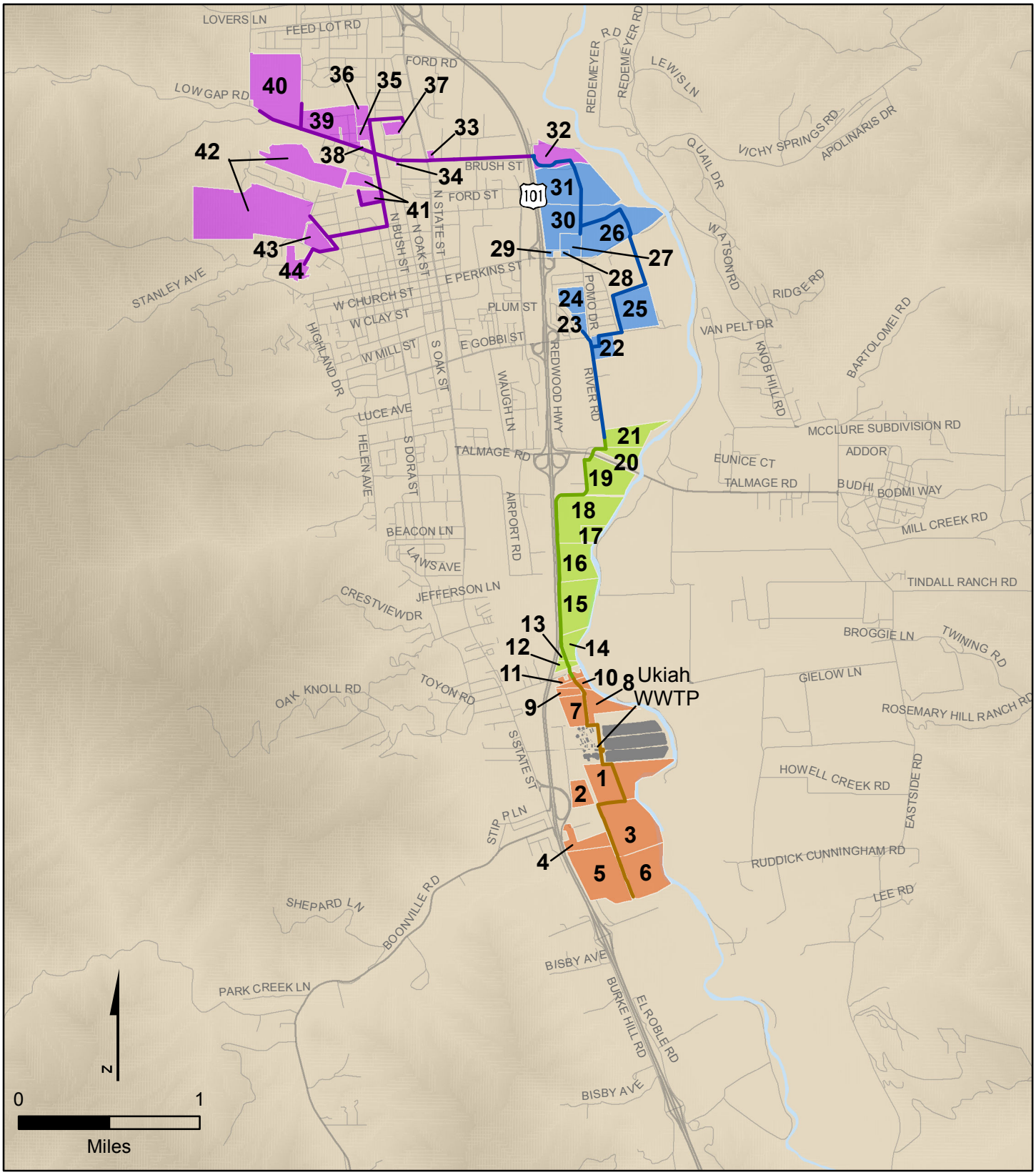
Table 7.4 Potential Agricultural Customers
Recycled Water Master Plan
City of Ukiah

Map ID	Name	Provided Irrigation Water	Provided Frost Protection	Storage Pond	Estimated Demand (afy)		Irrigable Acreage by Crop			
					Irrigation	Frost Protection	Vineyard	Orchard	Pasture	Other Row Crop
Phase 1										
1	Koball	Y	Y	Y	70.5	17.6	0.0	35.2	0.0	0.0
2	Gannon	Y	Y	N	18.5	4.6	0.0	9.2	0.0	0.0
3	Koball	Y	Y	Y	81.3	20.3	0.0	40.5	0.0	0.0
4	Milovina	Y	Y	Y	7.9	5.2	10.5	0.0	0.0	0.0
5	Milovina	Y	Y	Y	33.0	22.0	44.0	0.0	0.0	0.0
6	Koball	Y	Y	Y	57.0	14.2	0.0	28.4	0.0	0.0
7	City	Y	Y	N	10.3	6.9	13.8	0.0	0.0	0.0
8	Norgard	Y	Y	N	21.7	1.5	0.0	3.0	7.8	0.0
9	Norgard	Y	Y	N	4.4	1.5	2.0	0.9	0.6	0.0
10	Norgard	Y	Y	N	4.6	0.8	1.4	0.2	1.5	0.0
Phase 2										
11	Norgard	Y	Y	N	0.5	0.3	0.6	0.0	0.0	0.0
12	Norgard	Y	Y	N	2.0	1	1.5	0.5	0.0	0.0
13	Norgard	Y	Y	N	0.7	0.5	1.0	0.0	0.0	0.0
14	Norgard	Y	Y	N	12.1	3	0.0	6.0	0.0	0.0
15	Norgard	Y	N	N	54.4	0	0.0	27.1	0.0	0.0
16	Norgard	Y	N	N	43.4	0	0.0	21.6	0.0	0.0
17	Norgard	Y	N	N	10.2	0	0.0	5.1	0.0	0.0
18	Hildreth	Y	N	N	27.6	0	36.8	0.0	0.0	0.0
19	Hildreth	Y	N	N	48.4	0	0.0	24.1	0.0	0.0
20		Y	N	N	11.0	0	0.0	5.5	0.0	0.0
Phase 3										
21		Y	N	N	26.9	0	0.0	13.4	0.0	0.0
22		Y	N	N	4.5	0	6.1	0.0	0.0	0.0
25		Y	N	N	19.2	0	25.5	0.0	0.0	0.0
26		Y	Y	Y	98.9	24.7	0.0	49.3	0.0	0.0
27		Y	Y	Y	15.8	3.9	0.0	7.9	0.0	0.0
28		Y	N	Y	0.9	0	0.0	0.4	0.0	0.0
29		Y	N	N	2.2	0	0.0	1.1	0.0	0.0
30		Y	Y	Y	55.0	13.7	0.0	27.4	0.0	0.0
31		Y	N	N	88.4	0	0.0	44.1	0.0	0.0
Total					**831.4**	**141.7**	**143.3**	**351.2**	**9.9**	**0.00**

Table 7.5 Potential Landscape Irrigation Customers
Recycled Water Master Plan
City of Ukiah

Map ID	Name	Type	Irrigated Acreage	Estimated Annual Irrigation Demand[1] (afy)	Peak Demand[2] (gpm)	Current Potable Demand[3] (afy)
Phase 3						
23	Oak Manor Park	Park	3.4	6.9	27.9	10.4
24	Oak Manor School	School	7.5	15.3	61.2	9.6
Phase 4						
32	Ukiah Sports Complex[4]	Park	11.5	23.4	93.8	19.7
33	UUSD District Office	School	0.3	0.6	2.3	1.5
34	Brush Street Fountain	Park	0.3	0.7	2.8	
35	Ukiah Adult School	School	0.9	1.8	7.1	0.6
36	Frank Zeek School	School	3.5	7.0	28.1	2.3
37	Vinewood Park	Park	4.4	8.9	35.6	15.1
38	UUSD Special Education and Preschool	School	0.1	0.1	0.6	0.9
39	Russian River Cemetery	Other	26.6	53.9	216.3	18.5
40	Ukiah High School	School	39.6	80.4	322.4	62.4
41	Track and Baseball Fields (near Bus Barn)	Park	12.4	25.2	100.9	
42	City Golf Course	Golf Course	73.5	149.0	597.8	139.4
43	Todd Grove Park	Park	7.2	14.7	58.8	14.2
44	Anton Stadium	Park	7.4	14.9	59.9	12.8
Total			**198.6**	**402.7**	**1,615.4**	**307.4**

Notes:
(1) Based on irrigable acreage estimated from aerial photograph and water demand factors discussed in Chapter 5.
(2) Instantaneous demand based on seasonal peaking of 1.73, seven months of irrigation annually, and irrigation demands distributed evenly over 11 hours each night.
(3) Based on average usage from 2008 to 2010 billing data. Provided for reference; it should be noted that some potential customers, such as smaller schools, may not have dedicated irrigation meters, thus potential demand may be lower than that shown here.
(4) Ukiah Sports Complex is located at the north end of the pipeline proposed for Phase 3 and could be included in Phase 3 or Phase 4 depending on whether the City intends to implement Phase 4.



Legend

Pipelines by Phase	Potential Parcels by Phase	
1	1	WWTP Ponds and Buildings
2	2	River
3	3	Major Roads
4	4	Local Streets

Figure 7.2
PHASING OF
RECOMMENDED ALTERNATIVE
RECYCLED WATER MASTER PLAN
CITY OF UKIAH

Fig_7_2-Phasing_of_Recommended_Alternative.mxd

As shown in Table 7.4, the annual irrigation demand associated with irrigation of agricultural land for the recommended alternative is 831 acre-feet per year (AFY). Peak demand is estimated as 2,284 gpm based on flat seasonal peaking of irrigation demands and a 13-hour irrigation cycle in order to coordinate with the landscape irrigation schedule. If a 24-hour irrigation schedule were used, the peak demand is estimated at 1,237 gpm. Based on discussions with farmers, it is anticipated that scheduling of irrigation demands would be feasible.

As discussed in Chapter 6, an estimated supply of 2.34 mgd is projected to be available from the Ukiah WWTP during the month of August under 2035 conditions. Adding the landscape and agricultural irrigation demands results in peak seasonal demand of 2.85 mgd, anticipated to occur in July. By comparing the available monthly supply to the monthly demand variation (based on monthly irrigation requirements from evapotranspiration as discussed in Chapter 5), it is estimated that 18.6 MG (57 af) of seasonal storage would be required. In order to maximize the amount of irrigable land, it is anticipated that the City could coordinate irrigation of agricultural parcels with frost protection ponds to store irrigation water for their parcels in lieu of irrigation water from the distribution system for these peak periods. Alternatively, the City could construct a storage pond at the Ukiah WWTP to be used for seasonal irrigation storage, or fewer irrigation customers would need to be served.

It should be noted that the total number of customers listed in Table 7.4 and Table 7.5 differs slightly from the number of parcels listed in Alternative 4 in Chapter 6. Landscape irrigation customers with the same owner name for adjacent parcels were combined into a single customer, reducing the number from 60 parcels to 44 customers.

As shown in Table 7.5, the annual irrigation demand associated with landscape irrigation for the recommended alternative is 403 acre-feet per year (AFY). Peak demand for the landscape irrigation is estimated as 1,615 gpm, based on an assumed seasonal peaking factor of 1.73 and scheduling of landscape irrigation from 6 pm to 5 am. It should be noted that if demand management is not applied, landscape irrigation demands could be significantly higher (e.g., if City park sprinklers are set by timer to irrigate between 10 pm and 11 pm, demands would be significantly higher than if City park irrigation timer setpoints are evenly distributed between 6 pm and 5 am).

As will be discussed later, it is anticipated that landscape irrigation and agricultural demand schedules will be coordinated to maximize use of the pipeline network such that agricultural demands will be supplied between 5 am and 6 pm and landscape irrigation demands will be supplied between 6 pm and 5 am. If this coordination is not realized, additional storage may be required to buffer irrigation demands.

Instantaneous frost demand for the acreage provided frost protection would be estimated as 17,700 gpm. However, the majority of provided frost protection will be through farmer

provided frost protection storage ponds. Assuming recharge of farmer provided storage ponds during non-frost protection hours during the three days of a peak frost protection event and during a seven day recharge period between peak frost protection events is estimated as 520 gpm. Instantaneous frost protection demand for the parcels provided frost protection without storage ponds is estimated as 2,410 gpm. It should be noted that the sizing of individual farmer's frost protection ponds is assumed the responsibility of the individual agricultural parcel and was not evaluated as a part of this study.

Sizing of pipelines included in the pipeline alignment was based on the design criteria presented in Table 7.1. Pipeline length by phase, diameter, and construction condition is presented in Table 7.6.

Table 7.6 Pipeline Length by Phase
Recycled Water Master Plan
City of Ukiah

Phase	Type of Alignment[1]	Diameter (in)	Length (ft)
1	Ukiah WWTP Site Piping	16	1,300
1	Agricultural / Railroad Easements	12	5,600
2	Paved Street	16	5,600
2	Agricultural / Railroad Easements	16	4,200
3	Agricultural / Railroad Easements	16	9,000
3	Paved Street	16	4,000
3	Agricultural / Railroad Easements	12	400
3	Paved Street	8	1,000
4	Paved Street	12	4,700
4	Paved Street	8	13,800
Total			**49,600**

Note:
(1) Laterals to individual agricultural parcels are assumed to be the responsibility of the farmer or landowner and are not included in the lengths presented here.

As shown in Table 7.6, pipelines installed in the first phase are anticipated to be entirely within the treatment plant or along agricultural or railroad easements and would not be along paved roads. Phases 2 and 3 would be along both agricultural easements where possible, or along paved roads, primarily River Road, Babcock Lane, and Hastings Frontage Road. Pipelines installed as a part of the optional Phase 4 would be along paved streets, and are routed to enter the urban area from the east to minimize the total length of pipeline along paved streets.

7.1.1.4 Pump Station

A single pump station is included in the alignment shown in Figure 7.1 at the Ukiah WWTP. Recommended sizing for this pump station based on the criteria outlined in Table 7.1 is presented in Table 7.7.

Table 7.7 Pump Station Units by Phase
Recycled Water Master Plan
City of Ukiah

Phase	New Units	Elevation Served (ft-msl)	Head (ft)	Flow (gpm)	Power (hp)
1	2	560 - 580	310	800	200
2	2	580 - 590	310	800	200
3	-	600 - 610	-	-	-
4	-	610 - 710	-	-	-

Initially, it is planned that two pump units be installed in the pump station, with spare bays for two additional units, which would be installed in Phase 2. Phase 3 and 4 are not anticipated to require additional pump units, since the demands for frost protection are significantly higher than what would be required for urban landscape irrigation.

It should be noted that the recommended pump sizing is based on ultimately serving the urban uses in Phase 4, which are about 100 feet higher in elevation than the potential agricultural parcels. If only Phases 1 through 3 are implemented, the pump head could be reduced. Alternatively, a smaller booster pumping station could be implemented along with Phase 4 near the freeway crossing.

The elevation at the Ukiah WWTP is approximately 580 feet above mean seal level (ft-msl).

7.1.1.5 Storage

Storage is anticipated to include individual storage ponds at specific farmers, as well as a single storage pond at the wastewater treatment plant sized at 5 af (1.6 MG). The storage pond at the wastewater treatment plant is recommended both to accommodate the variation in potential customer demand patterns and as an equalization basin to buffer the potential variation in effluent flow at the WWTP.

It should be noted that as hourly flow data from the Ukiah WWTP was not available, sizing is estimated based on one third of the projected 2035 average annual wastewater flow volume of 4.65 mgd.

Increasing the size of the storage pond at the Ukiah WWTP beyond 5 af would allow additional users to be provided frost protection and increase operational flexibility related to the discharge limitations on Ukiah WWTP. If a sufficiently large pond is built, increasing the

size could also allow additional recycled water users to be supplied irrigation water during the summer, as the peak irrigation demand coincides with the minimal plant flows as discussed in Chapter 6.

7.1.1.6 Scheduling of Demands

In order to maximize use of the pipeline network, it is recommended that coordinated scheduling between landscape irrigation users and agricultural irrigation users be used. For the analyses included in this study, it was assumed that landscape irrigation users would schedule their demands between 6 p.m. and 5 a.m., and that the irrigation for all users would be spread out over this entire period. Agricultural irrigation users were scheduled between 5 a.m. and 6 p.m. While agricultural irrigation users were assumed within this study to continuously irrigate simultaneously, it is likely that the agricultural irrigation users would coordinate irrigation schedules to irrigate at different times for several days in a row. The scheduling of individual users would need to consider pipeline sizing and geographic distribution.

If irrigation times are reduced, increasing peak demands, larger pipeline sizes may be required (at increased capital cost).

7.2 COST ESTIMATE

The construction cost of the recommended recycled water system is summarized in Table 7.8 by phase. The total construction cost, including a construction contingency of 20 percent and an estimating contingency of 20 percent of the entire system, is estimated to be $18.7 million. As discussed in Chapter 6, project costs were estimated using an engineering/legal/administrative markup of 31 percent. The total project cost including contingency is estimated at $24.5 million (ENR of 10,199, October 2011, San Francisco).

Table 7.8 Cost Summary
Recycled Water Master Plan
City of Ukiah

Phase	Construction Cost (w/ Contingency)	Project Cost[1]
1	$3,797,300	$4,975,300
2	$5,353,120	$7,013,120
3	$4,677,680	$6,128,680
4	$4,897,800	$6,416,800
Total	**$18,725,900**	**$24,533,900**

Note:
(1) Includes markups for legal, administration, engineering, and design. Assumptions regarding costs are included in Chapter 6.

It should be noted that the total cost shown for the recommended alternative differs slightly from the cost shown in Chapter 6. This difference is due to the breakdown of construction into multiple phases.

Cost estimate details for each phase are included in Appendix D.

7.3 IMPLEMENTATION PLAN

The City will need to address the following project components in implementing the recycled water project (listed in no specific order):

- Design and construct the recommended alternative.
- Receive firm commitments and Agreements from landowners to use recycled water.
- Obtain permits and clearances from applicable regulatory agencies (RWQCB, CDPH, etc). Also includes the RW Policy Salt/Nutrient Management Plan development (defined in section 4.1.3).
- Conduct environmental process (CEQA) and develop compliance documents.
- Conduct a Proposition 218 process.
- Adopt a resolution for recycled water use.
- Prepare a cost of service rate study.

An implementation schedule is shown in Figure 7.3.

7.3.1 Recycled Water State Policy

The SWRCB recognizes that a burdensome and inconsistent permitting process can impede the implementation of recycled water projects. The SWRCB adopted a Recycled Water Policy (RW Policy) in 2009 to establish more uniform requirements for water recycling throughout the State and to streamline the permit application process in most instances.

The newly adopted RW Policy includes a mandate that the State increase the use of recycled water over 2002 levels by at least 200,000 AFY by 2020, and by at least 300,000 AFY by 2030. Also included are goals for stormwater reuse, conservation and potable water offsets by recycled water. The onus for achieving these mandates and goals is placed both on recycled water purveyors and potential users.

Absent unusual circumstances, the RW Policy puts forth that recycled water irrigation projects that meet CDPH requirements and other State or Local regulations, be adopted by Regional Boards within 120 days. These streamlined projects will not be required to include a monitoring component.

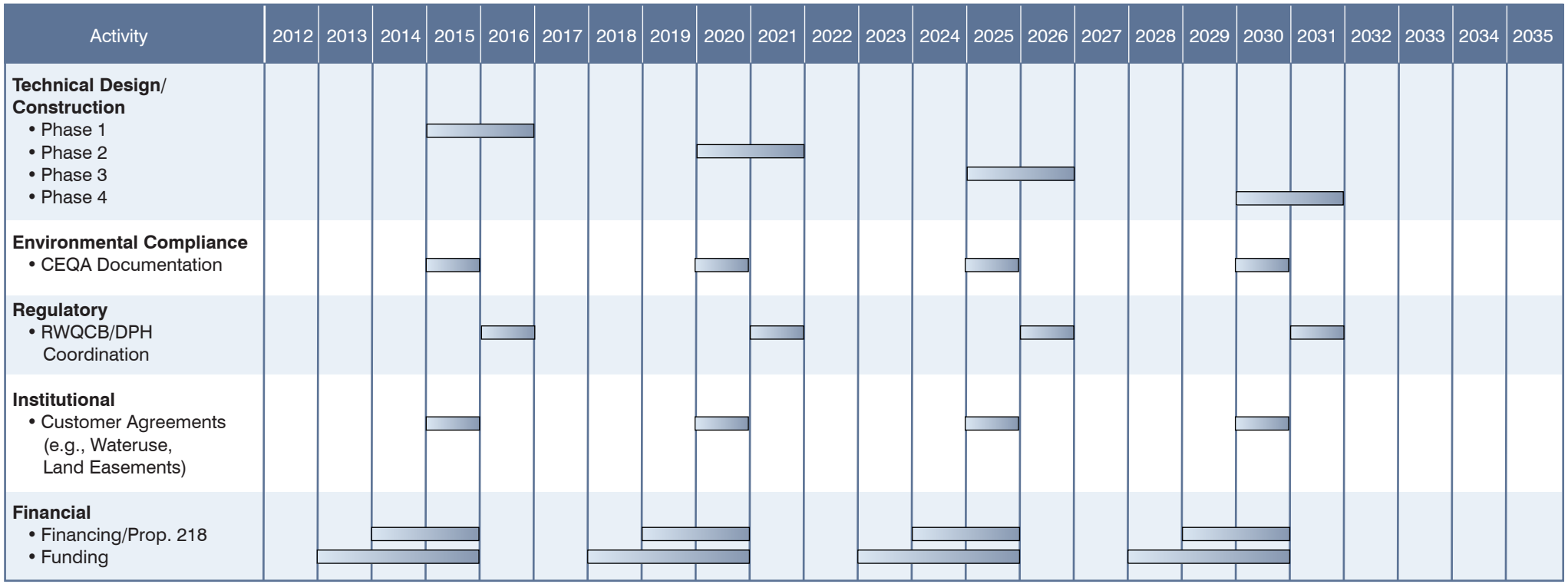


Figure 7.3
IMPLEMENTATION SCHEDULE
RECYCLED WATER FEASIBILITY STUDY
CITY OF UKIAH

uk112s1-8660.ai

CONSTRUCTION FINANCING PLAN AND REVENUE PROGRAM

8.1 FUNDING SOURCES AND CONSIDERATIONS

The adequate funding of capital costs is a primary constraint in implementing any construction project, especially water recycling projects. Recycled water projects have several State, Federal, and local funding sources available. Some are available directly to the City of Ukiah while others are available to individual water users.

This chapter describes potential funding opportunities and financing mechanisms for capital and operations costs, including an outline of current applicable grants and loan opportunities. The term “funding” refers to the method of collecting funds; the term “financing” refers to methods of addressing cash flow needs.

The recommended recycled water project is attractive for funding agencies for two primary reasons.

1. The project provides integrated benefits and meets various objectives:
    a. Helps meet State recycled water objectives.
    b. Improves environmental habitat.
    c. Protects surface water resources.
    d. Reduces cost associated with wastewater discharge management.
    e. Promotes a vibrant agricultural region.
    f. Demonstrates regional cooperation.
2. The project involves regional partnerships and provides benefits to numerous stakeholders:
    a. Calpella County Water District.
    b. Hopland Public Utility District.
    c. Millview County Water District.
    d. Redwood Valley Water District.
    e. Rogina Water Company.
    f. Willow County Water District.
    g. Agricultural Users.
    h. Ukiah Valley Sanitation District.
    i. Mendocino County Russian River Flood Control and Water Conservation Improvement District.

The pursuance of alternate funding is highly competitive. Competitive funding programs require enhanced recycled water programs to meet as many of the following objectives as possible:

- Regional partnerships.
- Integrated project benefits.
- Water conservation.
- Renewable energy improvements.
- Economic stimulus:
  - Job creation.
  - Job preservation.

Of the above objectives, the recommended City project meets all but the renewable energy improvement objectives.

8.2 FUNDING SOURCE IDENTIFICATION

Costs of the City's recycled water project consist of two components – capital cost for construction of distribution facilities and operation and maintenance (O&M) costs of the treatment and distribution systems.

The funding sources available range from traditional funding options such as pay-as-you go funding and bond funding to non-traditional funding sources such as grants and loans and market based programs. The sections that follow outline the mechanisms available to recover both capital and O&M costs.

The main instruments available for funding the capital costs include:

- Pay-as-you-go financing or upfront collection of project costs from existing and new users for future capital improvement projects.
- Debt financing or the acquisition of funds through borrowing mechanisms.
- Grants and loans or alternate source of funds at no or minimal interest cost. Examples include federal, state, and local programs that provide funding at zero interest for projects that meet select criteria.
- Market based programs that refer to financing through funds obtained from tax credits, purchase agreements, voluntary programs, and trading and offset programs.

All of these funding sources are discussed in additional detail in the following sections.

8.2.1 Pay-As-You-Go Financing

Pay-as-you-go financing involves periodic collection of capital charges or assessments from customers within the utilities jurisdiction for funding future capital improvements. These revenues are accumulated in a capital reserve fund and are used for capital projects in future years. Pay-as-you-go financing can be used to finance 100 percent or only a portion of a given project.

One of the primary advantages of pay-as-you-go financing is that it avoids the transaction costs (e.g., legal fees, underwriters' discounts, etc.) associated with debt financing alternatives, such as revenue bonds. However, there are two common disadvantages associated with this method. First, it is difficult to raise the required capital within the allowable time without charging existing users elevated rates. Second, it may result in inequities in that existing residents would be paying for facilities that would be utilized by, and benefit, future residents.

8.2.1.1 Utility Fees and Benefit Assessment Fees

Utility fees or benefit assessments, sometimes called service fees or user fees, consist of a fee imposed on each property in proportion to the service provided to that property. They are inherently flexible in that the City can select any assessment method that equitably relates the amount charged to the service provided. Benefit assessment fees are usually included as a separate line item on the annual property tax bill sent to each property owner.

Utility fees are usually billed on a monthly or bi-monthly interval. In all other respects, benefit assessments, utility fees and service charges are essentially identical. A utility has the authority to collect a benefit assessment fee, but only after approval by a majority of the voters, affected property owners, or ratepayers.

8.2.1.2 Development Charges/Connection Fees

The system development charges/connection fees/impact fees represent the cost of providing regional conveyance and treatment facilities to serve new recycled water customers. They are one-time fees charged to customers at the time of system connection approval or permit/contract issuance. The charges for individual properties may be based on whatever assessment measures the City desires for equity.

A disadvantage to utilizing impact fees is that the fees cannot be collected until the system constructions permit stage at the earliest. The amount collected each year depends solely on the rate of growth of the recycled water system. Consequently, funds may not be available to construct new facilities at the time it is needed.

8.2.2 Debt Financing

There are several different options for debt financing of recycled water projects, ranging from issuance of short- or long-term bonds.

8.2.2.1 Revenue Bonds

Revenue bonds are historically the principal method of incurring long-term debt. This method of debt obligation requires specific non-tax revenues such as user charges, facility income, and other funds, pledged to guarantee repayment. There is often no legal limitation on the amount of authorized revenue bonds that may be issued, but from a practical standpoint, the size of the issue must be limited to an amount where annual interest and

principal payments are well within the revenues available for debt service on the bonds. Revenue bond covenants generally include coverage provisions, which require that revenue from fees minus operating expenses be greater than debt service costs.

In the case of this project, based on policy decisions made regarding cost of service, any revenue bonds obtained would require proof of financial capacity to repay, using the City revenue sources that do not inequitably burden customers.

8.2.2.2 Certificates of Participation

Certificates of participation provide long-term financing through a lease agreement that does not require voter approval. The legislative body of the issuing agency is required to approve the lease arrangement by a resolution. The lessee (City), is required to make payments typically from revenues derived from the operation of the facilities. The amount financed may include reserves and capitalized interest for the period that facilities will be under construction. One disadvantage with certificates of participation, as compared with revenue bonds, is that interest rates can be slightly higher due to the insecurity associated with the obligation to make lease payments.

8.2.2.3 General Obligation Bonds

General obligation (GO) bonds are municipal securities secured by the issuer's pledge of its full faith, credit, and taxing power. GO bonds are backed by the general taxing authority of local governments and are often repaid using utility revenues when issued in support of a sewer or water enterprise fund. In the event that GO bonds are issued for this project, the City of Ukiah or Mendocino County tax revenue will need to be used to back the bonds.

8.2.2.4 Assessment District Bonds

Financing by this method involves initiating assessment proceedings. Assessment proceedings are documents in "Assessment Acts" and "Bond Acts." An assessment act specifies a procedure for the formation of a district (boundaries), the ordering, and making of an acquisition or improvement, and the levy and confirmation of an assessment secured by liens on land. A bond act provides the procedure for issuance of bonds to represent liens resulting from proceedings taken under an assessment act. Procedural acts include the Municipal Improvements Acts of 1911 and 1913. The commonly used bond acts are the 1911 Act and the Improvement Bond Act of 1915. The procedure most prevalent currently is a combination of the 1913 Improvement Act with the 1915 Bond Act. Charges for debt service can be included as a special assessment on the annual property tax bill. The procedure necessary to establish an assessment district may vary depending on the acts under which it is established and the district size.

8.2.3 Grants and Loans

Several grant and loan programs can be utilized to finance the recommended recycled water project alternative. These grants and loans are further discussed as state and federal

funding sources in the succeeding sections. Table 8.1 provides a summary of the available state and federal funding sources. The grant and loan options presented herein are accurate as of June 2010. Please refer to the contact or website for the most up to date information for each of these grants and loans.

There are numerous factors that should be considered in the pursuance of grant funding. Several factors that should be noted in pursuance of grant funding include:

- Grant applications require demonstration of the ability to construct, operate, and maintain the project without grant funding.
- Grant award or funding authorization is NOT a promise of grant reimbursement:
  - Most grants are reimbursements and not cash up front. This requires that a source of funding be available for the construction of the project.
  - Grant reimbursements are subject to annual budget and appropriations process and thus disbursement of grant funds on schedule is not guaranteed.
  - It may take several years after project completion to receive reimbursements, especially in difficult economic times.
  - Most grants require a minimum cost share by project sponsor.
  - Federal grants typically require investment of additional resources to obtain lobbying support.

Despite the competitive nature of alternate funding, available funding sources should be considered to minimize ratepayer impacts. The following sections summarize available state and federal funding options.

8.2.3.1 State Funding

Several state funding sources are applicable to the recycled water project alternatives. Due to the California state budget crisis, some of these programs may be suspended or not have funding available when the City of Ukiah is ready to move to construction.

8.2.3.1.1 *Water Recycling Funding Program*

One option for financing the Recycled Water Project is the Water Recycling Funding Program administered by the State Water Resources Control Board. The program offers funding for research, feasibility studies, planning, and construction. The program is financed through Propositions 13, 50, and the State Revolving Fund (SRF).

Recycling projects are categorized by their potential benefits to state and local communities, which in turn determine which funding sources are applicable.

Table 8.1 Funding Summary
Recycled Water Master Plan
City of Ukiah

Program	Agency	Type	Description
State			
Water Recycling Funding Program	State Water Resources and Control Board	Grant/Loan	Funding is available for projects in the following categories: 1. Category I projects will offset state water supplies and increase water to the Delta. 2. Category II projects will offset state water use, but do not provide benefits to the Delta. 3. Category III projects use recycled water to supplement local water supplies but have no impact on the state water supply or the Delta. 4. Category IV projects will treat and reuse groundwater contaminated by human activity. 5. Category V projects will treat and dispose wastewater to meet waste discharge regulations. 6. Category VI captures miscellaneous projects that do not fall into other categories and have no benefits to state or local water supplies. The maximum award for construction grants for Category I through IV projects is the lesser value of $5 million per project or 25 percent of construction costs. Category V and VI projects are only eligible for SRF loans. Loans are capped at $50 million per agency per year.
Integrated Regional Water Management Grants Program (Prop 84)	Department of Water Resources	Grants	Grants are available for projects that support IRWM Plans and are related to water supply reliability, groundwater recharge, water quality enhancement etc.
Specialty Crop Block Grant	California Department of Food and Agriculture	Grant	Eligible projects include those that will enhance the competitiveness of California specialty crops. Specialty crops include fruits, vegetables, tree nuts, dried fruits, horticulture, and nursery crops. Awards range from $75,000 to $500,000 per project.
Federal			
Title XVI	U.S. Bureau of Reclamation	Grants	Eligible projects include recycled water feasibility, demonstration, and construction projects. The program provides as much as 25 percent of construction costs with a maximum of $20 million. To meet eligibility requirements a project must have a Bureau of Reclamation approved feasibility study, comply with environmental regulations, and demonstrate the ability to pay the remainder of the construction costs.
USDA Agricultural Water Enhancement Program	U.S. Department of Agriculture (USDA)	Grants	Several grant programs awards to projects or programs that support sustainable agriculture and the conservation of water resources. • The Sustainable Agriculture Research and Education Program (SARE) provide grants of up to $60,000 for projects within a single state that promotes sustainable agriculture through outreach, education, training, and technical support. • The Environmental Quality Incentive Program grant program awards incentive payments, up to $50,000 per year, directly to agricultural producers who conserve soil, water, and air resources on their land. • The Agricultural Water Enhancement Program offers local units of government that work with EQIP participants the option to receive multi-million dollar grants for capital and non-capital projects that improve agricultural water quality or quantity.
Organic Farming Research Foundation	Organic Farming Research Foundation	Grants	Grants are available for research or public outreach projects related to organic farming. Grant awards have averaged approximately $5,000 to $12,000.

- Category I projects will offset state water supplies and increase water to the Delta.
- Category II projects will offset state water use, but do not provide benefits to the Delta.
- Category III projects use recycled water to supplement local water supplies but have no impact on the state water supply or the Delta.
- Category IV projects will treat and reuse groundwater contaminated by human activity.
- Category V projects will treat and dispose wastewater to meet waste discharge regulations.

Category VI captures miscellaneous projects that do not fall into other categories and have no benefits to state or local water supplies.

The recycled water alternatives will likely fall into Category II as it should offset state water use, will use recycled water to supplement local water supplies, but will have no impact on the Delta.

The source of available funding varies with the category in which the project is classified. The maximum award for construction grants for Category I through IV projects is the lesser value of $5 million per project or 25 percent of construction costs.

Category V and VI projects are only eligible for SRF loans. Loans are capped at $50 million per agency per year. The SRF interest rate is set at one-half of the state general obligation bond rate and has historically averaged around 2.5 percent.

The SWRCB provides one application package for both construction grants and SRF recycled water loans. The application package consists of:

- Financial Assistance Application.
- Facilities Plan composed of:
  - Project report.
  - Environmental documents including CEQA documents.
  - Construction Financing Plan.
  - Recycled Water Market Assurances documenting user participation in the project.
  - Authorized Representative Resolution (Legal Authority).

- Water Conservation Plan demonstrating that the applicant has a water conservation program in effect or has signed onto the California Urban Water Conservation Council's Memorandum of Understanding.

The SWRCB will review the application package and assess eligibility. Once the SWRCB receives and reviews the final plans and specs, it will issue project performance standards. Once performance standards are agreed to and the applicant chooses a contractor, the parties sign a funding agreement. The applicant must also have an Urban Water Management Plan filed with the Department of Water Resources to receive funds.

8.2.3.1.2 *Integrated Regional Water Management Implementation Grant Program*

Grants are available for projects that support IRWM Plans and are related to water supply reliability, groundwater recharge, water quality enhancement etc.

In transitioning from Prop 50 funding to Prop 84 funding, the DWR altered several of the standards it uses to evaluate regions including governance requirements, acknowledgement of water conflicts, and potential climate change requirements. To facilitate this change, DWR has allowed regions with standing IRWM plans to also receive funds under Prop 84 to comply with the new standards and to develop new projects. Projects seeking funding through this grant process generally submit a project summary to the respective local IRWM management group to review and assess the merits of a project and its ability to fulfill the intent of the IRWM plan. Once approved through this process, a project may be included in the region's implementation grant application.

8.2.3.1.3 *Specialty Crop Block Grant*

Since the project will supply water to agricultural irrigation, the City has the option of utilizing grant programs targeted at conservation within agricultural lands. At the state level, the California Department of Food and Agriculture awards grants annually to projects that will enhance the competitiveness of California specialty crops. Specialty crops include fruits, vegetables, tree nuts, dried fruits, horticulture, and nursery crops. Awards range from $75,000 to $500,000 per project. Eligible projects include the development of best management practices, conservation practices, special studies and research, education and outreach, and training and technical assistance. Past grant awards have not typically included funding for capital projects. However, the City could utilize Specialty Crop Block Grant Funds for outreach, education, training or the development of recycled water best management practices for its customers.

8.2.3.2 <u>Federal Funding</u>

In addition to local and State grants and loans, there are several highly competitive Federal grant and loan programs that provide financial resources to recycled water projects.

8.2.3.2.1 *Title XVI*

The U.S. Bureau of Reclamation administers funds for recycled water feasibility, demonstration, and construction projects through the Water Reclamation and Reuse Program authorized by the Reclamation Wastewater and Groundwater Study and Facilities Act of 1992 (Title XVI) and its amendments. The program provides as much as 25 percent of construction costs with a maximum of $20 million. To meet eligibility requirements a project must have a feasibility study, comply with environmental regulations, and demonstrate the ability to pay the remainder of the construction costs. Projects are authorized by Congress and recommended in the President's annual budget request by the Bureau of Reclamation. Congress then appropriates funds and the Bureau ranks and prioritizes projects and disburses the money on a competitive grant basis each year. Prioritized projects are those that postpone the development of new water supplies, reduce diversions from natural watercourses, reduce demand on federal water supply facilities, or that have a regional or watershed perspective.

8.2.3.2.2 *USDA Agricultural Water Enhancement Program*

The U.S. Department of Agriculture (USDA) offers several grant programs that give awards to projects or programs that support sustainable agriculture and the conservation of water resources. These programs are detailed below.

- The Sustainable Agriculture Research and Education Program (SARE) is administered by the USDA's Cooperative State Research, Education and Extension Service (CSREES) and universities nationwide to provide support for sustainable agriculture. SARE provides grants of up to $60,000 for projects within a single state that promote sustainable agriculture through outreach, education, training, and technical support. Applications are accepted throughout the year.

- Environmental Quality Incentive Program is grant program offered through the Environmental Quality Incentive Program (EQIP). This program awards incentive payments directly to agricultural producers who conserve soil, water, and air resources on their land. To participate, agricultural producers sign six-year commitments to conserve resources and the USDA provides payments of up to $50,000 per year. Well decommissioning and irrigation water pipelines, storage, and management are eligible uses of funds.

- The Agricultural Water Enhancement Program offers local units of government that work with EQIP participants the option to receive multi-million dollar grants for capital and non-capital projects that improve agricultural water quality or quantity.

8.2.3.2.3 *Organic Farming Research Foundation*

The Organic Farming Research Foundation offers small grants for research or public outreach projects related to organic farming. This grant program cannot provide funding to

offset the capital costs of the recycled water alternative, but funding could be used to garner support for recycled water use within the City service area for any customers utilizing organic farming practices. Past grant awards have averaged approximately $5,000 to $12,000. Applications are accepted in May and November of each year.

8.2.4 Funding Source and Timing Summary

The City proposes to utilize a combination of funding sources to construct the recycled water project. The priority of the funding will be to secure grants where available, pursue low interest loans such as the SRF loans, and then finally obtain debt financing in the form of GO or revenue bonds for the cost of the project not covered by grants and low interest loans. These funding options are summarized in Table 8.2. Typically, the anticipated sources of repayment for any loans consist of water, wastewater, and recycled water revenues.

Table 8.2 Funding Source Summary
Recycled Water Master Plan
City of Ukiah

Funding Source	Use	Amount	Timing
SRF Grants and Loans	Design/Construction	Up To $20.2 million(1)	2011
Other Federal and State Grants and Loans	Construction	TBD	2011
Debt	Construction	Cost not recovered by alternate supplies up to $20.2 million	2011

Note:
(1) Although SRF funding and grants have not yet been secured, the City plans to pursue grants and low interest loans for the construction of the recycled water facilities to the maximum extent possible.

8.3 RECYCLED WATER PRICING POLICY

Typically, the cost of recycled water projects is recovered through a combination of methods where costs are shared amongst recycled water customers, potable water customers, and wastewater customers.

Several recycled water cost recovery alternatives were considered relative to capital, O&M, and repair and replacement (R&R) costs. Dependent on the preferred cost recovery strategy, the corresponding pricing alternatives were developed.

8.3.1 Capital Cost Recovery

The capital costs associated with the recycled water system will consist of distribution system components – pump station, storage, and pipelines. No new treatment infrastructure is required as the City wastewater treatment plant has sufficient capacity to produce tertiary treated recycled water.

Implementation of expansive recycled water projects requires large up-front capital. The current project implementation plan proposes to finance the construction of the recommended project through a combination of SRF and other grants and loans, as well as the issuance of debt. There are several alternatives by which the associated debt service can be recovered. These include:

- Land based assessments where all parcels in the City service area are assessed a dollars per acre or dollars per parcel fee.
- Consumption based service charges where water, wastewater and recycled water users are assessed their fair share of the annual debt service of the recycled water project based on their quantity of potable or recycled water used.
- A combination of land based assessments and consumption based service charges where a portion of the debt service is recovered using both methods.
- System connection fees where users connecting to the water, wastewater, and recycled water systems pay a one-time fee for the system capacity utilized.

The construction of the recycled water distribution system reduces reliance on use of increasingly regulated Russian River water, reduces the need for perhaps more costly future water supplies, and facilitates City compliance with its wastewater discharge permit, which requires increased reuse of the tertiary treated effluent. Because the City currently has adequate potable water supplies to meet its water demands, and compliance with the City wastewater permit requirements is needed in the near term, the pricing policy for the capital cost component of the recycled water project consists of recovery through wastewater customers.

8.3.2 Operations and Maintenance Cost Recovery

The O&M costs associated with the recycled water system will consist of treatment and distribution components.

The City's wastewater permit requires tertiary treatment of its wastewater to meet specified effluent limits from October through May each year. During this period, no additional treatment is incurred to produce tertiary quality recycled water. The City is prohibited from discharging treated effluent to the Russian River from June through September and thus discharge secondary treated effluent to recharge ponds. Implementation of the recycled water program will now require tertiary treatment during the summer months for urban and

agricultural reuse, increasing O&M costs at the wastewater treatment facility. In addition to increased treatment cost during the summer, the City will incur recycled water distribution costs year-round.

O&M costs are most typically recovered using user charges. Similar to capital costs, it is possible for the City to recover its O&M costs using land based, consumption based, or combination methods. As the causation of the City's O&M costs are directly correlated to compliance with its wastewater permit and delivery of recycled water to specific recycled water users, the pricing policy proposes to recover the O&M costs on a consumption basis from wastewater and recycled water customers.

At this time, no purchase agreements are in place between the City and the recycled water users. As these agreements are further developed, the O&M pricing strategy will be modified to appropriately allocate and recover fixed and variable costs amongst users.

8.3.3 Repair and Replacement Cost Recovery

Similar to O&M costs, the R&R costs can also be recovered using land based, consumption based, or combination methods. The currently proposed recycled water pricing policy will recover annual R&R costs from its users through a consumption based fee with the assumption that any R&R required is a result of system use.

8.3.4 Costs Allocated to Water Pollution Control

The implementation of the recycled water project reduces reliance on use of increasingly regulated Russian River water, reduces the need for perhaps more costly future water supplies, and facilitates City compliance with its wastewater discharge permit, which requires increased reuse of the tertiary treated effluent. The project also extends the use of existing discharge ponds by reducing the need for construction of additional wastewater discharge ponds to meet future discharge needs.

As the primary drivers of this project are related to compliance with the City's wastewater discharge permit, much of the capital and O&M costs of the project are allocated to wastewater pollution control. Similarly, much of the capital repair and replacement cost is allocated to water pollution control as a fully functional and reliable system is required to comply with discharge regulations.

8.3.5 Costs Allocated to Potable Water

Implementation of the recycled water project may facilitate compliance with the 2009 CA Water Conservation Act to reduce 20% urban water use by 2020. Additionally, the project may help reduce the need for and the size of future, perhaps more costly, water supplies.

The recommended alternative will not result in sizable potable water offsets until the final, optional phase of the project is constructed. The City's Urban Water Management Plan projects the baseline water demand in 2035 to equal 5,217 AFY. The preferred recycled

water alternative is projected to offset approximately 400 AFY, or approximately 10 percent of the City's average potable water demands between 1995 to 2008 if the optional phase is implemented (demands have decreased by about 25 percent in 2009 and 2010) . Currently, the City has sufficient water supplies to meet water demand and has already achieved the conservation targets set by the State. Therefore, the City does not intend to recover cost associated with the initial phases of the recycled water project from water ratepayers. THe City does however, plan to evaluate allocation of a portion of the capital costs associated with construction of this portion of the system to water ratepayers or private developers benefitting from potable offsets at the time of construction of Phase 4.

8.3.6 Recycled Water Pricing Summary

The recycled water pricing summary for the various project cost elements is summarized in Table 8.4. The City plans to conduct a cost of service study in the future to appropriately and equitably determine the impacts to water, wastewater, and recycled water rates.

Table 8.4 Funding Source Summary
Recycled Water Master Plan
City of Ukiah

Cost Description	Allocation	Cost Unit(1)
Capital Cost	Wastewater	$ per hcf or af(1)
O&M and R&R Cost	Treatment – Recycled Water Distribution - Wastewater	$ per hcf or af(1)

Note:
(1) Cost recovery strategy of consumptive based charges was determined to be most appropriate at this stage of the recycled water project. Rates would be set to recover the annual debt service, O&M, and R&R costs from water, wastewater, and recycled water users as appropriate.

8.4 ANNUAL COST PROJECTIONS

8.4.1 Capital Costs

The total project cost for the recommended alternative is estimated to be approximately $24.5 million for construction of all phases of the project (including the optional phase). The estimated costs do not include retrofit costs or costs associated with piping required within the individual users' property lines.

It was assumed for planning purposes that the project would be funded through a 30-year loan. Annual debt service was calculated using a 5 percent interest rate over a 30-year period for each project phase.

The annual cash flow projections for assuming debt financing is presented in Appendix G. It was assumed that the annual payments collected from wastewater and recycled water revenues will be equal to the annual debt service.

8.4.1.1 Sunk Costs

In the last three years, the City has spent approximately $150,000 on this engineering feasibility report, public outreach, CEQA review, and preliminary engineering to promote recycled water use within its service area.

The estimated indebtedness for construction of necessary facilities is $24.5 million. The costs associated with project planning and construction will also be sunk costs upon project completion.

8.4.1.2 Salvage Value

The salvage value of the system at the end of the debt period was calculated assuming an average useful life of 50 years for the system. Engineering, legal, and administrative costs were assumed to have no salvage value. The salvage value of the distribution system is estimated at $112,731.

8.4.2 Operations and Maintenance Costs

The O&M costs associated with the recycled water program will be dependent upon the volume of recycled water production. Potential O&M costs include:

- Recycled water pumping costs.
- Inspections costs.
- Metering and meter reading costs.
- Billing costs.
- System cleaning and maintenance costs.
- Public outreach costs.

Table 8.5 summarizes the estimated annual O&M costs of the system.

Table 8.5 Operations and Maintenance Cost Summary
Recycled Water Master Plan
City of Ukiah

Description	Annual Cost (2010 Dollars)
Recycled Water Pumping	$150,000
Inspection Personnel (0.25 FTE)	$25,000
Metering and Meter Reading (0.25 FTE)	$25,000
System Cleaning and Maintenance (0.25 FTE)	$25,000
Billing Support	$5,000
Public Outreach	$5,000
Total	**$235,000**

Note:
(1) Assumes Full Time Equivalent (FTE) = $100,000 per year for salary and benefits.

8.4.3 Repair and Rehabilitation Costs

The City currently replaces its tertiary filter media approximately every five years. The media replacement costs approximately $500,000; the City plans to allocate 50 percent of the media replacement cost to the recycled water system operation, resulting in an estimated annual R&R need of $50,000.

8.4.4 Total Annual Project Expenses

Table 8.6 presents a summary of the estimated project costs for the recommended project and the allocation of costs to water, wastewater, and recycled water customers. Since project implementation helps reduce the capacity of future water supply needs, the City water enterprise may opt to recover the costs allocated to the water system from future water customers. Similarly, the City's wastewater enterprise may opt to allocate costs to both existing and future customers. For the purposes of this study, it is assumed that annual debt service allocated to water and wastewater will be recovered from existing customers. As there are no existing recycled water users, 100 percent of the costs are allocated to future users.

Table 8.6 Recommended Project Annual Cost Summary and Allocation
Recycled Water Master Plan
City of Ukiah

Expense Type	Total Annual Expense	Water Customers[1]	Wastewater Customers[1]	Recycled Water Customers[2]
Capital (Debt Service/Loan Repayment)[3]				
Existing	$1,179,000	$0	$1,179,000	$0
Future	$0	$0	$0	$0
Operating Expense				
Treatment O&M	$352,500	$0	$352,500	$0
Distribution O&M	$12,311	$0	$0	$12,311
Capital Replacement				
Annual R&R	$50,000	$0	$50,000	$0
Total Annual Revenue Requirement	**$1,593,811**	**$0**	**$1,581,500**	**$12,311**

Notes:

(1) The City's water and wastewater enterprise may opt to allocate costs to both existing and future customers. For the purposes of this study, it is assumed that annual costs allocated to water and wastewater will be recovered from existing customers.

(2) Only customers who use recycled water are allocated distribution system O&M costs.

(3) The debt service presented is the debt service associated with a 30-year term and 5 percent interest.

A cash flow forecast was developed over a 30 year period for the recycled water project assuming that the first phase of project will start design in fiscal year (FY) 2015 and complete construction in FY 2016. Each subsequent phase of the project was assumed to be initiated in five-year increments with phase construction requiring two years. A summary of the cash flows for these scenarios is presented in Appendix G. It was assumed that the annual payments collected from property owners would be equal to the annual debt service and operations costs.

8.4.5 Recycled Water Use Projections and Unit Costs

The projected recycled water use for the recommended alternative (based on acreage and land use) is 1,376 acre-feet per year. All projected recycled water use is anticipated to be for irrigation and frost protection.

Preliminary unit costs for each user category were developed using the proposed cost recovery strategy. These costs assume that only Phases 1 through 3 of the project will be constructed. Phase 4 is considered as optional. Table 8.7 presents a summary of the unit costs. These unit costs are preliminary and are not based on a detailed cost of service study. The allocation of costs, unit costs, and rates for water, wastewater and recycled will be developed to recover the cost of construction and operation through the cost of service study. The City plans to pursue a detailed cost of service and assessment study prior to the initiation of a Proposition 218 process and adoption of rates.

Table 8.7 Summary of Unit Costs
Recycled Water Master Plan
City of Ukiah

Expense Type	Total Annual Expense	Unit Cost(1)		
		Water(1)	Wastewater(2)	Recycled Water(3)
Capital Costs		0		
Annual Debt Service(4)	$1,179,000	$0.00	$0.81 per hcf ($263.17 per acre-foot)	$0.00
Operating Costs				
Treatment and Distribution O&M	$364,811	$0.00	$0.24 per hcf ($78.68 per acre-foot)	$0.03 per hcf ($12.37 per acre-foot)
Capital Repair and Replacement Costs				
Annual R&R	$50,000	$0.00	$0.15 per hcf ($50.24 per acre-foot)	$0.00

Notes:
(1) Costs associated with Phases 1 through 3 of the recommended project are not expected to be allocated to water ratepayers.
(2) Unit costs based on estimated average annual wastewater flow of 4 mgd or 4,480 AFY.
(3) Unit costs presented are based on use of 1,376 acre-feet per year for the total annual cost.
(4) Assumes a 30-year term with an interest rate of 5 percent.

8.4.6 Preliminary Recycled Water Price

The cost recovery strategy proposed to recover the cost associated with capital infrastructure and recycled water system operation is through a combination of wastewater and recycled water rates.

As previously discussed, the repayment of the project costs is anticipated to be spread across all project beneficiaries. Table 8.8 summarizes the estimates of project costs per acre and per acre-foot of consumption.

Table 8.8 Price of Recycled Water for Repayment of Capital Costs
Recycled Water Master Plan
City of Ukiah

Cost Summary	
Project Cost[1]	$24,533,900
Annual O&M Costs	$364,811
Annual R&R Costs	$50,000
Acreage Summary	
Acreage Irrigated	1,030
Acreage Frost Protected	284
Total Acreage	1,030
Consumption Summary	
Projected Annual Consumption	1,376
Price Summary	
Unit Price of Project Construction[2]	$1,180
Unit Price of Delivered Water[3]	$370
Unit Price of Project over 20 Years[4]	$1,300

Notes:

(1) Project costs include estimating contingencies and estimates for engineering, legal, administrative, and environmental costs.

(2) Price presented is for costs and volume associated with Phases 1 through 3.

(3) Price per acre-foot is applicable to only metered recycled water customers. This price is based on annual use of 1,376 acre-feet per year and includes both annual O&M and annual R&R costs.

(4) The unit price shown was calculated using the SWRCB present worth analysis methodology. The present worth analysis was conducted on the projected cash flows over a 20-year period using a present worth factor of 4.6%.

8.4.7 Comparison to Water Prices

Based on the City's most current utility rate sheet, the monthly service charge for a residential 1-inch water connection is $24.41. The unit consumption rate is $1.20 per hundred cubic feet (hcf) or approximately $1.60 per 1,000 gallons. Appendix E provides the City's most recent utility rate information.

In comparison, the unit recycled water price (including project construction cost), using total annual cost and the estimated recycled water delivery of 1,376 acre-feet per year is $2.71. The unit recycled water price is 125 percent higher than the unit water price. However, as the total cost of the project is expected to be allocated to all project beneficiaries, including wastewater, and recycled water customers, the individual customer price will be lower than the above unit price.

8.4.8 Sensitivity Analysis

It is possible that the actual recycled water consumption is above and below the projected assumed recycled water consumption. A sensitivity analysis was conducted to evaluate the impact of change in consumption on unit recycled water price. Table 8.9 summarizes this sensitivity analysis.

8.4.9 Recommended Project Benefit-Cost Analysis

In order to calculate the quantitative benefit cost of the project cost, a present worth analysis was conducted on the projected cash flows over a 20-year period using a present worth factor of 4.6 percent. The unit cost of the recommended project was estimated using the present value of the project capital and O&M costs as well as recycled water consumption. The estimated unit cost was $1,300 per acre-foot. Detailed calculations are provided in Appendix E.

Qualitative costs of the project include short-term construction impacts such as noise, environmental and aesthetic nuisance. Qualitative benefits of the recommended project include the following:

- The promotion of sustainability through the availability of the new drought proof supply.
- Alternate disposal of treated effluent through irrigation use.
- Facilitation of compliance with future WWTP permit requirements.
- Facilitation of compliance with the 2009 CA Water Conservation Act goal to achieve a 20 percent reduction in urban water consumption by 2020.
- Extension of existing storage ponds useful life and capacity.
- Reduction in Russian River water withdrawals.
- Alternate water supply source for frost protection.
- The maintenance of the viability of agriculture in the region.
- The avoided use of ground and surface water resources in the region.

Table 8.9 Sensitivity Analysis
Recycled Water Master Plan
City of Ukiah

	Price @ No Change in Consumption	Price @ 5% Less Consumption	Price @ 10% Less Consumption	Price @ 25% Less Consumption
Annual Recycled Water Consumption	995 AFY	945 AFY	896 AFY	746 AFY
Capital Costs(1)				
Price per Acre-Foot	$1,180	$1,250	$1,320	$1,580
O&M and R&R Costs				
Unit Price	$0.85 per hcf ($370 per acre-foot)	$0.9 per hcf ($390 per acre-foot)	$0.94 per hcf ($410 per acre-foot)	$1.12 per hcf ($490 per acre-foot)

Note:
(1) As capital costs are based on estimated debt service for a 30-year term at 5 percent interest.

APPENDIX A - QUESTIONNAIRE RESPONSES

CITY OF UKIAH

RECYCLED WATER USE QUESTIONNAIRE

The purpose of this questionnaire is to gather information and understand your department/agency/businesses' interest in using recycled water for irrigation/frost protection.

PLEASE RETURN YOUR COMPLETED QUESTIONNAIRE BY APRIL 30, 2011 TO:
Jarod Thiele, City of Ukiah, Public Works Administration, 300 Seminary Ave, Ukiah, CA 95482 or at jthiele@cityofukiah.com. An electronic or hard copy is fine.

1. Land Owner Name: Beckstoffer Vineyards

2. Property Address: Talmage / Hopland

3. Type of land to be irrigated (grass/landscaping, pasture, vines, orchard, etc):

Vineyard

4. Existing irrigated acreage: ±700 acres

Assumed 200. 164 acres ID'd through GIS.

Planned additional irrigable acreage: _____ acres

5. Current irrigation/frost protection water source(s):

Water Source:	Used? (Y/N)	Description of Use (e.g. irrigation, frost protection):
Groundwater wells	Y	Irr/frost
Stream/surface water	Y	Irr/frost
Potable (City) water		
Other		

6. Existing Water Storage: ~1200 acre-feet

Any plans to add more storage: _____ YES _____ NO

If yes, how much storage will be added? _____acre-feet

7. Do you have any concerns or issues with using recycled water? Please check all that apply and explain:

X Cost of the recycled water

X Cost of the delivery system (e.g., pipelines, pump stations, etc.)

X Water quality

___ Daily timing of deliveries

___ Seasonal timing of deliveries

___ Pressure

___ Other (please list)

all manageable based on Sonoma Experience

8. Please list other water usage considerations you feel would be important to your possible use of recycled water (e.g., time of year, days of week, hours of day, pressure considerations, volumes, duration of irrigation, etc):

9. Are you interested in using recycled water for irrigation and/or frost protection purposes?

X YES _____ NO

In checking yes, I understand I am expressing interest in potentially using recycled water for irrigation and/or frost protection purposes provided the recycled water available is of comparable quality and reasonable cost to the water currently used for irrigation and/or frost protection.

Richard K. Schaefers

Name of Representative

Signature of Representative

6-8-11

Date

Thank you for your help and participation in this very important City of Ukiah project. We welcome your participation throughout the planning process. Please see the accompanying letter on how you can stay involved.

CITY OF UKIAH
RECYCLED WATER USE QUESTIONNAIRE

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1. Land Owner Name: Michael Boer

2. Property Address: 301 – 901 Boonville Rd

3. Type of land to be irrigated (grass/landscaping, pasture, vines, orchard, etc):

Grapes

4. Existing irrigated acreage: 20 acres

   Planned additional irrigable acreage: 0 acres

5. Current irrigation/frost protection water source(s):

Water Source:	Used? (Y/N)	Description of Use (e.g. irrigation, frost protection):
Groundwater wells	Y	IRRIGATION
Stream/surface water	N	
Potable (City) water	N	
Other	N	

6. Existing Water Storage: 0 acre-feet

Any plans to add more storage: X YES ____ NO

If yes, how much storage will be added? 25 acre-feet

7. Do you have any concerns or issues with using recycled water? Please check all that apply and explain:

✓ Cost of the recycled water

___ Cost of the delivery system (e.g., pipelines, pump stations, etc.)

___ Water quality

___ Daily timing of deliveries

___ Seasonal timing of deliveries

___ Pressure

___ Other (please list)

8. Please list other water usage considerations you feel would be important to your possible use of recycled water (e.g., time of year, days of week, hours of day, pressure considerations, volumes, duration of irrigation, etc):

9. Are you interested in using recycled water for irrigation and/or frost protection purposes?

X YES _____NO

In checking yes, I understand I am expressing interest in potentially using recycled water for irrigation and/or frost protection purposes provided the recycled water available is of comparable quality and reasonable cost to the water currently used for irrigation and/or frost protection.

Michael Ben

Name of Representative

Signature of Representative

6/8/11

Date

Thank you for your help and participation in this very important City of Ukiah project. We welcome your participation throughout the planning process. Please see the accompanying letter on how you can stay involved.

CITY OF UKIAH
RECYCLED WATER USE QUESTIONNAIRE

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1. Land Owner Name: City of Ukiah Group 1

2. Property Address:
Anton Stadium (506 Park Blvd) / Giorno Field (506 Park Blvd) / Lions Field (506 Park Blvd)- these ball fields all border each other and are 12 acres

Todd Grove Park (600 Live Oak Ave)- 16 acres

Golf Course (599 Park Ave)- 80 acres

3. Type of land to be irrigated (grass/landscaping, pasture, vines, orchard, etc):

Grass

4. Existing irrigated acreage: 108 acres total

Planned additional irrigable acreage: 0 acres

5. Current irrigation/frost protection water source(s):

2010 Usage
Anton/Giorno/Lions — 12.97 AF (4,226,948 gal)
Todd Grove — 11.96 AFY (3,909072 gal)
Golf Course — 124 AFY (40,419,676 gal)

Water Source:	Used? (Y/N)	Description of Use (e.g. irrigation, frost protection):
Groundwater wells		
Stream/surface water		
Potable (City) water	yes	grass irrigation
Other		

6. Existing Water Storage: ____0_____acre-feet

Any plans to add more storage: _____ YES __X___ NO

If yes, how much storage will be added? ____0_____acre-feet

7. Do you have any concerns or issues with using recycled water? Please check all that apply and explain:

___ Cost of the recycled water

_X__ Cost of the delivery system (e.g., pipelines, pump stations, etc.)

___ Water quality

___ Daily timing of deliveries

_X__ Seasonal timing of deliveries

___ Pressure

___ Other (please list)

_____

_____

_____

_____

_____

8. Please list other water usage considerations you feel would be important to your possible use of recycled water (e.g., time of year, days of week, hours of day, pressure considerations, volumes, duration of irrigation, etc):

_____

_____

9. Are you interested in using recycled water for irrigation and/or frost protection purposes?

_X____YES _____NO

In checking yes, I understand I am expressing interest in potentially using recycled water for irrigation and/or frost protection purposes provided the recycled water available is of comparable quality and reasonable cost to the water currently used for irrigation and/or frost protection.

Sage Sangiacomo, Assistant City Manager

Name of Representative

Signature of Representative

6/24/11

Date

Thank you for your help and participation in this very important City of Ukiah project. We welcome your participation throughout the planning process. Please see the accompanying letter on how you can stay involved.

CITY OF UKIAH
RECYCLED WATER USE QUESTIONNAIRE

The purpose of this questionnaire is to gather information and understand your department/agency/businesses' interest in using recycled water for irrigation/frost protection.

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1. Land Owner Name: City of Ukiah Group 2_____

2. Property Address: Riverside Park (E. Gobbi St by Russian River) 2010 Usage - 0 AF

3. Type of land to be irrigated (grass/landscaping, pasture, vines, orchard, etc):

Grass

4. Existing irrigated acreage: ____0_____acres

   Planned additional irrigable acreage: _____4_____acres

5. Current irrigation/frost protection water source(s):

Water Source:	Used? (Y/N)	Description of Use (e.g. irrigation, frost protection):
Groundwater wells	yes	Grass irrigation
Stream/surface water	No	
Potable (City) water	No	
Other	No	

2

9. Are you interested in using recycled water for irrigation and/or frost protection purposes?

_X_YES _____NO

In checking yes, I understand I am expressing interest in potentially using recycled water for irrigation and/or frost protection purposes provided the recycled water available is of comparable quality and reasonable cost to the water currently used for irrigation and/or frost protection.

Sage Sangiacomo

Name of Representative

Signature of Representative

6/24/11

Date

Thank you for your help and participation in this very important City of Ukiah project. We welcome your participation throughout the planning process. Please see the accompanying letter on how you can stay involved.

CITY OF UKIAH
RECYCLED WATER USE QUESTIONNAIRE

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1. Land Owner Name: City of Ukiah Group 3- Downtown Area

2010 usage

2. Property Address: Alex Thomas Plaza (300 S. School St.), - 8/10 acre – 1.71 AF (559,504 gal)
Hudson-Carpenter Park/Community Garden (431 S. Main St), - 8/10 acre – 3.8 AF (1,239,436 gal)
Ukiah Civic Center (300 Seminary Ave),- 2.5 acres – Purdy Park – .28 AF (92,004 gal)
McGarvey Park (310 S. Dora St)- 1 acre – 2.56 AF (834,768 gal)

3. Type of land to be irrigated (grass/landscaping, pasture, vines, orchard, etc):

Grass

4. Existing irrigated acreage: __5.1 total acres

Planned additional irrigable acreage: ____0_____acres

5. Current irrigation/frost protection water source(s):

Water Source:	Used? (Y/N)	Description of Use (e.g. irrigation, frost protection):
Groundwater wells		
Stream/surface water		
Potable (City) water	yes	Grass irrigation
Other		

6. Existing Water Storage: ____0_____acre-feet

Any plans to add more storage: _____ YES ___X__ NO

If yes, how much storage will be added? _____acre-feet

7. Do you have any concerns or issues with using recycled water? Please check all that apply and explain:

___ Cost of the recycled water

_X__ Cost of the delivery system (e.g., pipelines, pump stations, etc.)

___ Water quality

___ Daily timing of deliveries

__X_ Seasonal timing of deliveries

___ Pressure

___ Other (please list)

_____

_____

_____

_____

_____

8. Please list other water usage considerations you feel would be important to your possible use of recycled water (e.g., time of year, days of week, hours of day, pressure considerations, volumes, duration of irrigation, etc):

_____

_____

_____

_____

9. Are you interested in using recycled water for irrigation and/or frost protection purposes?

__X___YES _____NO

In checking yes, I understand I am expressing interest in potentially using recycled water for irrigation and/or frost protection purposes provided the recycled water available is of comparable quality and reasonable cost to the water currently used for irrigation and/or frost protection.

Sage Sangiacomo

Name of Representative

Signature of Representative

6/24/11

Date

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CITY OF UKIAH
RECYCLED WATER USE QUESTIONNAIRE

The purpose of this questionnaire is to gather information and understand your department/agency/businesses' interest in using recycled water for irrigation/frost protection.

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Jarod Thiele, City of Ukiah, Public Works Administration, 300 Seminary Ave, Ukiah, CA 95482 or at jthiele@cityofukiah.com. An electronic or hard copy is fine.

1. Land Owner Name: City of Ukiah Group 4

2. Property Address: Observatory Park (432 Observatory St.) & Community Garden

2010 Usage 4.89 AF (1,594,736 gal)

3. Type of land to be irrigated (grass/landscaping, pasture, vines, orchard, etc):

Grass

4. Existing irrigated acreage: 2.5 acres

   Planned additional irrigable acreage: _____ acres

5. Current irrigation/frost protection water source(s):

Water Source:	Used? (Y/N)	Description of Use (e.g. irrigation, frost protection):
Groundwater wells		
Stream/surface water		
Potable (City) water	X	landscape irrigation
Other		

6. Existing Water Storage: 0 acre-feet

Any plans to add more storage: ~~YES~~ ____ NO

If yes, how much storage will be added? 0 acre-feet

7. Do you have any concerns or issues with using recycled water? Please check all that apply and explain:

___ Cost of the recycled water

X Cost of the delivery system (e.g., pipelines, pump stations, etc.)

___ Water quality

___ Daily timing of deliveries

X Seasonal timing of deliveries

___ Pressure

___ Other (please list)

8. Please list other water usage considerations you feel would be important to your possible use of recycled water (e.g., time of year, days of week, hours of day, pressure considerations, volumes, duration of irrigation, etc):

9. Are you interested in using recycled water for irrigation and/or frost protection purposes?

X YES _____NO

In checking yes, I understand I am expressing interest in potentially using recycled water for irrigation and/or frost protection purposes provided the recycled water available is of comparable quality and reasonable cost to the water currently used for irrigation and/or frost protection.

Sage Sangiacomo
Name of Representative

Signature of Representative

6/24/11
Date

Thank you for your help and participation in this very important City of Ukiah project. We welcome your participation throughout the planning process. Please see the accompanying letter on how you can stay involved.

CITY OF UKIAH
RECYCLED WATER USE QUESTIONNAIRE

The purpose of this questionnaire is to gather information and understand your department/agency/businesses' interest in using recycled water for irrigation/frost protection.

PLEASE RETURN YOUR COMPLETED QUESTIONNAIRE BY APRIL 30, 2011 TO:
Jarod Thiele, City of Ukiah, Public Works Administration, 300 Seminary Ave, Ukiah, CA 95482 or at jthiele@cityofukiah.com. An electronic or hard copy is fine.

1. Land Owner Name: City of Ukiah Group 5

2. Property Address: Oak Manor Park (500 Oak Manor Dr.) 2010 Usage 9.32 AF (3,037,628 gal)

3. Type of land to be irrigated (grass/landscaping, pasture, vines, orchard, etc):

Grass

4. Existing irrigated acreage: 4 acres

   Planned additional irrigable acreage: — acres

5. Current irrigation/frost protection water source(s):

Water Source:	Used? (Y/N)	Description of Use (e.g. irrigation, frost protection):
Groundwater wells		
Stream/surface water		
Potable (City) water	X	landscape irrigation
Other		

5

9. Are you interested in using recycled water for irrigation and/or frost protection purposes?

X YES _____NO

In checking yes, I understand I am expressing interest in potentially using recycled water for irrigation and/or frost protection purposes provided the recycled water available is of comparable quality and reasonable cost to the water currently used for irrigation and/or frost protection.

Sage Sangiacomo

Name of Representative

Sage Sangiacomo

Signature of Representative

6/24/11

Date

Thank you for your help and participation in this very important City of Ukiah project. We welcome your participation throughout the planning process. Please see the accompanying letter on how you can stay involved.

6. Existing Water Storage: _____acre-feet

Any plans to add more storage: ~~YES~~ NO

If yes, how much storage will be added? _____acre-feet

7. Do you have any concerns or issues with using recycled water? Please check all that apply and explain:

___ Cost of the recycled water

X Cost of the delivery system (e.g., pipelines, pump stations, etc.)

___ Water quality

___ Daily timing of deliveries

X Seasonal timing of deliveries

___ Pressure

___ Other (please list)

8. Please list other water usage considerations you feel would be important to your possible use of recycled water (e.g., time of year, days of week, hours of day, pressure considerations, volumes, duration of irrigation, etc):

CITY OF UKIAH
RECYCLED WATER USE QUESTIONNAIRE

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Jarod Thiele, City of Ukiah, Public Works Administration, 300 Seminary Ave, Ukiah, CA 95482 or at jthiele@cityofukiah.com. An electronic or hard copy is fine.

1. Land Owner Name: City of Ukiah Group 6

2. Property Address: Cindee Park (707 Cindee Drive) Orchard Park 2010 usage 1.52 AF (495,924 gal)

3. Type of land to be irrigated (grass/landscaping, pasture, vines, orchard, etc):

Grass

4. Existing irrigated acreage: 2 acres

   Planned additional irrigable acreage: _____ acres

5. Current irrigation/frost protection water source(s):

Water Source:	Used? (Y/N)	Description of Use (e.g. irrigation, frost protection):
Groundwater wells		
Stream/surface water		
Potable (City) water	yes	landscape irrigation
Other		

6

6. Existing Water Storage: 0 acre-feet

Any plans to add more storage: — YES — NO

If yes, how much storage will be added? — acre-feet

7. Do you have any concerns or issues with using recycled water? Please check all that apply and explain:

___ Cost of the recycled water

X Cost of the delivery system (e.g., pipelines, pump stations, etc.)

___ Water quality

___ Daily timing of deliveries

X Seasonal timing of deliveries

___ Pressure

___ Other (please list)

8. Please list other water usage considerations you feel would be important to your possible use of recycled water (e.g., time of year, days of week, hours of day, pressure considerations, volumes, duration of irrigation, etc):

9. Are you interested in using recycled water for irrigation and/or frost protection purposes?

_X_YES _____NO

In checking yes, I understand I am expressing interest in potentially using recycled water for irrigation and/or frost protection purposes provided the recycled water available is of comparable quality and reasonable cost to the water currently used for irrigation and/or frost protection.

Sage Sangiacomo

Name of Representative

Signature of Representative

6/24/11

Date

Thank you for your help and participation in this very important City of Ukiah project. We welcome your participation throughout the planning process. Please see the accompanying letter on how you can stay involved.

CITY OF UKIAH
RECYCLED WATER USE QUESTIONNAIRE

The purpose of this questionnaire is to gather information and understand your department/agency/businesses' interest in using recycled water for irrigation/frost protection.

PLEASE RETURN YOUR COMPLETED QUESTIONNAIRE BY APRIL 30, 2011 TO:
Jarod Thiele, City of Ukiah, Public Works Administration, 300 Seminary Ave, Ukiah, CA 95482 or at jthiele@cityofukiah.com. An electronic or hard copy is fine.

1. Land Owner Name: City of Ukiah Group 7

2. Property Address: Vinewood Park (1260 Elm St) 2010 usage 10.62 AF (3,463,240 gal)

3. Type of land to be irrigated (grass/landscaping, pasture, vines, orchard, etc):

Grass

4. Existing irrigated acreage: 4.7 acres

   Planned additional irrigable acreage: _____ acres

5. Current irrigation/frost protection water source(s):

Water Source:	Used? (Y/N)	Description of Use (e.g. irrigation, frost protection):
Groundwater wells		
Stream/surface water		
Potable (City) water	yes	landscape irrigation
Other		

6. Existing Water Storage: 0 acre-feet

Any plans to add more storage: ✓ YES ____ NO

If yes, how much storage will be added? — acre-feet

7. Do you have any concerns or issues with using recycled water? Please check all that apply and explain:

✓ Cost of the recycled water

___ Cost of the delivery system (e.g., pipelines, pump stations, etc.)

___ Water quality

___ Daily timing of deliveries

✓ Seasonal timing of deliveries

___ Pressure

___ Other (please list)

8. Please list other water usage considerations you feel would be important to your possible use of recycled water (e.g., time of year, days of week, hours of day, pressure considerations, volumes, duration of irrigation, etc):

9. Are you interested in using recycled water for irrigation and/or frost protection purposes?

X YES _____NO

In checking yes, I understand I am expressing interest in potentially using recycled water for irrigation and/or frost protection purposes provided the recycled water available is of comparable quality and reasonable cost to the water currently used for irrigation and/or frost protection.

Sage Sangiacomo

Name of Representative

Signature of Representative

6/24/11

Date

Thank you for your help and participation in this very important City of Ukiah project. We welcome your participation throughout the planning process. Please see the accompanying letter on how you can stay involved.

CITY OF UKIAH
RECYCLED WATER USE QUESTIONNAIRE

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1. Land Owner Name: City of Ukiah Group 8

2. Property Address: Softball Complex (River St Exit of Hwy 101) 2010 usage 14.54 AF (4,739,326 gal)

3. Type of land to be irrigated (grass/landscaping, pasture, vines, orchard, etc):

Grass

4. Existing irrigated acreage: 10.3 acres

   Planned additional irrigable acreage: _____ acres

5. Current irrigation/frost protection water source(s):

Water Source:	Used? (Y/N)	Description of Use (e.g. irrigation, frost protection):
Groundwater wells	no	
Stream/surface water	no	
Potable (City) water	yes	landscape irrigation
Other	no	

9

6. Existing Water Storage: 0 acre-feet

Any plans to add more storage: — YES — NO

If yes, how much storage will be added? — acre-feet

7. Do you have any concerns or issues with using recycled water? Please check all that apply and explain:

___ Cost of the recycled water

X Cost of the delivery system (e.g., pipelines, pump stations, etc.)

___ Water quality

___ Daily timing of deliveries

X Seasonal timing of deliveries

___ Pressure

___ Other (please list)

8. Please list other water usage considerations you feel would be important to your possible use of recycled water (e.g., time of year, days of week, hours of day, pressure considerations, volumes, duration of irrigation, etc):

9. Are you interested in using recycled water for irrigation and/or frost protection purposes?

X YES _____NO

In checking yes, I understand I am expressing interest in potentially using recycled water for irrigation and/or frost protection purposes provided the recycled water available is of comparable quality and reasonable cost to the water currently used for irrigation and/or frost protection.

Sage Sangiacomo

Name of Representative

Signature of Representative

6/24/11

Date

Thank you for your help and participation in this very important City of Ukiah project. We welcome your participation throughout the planning process. Please see the accompanying letter on how you can stay involved.

CITY OF UKIAH
RECYCLED WATER USE QUESTIONNAIRE

The purpose of this questionnaire is to gather information and understand your department/agency/businesses' interest in using recycled water for irrigation/frost protection.

PLEASE RETURN YOUR COMPLETED QUESTIONNAIRE BY APRIL 30, 2011 TO:
Jarod Thiele, City of Ukiah, Public Works Administration, 300 Seminary Ave, Ukiah, CA 95482 or at jthiele@cityofukiah.com. An electronic or hard copy is fine.

1. Land Owner Name: Catherine Golden + Gannon Family LLC

2. Property Address: 3301 S. State St. Ukiah

3. Type of land to be irrigated (grass/landscaping, pasture, vines, orchard, etc):

agricultural → Whispering Pine Nursery

4. Existing irrigated acreage: 0 acres

   Planned additional irrigable acreage: 0 acres

5. Current irrigation/frost protection water source(s):

Water Source:	Used? (Y/N)	Description of Use (e.g. irrigation, frost protection):
Groundwater wells	Ø	
Stream/surface water	Ø	
Potable (City) water	Ø	Willow County Water District street water
Other	Yes	↓

6. Existing Water Storage: ___Ø___ acre-feet

Any plans to add more storage: ____ YES ___✓___ NO

If yes, how much storage will be added? ___Ø___ acre-feet

7. Do you have any concerns or issues with using recycled water? Please check all that apply and explain:

___✓___ Cost of the recycled water

___✓___ Cost of the delivery system (e.g., pipelines, pump stations, etc.)

___✓___ Water quality

___ Daily timing of deliveries

___ Seasonal timing of deliveries

___✓___ Pressure

___ Other (please list)

There is serious concern regarding the quality of the recycled water. Mr O'Neil is concerned it could damage his plants

8. Please list other water usage considerations you feel would be important to your possible use of recycled water (e.g., time of year, days of week, hours of day, pressure considerations, volumes, duration of irrigation, etc):

Ø

9. Are you interested in using recycled water for irrigation and/or frost protection purposes?

_____YES ✓ NO

In checking yes, I understand I am expressing interest in potentially using recycled water for irrigation and/or frost protection purposes provided the recycled water available is of comparable quality and reasonable cost to the water currently used for irrigation and/or frost protection.

Maureen Gannon Riedy
Name of Representative

Maureen Gannon Riedy
Signature of Representative

April 30, 2011
Date

Thank you for your help and participation in this very important City of Ukiah project. We welcome your participation throughout the planning process. Please see the accompanying letter on how you can stay involved.

phoned interview 4/30/11
Jim O'Neil - nursery owner/tenant at 3301 S State.
If recycled water becomes available & can be guaranteed not to harm plants - it might be worth contacting Mr. O'Neil w/ the information & cost factors (707) 462-0422

Maureen G Riedy
(415) 453-8390
mgriedy@gmail.com
273 Butterfield Rd.
San Anselmo, Ca
94960

RECEIVED
APR 25 2011
City of Ukiah

CITY OF UKIAH
RECYCLED WATER USE QUESTIONNAIRE

The purpose of this questionnaire is to gather information and understand your department/agency/businesses' interest in using recycled water for irrigation/frost protection.

PLEASE RETURN YOUR COMPLETED QUESTIONNAIRE BY APRIL 30, 2011 TO:
Jarod Thiele, City of Ukiah, Public Works Administration, 300 Seminary Ave, Ukiah, CA 95482 or at jthiele@cityofukiah.com. An electronic or hard copy is fine.

1. Land Owner Name: Devin W. Gordon

2. Property Address: 4550 El Roble Rd Ukiah

3. Type of land to be irrigated (grass/landscaping, pasture, vines, orchard, etc):

Vineyard

4. Existing irrigated acreage: 32 acres

Planned additional irrigable acreage: 0 acres

5. Current irrigation/frost protection water source(s):

Water Source:	Used? (Y/N)	Description of Use (e.g. irrigation, frost protection):
Groundwater wells	YES	Drip Irrigation
Stream/surface water	YES	Frost Protection
Potable (City) water		
Other		

6. Existing Water Storage: ~10 acre-feet

Any plans to add more storage: _____ YES ✓ NO

If yes, how much storage will be added? _____ acre-feet

7. Do you have any concerns or issues with using recycled water? Please check all that apply and explain:

✓ Cost of the recycled water

✓ Cost of the delivery system (e.g., pipelines, pump stations, etc.)

✓ Water quality

___ Daily timing of deliveries

___ Seasonal timing of deliveries

___ Pressure

✓ Other (please list)

What would usage of the treated water mean to my water right, if I displace my water right water with your water what does SWRB do?

8. Please list other water usage considerations you feel would be important to your possible use of recycled water (e.g., time of year, days of week, hours of day, pressure considerations, volumes, duration of irrigation, etc):

9. Are you interested in using recycled water for irrigation and/or frost protection purposes?

_X_YES _____NO

In checking yes, I understand I am expressing interest in potentially using recycled water for irrigation and/or frost protection purposes provided the recycled water available is of comparable quality and reasonable cost to the water currently used for irrigation and/or frost protection.

DEVIN W. GORDON

Name of Representative

Signature of Representative

4/22/2011

Date

Thank you for your help and participation in this very important City of Ukiah project. We welcome your participation throughout the planning process. Please see the accompanying letter on how you can stay involved.

RECEIVED
APR 20 2011
City of Ukiah

CITY OF UKIAH
RECYCLED WATER USE QUESTIONNAIRE

The purpose of this questionnaire is to gather information and understand your department/agency/businesses' interest in using recycled water for irrigation/frost protection.

PLEASE RETURN YOUR COMPLETED QUESTIONNAIRE BY APRIL 30, 2011 TO:
Jarod Thiele, City of Ukiah, Public Works Administration, 300 Seminary Ave, Ukiah, CA 95482 or at jthiele@cityofukiah.com. An electronic or hard copy is fine.

1. Land Owner Name: Hildreth Farms Inc and Michael L. Hildreth

2. Property Address: Hastings Rd and Talmage Rd. AND 3750 Burke Hill Rd

3. Type of land to be irrigated (grass/landscaping, pasture, vines, orchard, etc):

Pear Orchards - Vineyards

4. Existing irrigated acreage: 30ac acres Vineyard 64ac Pears

Planned additional irrigable acreage: 0 acres

5. Current irrigation/frost protection water source(s):

Water Source:	Used? (Y/N)	Description of Use (e.g. irrigation, frost protection):
Groundwater wells		
Stream/surface water	Y	Irrigation AND Frost protection (Pears) Frost Protect + Drip Irrigation (Grapes)
Potable (City) water		
Other	Willow water District	Drip Irrigation

6. Existing Water Storage: 23.6 acre-feet

Any plans to add more storage: _____ YES X NO

If yes, how much storage will be added? _____acre-feet

7. Do you have any concerns or issues with using recycled water? Please check all that apply and explain:

✓ Cost of the recycled water

✓ Cost of the delivery system (e.g., pipelines, pump stations, etc.)

✓ Water quality

✓ Daily timing of deliveries

✓ Seasonal timing of deliveries

✓ Pressure

✓ Other (please list)

Has to be exceptable to the fresh fruit and Cannery markets as well as the wineries.

8. Please list other water usage considerations you feel would be important to your possible use of recycled water (e.g., time of year, days of week, hours of day, pressure considerations, volumes, duration of irrigation, etc):

orchard @ Hastings Rd

Could use irrigation water at 10 To 14 day intervals for 24 Hr sets, pressurized to my lines @ 50psi. Summer irrigation use begins Late April to end of September - Total use 100 To 125 ac ft./season. (1200 gal/min.) required

Vineyard @ 3750 Burke Hill Rd.

Could use water to recharge and fill Reservoir

Possible use for drip irrigation during summer season

30 To 40 ac ft/season.

Frost Protection in the spring. 1500 gal/min out of Reservoir. Hours and total amount depends on the year.

9. Are you interested in using recycled water for irrigation and/or frost protection purposes?

✓ YES _____ NO Depending on Costs.

In checking yes, I understand I am expressing interest in potentially using recycled water for irrigation and/or frost protection purposes provided the recycled water available is of comparable quality and reasonable cost to the water currently used for irrigation and/or frost protection.

Hildreth Farms Inc

Name of Representative

Michael S. Hildreth

Signature of Representative

4-19-2011

Date

Thank you for your help and participation in this very important City of Ukiah project. We welcome your participation throughout the planning process. Please see the accompanying letter on how you can stay involved.

CITY OF UKIAH
RECYCLED WATER USE QUESTIONNAIRE

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Jarod Thiele, City of Ukiah, Public Works Administration, 300 Seminary Ave, Ukiah, CA 95482 or at jthiele@cityofukiah.com. An electronic or hard copy is fine.

1. Land Owner Name: William T. Johnson

2. Property Address: 801 Babcock Lane Ukiah, CA 95482

3. Type of land to be irrigated (grass/landscaping, pasture, vines, orchard, etc):

Pears + Grapes
50 30

4. Existing irrigated acreage: 80 acres

   Planned additional irrigable acreage: 80 acres

5. Current irrigation/frost protection water source(s):

Water Source:	Used? (Y/N)	Description of Use (e.g. irrigation, frost protection):
Groundwater wells	Y	Frost + Irrigation
Stream/surface water	Y	Frost + Irrigation
Potable (City) water		
Other	~~N~~ Y	Russian River Flood control water for Irrigation + Frost

6. Existing Water Storage: Not @ this Ranch acre-feet

Any plans to add more storage: ___?___ YES _____ NO

If yes, how much storage will be added? ___?___ acre-feet

7. Do you have any concerns or issues with using recycled water? Please check all that apply and explain:

✓ Cost of the recycled water

✓ Cost of the delivery system (e.g., pipelines, pump stations, etc.)

___ Water quality

✓ Daily timing of deliveries

✓ Seasonal timing of deliveries

___ Pressure

___ Other (please list)

8. Please list other water usage considerations you feel would be important to your possible use of recycled water (e.g., time of year, days of week, hours of day, pressure considerations, volumes, duration of irrigation, etc):

yes all of these could be possible issues

9. Are you interested in using recycled water for irrigation and/or frost protection purposes?

__X__YES _____NO

In checking yes, I understand I am expressing interest in potentially using recycled water for irrigation and/or frost protection purposes provided the recycled water available is of comparable quality and reasonable cost to the water currently used for irrigation and/or frost protection.

Peter Johnson

Name of Representative

Peter Johnson

Signature of Representative

May 8th 2011

Date

Thank you for your help and participation in this very important City of Ukiah project. We welcome your participation throughout the planning process. Please see the accompanying letter on how you can stay involved.

CITY OF UKIAH

RECYCLED WATER USE QUESTIONNAIRE

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Jarod Thiele, City of Ukiah, Public Works Administration, 300 Seminary Ave, Ukiah, CA 95482 or at jthiele@cityofukiah.com. An electronic or hard copy is fine.

1. Land Owner Name: David Kotall (revised)

2. Property Address: 3495 Taylor Drive.

3. Type of land to be irrigated (grass/landscaping, pasture, vines, orchard, etc):

Pasture, alfalfa, grapes, hops

4. Existing irrigated acreage: 80 acres

Planned additional irrigable acreage: 32 acres → 2012
80 → 2022?

Phone call 07/26/11:
2012:
28 acres alphalfa
12 acres grapes
12 acres pasture
11 acres of storage
2022:
40 acres total

5. Current irrigation/frost protection water source(s):

Water Source:	Used? (Y/N)	Description of Use (e.g. irrigation, frost protection):
Groundwater wells	N	
Stream/surface water	Y	irrigation + frost protection
Potable (City) water	N	
Other		

6. Existing Water Storage: ___0___ acre-feet

Any plans to add more storage: ___X___ YES _____ NO

If yes, how much storage will be added? ___11___ acre-feet minimum

40 AF max - depending upon system design + grant funding.

7. Do you have any concerns or issues with using recycled water? Please check all that apply and explain:

___X___ Cost of the recycled water

___X___ Cost of the delivery system (e.g., pipelines, pump stations, etc.)

___ Water quality

___X___ Daily timing of deliveries

___X___ Seasonal timing of deliveries

___ Pressure

___ Other (please list)

- Organic use
- Regional WQCB requirements.

8. Please list other water usage considerations you feel would be important to your possible use of recycled water (e.g., time of year, days of week, hours of day, pressure considerations, volumes, duration of irrigation, etc):

- storage volume needed, ability to seasonally recharge ponds, ability to recharge during severe frost events.

9. Are you interested in using recycled water for irrigation and/or frost protection purposes?

X YES _____NO

In checking yes, I understand I am expressing interest in potentially using recycled water for irrigation and/or frost protection purposes provided the recycled water available is of comparable quality and reasonable cost to the water currently used for irrigation and/or frost protection.

David Koball

Name of Representative

Signature of Representative

6/7/11

Date

Thank you for your help and participation in this very important City of Ukiah project. We welcome your participation throughout the planning process. Please see the accompanying letter on how you can stay involved.

RECEIVED
APR 20 2011
City of Ukiah

CITY OF UKIAH
RECYCLED WATER USE QUESTIONNAIRE

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Jarod Thiele, City of Ukiah, Public Works Administration, 300 Seminary Ave, Ukiah, CA 95482 or at jthiele@cityofukiah.com. An electronic or hard copy is fine.

1. Land Owner Name: David Koball and Amy Smith

2. Property Address: 3493 + 3495 Taylor Drive

3. Type of land to be irrigated (grass/landscaping, pasture, vines, orchard, etc):

Pasture, Alfalfa, Vineyard

4. Existing irrigated acreage: 30 acres

   Planned additional irrigable acreage: 30 acres

5. Current irrigation/frost protection water source(s):

Water Source:	Used? (Y/N)	Description of Use (e.g. irrigation, frost protection):
Groundwater wells	N	
Stream/surface water	Y	Irrigation + frost protection
Potable (City) water	N	
Other	N	

6. Existing Water Storage: Ø acre-feet

Any plans to add more storage: X YES ____ NO

If yes, how much storage will be added? 15 acre-feet

7. Do you have any concerns or issues with using recycled water? Please check all that apply and explain:

X Cost of the recycled water

X Cost of the delivery system (e.g., pipelines, pump stations, etc.)

___ Water quality

X Daily timing of deliveries

X Seasonal timing of deliveries

___ Pressure

X Other (please list)

- Compatibility with organic production
- regional water quality guidelines needing to control runoff

8. Please list other water usage considerations you feel would be important to your possible use of recycled water (e.g., time of year, days of week, hours of day, pressure considerations, volumes, duration of irrigation, etc):

9. Are you interested in using recycled water for irrigation and/or frost protection purposes?

_X_YES _____NO

In checking yes, I understand I am expressing interest in potentially using recycled water for irrigation and/or frost protection purposes provided the recycled water available is of comparable quality and reasonable cost to the water currently used for irrigation and/or frost protection.

David Kotvall Pres. K2 Farming LLC

Name of Representative

Signature of Representative

4/15/11

Date

Thank you for your help and participation in this very important City of Ukiah project. We welcome your participation throughout the planning process. Please see the accompanying letter on how you can stay involved.

CITY OF UKIAH

RECYCLED WATER USE QUESTIONNAIRE

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1. Land Owner Name: LELAND LA MALFA

2. Property Address: 251 Stipp Ln

3. Type of land to be irrigated (grass/landscaping, pasture, vines, orchard, etc):

VINES

4. Existing irrigated acreage: 8 acres

   Planned additional irrigable acreage: 4 acres

5. Current irrigation/frost protection water source(s):

Water Source:	Used? (Y/N)	Description of Use (e.g. irrigation, frost protection):
Groundwater wells		
Stream/surface water		
Potable (City) water		
Other		

Information for questions 5 through 9 are the same as those included in the La Malfa, R. questionnaire. This form was completed by Richard La Malfa on behalf of Leland La Malfa.

6. Existing Water Storage: _____acre-feet

Any plans to add more storage: _____ YES _____ NO

If yes, how much storage will be added? _____acre-feet

7. Do you have any concerns or issues with using recycled water? Please check all that apply and explain:

___ Cost of the recycled water

___ Cost of the delivery system (e.g., pipelines, pump stations, etc.)

___ Water quality

___ Daily timing of deliveries

___ Seasonal timing of deliveries

___ Pressure

___ Other (please list)

_____
_____
_____
_____
_____

8. Please list other water usage considerations you feel would be important to your possible use of recycled water (e.g., time of year, days of week, hours of day, pressure considerations, volumes, duration of irrigation, etc):

_____
_____
_____
_____

9. Are you interested in using recycled water for irrigation and/or frost protection purposes?

_____YES _____NO

In checking yes, I understand I am expressing interest in potentially using recycled water for irrigation and/or frost protection purposes provided the recycled water available is of comparable quality and reasonable cost to the water currently used for irrigation and/or frost protection.

_____

Name of Representative

_____ _____

Signature of Representative Date

Thank you for your help and participation in this very important City of Ukiah project. We welcome your participation throughout the planning process. Please see the accompanying letter on how you can stay involved.

CITY OF UKIAH
RECYCLED WATER USE QUESTIONNAIRE

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Jarod Thiele, City of Ukiah, Public Works Administration, 300 Seminary Ave, Ukiah, CA 95482 or at jthiele@cityofukiah.com. An electronic or hard copy is fine.

1. Land Owner Name: RICHARD LAMALFA

2. Property Address: 3600 LELAND LANE / 4607 El Roble RD

3. Type of land to be irrigated (grass/landscaping, pasture, vines, orchard, etc):

VINE / ORCHARD

40 AC PEARS 9 AC

4. Existing irrigated acreage: ~~60~~ 50 acres

   Planned additional irrigable acreage: 15 acres

5. Current irrigation/frost protection water source(s):

Water Source:	Used? (Y/N)	Description of Use (e.g. irrigation, frost protection):
Groundwater wells	Y	IRRIGATION & FROST
Stream/surface water	Y	" "
Potable (City) water	N	
Other	N	

6. Existing Water Storage: 15 acre-feet

Any plans to add more storage: _____ YES X NO

If yes, how much storage will be added? _____acre-feet

7. Do you have any concerns or issues with using recycled water? Please check all that apply and explain:

X Cost of the recycled water

X Cost of the delivery system (e.g., pipelines, pump stations, etc.)

X Water quality

X Daily timing of deliveries

X Seasonal timing of deliveries

X Pressure

___ Other (please list)

8. Please list other water usage considerations you feel would be important to your possible use of recycled water (e.g., time of year, days of week, hours of day, pressure considerations, volumes, duration of irrigation, etc):

9. Are you interested in using recycled water for irrigation and/or frost protection purposes?

X YES _____NO

In checking yes, I understand I am expressing interest in potentially using recycled water for irrigation and/or frost protection purposes provided the recycled water available is of comparable quality and reasonable cost to the water currently used for irrigation and/or frost protection.

_____

Name of Representative

Richard LaMoy

Signature of Representative

6/8/11

Date

Thank you for your help and participation in this very important City of Ukiah project. We welcome your participation throughout the planning process. Please see the accompanying letter on how you can stay involved.

CITY OF UKIAH
RECYCLED WATER USE QUESTIONNAIRE

The purpose of this questionnaire is to gather information and understand your department/agency/businesses' interest in using recycled water for irrigation/frost protection.

PLEASE RETURN YOUR COMPLETED QUESTIONNAIRE BY APRIL 30, 2011 TO:
Jarod Thiele, City of Ukiah, Public Works Administration, 300 Seminary Ave, Ukiah, CA 95482 or at jthiele@cityofukiah.com. An electronic or hard copy is fine.

1. Land Owner Name: MILOVINA VINEYARDS

2. Property Address: 3551 TAYLOR RD

3. Type of land to be irrigated (grass/landscaping, pasture, vines, orchard, etc):

VINES

4. Existing irrigated acreage: 40 acres

   Planned additional irrigable acreage: 13 acres

5. Current irrigation/frost protection water source(s):

Water Source:	Used? (Y/N)	Description of Use (e.g. irrigation, frost protection):
Groundwater wells		
Stream/surface water	Y	FROST, IRRIGATION
Potable (City) water		
Other		

6. Existing Water Storage: ___0___acre-feet

Any plans to add more storage: _✓_ YES _____ NO

If yes, how much storage will be added? __10__acre-feet

7. Do you have any concerns or issues with using recycled water? Please check all that apply and explain:

_✓_ Cost of the recycled water

_✓_ Cost of the delivery system (e.g., pipelines, pump stations, etc.)

_✓_ Water quality

_✓_ Daily timing of deliveries

_✓_ Seasonal timing of deliveries

_✓_ Pressure

___ Other (please list)

8. Please list other water usage considerations you feel would be important to your possible use of recycled water (e.g., time of year, days of week, hours of day, pressure considerations, volumes, duration of irrigation, etc):

9. Are you interested in using recycled water for irrigation and/or frost protection purposes?

✓ YES _____ NO

In checking yes, I understand I am expressing interest in potentially using recycled water for irrigation and/or frost protection purposes provided the recycled water available is of comparable quality and reasonable cost to the water currently used for irrigation and/or frost protection.

JOHN MILOVINA

Name of Representative

John Milovina

Signature of Representative

5-11-11

Date

Thank you for your help and participation in this very important City of Ukiah project. We welcome your participation throughout the planning process. Please see the accompanying letter on how you can stay involved.

CITY OF UKIAH
RECYCLED WATER USE QUESTIONNAIRE

The purpose of this questionnaire is to gather information and understand your department/agency/businesses' interest in using recycled water for irrigation/frost protection.

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Jarod Thiele, City of Ukiah, Public Works Administration, 300 Seminary Ave, Ukiah, CA 95482 or at jthiele@cityofukiah.com. An electronic or hard copy is fine.

1. Land Owner Name: Norgard Properties, Inc.

2. Property Address: South of 381 Norgard Lane

3. Type of land to be irrigated (grass/landscaping, pasture, vines, orchard, etc):

Vineyard

4. Existing irrigated acreage: 8 acres

   Planned additional irrigable acreage: _____ acres

5. Current irrigation/frost protection water source(s):

Water Source:	Used? (Y/N)	Description of Use (e.g. irrigation, frost protection):
Groundwater wells		
Stream/surface water	Y	irrigation, frost, cooling
Potable (City) water	Y	irrigation, frost, cooling
Other		

6. Existing Water Storage: _____acre-feet

Any plans to add more storage: _____ YES ✓ NO

If yes, how much storage will be added? _____acre-feet

7. Do you have any concerns or issues with using recycled water? Please check all that apply and explain:

___ Cost of the recycled water

___ Cost of the delivery system (e.g., pipelines, pump stations, etc.)

___ Water quality

___ Daily timing of deliveries

___ Seasonal timing of deliveries

___ Pressure

___ Other (please list)

_____

_____

_____

_____

_____

8. Please list other water usage considerations you feel would be important to your possible use of recycled water (e.g., time of year, days of week, hours of day, pressure considerations, volumes, duration of irrigation, etc):

_____

_____

_____

_____

9. Are you interested in using recycled water for irrigation and/or frost protection purposes?

✓ YES _____NO

In checking yes, I understand I am expressing interest in potentially using recycled water for irrigation and/or frost protection purposes provided the recycled water available is of comparable quality and reasonable cost to the water currently used for irrigation and/or frost protection.

Timothy Norgard
Name of Representative

Timothy L. Norgard
Signature of Representative

5/10/11
Date

Thank you for your help and participation in this very important City of Ukiah project. We welcome your participation throughout the planning process. Please see the accompanying letter on how you can stay involved.

RECEIVED
MAY 26 2011
City of Ukiah

CITY OF UKIAH

RECYCLED WATER USE QUESTIONNAIRE

The purpose of this questionnaire is to gather information and understand your department/agency/businesses' interest in using recycled water for irrigation/frost protection.

PLEASE RETURN YOUR COMPLETED QUESTIONNAIRE BY APRIL 30, 2011 TO:
Jarod Thiele, City of Ukiah, Public Works Administration, 300 Seminary Ave, Ukiah, CA 95482 or at jthiele@cityofukiah.com. An electronic or hard copy is fine.

1. Land Owner Name: UKIAH UNIFIED School DIST

2. Property Address: _____

3. Type of land to be irrigated (grass/landscaping, pasture, vines, orchard, etc):

TURF

4. Existing irrigated acreage: 38.8 acres

   Planned additional irrigable acreage: Ø acres

5. Current irrigation/frost protection water source(s):

Water Source:	Used? (Y/N)	Description of Use (e.g. irrigation, frost protection):
Groundwater wells	N	
Stream/surface water	N	
Potable (City) water	Y	
Other		38.8 ACRES OF IRRIGATED TURF within TOWN BOUNDARIES

6. Existing Water Storage: N/A acre-feet

Any plans to add more storage: _____ YES _____ NO

If yes, how much storage will be added? _____acre-feet

7. Do you have any concerns or issues with using recycled water? Please check all that apply and explain:

✓ Cost of the recycled water

✓ Cost of the delivery system (e.g., pipelines, pump stations, etc.)

✓ Water quality

✓ Daily timing of deliveries

✓ Seasonal timing of deliveries

✓ Pressure

___ Other (please list)

8. Please list other water usage considerations you feel would be important to your possible use of recycled water (e.g., time of year, days of week, hours of day, pressure considerations, volumes, duration of irrigation, etc):

9. Are you interested in using recycled water for irrigation and/or frost protection purposes?

✓ YES _____NO

In checking yes, I understand I am expressing interest in potentially using recycled water for irrigation and/or frost protection purposes provided the recycled water available is of comparable quality and reasonable cost to the water currently used for irrigation and/or frost protection.

Tom Birse

Name of Representative

Tom Birse

Signature of Representative

5/24/11

Date

Thank you for your help and participation in this very important City of Ukiah project. We welcome your participation throughout the planning process. Please see the accompanying letter on how you can stay involved.

APPENDIX B – POTENTIAL RECYCLED WATER CUSTOMERS

Appendix B - Potential Recycled Water Customers
Recycled Water Master Plan
City of Ukiah

Site or Farmer Name	Parcel APN	Owner (per Parcel GIS Layer from County Assessor's Office)	Site Address	City	Parcel Acreage based on GIS (from Aerial Photograph)	Irrigated Acreage based on GIS (from Aerial Photograph)	Irrigated Acreage from Parcel GIS Layer	Crop or Site Type	Storage	Existing Storage (af)	Planned Future Storage (af)	Irrigated Vineyard Acreage	Irrigated Orchard Acreage	Irrigated Pasture Acreage	Irrigated Row Crop Acreage
	17903002	Thomas Alexander R III & Mary			8.4	7.9	7.4	Orchard	Yes	50	0	0.0	7.9	0.0	0.0
Norgard	18009003	Norgard Properties Inc	1301 Hastings Frontage Rd	TA	6.3	5.1	4.9	Orchard	No	0	0	0.0	5.1	0.0	0.0
	17904001	Thomas Alexander R III & Mary			5.8	4.0	3.7	Orchard	No	0	0	0.0	4.0	0.0	0.0
	17903001	Thomas Alexander R III & Mary	802 E Perkins St	UK	28.1	27.4	37.4	Orchard	Yes	0	0	0.0	27.4	0.0	0.0
	17912001	Ukiah City Of			1.4	0.7	0.8	Orchard	No	0	0	0.0	0.7	0.0	0.0
	17912004	Thomas Alexander R III & Mary			28.0	15.8	16.7	Orchard	No	0	0	0.0	15.8	0.0	0.0
	17902001	Thomas Alexander R III & Mary	224 Vichy Hill Rd	UK	53.6	44.1	28.5	Orchard	No	0	0	0.0	44.1	0.0	0.0
	17914104	Thomas John H			4.4	0.5	0.2	Orchard	No	0	0	0.0	0.5	0.0	0.0
	17903003	Thomas Alexander R III & Mary			1.3	1.1	0.0	Orchard	No	0	0	0.0	1.1	0.0	0.0
	17903005	Thomas Alexander R III & Mary			1.2	0.4	0.0	Orchard	Yes	0	0	0.0	0.4	0.0	0.0
	18413039	Zaina Vineyards LLC	204 Stipp Ln	UK	22.0	20.0	21.2	Vineyard	No	0	0	20.0	0.0	0.0	0.0
Norgard	18011003	Norgard Properties Inc	1900 Hastings Rd	UK	31.9	27.1	25.6	Orchard	No	0	0	0.0	27.1	0.0	0.0
Nova Partners Ltd	18420001	Nova Partners Ltd	4001 Cox Schrader Rd	UK	70.0	59.2	60.5	Vineyard	No	0	0	59.2	0.0	0.0	0.0
Nova Partners Ltd	18422003	Nova Partners Ltd	4301 Cox Schrader Rd	UK	22.6	17.8	20.0	Vineyard	No	0	0	17.8	0.0	0.0	0.0
Nova Partners Ltd	18424002	Nova Partners Ltd			53.1	30.9	26.8	Vineyard	No	0	0	30.9	0.0	0.0	0.0
Koball	18416001	Thomas Alexander R III & Mary	3493 Taylor Dr	UK	46.9	40.5	39.0	Orchard	Yes	0	0	0.0	40.5	0.0	0.0
	18412002	Kummert Jack H & Elizabeth J			3.3	3.0	0.0	Vineyard	No	0	0	3.0	0.0	0.0	0.0
	18601017	Mccarn Jerry D	4520 Burke Hill Dr	UK	1.1	0.3	0.2	Vineyard	No	0	0	0.3	0.0	0.0	0.0
	18412003	Kummert Jack H & Elizabeth J	250 Gobalet Ln	UK	1.9	0.4	0.3	Vineyard	No	0	0	0.4	0.0	0.0	0.0
Boer	18505004	Boer Michael P & Nadine E			3.9	2.7	2.1	Vineyard	Yes	0	0	2.7	0.0	0.0	0.0
Boer	18506015	Boer Michael P & Nadine E			9.5	7.9	8.0	Vineyard/Other Row/Orchard	Yes	0	0	7.1	0.8	0.0	1.5
Beckstoffer	18606002	Beckstoffer Vineyard XI Inc	4801 El Roble Rd	UK	9.7	9.0	12.9	Vineyard	Yes	0	0	9.0	0.0	0.0	0.0
Boer	18505001	Kirby Robert W & M Louise Ttee	501 Boonville Rd	UK	1.2	0.1	0.0	Vineyard	Yes	0	0	0.1	0.0	0.0	0.0
Koball	18419001	Thomas Alexander R III & Mary			35.3	28.4	31.2	Orchard	Yes	0	0	0.0	28.4	0.0	0.0
Nova Partners Ltd	18422002	Nova Partners Ltd			32.4	23.7	22.0	Vineyard	No	0	0	23.7	0.0	0.0	0.0
	18524003	Gerhart Katherine E	4100 Burke Hill Dr	UK	20.7	2.0	1.5	Vineyard	No	0	0	2.0	0.0	0.0	0.0
Gordon	18423004	Schrader G K & Eleanor			0.3	0.1	0.1	Vineyard	Yes	0	0	0.1	0.0	0.0	0.0
Beckstoffer	18611003	Beckstoffer Vineyard XI Inc			22.2	14.6	9.5	Vineyard	Yes	0	0	14.6	0.0	0.0	0.0
Gordon	18423006	Gordon Devin W	4550 El Roble Rd	UK	16.5	13.9	15.1	Vineyard	Yes	0	0	13.9	0.0	0.0	0.0
Vau	18602002	Vau Charles & Kerri	4501 El Roble Rd	UK	8.9	6.3	5.4	Vineyard	No	0	0	6.3	0.0	0.0	0.0
Beckstoffer	18604001	Beckstoffer Vineyard XI Inc	4801 S Hwy 101	UK	45.3	41.0	45.3	Vineyard	Yes	0	0	41.0	0.0	0.0	0.0
	18525006	Mccarn Jerry D	4520 Burke Hill Dr	UK	5.9	0.3	0.2	Vineyard	No	0	0	0.3	0.0	0.0	0.0
Beckstoffer	18606005	Beckstoffer Vineyard XI Inc	4701 El Roble Rd	UK	19.0	13.7	14.4	Vineyard	Yes	0	0	13.7	0.0	0.0	0.0
Gordon	18423007	Gordon Devin W			13.9	11.4	12.8	Vineyard	Yes	0	0	11.4	0.0	0.0	0.0
Nova Partners Ltd	18424004	Willow County Water District			4.2	0.4	0.3	Vineyard	No	0	0	0.4	0.0	0.0	0.0
LaMalfa	18603001	Lamalfa Joseph A & Lena Ttees	4607 El Roble Rd	UK	50.7	46.3	51.3	Vineyard	Yes	15	0	46.3	0.0	0.0	0.0
	18608004	Larramendy William L & Jeannet	5040 Burke Hill Dr	UK	4.8	0.3	0.3	Vineyard	No	0	0	0.3	0.0	0.0	0.0
Gordon	18423001	Cox Jack L	4552 El Roble Rd	UK	1.1	0.4	0.5	Vineyard	Yes	10	0	0.4	0.0	0.0	0.0
	18602001	Vau Charles & Kerri			1.0	0.8	1.0	Vineyard	No	0	0	0.8	0.0	0.0	0.0
	18601016	Pettrone Catherine A 1/2	4540 Burke Hill Dr	UK	5.1	2.1	2.1	Vineyard	No	0	0	2.1	0.0	0.0	0.0
Beckstoffer	18602004	Beckstoffer Vineyard XI Inc	4701 El Roble Rd	UK	9.9	9.3	10.8	Vineyard	Yes	60	0	9.3	0.0	0.0	0.0
Beckstoffer	18605002	Beckstoffer Vineyard XI Inc	4701 El Roble Rd	UK	46.7	38.3	44.4	Vineyard/PTL	Yes	0	0	21.5	0.0	16.9	0.0
	18607033	Gordon Devin W	4752 Burke Hill Dr	UK	11.8	6.3	4.8	Vineyard	No	0	0	6.3	0.0	0.0	0.0
Beckstoffer	18606001	Beckstoffer Vineyard XI Inc	4901 El Roble Rd	UK	6.7	5.1	0.0	Vineyard	Yes	0	0	5.1	0.0	0.0	0.0
	18608005	Larramendy William L & Jeannet	5050 Burke Hill Dr	UK	26.5	17.8	15.4	Vineyard	No	0	0	17.8	0.0	0.0	0.0
	18421005	Jahnke Suzanne	4101 Cox Schrader Rd	UK	3.6	2.4	2.4	Vineyard	No	0	0	2.4	0.0	0.0	0.0
	17020011	Sawyer Charles A & Nancy J Tte			15.3	9.5	6.0	Vineyard	No	0	0	9.5	0.0	0.0	0.0
	17911002	Golden Catherine T	1050 E Gobbi St	UK	33.3	28.2	25.4	Vineyard	No	0	0	28.2	0.0	0.0	0.0
	17904004	Thomas Alexander R III & Mary	1000 Vichy Springs Rd	UK	55.9	49.3	66.2	Orchard	Yes	0	0	0.0	49.3	0.0	0.0
	17910001	Thomas John Hall	1001 Vichy Springs Rd	UK	74.2	61.3	64.3	Orchard/Vineyard	No	0	0	2.5	58.8	0.0	0.0
	17911001	Nunez Humberto	1000 E Gobbi St	UK	28.3	25.5	27.1	Vineyard	No	0	0	25.5	0.0	0.0	0.0
Nova Partners Ltd	18421004	Nova Partners Ltd	4101 Cox Schrader Rd	UK	0.2	0.1	0.1	Vineyard	No	0	0	0.1	0.0	0.0	0.0
	18003005	Mountanos Mark P Ttee	701 E Gobbi St	UK	8.4	5.1	0.0	Vineyard	Yes	0	0	5.1	0.0	0.0	0.0
	18003001	Mountanos Mark P Ttee	701 E Gobbi St	UK	26.9	24.1	25.3	Vineyard	Yes	0	0	24.1	0.0	0.0	0.0
Norgard	18010003	Norgard Properties Inc	1801 Hastings Rd	UK	24.8	21.6	22.6	Orchard	No	0	0	0.0	21.6	0.0	0.0
Boer	18505003	Boer Michael P & Nadine E	401 Boonville Rd	UK	4.5	3.7	0.0	Vineyard	Yes	0	0	3.7	0.0	0.0	0.0
Hildreth	18504004	Hildreth Michael L & Susan K T	3800 Burke Hill Dr	UK	15.5	13.7	13.6	Vineyard	Yes	0	0	13.7	0.0	0.0	0.0
	18002001	Shultz Paul	801 E Gobbi St	UK	10.0	6.1	6.3	Vineyard	No	0	0	6.1	0.0	0.0	0.0
Hildreth	18505009	Hildreth Michael L & Susan K T	4020 Burke Hill Dr	UK	14.0	11.8	10.7	Vineyard	Yes	0	0	11.8	0.0	0.0	0.0
	18421003	Nova Partners Ltd	4101 Cox Schrader Rd	UK	36.7	28.8	27.4	Vineyard	No	0	0	28.8	0.0	0.0	0.0
	18510047	Hatch Bruce G & Judy A	4016 Fracchia Rd	UK	10.9	9.0	9.1	Vineyard	No	0	0	9.0	0.0	0.0	0.0
Hildreth	18009004	Hildreth Farms Incorporated	1401 Hastings Frontage Rd	UK	41.1	36.8	36.0	Vineyard	No	0	0	36.8	0.0	0.0	0.0
	18524002	Gerhart Katherine E	4100 Burke Hill Dr	UK	29.1	21.7	22.8	Vineyard	No	0	0	21.7	0.0	0.0	0.0
	18002002	Johnson William T 1/4	801 Babcock Ln	UK	56.0	49.5	47.3	Orchard/Vineyard	No	0	0	19.8	29.7	0.0	0.0
	18005001	Norgard Properties Inc	951 Babcock Ln	UK	15.0	14.7	14.5	Orchard/PTL	No	0	0	0.0	8.8	5.9	0.0
	18005002	Hildreth Janis A Ttee	1001 Babcock Ln	UK	31.9	29.2	27.1	Orchard/Vineyard	No	0	0	13.4	15.8	0.0	0.0
	18005004	Norgard Properties Inc	1101 Babcock Ln	UK	20.3	13.4	12.6	Orchard	No	0	0	0.0	13.4	0.0	0.0
	18006005	Norgard Properties Inc			9.6	5.5	5.6	Orchard	No	0	0	0.0	5.5	0.0	0.0
Hildreth	18006007	Hildreth Michael L & Susan K	725 Talmage Rd	UK	26.8	24.1	25.2	Orchard	No	0	0	0.0	24.1	0.0	0.0
City	18409006	Mattern Richard H & Donna M	217 Norgard Ln	UK	14.1	13.8	13.7	Vineyard	No	0	0	13.8	0.0	0.0	0.0

Site or Farmer Name	Parcel APN	Owner (per Parcel GIS Layer from County Assessor's Office)	Site Address	City	Parcel Acreage based on GIS (from Aerial Photograph)	Irrigated Acreage based on GIS (from Aerial Photograph)	Irrigated Acreage from Parcel GIS Layer	Crop or Site Type	Storage	Existing Storage (af)	Planned Future Storage (af)	Irrigated Vineyard Acreage	Irrigated Orchard Acreage	Irrigated Pasture Acreage	Irrigated Row Crop Acreage
Norgard	18410004	Norgard Properties Inc			12.6	9.7	8.1	PTL	No	0	0	0.0	0.0	9.7	0.0
	18411022	Mattern Richard H & Donna M	2801 S State St	UK	2.0	1.1	1.2	Vineyard	No	0	0	1.1	0.0	0.0	0.0
	17020010	Sawyer Charles A & Nancy J Tte			32.2	29.2	29.3	Vineyard	Yes	8	0	29.2	0.0	0.0	0.0
	17021005	Sawyer Charles A & Nancy J Tte			41.7	28.9	25.3	Vineyard	No	0	0	28.9	0.0	0.0	0.0
Norgard	18012006	Norgard Properties Inc			9.1	6.0	5.7	Orchard	No	0	0	0.0	6.0	0.0	0.0
Norgard	18012005	Norgard Properties Inc		UK	1.9	1.0	0.7	Vineyard	No	0	0	1.0	0.0	0.0	0.0
Norgard	18408025	Norgard Properties Inc			3.2	2.0	1.8	Vineyard/Orchard	No	0	0	1.5	0.5	0.0	0.0
	18601018	Alessi Richard L & Patricia Q	4650 Burke Hill Dr	UK	12.6	7.4	7.9	Vineyard	No	0	0	7.4	0.0	0.0	0.0
Koball	18415001	Thomas Alexander R III & Mary	3495 Taylor Dr	UK	43.9	35.2	34.4	Orchard	Yes	0	25.5	0.0	35.2	0.0	0.0
	18412001	Ukiah Land LLC	3000 S State St	UK	26.6	12.0	13.1	Vineyard	No	0	0	12.0	0.0	0.0	0.0
	18411019	Ukiah Land LLC	3000 S State St	UK	18.3	17.4	17.2	Vineyard	No	0	0	17.4	0.0	0.0	0.0
	18414014	Zaina Vineyards LLC	3150 S State St	UK	17.4	16.0	18.1	Vineyard	No	0	0	16.0	0.0	0.0	0.0
	18414002				2.0	1.2	0.0	Vineyard	No	0	0	1.2	0.0	0.0	0.0
Norgard	18408027	Norgard Properties Inc	341 Norgard Ln	UK	3.7	0.6	0.0	Vineyard	No	0	0	0.6	0.0	0.0	0.0
Norgard	18408028	Norgard Properties Inc			4.7	3.2	2.7	PTL/VineyardC/Orchard	No	0	0	1.4	0.2	1.5	0.0
Norgard	18409001	Norgard Properties Inc			3.7	3.5	3.8	Vineyard/Orchard/PTL/	No	0	0	2.0	0.9	0.6	0.0
Norgard	18409007	Norgard Properties Inc			14.5	10.8	10.4	PTL/Orchard	No	0	0	0.0	3.0	7.8	0.0
	18407015	Mattern Richard H & Donna M	2601 S State St	UK	11.7	9.9	9.4	Vineyard	No	0	0	9.9	0.0	0.0	0.0
Gannon	18414010	Riedy Mary Maureen Ttee 1/4	3201 Taylor Dr	UK	9.9	9.2	0.0	Orchard	No	0	0	0.0	9.2	0.0	0.0
	18414003	Stambaugh Pierina	3160 S State St	UK	0.3	0.3	0.3	Vineyard	No	0	0	0.3	0.0	0.0	0.0
	18414004	Zaina Vineyards LLC	3200 S State St	UK	1.7	0.9	0.9	Vineyard	No	0	0	0.9	0.0	0.0	0.0
	18413041	Stolich Sandra M	3381 Zaina Ln	UK	3.5	2.4	0.2	Vineyard	No	0	0	2.4	0.0	0.0	0.0
	18413017	Mcchesney Richard & Sandra	3311 Zaina Ln	UK	2.8	0.5	0.5	Vineyard	No	0	0	0.5	0.0	0.0	0.0
	18414016	Zaina Vineyards LLC	3150 S State St	UK	0.3	0.3	0.0	Vineyard	No	0	0	0.3	0.0	0.0	0.0
	18414015	Zaina Vineyards LLC	3150 S State St	UK	0.8	0.8	0.0	Vineyard	No	0	0	0.8	0.0	0.0	0.0
	18502007	Lamalfa Joseph A & Lena Ttees	251 Stipp Ln	UK	17.0	10.2	9.3	Vineyard/Orchard	No	0	0	7.2	3.1	0.0	0.0
Milovina	18417010	Milovina James D & Lyle P	3525 Taylor Dr	UK	12.9	10.5	11.1	Vineyard	Yes	0	10	10.5	0.0	0.0	0.0
Boer	18502005	Boer Michael P & Nadine E	253 Boonville Rd	UK	5.9	4.8	0.0	Vineyard	Yes	0	0	4.8	0.0	0.0	0.0
	18502004	Boer Adrian E & Susan J	301 Boonville Rd	UK	1.9	0.6	0.5	Orchard	No	0	0	0.0	0.6	0.0	0.0
Milovina	18418001	Milovina James D & Lyle P	3525 S Hwy 101	UK	46.6	44.0	42.9	Vineyard	Yes	0	0	44.0	0.0	0.0	0.0
	18502003	Boer Michael P & Nadine E	351 Boonville Rd	UK	2.4	1.5	1.4	Orchard	Yes	0	25	0.0	1.5	0.0	0.0
LaMalfa	18504002	Lamalfa Joseph A & Lena Ttees	3600 Leland Ln	UK	17.1	13.8	0.0	Orchard	No	0	0	0.0	13.8	0.0	0.0
Boer	18505005	Boer Michael P & Nadine E			27.0	24.1	26.3	Vineyard	Yes	0	0	24.1	0.0	0.0	0.0
	18510044	Hildreth Michael L & Susan K T	3750 Burke Hill Dr	UK	10.8	4.9	4.6	Vineyard	Yes	23.6	0	4.9	0.0	0.0	0.0
Boer	18506005	Boer Michael P & Nadine E			2.1	0.7	1.0	Vineyard/Other Row	Yes	0	0	0.7	0.0	0.0	0.2
Boer	18508001	Boer Michael P & Nadine E			12.7	8.7	11.7	Other Row/Orchard	Yes	0	0	4.7	4.0	0.0	4.7
Boer	18508004	Boer Michael P & Nadine E			2.3	1.7	2.8	Other Row	Yes	0	0	1.7	0.0	0.0	1.7
Boer	18507210	Boer Michael P & Nadine E			4.2	1.2	1.2	Other Row	Yes	0	0	1.2	0.0	0.0	1.2
	18508008	Boer Michael P & Nadine E			1.0	0.2	0.3	Orchard	No	0	0	0.0	0.2	0.0	0.0
	18508009	Lazaro John Lee & Marcia Morga	1071 Boonville Rd	UK	6.8	1.9	1.7	Vineyard	No	0	0	1.9	0.0	0.0	0.0
	18510048	Hatch Bruce G & Judy A	304 Bisby Ave	UK	8.5	3.3	4.9	Vineyard	No	0	0	3.3	0.0	0.0	0.0
	18522001	Gerhart Katherine			4.0	1.4	1.3	Vineyard	No	0	0	1.4	0.0	0.0	0.0
	18413040	Larose Mark E & Teresa M	3331 Zaina Ln	UK	0.6	0.2	0.2	Vineyard	No	0	0	0.2	0.0	0.0	0.0
12th District Fair Grounds	00136038	Pan Pacific Retail Properties	1275 Ford Rd		1.5	0.7	0.6	Agriculture							
City Park/Community Garden	00228127	City of Ukiah			3.0	2.2	0.0	Park							
City Park/Community Garden	00228126	City of Ukiah			0.8	0.4	0.0	Park							
City Park/Community Garden	00228115	City of Ukiah			0.2	0.2	0.0	Park							
City Park/Community Garden	00228119	Johnson Thomas F	220 Cleveland Ln		0.5	0.2	0.0	Park							
City Park/Community Garden	00228118	Johnson Thomas F			0.2	0.2	0.0	Park							
City Softball Field/irrigation	17901009	City of Ukiah			19.3	11.5	12.4	Park							
12th District Fair Grounds	00201001	Twelfth District Agricultural			7.3	3.2	3.5	Agriculture							
UUSD/Ukiah High School	00102074	Ukiah Unified School District			50.0	34.6	0.0	School							
UUSD/special ed/preschool	00143004	Mendocino County Board of Educ	518 Low Gap Rd	UK	0.1	<0.1	0.0	School							
UUSD/special ed/preschool	00143019	Nordvick Virginia H	512 Low Gap Rd	UK	0.1	0.1	0.0	School							
UUSD/District Office	00204023	Zimmerman Rodney Lee & Marylou	925 N State St	UK	0.8	0.2	0.0	School							
UUSD/District Office	00204026	Zimmerman Rodney Lee & Marylou			0.2	0.1	0.0	School							
UUSD/District Office	00204027	Ung Lim /	915 N State St	UK	0.3	0.0	0.0	School							
City Park/irrigation/fountain	00207210	City of Ukiah	251 Low Gap Rd	UK	0.4	0.3	0.0	Park							
12th District Fair Grounds	00136036	Twelfth District Agricultural			26.3	14.7	0.0	Agriculture							
UUSD/Frank Zeek School	00102066	Ukiah Union Elementary School			5.5	3.5	3.1	School							
City Park/Vinewood Park	00145001	City of Ukiah			4.7	4.4	4.5	Park							
Russian River Cemetery	00143002	Russian River Cemetery Distric			0.4	0.2	0.0	Other							
UUSD/Ukiah High School	00102060	Ukiah Unified School District			8.7	3.2	3.2	School							
Russian River Cemetery	00102050	Russian River Cemetery Distric			26.6	22.0	0.0	Other							
Russian River Cemetery	00102049	Russian River Cemetery Distric			5.0	4.4	0.0	Other							
UUSD/Ukiah High School	00102061	Ukiah Unified School District			5.3	1.8	2.1	School							
UUSD/Ukiah Adult School	00143026	Ukiah Union Elementary School			4.2	0.9	0.8	School							
12th District Fair Grounds	00136039	Erickson Henry O Ttee 1/2	1211 N State St		10.8	7.7	7.3	Agriculture							
12th District Fair Grounds	00136002	Twelfth District Agricultural			13.3	10.4	11.0	Agriculture							
City Golf Course	00102078	City of Ukiah			37.5	37.5	41.6	Golf Course							
City Golf Course	00103001	City of Ukiah			96.3	24.4	11.7	Golf Course							
City Golf Course	00109001	City of Ukiah			13.0	11.6	8.9	Golf Course							
City Park/Todd Grove Park	00109002	City of Ukiah			7.2	5.7	5.9	Park							

Site or Farmer Name	Parcel APN	Owner (per Parcel GIS Layer from County Assessor's Office)	Site Address	City	Parcel Acreage based on GIS (from Aerial Photograph)	Irrigated Acreage based on GIS (from Aerial Photograph)	Irrigated Acreage from Parcel GIS Layer	Crop or Site Type	Storage	Existing Storage (af)	Planned Future Storage (af)	Irrigated Vineyard Acreage	Irrigated Orchard Acreage	Irrigated Pasture Acreage	Irrigated Row Crop Acreage
City Park/Todd Grove Park	00114101	City of Ukiah			2.3	1.5	1.8	Park							
City Parks/Anton Stadium	00113029	City of Ukiah			2.5	2.0	1.7	Park							
City Park/Giorno Park	00113052	Williams James E Trust	1217 Standley Ave	UK	1.2	1.2	0.0	Park							
City Parks/Anton Stadium	00113028	City of Ukiah			6.1	2.8	2.3	Park							
City Parks/Anton Stadium	00116005	City of Ukiah			1.9	1.6	1.8	Park							
City Parks/Anton Stadium	00117101	City of Ukiah			1.1	1.0	0.9	Park							
City Parking Lots/irrigation	00221803	City of Ukiah			0.1	0.0	0.0	Other							
City Parking Lots/irrigation	00221802	City of Ukiah			0.1	0.0	0.0	Other							
City Parking Lots/irrigation	00221807	City of Ukiah			0.1	0.0	0.0	Other							
City Parking Lots/irrigation	00221808	City of Ukiah			0.1	0.0	0.0	Other							
City Parking Lots/irrigation	00221806	City of Ukiah			0.2	0.0	0.0	Other							
City Parking Lots/irrigation	00221805	City of Ukiah			0.2	0.1	0.0	Other							
City Parking Lots/irrigation	00221804	City of Ukiah			0.2	0.0	0.0	Other							
City Park/Depot Park	00219315	Quan Jing G 1/2	400 E Perkins St	UK	0.8	0.8	0.0	Park							
City Park/Depot Park	00219353	Valentic John P & Patricia A			0.4	0.1	0.0	Park							
City Park/Depot Park	00219354	Keszler Gary R & J Marlene	135 Hospital Dr	UK	0.3	<0.1	0.0	Park							
City Park/Depot Park	00219355	Cho Peter Young & Sharon Misun	320 E Perkins St	UK	0.4	0.1	0.0	Park							
City Park/Depot Park	00219314	Quan Jing	326 E Perkins St	UK	0.2	0.2	0.0	Park							
City Park/Gardner Park	00221703	Rosen Norman & Karen Ttees 1/2	280 N Oak St	UK	0.2	0.1	0.0	Park							
City Park/irrigation planter	00222501	County of Mendocino			0.9	0.4	0.0	Park							
City Parks/irrigation planter	00222303	Abell Masonic Temple Associati	102 S School St	UK	0.2	0.0	0.0	Park							
City Parks/irrigation planter	00222306	Sanchez Francis J & Margie K	110 S School St	UK	0.1	0.0	0.0	Park							
City Parks/irrigation planter	00222307	Poma David 1/3	198 S School St	UK	0.1	0.0	0.0	Park							
UUSD/Oak Manor School	17906108	Ukiah Union Elementary School	400 Oak Manor Dr	UK	8.0	4.2	4.2	School							
UUSD/Oak Manor School	17906107	Ukiah Union Elementary School	400 Oak Manor Dr	UK	3.6	3.3	3.6	School							
City Parks/Alex Thomas Plaza	00226509	Ukiah Redevelopment Agency	300 S State St	UK	0.6	0.3	0.0	Park							
City Parking Lots/irrigation	00226203	Preston Hugh L	207 We Stephenson St	UK	0.1	<0.1	0.0	Other							
City Parking Lots/irrigation	00226208	City of Ukiah			0.2	0.1	0.0	Other							
City Parking Lots/irrigation	00226207	Carter David A /	308 S School St	UK	0.1	0.0	0.0	Other							
City Parking Lots/irrigation	00226204	City of Ukiah	351 S Oak St	UK	0.1	0.0	0.0	Other							
City Parking Lots/irrigation	00226205	City of Ukiah			0.4	0.2	0.0	Other							
City Parks/McGarvey Park	00225201	City of Ukiah			0.9	0.8	0.0	Park							
City Park/Purdy Park	00225503	City of Ukiah			6.5	2.2	2.2	Park							
UUSD/South Valley High School	00225502	City of Ukiah			0.9	0.4	0.4	School							
City Park/Oak Manor Park	17905009	City of Ukiah			2.3	1.3	0.0	Park							
City Park/Oak Manor Park	17905008	City of Ukiah			2.2	2.1	2.3	Park							
UUSD/Yokayo Gym	00131403	Ukiah Union Elementary School			8.8	4.0	0.0	School							
City Park/Cindee Park	00318136	City of Ukiah	855 Cindee Dr	UK	0.9	0.6	0.0	Park							
City Park/Observatory Park	00306203	City of Ukiah	407 Luce Ave	UK	0.7	0.7	0.0	Park							
City Park/Community Garden Observatory	00306205	City of Ukiah	432 Observatory Ave	UK	1.9	1.8	0.0	Park							

APPENDIX C – COST ESTIMATES FOR PROJECT ALTERNATIVES

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PROJECT SUMMARY

		Estimate Class:	**Class 5**
Project:	**Recycled Water Master Plan**	**PIC:**	**LC**
Job #:	**8660A00**	**PM:**	**TAC**
Location:	**Ukiah, CA**	**Date:**	**February 1, 2011**
Zip Code:	**95482**	**By:**	**BB**
Alternative:	**Scenario 1 Parcels with Storage**	**Reviewed:**	

NO.		DESCRIPTION	SIZE/LENGTH	UNIT	TOTAL
1		Distribution System Pipelines			
		Pipelines along Unpaved Agricultural Easements			
		8-inches in Diameter	12,400	ft	$1,349,120
		12-inches in Diameter	11,800	ft	$1,925,760
		16-inches in Diameter	700	ft	$152,320
		Pipelines along Paved Streets			
		8-inches in Diameter	4,300	ft	$584,800
		12-inches in Diameter	1,400	ft	$285,600
		Subtotal			$4,297,600
2		Pump Station	150	hp	$1,110,000
3		Storage Pond	650,000	gal	$65,000
			Subtotal		$5,472,600
		Construction Contingency	20.0%		$1,095,000
		Estimating Contingency	20.0%		$1,314,000
		TOTAL ESTIMATED CONSTRUCTION COST W/ CONTINGENCY			**$7,881,600**
		Engineering and Design	21.0%		
		Administrative	5.0%		
		Legal	5.0%		
		Subtotal Markups	31.0%		$2,444,000
		TOTAL ESTIMATED PROJECT COST			**$10,325,600**

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PROJECT SUMMARY

		Estimate Class:	**Class 5**
Project:	**Recycled Water Master Plan**	**PIC:**	**LC**
Job #:	**8660A00**	**PM:**	**TAC**
Location:	**Ukiah, CA**	**Date:**	**February 1, 2011**
Zip Code:	**95482**	**By:**	**BB**
Alternative:	**Scenario 1B Maximize Irrigation**	**Reviewed:**	

NO.		DESCRIPTION	SIZE/LENGTH	UNIT	TOTAL
1		Distribution System Pipelines			
		Pipelines along Unpaved Agricultural Easements			
		8-inches in Diameter	14,300	ft	$1,555,840
		12-inches in Diameter	11,800	ft	$1,925,760
		16-inches in Diameter	700	ft	$152,320
		Pipelines along Paved Streets			
		8-inches in Diameter	10,400	ft	$1,414,400
		12-inches in Diameter	1,400	ft	$285,600
		Subtotal			$5,333,920
2		Pump Station	150	hp	$1,110,000
3		Storage Pond	650,000	gal	$65,000
			Subtotal		$6,508,920
		Construction Contingency	20.0%		$1,302,000
		Estimating Contingency	20.0%		$1,562,500
		TOTAL ESTIMATED CONSTRUCTION COST W/ CONTINGENCY			**$9,373,420**
		Engineering and Design	21.0%		
		Administrative	5.0%		
		Legal	5.0%		
		Subtotal Markups	31.0%		$2,906,000
		TOTAL ESTIMATED PROJECT COST			**$12,279,420**

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PROJECT SUMMARY

		Estimate Class:	**Class 5**
Project:	**Recycled Water Master Plan**	**PIC:**	**LC**
Job #:	**8660A00**	**PM:**	**TAC**
Location:	**Ukiah, CA**	**Date:**	**February 1, 2011**
Zip Code:	**95482**	**By:**	**BB**
Alternative:	**Scenario 2 Grower Storage**	**Reviewed:**	

NO.		DESCRIPTION	SIZE/LENGTH	UNIT	TOTAL
1		Distribution System Pipelines			
		Pipelines along Unpaved Agricultural Easements			
		8-inches in Diameter	4,100	ft	$446,080
		12-inches in Diameter	11,800	ft	$1,925,760
		16-inches in Diameter	400	ft	$87,040
		Pipelines along Paved Streets			
		12-inches in Diameter	4,300	ft	$877,200
		Subtotal			$3,336,080
2		Pump Station	75	hp	$735,000
3		Storage Pond	1.6	MG	$160,000
			Subtotal		$4,231,080
		Construction Contingency	20.0%		$846,500
		Estimating Contingency	20.0%		$1,016,000
		TOTAL ESTIMATED CONSTRUCTION COST W/ CONTINGENCY			**$6,093,580**
		Engineering and Design	21.0%		
		Administrative	5.0%		
		Legal	5.0%		
		Subtotal Markups	31.0%		$1,890,000
		TOTAL ESTIMATED PROJECT COST			**$7,983,580**

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PROJECT SUMMARY

		Estimate Class:	**Class 5**
Project:	**Recycled Water Master Plan**	**PIC:**	**LC**
Job #:	**8660A00**	**PM:**	**TAC**
Location:	**Ukiah, CA**	**Date:**	**February 1, 2011**
Zip Code:	**95482**	**By:**	**BB**
Alternative:	**Scenario 3 Centralized Storage**	**Reviewed:**	

NO.		DESCRIPTION	SIZE/LENGTH	UNIT	TOTAL
1		Distribution System Pipelines			
		Pipelines along Unpaved Agricultural Easements			
		8-inches in Diameter	1,800	ft	$195,840
		12-inches in Diameter	1,500	ft	$244,800
		16-inches in Diameter	0	ft	$0
		20-inches in Diameter	2,200	ft	$598,400
		24-inches in Diameter	2,300	ft	$750,720
		36-inches in Diameter	2,600	ft	$1,272,960
		42-inches in Diameter	2,100	ft	$1,199,520
		48-inches in Diameter	4,000	ft	$2,611,200
		Pipelines along Paved Streets			
		8-inches in Diameter	600	ft	$244,800
		12-inches in Diameter	0	ft	$306,000
		16-inches in Diameter	0	ft	$0
		20-inches in Diameter	500	ft	$748,000
		24-inches in Diameter	4,800	ft	$938,400
		36-inches in Diameter	4,700	ft	$1,591,200
		42-inches in Diameter	2,900	ft	$1,499,400
		48-inches in Diameter	1,500	ft	$3,264,000
		Subtotal			$15,465,240
2		Pump Station	1,400	hp	$8,960,000
3		Storage Pond	200.0	af	$6,517,012
			Subtotal		$30,942,252
		Construction Contingency	20.0%		$6,188,500
		Estimating Contingency	20.0%		$7,426,500
		TOTAL ESTIMATED CONSTRUCTION COST W/ CONTINGENCY			**$44,557,252**
		Engineering and Design	21.0%		
		Administrative	5.0%		
		Legal	5.0%		
		Subtotal Markups	31.0%		$13,813,000
		TOTAL ESTIMATED PROJECT COST			**$58,370,252**

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PROJECT SUMMARY

		Estimate Class:	**Class 5**
Project:	**Recycled Water Master Plan**	**PIC:**	**LC**
Job #:	**8660A00**	**PM:**	**TAC**
Location:	**Ukiah, CA**	**Date:**	**February 1, 2011**
Zip Code:	**95482**	**By:**	**BB**
Alternative:	**Scenario 3B Centralized Storage Maximizing Irriga**	**Reviewed:**	

NO.		DESCRIPTION	SIZE/LENGTH	UNIT	TOTAL
1		Distribution System Pipelines			
		Pipelines along Unpaved Agricultural Easements			
		8-inches in Diameter	4,400	ft	$478,720
		12-inches in Diameter	12,200	ft	$1,991,040
		16-inches in Diameter	0	ft	$0
		20-inches in Diameter	2,200	ft	$598,400
		24-inches in Diameter	2,300	ft	$750,720
		36-inches in Diameter	2,600	ft	$1,272,960
		42-inches in Diameter	2,100	ft	$1,199,520
		48-inches in Diameter	4,000	ft	$2,611,200
		Pipelines along Paved Streets			
		8-inches in Diameter	0	ft	$598,400
		12-inches in Diameter	0	ft	$2,488,800
		16-inches in Diameter	0	ft	$0
		20-inches in Diameter	500	ft	$748,000
		24-inches in Diameter	4,800	ft	$938,400
		36-inches in Diameter	4,700	ft	$1,591,200
		42-inches in Diameter	2,900	ft	$1,499,400
		48-inches in Diameter	1,500	ft	$3,264,000
		Subtotal			$20,030,760
2		Pump Station	1,400	hp	$8,960,000
3		Storage Pond	200.0	af	$6,517,012
			Subtotal		$35,507,772
		Construction Contingency	20.0%		$7,102,000
		Estimating Contingency	20.0%		$8,522,000
		TOTAL ESTIMATED CONSTRUCTION COST W/ CONTINGENCY			**$51,131,772**
		Engineering and Design	21.0%		
		Administrative	5.0%		
		Legal	5.0%		
		Subtotal Markups	31.0%		$15,851,000
		TOTAL ESTIMATED PROJECT COST			**$66,982,772**

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PROJECT SUMMARY

		Estimate Class:	**Class 5**
Project:	**Recycled Water Master Plan**	**PIC:**	**LC**
Job #:	**8660A00**	**PM:**	**TAC**
Location:	**Ukiah, CA**	**Date:**	**February 1, 2011**
Zip Code:	**95482**	**By:**	**BB**
Alternative:	**Scenario 4 Urban Use**	**Reviewed:**	

NO.		DESCRIPTION	SIZE/LENGTH	UNIT	TOTAL
1		Distribution System Pipelines			
		Pipelines along Unpaved Agricultural Easements			
		12-inches in Diameter	6,000	ft	$979,200
		16-inches in Diameter	14,500	ft	$3,155,200
		Pipelines along Paved Streets			
		8-inches in Diameter	10,900	ft	$1,482,400
		12-inches in Diameter	8,600	ft	$1,754,400
		16-inches in Diameter	9,600	ft	$2,611,200
		Jack and Bore Construction	250	ft	$300,000
		Subtotal			$10,282,400
2		Pump Station	400	hp	$2,960,000
3		Storage Pond	1.6	MG	$160,000
			Subtotal		$13,402,400
		Construction Contingency	20.0%		$2,680,500
		Estimating Contingency	20.0%		$3,217,000
		TOTAL ESTIMATED CONSTRUCTION COST W/ CONTINGENCY			**$19,299,900**
		Engineering and Design	21.0%		
		Administrative	5.0%		
		Legal	5.0%		
		Subtotal Markups	31.0%		$5,983,000
		TOTAL ESTIMATED PROJECT COST			**$25,282,900**

APPENDIX - D – PHASED COST ESTIMATE FOR RECOMMENDED ALTERNATIVE

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PROJECT SUMMARY

		Estimate Class:	**Class 5**
Project:	**Recycled Water Master Plan**	**PIC:**	**LC**
Job #:	**8660A00**	**PM:**	**TAC**
Location:	**Ukiah, CA**	**Date:**	**February 1, 2011**
Zip Code:	**95482**	**By:**	**BB**
Alternative:	**Scenario 4 Urban Use**	**Reviewed:**	

NO.		DESCRIPTION	SIZE/LENGTH	UNIT	TOTAL
1		Distribution System Pipelines			
		Pipelines along Unpaved Agricultural Easements			
		12-inches in Diameter	5,600	ft	$913,920
		16-inches in Diameter	1,300	ft	$282,880
		Subtotal			$1,196,800
2		Pump Station	200	hp	$1,280,000
3		Storage Pond	1.6	MG	$160,000
			Subtotal		$2,636,800
		Construction Contingency	20.0%		$527,500
		Estimating Contingency	20.0%		$633,000
		TOTAL ESTIMATED CONSTRUCTION COST W/ CONTINGENCY			**$3,797,300**
		Engineering and Design	21.0%		
		Administrative	5.0%		
		Legal	5.0%		
		Subtotal Markups	31.0%		$1,178,000
		TOTAL ESTIMATED PROJECT COST			**$4,975,300**

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PROJECT SUMMARY

		Estimate Class:	**Class 5**
Project:	**Recycled Water Master Plan**	**PIC:**	**LC**
Job #:	**8660A00**	**PM:**	**TAC**
Location:	**Ukiah, CA**	**Date:**	**February 1, 2011**
Zip Code:	**95482**	**By:**	**BB**
Alternative:	**Scenario 4 Urban Use**	**Reviewed:**	

NO.		DESCRIPTION	SIZE/LENGTH	UNIT	TOTAL
1		Distribution System Pipelines			
		Pipelines along Unpaved Agricultural Easements			
		16-inches in Diameter	4,200	ft	$913,920
		Pipelines along Paved Streets			
		16-inches in Diameter	5,600	ft	$1,523,200
		Subtotal			$2,437,120
2		Pump Station	200	hp	$1,280,000
			Subtotal		$3,717,120
		Construction Contingency	20.0%		$743,500
		Estimating Contingency	20.0%		$892,500
		TOTAL ESTIMATED CONSTRUCTION COST W/ CONTINGENCY			**$5,353,120**
		Engineering and Design	21.0%		
		Administrative	5.0%		
		Legal	5.0%		
		Subtotal Markups	31.0%		$1,660,000
		TOTAL ESTIMATED PROJECT COST			**$7,013,120**

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PROJECT SUMMARY

		Estimate Class:	**Class 5**
Project:	**Recycled Water Master Plan**	**PIC:**	**LC**
Job #:	**8660A00**	**PM:**	**TAC**
Location:	**Ukiah, CA**	**Date:**	**February 1, 2011**
Zip Code:	**95482**	**By:**	**BB**
Alternative:	**Scenario 4 Urban Use**	**Reviewed:**	

NO.		DESCRIPTION	SIZE/LENGTH	UNIT	TOTAL
1		Distribution System Pipelines			
		Pipelines along Unpaved Agricultural Easements			
		12-inches in Diameter	400	ft	$65,280
		16-inches in Diameter	9,000	ft	$1,958,400
		Pipelines along Paved Streets			
		8-inches in Diameter	1,000	ft	$136,000
		16-inches in Diameter	4,000	ft	$1,088,000
		Subtotal			$3,247,680
			Subtotal		$3,247,680
		Construction Contingency	20.0%		$650,000
		Estimating Contingency	20.0%		$780,000
		TOTAL ESTIMATED CONSTRUCTION COST W/ CONTINGENCY			**$4,677,680**
		Engineering and Design	21.0%		
		Administrative	5.0%		
		Legal	5.0%		
		Subtotal Markups	31.0%		$1,451,000
		TOTAL ESTIMATED PROJECT COST			**$6,128,680**

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PROJECT SUMMARY

		Estimate Class:	**Class 5**
Project:	**Recycled Water Master Plan**	**PIC:**	**LC**
Job #:	**8660A00**	**PM:**	**TAC**
Location:	**Ukiah, CA**	**Date:**	**February 1, 2011**
Zip Code:	**95482**	**By:**	**BB**
Alternative:	**Scenario 4 Urban Use**	**Reviewed:**	

NO.		DESCRIPTION	SIZE/LENGTH	UNIT	TOTAL
1		Distribution System Pipelines			
		Pipelines along Paved Streets			
		8-inches in Diameter	9,900	ft	$1,346,400
		12-inches in Diameter	8,600	ft	$1,754,400
		Jack and Bore Construction	250	ft	$300,000
		Subtotal			$3,400,800
			Subtotal		$3,400,800
		Construction Contingency	20.0%		$680,500
		Estimating Contingency	20.0%		$816,500
		TOTAL ESTIMATED CONSTRUCTION COST W/ CONTINGENCY			**$4,897,800**
		Engineering and Design	21.0%		
		Administrative	5.0%		
		Legal	5.0%		
		Subtotal Markups	31.0%		$1,519,000
		TOTAL ESTIMATED PROJECT COST			**$6,416,800**

APPENDIX E – FINANCIAL MODEL

City of Ukiah
Recycled Water Feasibility Study
Assumptions

	User Input
Recycled Water Used (Phases 1 to 3) (AFY)	995
Frost Protection (AFY)	142
Irrigation (AFY)	854
Potable Water Offset (Phases 1 to 3) (AFY)	22
Capital Cost Escalation	0%
O&M Cost Escalation	0%
Interest Rate	0%
Include Annual Rate Increase?	◉ Yes ○ No
Annual Service Charge Rate Increase	2.5%
Recycled Water Rate ($/AF)	$12.37

Loan/Debt Assumptions

SRF Loan (Check Box if Yes)	☐ Yes
Debt Term	30
Interest Rate	5.0%
Annual Debt Service	
Phase 1	324,000
Phase 2	456,000
Phase 3	399,000
Phase 4 (Optional)	417,000
Payments Over Duration of Debt	$47,880,000

Capital Costs	Cost	Start Year
Phase 1	4,975,300	2015
Phase 2	7,013,120	2020
Phase 3	6,128,680	2025
Phase 4 (Optional)	6,416,800	2030

O&M Costs (1)	Treatment	Distribution
Unit Cost	$12.37	
Phase 1	4,995	47,500
Phase 2	2,661	70,000
Phase 3	4,655	100,000
Phase 4 (Optional)	4,708	150,000
Recycled Water Operations (Phases 1 to 3)	12,311	217,500
Inspection Personnel (0.25 FTE)	25,000	
Metering and Meter Reading (0.25 FTE)	25,000	
System Cleaning and Maintenance (0.25 FTE)	25,000	
Billing Support	5,000	
Public Outreach	5,000	
		85,000
Repair and Replacement (2)	50,000	
Percentage Variable (Phases 1 to 3)	63.0%	

Notes:
(1) Assumes Full Time Equivalent (FTE) = $100,000 per year for salary and benefits.
(2) A repair and replacement reserve of $50,000 per year is estimated per year over the duration of the project.

City of Ukiah
Recycled Water
Feasibility Study
Cash Flow Forecast

	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024
	1	2	3	4	5	6	7	8	9	10	11	12	13
BEGINNING FUND BALANCE	$0	$0	$0	$0	$2,487,650	$0	$0	$0	$0	$3,506,560	$0	$0	$0
SOURCES OF FUNDS													
Wastewater Revenues (1)	-	-	-	-	324,000	505,702	505,558	505,409	505,257	961,101	1,165,111	1,164,860	1,164,602
Recycled Water Revenues	-	-	-	-	-	5,793	5,937	6,086	6,238	6,394	10,045	10,296	10,554
Loan Proceeds	-	-	-	4,975,300	-	-	-	-	7,013,120	-	-	-	-
Interest Income	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL SOURCES	$0	$0	$0	$4,975,300	$324,000	$511,495	$511,495	$511,495	$7,524,615	$967,495	$1,175,156	$1,175,156	$1,175,156
USES OF FUNDS													
O&M and R&R	$0	$0	$0	$0	$0	$187,495	$187,495	$187,495	$187,495	$187,495	$395,156	$395,156	$395,156
Debt Service	-	-	-	-	324,000	324,000	324,000	324,000	324,000	780,000	780,000	780,000	780,000
CIP Program	-	-	-	2,487,650	2,487,650	-	-	-	3,506,560	3,506,560	-	-	-
Other	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL USES	$0	$0	$0	$2,487,650	$2,811,650	$511,495	$511,495	$511,495	$4,018,055	$4,474,055	$1,175,156	$1,175,156	$1,175,156
ENDING FUND BALANCE	$0	$0	$0	$2,487,650	$0	$0	$0	$0	$3,506,560	$0	$0	$0	$0

Notes:
(1) This cash flow analysis assumes that the annual amount collected for repayment of project costs will equal the annual debt service payment requirement.

Volume of Recycled Water Use	**FY 2012**	**FY 2013**	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**	**FY 2019**	**FY 2020**	**FY 2021**	**FY 2022**	**FY 2023**	**FY 2024**
Phase 1	0	0	0	0	0	404	404	404	404	404	404	404	404
Phase 2	0	0	0	0	0	0	0	0	0	0	215	215	215
Phase 3	0	0	0	0	0	0	0	0	0	0	0	0	0
Phase 4	0	0	0	0	0	0	0	0	0	0	0	0	0
Sum of Phases 1 - 3	0	0	0	0	0	404	404	404	404	404	619	619	619

Project Phase Construction Cost	**FY 2012**	**FY 2013**	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**	**FY 2019**	**FY 2020**	**FY 2021**	**FY 2022**	**FY 2023**	**FY 2024**
Phase 1	$0	$0	$0	$2,487,650	$2,487,650	$0	$0	$0	$0	$0	$0	$0	$0
Phase 2	$0	$0	$0	$0	$0	$0	$0	$0	$3,506,560	$3,506,560	$0	$0	$0
Phase 3	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Phase 4	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Sum of Phases 1 - 3	0	0	0	2,487,650	2,487,650	0	0	0	3,506,560	3,506,560	0	0	0

Loan Issuance	**FY 2012**	**FY 2013**	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**	**FY 2019**	**FY 2020**	**FY 2021**	**FY 2022**	**FY 2023**	**FY 2024**
Phase 1	$0	$0	$0	$4,975,300	$0	$0	$0	$0	$0	$0	$0	$0	$0

City of Ukiah
Recycled Water
Feasibility Study
Cash Flow Forecast

	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024
Phase 2	$0	$0	$0	$0	$0	$0	$0	$0	$7,013,120	$0	$0	$0	$0
Phase 3	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Phase 4	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Project Phase D/S	**FY 2012**	**FY 2013**	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**	**FY 2019**	**FY 2020**	**FY 2021**	**FY 2022**	**FY 2023**	**FY 2024**
Phase 1	$0	$0	$0	$0	$324,000	$324,000	$324,000	$324,000	$324,000	$324,000	$324,000	$324,000	$324,000
Phase 2	$0	$0	$0	$0	$0	$0	$0	$0	$0	$456,000	$456,000	$456,000	$456,000
Phase 3	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Phase 4	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
O&M Costs	**FY 2012**	**FY 2013**	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**	**FY 2018**	**FY 2019**	**FY 2020**	**FY 2021**	**FY 2022**	**FY 2023**	**FY 2024**
Phase 1	$0	$0	$0	$0	$0	$187,495	$187,495	$187,495	$187,495	$187,495	$187,495	$187,495	$187,495
Phase 2	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$207,661	$207,661	$207,661
Phase 3	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Phase 4	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Sum of Phases 1 - 3	0	0	0	0	0	187,495	187,495	187,495	187,495	187,495	395,156	395,156	395,156

City of Ukiah
Recycled Water
Feasibility Study
Cash Flow Forecast

	FY 2025	FY 2026	FY 2027	FY 2028	FY 2029	FY 2030	FY 2031	FY 2032	FY 2033	FY 2034	FY 2035	FY 2036	FY 2037
	14	15	16	17	18	19	20	21	22	23	24	25	26
BEGINNING FUND BALANCE	$0	$3,064,340	$0	$0	$0	$0	$3,208,400	$0	$0	$0	$0	$0	$0
SOURCES OF FUNDS													
Wastewater Revenues (1)	1,164,338	1,563,068	1,795,535	1,795,079	1,794,610	1,794,130	2,210,638	2,491,934	2,491,220	2,490,487	2,489,737	2,488,967	2,488,178
Recycled Water Revenues	10,817	11,088	18,275	18,732	19,200	19,680	20,172	28,584	29,299	30,031	30,782	31,552	32,340
Loan Proceeds	6,128,680	-	-	-	-	6,416,800	-	-	-	-	-	-	-
Interest Income	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL SOURCES	$7,303,836	1,574,156	$1,813,811	$1,813,811	$1,813,811	$8,230,611	$2,230,811	$2,520,519	$2,520,519	$2,520,519	$2,520,519	$2,520,519	$2,520,519
USES OF FUNDS													
O&M and R&R	$395,156	$395,156	$634,811	$634,811	$634,811	$634,811	$634,811	$924,519	$924,519	$924,519	$924,519	$924,519	$924,519
Debt Service	780,000	1,179,000	1,179,000	1,179,000	1,179,000	1,179,000	1,596,000	1,596,000	1,596,000	1,596,000	1,596,000	1,596,000	1,596,000
CIP Program	3,064,340	3,064,340	-	-	-	3,208,400	3,208,400	-	-	-	-	-	-
Other	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL USES	$4,239,496	$4,638,496	$1,813,811	$1,813,811	$1,813,811	$5,022,211	$5,439,211	$2,520,519	$2,520,519	$2,520,519	$2,520,519	$2,520,519	$2,520,519
ENDING FUND BALANCE	$3,064,340	$0	$0	$0	$0	$3,208,400	$0	$0	$0	$0	$0	$0	$0

Notes:
(1) This cash flow analysis assumes

Volume of Recycled Water Use	**FY 2025**	**FY 2026**	**FY 2027**	**FY 2028**	**FY 2029**	**FY 2030**	**FY 2031**	**FY 2032**	**FY 2033**	**FY 2034**	**FY 2035**	**FY 2036**	**FY 2037**
Phase 1	404	404	404	404	404	404	404	404	404	404	404	404	404
Phase 2	215	215	215	215	215	215	215	215	215	215	215	215	215
Phase 3	0	0	376	376	376	376	376	376	376	376	376	376	376
Phase 4	0	0	0	0	0	0	0	381	381	381	381	381	381
Sum of Phases 1 - 3	619	619	995	995	995	995	995	995	995	995	995	995	995

Project Phase Construction Cost	**FY 2025**	**FY 2026**	**FY 2027**	**FY 2028**	**FY 2029**	**FY 2030**	**FY 2031**	**FY 2032**	**FY 2033**	**FY 2034**	**FY 2035**	**FY 2036**	**FY 2037**
Phase 1	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Phase 2	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Phase 3	$3,064,340	$3,064,340	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Phase 4	$0	$0	$0	$0	$0	$3,208,400	$3,208,400	$0	$0	$0	$0	$0	$0
Sum of Phases 1 - 3	3,064,340	3,064,340	0	0	0	0	0	0	0	0	0	0	0

Loan Issuance	**FY 2025**	**FY 2026**	**FY 2027**	**FY 2028**	**FY 2029**	**FY 2030**	**FY 2031**	**FY 2032**	**FY 2033**	**FY 2034**	**FY 2035**	**FY 2036**	**FY 2037**
Phase 1	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0

City of Ukiah
Recycled Water
Feasibility Study
Cash Flow Forecast

	FY 2025	FY 2026	FY 2027	FY 2028	FY 2029	FY 2030	FY 2031	FY 2032	FY 2033	FY 2034	FY 2035	FY 2036	FY 2037
Phase 2	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Phase 3	$6,128,680	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Phase 4	$0	$0	$0	$0	$0	$6,416,800	$0	$0	$0	$0	$0	$0	$0

Project Phase D/S	**FY 2025**	**FY 2026**	**FY 2027**	**FY 2028**	**FY 2029**	**FY 2030**	**FY 2031**	**FY 2032**	**FY 2033**	**FY 2034**	**FY 2035**	**FY 2036**	**FY 2037**
Phase 1	$324,000	$324,000	$324,000	$324,000	$324,000	$324,000	$324,000	$324,000	$324,000	$324,000	$324,000	$324,000	$324,000
Phase 2	$456,000	$456,000	$456,000	$456,000	$456,000	$456,000	$456,000	$456,000	$456,000	$456,000	$456,000	$456,000	$456,000
Phase 3	$0	$399,000	$399,000	$399,000	$399,000	$399,000	$399,000	$399,000	$399,000	$399,000	$399,000	$399,000	$399,000
Phase 4	$0	$0	$0	$0	$0	$0	$417,000	$417,000	$417,000	$417,000	$417,000	$417,000	$417,000

O&M Costs	**FY 2025**	**FY 2026**	**FY 2027**	**FY 2028**	**FY 2029**	**FY 2030**	**FY 2031**	**FY 2032**	**FY 2033**	**FY 2034**	**FY 2035**	**FY 2036**	**FY 2037**
Phase 1	$187,495	$187,495	$187,495	$187,495	$187,495	$187,495	$187,495	$187,495	$187,495	$187,495	$187,495	$187,495	$187,495
Phase 2	$207,661	$207,661	$207,661	$207,661	$207,661	$207,661	$207,661	$207,661	$207,661	$207,661	$207,661	$207,661	$207,661
Phase 3	$0	$0	$239,655	$239,655	$239,655	$239,655	$239,655	$239,655	$239,655	$239,655	$239,655	$239,655	$239,655
Phase 4	$0	$0	$0	$0	$0	$0	$0	$289,708	$289,708	$289,708	$289,708	$289,708	$289,708
Sum of Phases 1 - 3	395,156	395,156	634,811	634,811	634,811	634,811	634,811	634,811	634,811	634,811	634,811	634,811	634,811

City of Ukiah
Recycled Water
Feasibility Study
Cash Flow Forecast

	FY 2038	FY 2039	FY 2040	FY 2041	FY 2042	FY 2043	FY 2044	FY 2045
	27	28	29	30	31	32	33	34
BEGINNING FUND BALANCE	$0	$0	$0	$0	$0	$0	$0	$0
SOURCES OF FUNDS								
Wastewater Revenues (1)	2,487,370	2,486,541	2,485,692	2,484,821	2,483,928	2,483,014	2,482,076	2,481,115
Recycled Water Revenues								
Loan Proceeds	**FY 2038**	**FY 2039**	**FY 2040**	**FY 2041**	**FY 2042**	**FY 2043**	**FY 2044**	**FY 2045**
Interest Income	27	28	29	30	31	32	33	34
TOTAL SOURCES	$0	$0	$0	$0	$0	$0	$0	$0
USES OF FUNDS								
O&M and R&R	2,487,370	2,486,541	2,485,692	2,484,821	2,483,928	2,483,014	2,482,076	2,481,115
Debt Service	33,149	33,978	34,827	35,698	36,590	37,505	38,443	39,404
CIP Program	-	-	-	-	-	-	-	-
Other	-	-	-	-	-	-	-	-
TOTAL USES	$2,520,519	$2,520,519	$2,520,519	$2,520,519	$2,520,519	$2,520,519	$2,520,519	$2,520,519
ENDING FUND BALANCE	$924,519	$924,519	$924,519	$924,519	$924,519	$924,519	$924,519	$924,519
	1,596,000	1,596,000	1,596,000	1,596,000	1,596,000	1,596,000	1,596,000	1,596,000
Notes:	-	-	-	-	-	-	-	-
(1) This cash flow analysis assumes	-	-	-	-	-	-	-	-
	$2,520,519	$2,520,519	$2,520,519	$2,520,519	$2,520,519	$2,520,519	$2,520,519	$2,520,519
Volume of Recycled Water Use	$0	$0	$0	$0	$0	$0	$0	$0
Phase 1								
Phase 2								
Phase 3								
Phase 4								
Sum of Phases 1 - 3								
Project Phase Construction Cost	**FY 2038**	**FY 2039**	**FY 2040**	**FY 2041**	**FY 2042**	**FY 2043**	**FY 2044**	**FY 2045**
Phase 1	404	404	404	404	404	404	404	404
Phase 2	215	215	215	215	215	215	215	215
Phase 3	376	376	376	376	376	376	376	376
Phase 4	381	381	381	381	381	381	381	381
Sum of Phases 1 - 3	995	995	995	995	995	995	995	995
Loan Issuance	**FY 2038**	**FY 2039**	**FY 2040**	**FY 2041**	**FY 2042**	**FY 2043**	**FY 2044**	**FY 2045**
Phase 1	$0	$0	$0	$0	$0	$0	$0	$0

City of Ukiah
Recycled Water
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Cash Flow Forecast

	FY 2038	FY 2039	FY 2040	FY 2041	FY 2042	FY 2043	FY 2044	FY 2045
Phase 2	$0	$0	$0	$0	$0	$0	$0	$0
Phase 3	$0	$0	$0	$0	$0	$0	$0	$0
Phase 4	$0	$0	$0	$0	$0	$0	$0	$0
Project Phase D/S	**FY 2038**	**FY 2039**	**FY 2040**	**FY 2041**	**FY 2042**	**FY 2043**	**FY 2044**	**FY 2045**
Phase 1	$324,000	$324,000	$324,000	$324,000	$324,000	$324,000	$324,000	$324,000
Phase 2	$456,000	$456,000	$456,000	$456,000	$456,000	$456,000	$456,000	$456,000
Phase 3	$399,000	$399,000	$399,000	$399,000	$399,000	$399,000	$399,000	$399,000
Phase 4	$417,000	$417,000	$417,000	$417,000	$417,000	$417,000	$417,000	$417,000
O&M Costs	**FY 2038**	**FY 2039**	**FY 2040**	**FY 2041**	**FY 2042**	**FY 2043**	**FY 2044**	**FY 2045**
Phase 1	$187,495	$187,495	$187,495	$187,495	$187,495	$187,495	$187,495	$187,495
Phase 2	$207,661	$207,661	$207,661	$207,661	$207,661	$207,661	$207,661	$207,661
Phase 3	$239,655	$239,655	$239,655	$239,655	$239,655	$239,655	$239,655	$239,655
Phase 4	$289,708	$289,708	$289,708	$289,708	$289,708	$289,708	$289,708	$289,708
Sum of Phases 1 - 3	634,811	634,811	634,811	634,811	634,811	634,811	634,811	634,811

City of Ukiah
Recycled Water Feasibility Study
Recycled Water Price

Total Annual D/S (Phases 1 through 3)	$1,179,000
Total Annual O&M (Phases 1 through 3)	$364,811
Annual Recycled Water Consumption	995
Total Price per Acre-Foot	$1,550
Total Price per hcf	$3.56
Allocation to Potable Water	
Potable Water Offset	22
Total Potable Water Demand in 2035	5,217
Percentage of Water Portfolio	0.43%
Total Annual D/S	$1,179,000
Annual D/S Cost Allocated to Water	$0
Annual O&M and R&R Allocated to Water	$0
Unit Cost to Water per Acre-Foot	$0.00
Total Price per hcf	$0.00
Allocation to Wastewater	
Total Annual D/S	$1,179,000
Less: Allocation to Recycled Water	$0
Less: Allocation to Potable Water	$0
Annual D/S Allocated to Wastewater	$1,179,000
Annual O&M and R&R Allocated to Wastewater	$352,500
Total Annual Cost Allocated to Wastewater	$1,531,500
Average Wastewater Flow Treated (AFY)	4,480
Unit Cost to Wastewater per Acre-Foot	$341.85
Total Price per hcf	$0.78
Allocation to Recycled Water	
Total Annual D/S Allocated to Recycled Water	$0
Total Annual O&M and R&R Allocated to Recycled Water	$12,311
Total Cost Allocated to Recycled Water	$12,311
Annual Recycled Water Use (AF)	995
Unit Cost to Water per Acre-Foot	$12.37
Total Price per hcf	$0.03

For Comparison:

Full Pumping and Treatment Cost to RW ($/AF)	$230.92
Total Price per hcf	$0.53
Full O&M (w/o R&R) to RW ($/AF)	$316.33
Total Price per hcf	$0.73

Year	Reclaimed Water Sales, AF	Design & Construc-tion Cost $ /a/	O&M Costs, $		Salvage Value, $ /c/	Present Worth Factor at 4.6%	Present Worth of Costs, $					Recycled Water Sales AF
			Fixed /b/	Variable /b/			Design & Construc-tion Cost	O & M Costs		Salvage Value	Total	
								Fixed	Variable			
2012	-	-	-	-		1.00000	0	0	0		0	0
2013	-	-	-	-		0.95602	0	0	0		0	0
2014	-	-	-	-		0.91398	0	0	0		0	0
2015	-	2,487,650	-	-		0.87379	2,173,673	0	0		2,173,673	0
2016	-	2,487,650	-	-		0.83536	2,078,081	0	0		2,078,081	0
2017	404	-	69,383	118,112		0.79862	0	55,411	94,327		149,738	404
2018	404	-	69,383	118,112		0.76350	0	52,974	90,178		143,153	404
2019	404	-	69,383	118,112		0.72992	0	50,645	86,213		136,857	404
2020	404	3,506,560	69,383	118,112		0.69782	2,446,965	48,418	82,421		2,577,804	404
2021	404	3,506,560	69,383	118,112		0.66714	2,339,355	46,288	78,797		2,464,440	404
2022	619	-	146,229	248,926		0.63780	0	93,265	158,765		252,030	619
2023	619	-	146,229	248,926		0.60975	0	89,163	151,783		240,946	619
2024	619	-	146,229	248,926		0.58293	0	85,242	145,108		230,350	619
2025	619	3,064,340	146,229	248,926		0.55730	1,707,753	81,493	138,726		1,927,973	619
2026	619	3,064,340	146,229	248,926		0.53279	1,632,651	77,910	132,626		1,843,186	619
2027	995	-	234,915	399,896		0.50936	0	119,656	203,691		323,347	995
2028	995	-	234,915	399,896		0.48696	0	114,394	194,733		309,127	995
2029	995	-	234,915	399,896		0.46554	0	109,363	186,169		295,533	995
2030	995	-	234,915	399,896		0.44507	0	104,554	177,982		282,536	995
2031	995	-	234,915	399,896		0.42550	0	99,956	170,155		270,111	995
2032	995	-	234,915	399,896		0.40679	0	95,560	162,672		258,232	995
2033	995	-	234,915	399,896	289,874	0.38890	0	91,358	155,518	112,731	134,145	995
Total		18,117,100					12,378,479	1,415,651	2,409,863	112,731	16,091,262	12,080

Unit Cost ($/AF) = (Total present worth of costs)/(Total present worth of sales)= $1,300 per acre-foot

/a/ All costs adjusted to 2012 dollars

/b/ Assumed that fixed costs equals all costs except for the cost of water treatment and distribution.

/c/ Useful lives: Average useful life of 50 years assumed for the infrastructure. No salvage value for engineering, legal & administration costs which are assumed to equal 25% of the presented cost.

CURRENT AND PROPOSED WATER RATES (TABLE 1)

		Proposed				
USE	Current	August 1, 2010	July 1, 2011	July 1, 2012	July 1, 2013	July 1, 2014
Consumption Rate ($/unit; 1 unit is 748 gallons						
Single Family Residential	$1.29	$1.92	$2.21	$2.41	$2.65	$2.73
All other customers	1.29	$1.92	$2.21	$2.41	$2.65	$2.73
Minimum base charge by: Meter Size/Class Description						
3/4" Meter	$15.24	$22.71	$26.11	$28.46	$31.31	$32.25
1" Meter	25.90	38.59	44.38	48.37	53.21	54.81
1 1/2" Meter	50.28	74.92	86.15	93.91	103.3	106.4
2" Meter	80.75	120.32	138.37	150.82	165.90	170.88
3" Meter	152.36	227.02	261.07	284.57	313.02	322.41
4" Meter	254.45	379.13	436.00	475.24	522.76	538.45
6" Meter	507.37	755.98	869.38	947.62	1,042.38	1,073.66
Fire Service 2" & Under	16.15	24.06	27.67	30.16	33.18	34.18
Fire Service 3" Meter	30.47	45.40	52.21	56.91	62.60	64.48
Fire Service 4" Meter	50.89	75.83	87.20	95.05	104.55	107.69
Fire Service 6" & Up	101.47	151.19	173.87	189.52	208.47	214.72

How Do I Calculate My New Water Rate

Basis of Proposed Rates: The proposed rates were designed to fairly and equitable recover the cost of providing water service from across all customer groups. The cost of providing service will be recovered through a fixed fee, called the **monthly service charge** and through a **consumption fee** that will apply to the amount of water you consume. The **monthly service charge** is determined by the meter size. The **monthly service charges** will increase across meter sizes as established by industry and regulatory standards.

Estimating your New Water Bill

The fixed fee (called a monthly service charge) and the consumption fee, that will apply to the amount of water you consume, may be estimated as follows:

Step 1: Find your monthly service charge—Your water meter size will determine your **Monthly Service Charge.** The Proposed Rate Table, located above, shows the proposed **Monthly Service Charge** for each meter size.

Step 2: Determine your level of consumption—You can find this information in your most recent water bill on the bottom right hand corner under water usage. The proposed consumption rates are listed at the top of the Proposed Rate Table located above.

Step 3: Estimate your new water bill—To calculate how much your new water bill will be, add your **monthly service charge** to your **consumption charge** (which is the number of units of water you consume multiplied by the per unit consumption fee).

The sample calculation on the right is for a single family home with a 3/4" meter and 11 units of consumption. Your monthly water bill will vary, depending on the number of units recorded on your meter each month.

Estimating your New Water Bill:

Sample calculation using rates effective August 1, 2010

Step 1: Monthly Service Charge
From the proposed water rate table above, determine the monthly service charge
3/4" meter = $22.71/month

Step 2: Consumption Charge
Assuming this family uses 11 units of water each month
11 units @ $1.92 per unit = $21.12/month

Step 3: Estimate you new bill

Monthly service charge:	$22.71
Consumption charge:	$21.12
Projected new bill:	$43.83

Sample calculation based on a single family home using 11 units of water per month.

Proposition 218 Notification
NOTICE TO PROPERTY OWNERS OF PUBLIC HEARING
ON PROPOSED WATER SERVICE RATE ADJUSTMENT
(Please share this information with tenants)

Hearing Date & Time: July 21, 2010 at 6:00PM or as soon thereafter as possible
Hearing Location: City of Ukiah, Council Chambers
300 Seminary Avenue, Ukiah, CA 95482

The hearing will cover the proposed 2010, 2011, 2012, 2013, and 2014 rate adjustment for water service. This notice has been sent to all customers who currently receive this service provided by the City of Ukiah. If adopted, the proposed rate adjustment will become effective for bills issued on or after August 1, 2010 and for bills issued on or after July 1, 2011, 2012, 2013, and 2014.

This Notice of Public Hearing provides information regarding the proposed rate adjustment to the City's water service customers pursuant to the requirements of California Constitution Article XIII D Section 6 (commonly referred to as Proposition 218). The proposed rate adjustment will be presented to the City Council for adoption on July 21, 2010, at 6:00 p.m. in the Council Chambers. This notice also provides information on how rates are calculated, the reasons for the required rate adjustment, how customers can receive more information on the effect of the proposed rate adjustment on their water bill and how to file a protest against the proposed rate adjustment.

Annually the City prepares an analysis of the revenues and expenditures for the Water enterprise to ensure sufficient revenues are collected to effectively provide for the short and long-term water service needs of the community. Revenues received from water charges are restricted solely for these purposes.

HOW WATER RATES ARE CALCULATED:

Multi-Year Rate Setting Strategy—The in-depth analysis that is conducted include a minimum five-year look ahead at operating and capital program costs in order to adequately prepare the funds for upcoming expenses and avoid significant unexpected increases in rates. To achieve planned service goals, incremental rate increases over a number of years are the preferred method for ensuring rate stability. Table 1 of this notice shows the proposed rates. The proposed rates are consistent with the approach taken five years ago when the current rate schedule was adopted.

Rates Based on Customer Usage Choices - Under the City's water rate structure, bills are based on customer usage choices and resulting demand on the water system. The City has a two component water rate—a minimum base charge and a service charge based on the volume of water used.

WHAT ACTION HAS BEEN TAKEN TO CONTROL COSTS:

Keeping costs down is one of our main concerns, especially during these difficult economic times. The City has used layoffs, furloughs and salary reductions to reduce expenditures in all operations. Water operations are an independent business. Expenditures and revenues must balance. The City, including the employees in the Water Department, have worked to minimize costs, budgeting and examining the amount of each expense from scratch with no assumed increases.

Some costs, such as for the electrical power needed to run treatment plant and pumps have increased. However, quantities for disinfectant and process chemicals have decreased. These cost control measures must be delicately balanced against the ever increasing requirements from the State of California. Though at times the new requirements seem onerous, they are all ultimately intended to protect the water quality in our Valley.

Concerns, Please Contact Us For More Information:

If you have questions or comments about the proposed water rate adjustment or wish to protest, you may:

Address The Council: Attend the Public Hearing on July 21, 2010

Telephone: (707) 463-6217

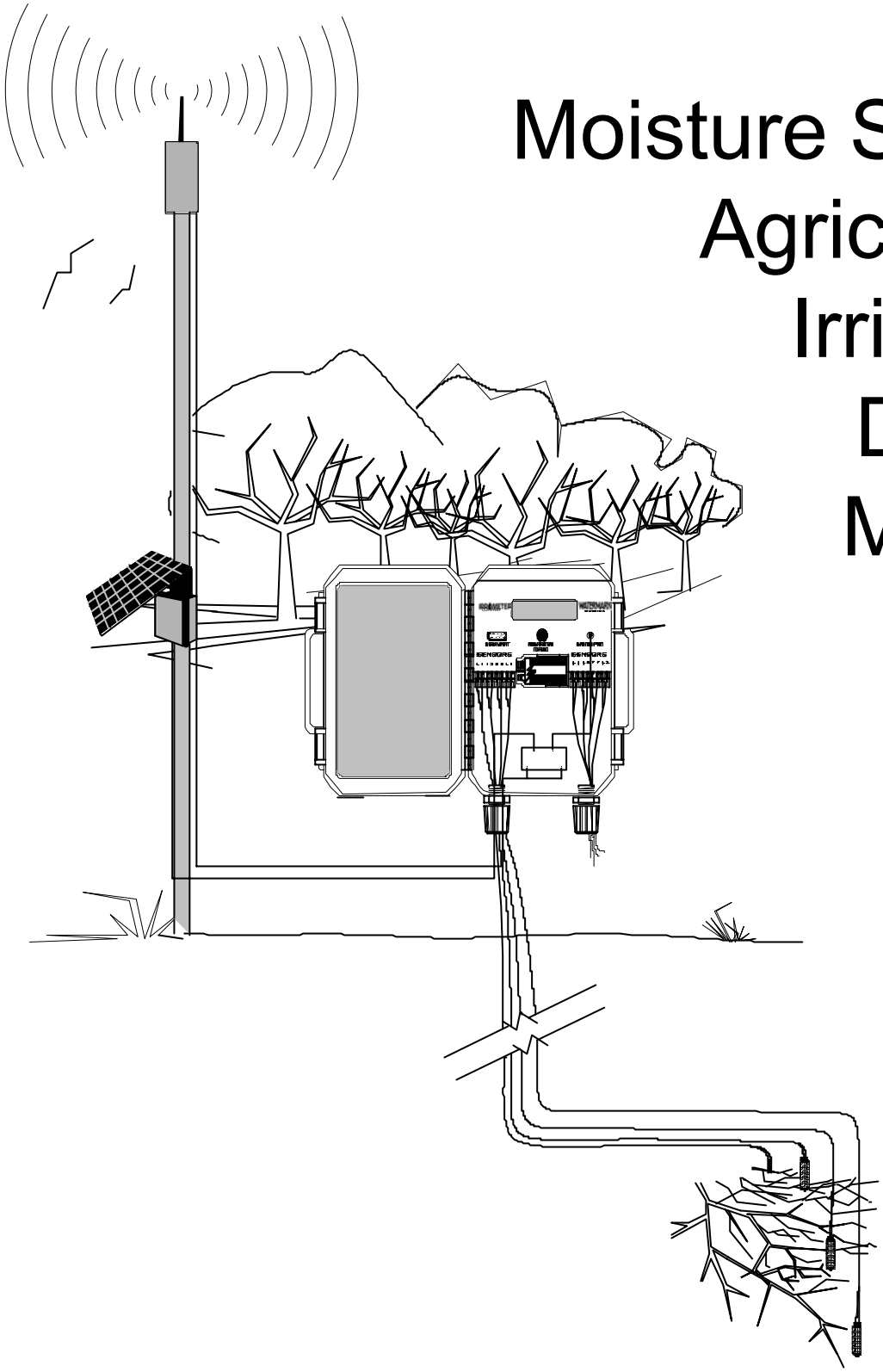
Write: 300 Seminary Avenue, Ukiah, CA 95482

Protests against the proposal must be submitted in writing, identify the property by street address or Mendocino County Assessor's Parcel Number, the owner(s) of the property, and include the signature(s) of the property owner(s). The term "owner" includes tenants who are responsible for paying the monthly water bill. If written protests against the proposed increases in the fee for water service are filed at or prior to the hearing by a majority of the affected property owners, the City Council will not approve the increases.

IRROMETER CO.

...simple tools for optimizing irrigation, worldwide.

Moisture Sensor Agricultural Irrigation Design Manual



FOREWARD

Since 1951 Irrometer Company, Inc. has been providing simple tools that help to answer the age old questions:

WHEN should I irrigate (How Often)

and

How long should I irrigate? (Cycle run time)

The need for knowing how to answer these two questions is even more important today than it was in 1951. World experts agree that water will be the limiting factor in World Food Production. Not land, not technology, but *WATER*.

Many moisture sensing products have come and gone over the years but Irrometer Company, Inc. continues to be synonymous with quality, high value products.

This manual will introduce you to some of our products. We also show typical applications and illustrate how they can be specified. This manual does not show every application but feel free to call us to discuss your particular project needs.

For more information:

Phone: (951) 689-1701
Fax: (951) 689-3706
E-mail: sales@irrometer.com
Website: www.irrometer.com

Information contained in this manual is based on generally accepted information and practices. If any problems, difficulties, or injury arise from or in conjunction with the use of this information, or if there is any error herein, typographical or otherwise, Irrometer Company, Inc., and its agents or employees thereof, shall not be responsible or liable therefore.

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INTRODUCTION

Irrigation scheduling, A practical background

Since the dawn of mankind, irrigation has enhanced crop production. History records the benefits of irrigation, as well as the dismal failures caused by irrigation mismanagement. Today we are faced with dwindling water supplies, loss of water resources from pollution and permanent damage to land resources, in many cases due to mismanaging our most precious resource – water. “Water Conservation” is becoming the principal objective – often simply stated to the detriment of irrigated agriculture and landscapes. But the real “truth” of using irrigation wisely is simple – good agronomy. When irrigation is managed correctly, soil moisture
is maintained in an optimum condition for the creation of the best possible crop/plant health. Production can be maximized. Quality can be enhanced. Pests and disease are mitigated. Nutrients are efficiently utilized and not wasted. Energy is conserved, and, usually water use is decreased. The elimination of excessive irrigation also protects our water quality.

Soil moisture measurement has been proven for almost eight decades to be a very important and productive tool for managing and scheduling irrigation. The principal tools, consistently used throughout these years, are tensiometers (Irrometers) and electrical resistance blocks (Watermarks). These simple, inexpensive, easy to use yet scientific devices allow an irrigation manager to “read” his soil moisture and to manage the irrigation system to produce the correct answer to the only important questions that occur:

WHEN to irrigate
HOW MUCH to apply

Based on your sensor “reading” you can determine when you need to “Refill” your soil moisture reservoir (irrigate) and from experience to verify that your irrigation amount (or rainfall) indeed restored your soil to “Field Capacity”. Simply stated, Field Capacity is that condition which exists when the soil has been fully wetted by irrigation or rainfall, drainage has ceasedand the soil water reservoir is storing as much water as it can hold. It’s nature’s balance of soil, water and air.

What the irrigation manager needs to do to use this technology is to install the Irrometers and/or Watermarks in key locations throughout the fields and to “read” them 2 – 3 times between irrigations. The readings will tell you how fast the crop is extracting water (how fast the soil is drying out) and warn you in advance of needed irrigations.

- Produce better yield and quality
- Optimize production
- Reduce water waste
- Manage energy efficiently
- Maximize nutrient use
- Mitigate excessive runoff and deep percolation loss
- Help protect water quality

In short, more money in the bank at harvest.

Irrometer Soil Moisture Sensors

Manual Irrometers

Model R

Reading the vacuum gauge gives soil moisture tension at the placement depth. Standard lengths are 6”, 12”, 18”, 24”, 36”, 48”, 60” and 72”.

The Model R: Standard Irrometer for use in row, tree and field crops. Scale is 0 to 100 centibars (kPa).

Model SR

The Model SR: A Model R with a threaded removeable tip.

The Model LT: Has a “Quick-Flo” tip for use in very light (coarse) soils and non-soil planting media where irrigation decisions are made in the very wet (Low Tension) end of the soil moisture spectrum. Scale is 0 to 40 centibars (kPa).

Model LT

The Model MLT: This is a miniature version of the Model LT for use with small containers in greenhouse applications.

Automatic Irrometers

Model MLT

These instruments are fitted with switches for automating irrigation decision or with transducers for integration with computerized control systems.

The Model RA: This is a Model R with direct switching capabilities. Adjustable selector switch can be set to any desired moisture level. Switch closes past the setting to actuate solenoid valve, time clock or warning light.

Model RA

The Model SRA: This is a Model SR with the same direct switching capabilities.

The Model LTA: This is a Model LT with the same direct switching capabilities.

Model RSU

The Model RSU: This replaces the gauge on any Irrometer thus Converting the reading to a 4-20mA loop current signal. For example: SR-RSU-12”. Calibrations vary with instrument measurement range.

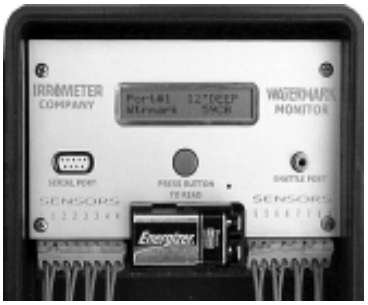
Watermark Sensors

Watermark
Soil Moisture Sensor

The Watermark is a resistance type granular matrix sensor. The resistance across a pair of electrodes imbedded within the granular matrix varies with moisture content. This varied resistance is calibrated against known values and reported as soil water tension, the same value we obtain from an Irrometer tensiometer reading. Internally installed gypsum is used as a buffering agent to compensate for the effects of varying salinity levels typically found in the irrigated agricultural environment. Watermarks sensors can be read by several different devices.

Watermark Electronic
Meter (30-KTCD-NL)

The Watermark Meter is a solid state alternating current resistance bridge meter for reading Watermark sensors. It is adjustable for soil temperature variations. One meter is required to read an unlimited number of sensors, one at a time. The Meter includes: touch pad operating panel, durable case and field changeable cable assembly. Read from 0 cb (wet) to 199 cb (very dry).



Watermark
Monitor

The Watermark Monitor automatically reads up to eight sensors. The readings can be downloaded to a computer for graphical representation, which makes the changes in soil moisture status easier to identify. Current readings are also displayed in the field for making on the spot scheduling decisions. Several sensor selections are available for each input port. Either Watermark soil moisture sensors, soil temperature sensors, dry contact switch closure sensors, Irrometer Model RSU tensiometers and other 4-20mA or voltage input sensors can be utilized. Data can be downloaded directly to a computer, via a PDA, via radio or via cellular telemetry.

Watermark Electronic
Module (WEM)

The Watermark Electronic Module (WEM) uses two Watermark sensors placed at varying depths within the root zone. The total tension is measured and averaged to report the overall condition within the root zone. This device typically works in conjunction with a standard 24 VAC irrigation controller. The WEM is in effect a switch which interrupts the common ground connection between the control valves and the controller. The irrigation scheduler selects the appropriate moisture level on the dial of the WEM, and the controller is allowed to only run the irrigation cycles necessary. Truly “automatic” scheduling is provided.

CHOOSING BETWEEN IRROMETERS AND WATERMARKS

SELECTION GUIDELINES

GENERAL

1. Maintenance Requirement - Some maintenance is required with Irrometers, no maintenance with Watermarks
2. Irrometers need to be protected from damage by freezing temperatures, Watermarks do not.
3. Cost - Irrometers are less expensive up to 6 sensors. With more sensors, Watermarks become less costly.
4. Sensitivity/Accuracy - Irrometers react quicker to soil moisture changes than Watermarks and are more accurate and sensitive, especially in the “wet” end (below 25 centibars). Model LT is best suited to these applications, from 5 to 20 centibars.

SPECIFIC

Factors to be considered:

- Soil type
- Crop sensitivity to moisture stress
- Irrigation method being used
- Soil suction thresholds

Model LT - Most sensitivity and accuracy in the low tension range, from 0 to 40 centibars, direct reading method

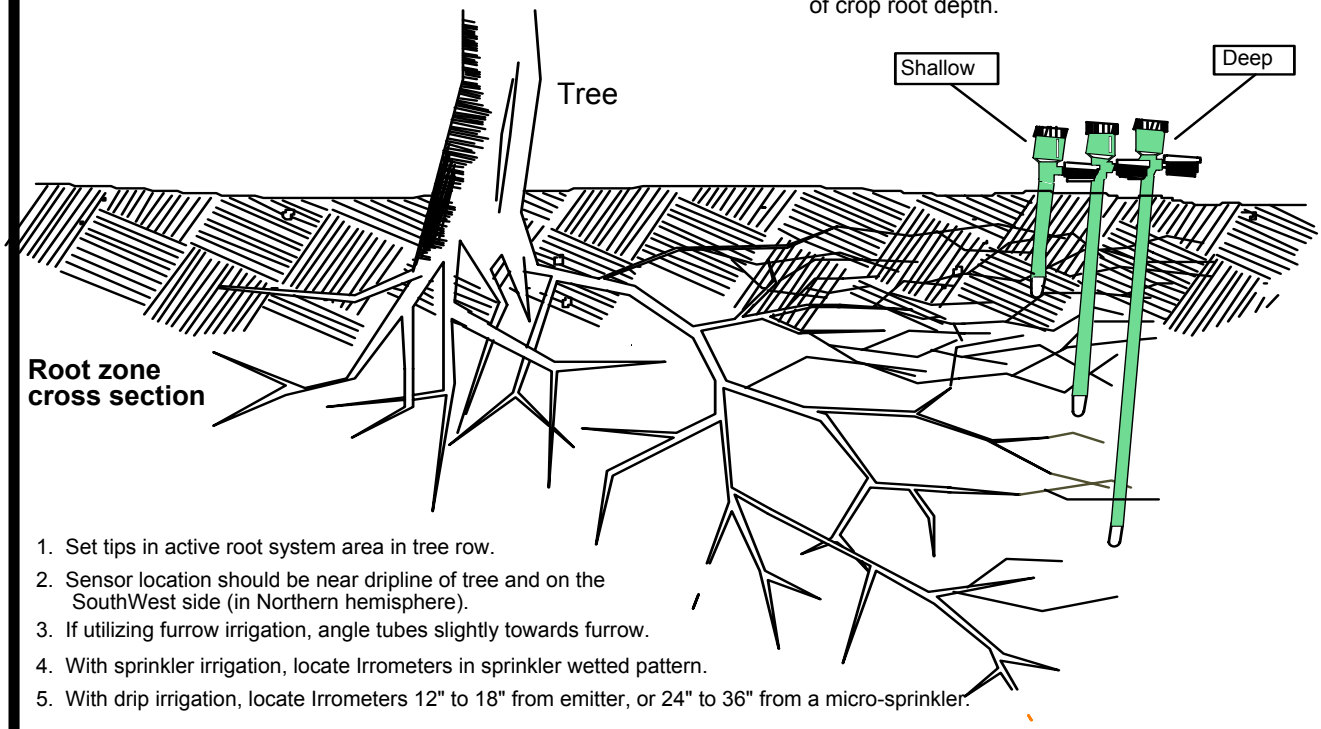
Model R/SR - Sensitive and accurate through 80 centibars, direct reading method

Watermark - Less sensitive and slower to respond in the wet end, but can go much higher in the dry end, to 199 centibars, indirect reading method.

	Soil Type	Crop Sensitivity	Irrigation Method	Soil Suction
Model R/SR	Lighter to Medium Soils	Sensitive to Medium Sensitivity	Drip, Sprinkler, Furrow, Center Pivot	15 to 75 centibars
Model LT	Non-Soil Media, Amended Soils, Coarse Sandy Soils	Very Sensitive Crops	Drip, Trickle, Micro Spray, Capillary	5 to 20 centibars
Watermark	Medium to Heavier Soils	Medium to Drought Tolerant Crops	Drip, Sprinkler, Furrow, Flood, Center Pivot	20 to200 centibars

Irrometer installation detail - Orchards

NOTE: Irrometer placement depth is a function of crop root depth.

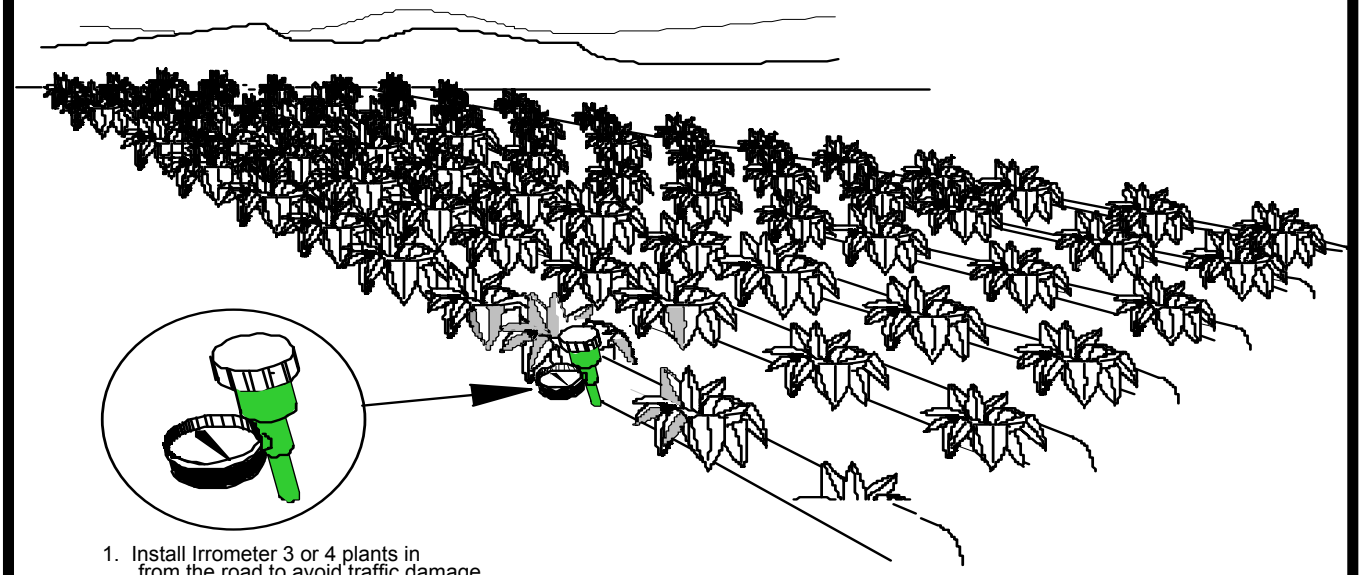


1. Set tips in active root system area in tree row.
2. Sensor location should be near dripline of tree and on the SouthWest side (in Northern hemisphere).
3. If utilizing furrow irrigation, angle tubes slightly towards furrow.
4. With sprinkler irrigation, locate Irrometers in sprinkler wetted pattern.
5. With drip irrigation, locate Irrometers 12" to 18" from emitter, or 24" to 36" from a micro-sprinkler.

Irrometer 1 01/30/02

Irrometer installation detail - Row Crops

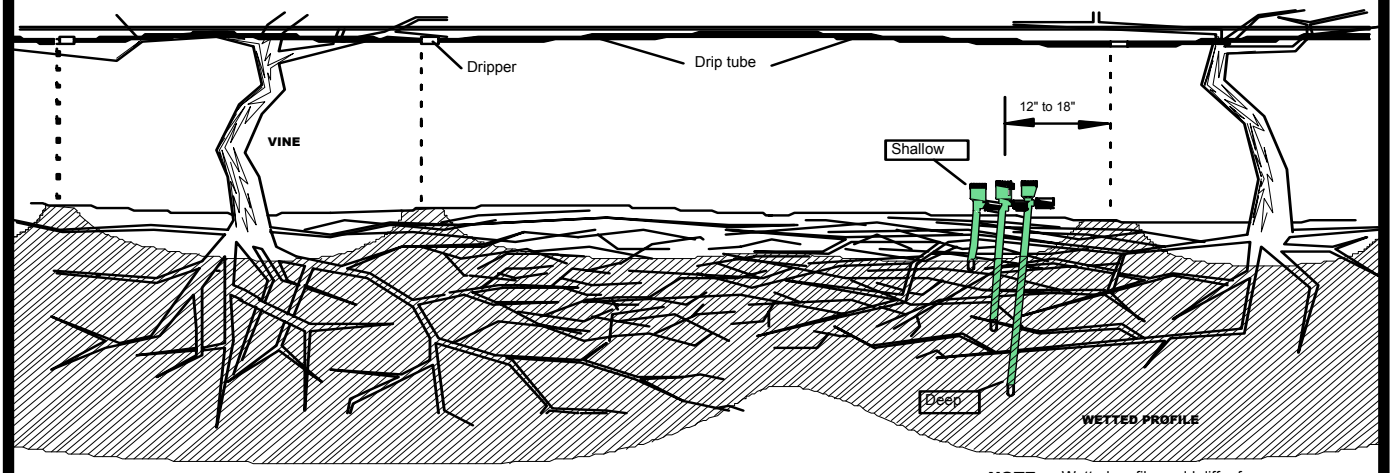
NOTE: Irrometer placement depth is a function of crop root depth.



1. Install Irrometer 3 or 4 plants in from the road to avoid traffic damage.
2. Install instrument at root zone, and in the crop row.
3. On larger irrigation blocks, a monitoring location every 15 to 20 acres is recommended.
4. Use short (shallow) and long (deeper) Irrometers on 18" or deeper root systems.

Irrometer 2 01/30/02

Irrometer Installation detail - Vines on Drip



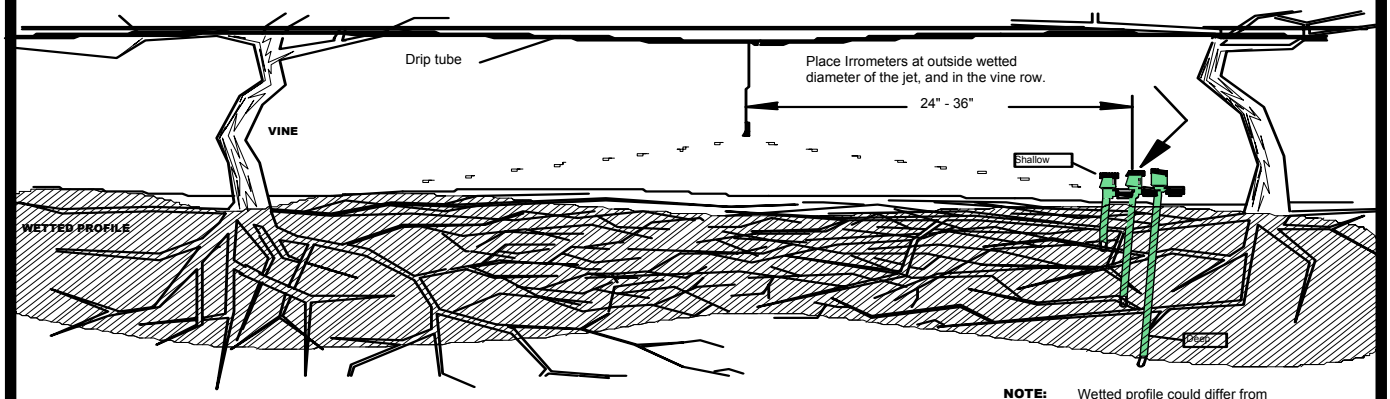
NOTE: Wetted profile could differ from that shown above depending on soil types.

1. Install Irrometers 3 or 4 vines in from the road to avoid traffic damage.
2. Install instruments in the active root zone in the vine row.
3. On larger irrigation blocks, a monitoring location every 15 to 20 acres is recommended.
4. Use short (shallow) and long (deeper) Irrometers on 18" or deeper root systems.

NOTE: Irrometer placement depth is a function of crop root depth.

Irrometer 3 - Vines on Drip | 02/25/02

Irrometer Installation detail - Vines on Jets or Microsprinklers



NOTE: Wetted profile could differ from that shown above depending on soil types.

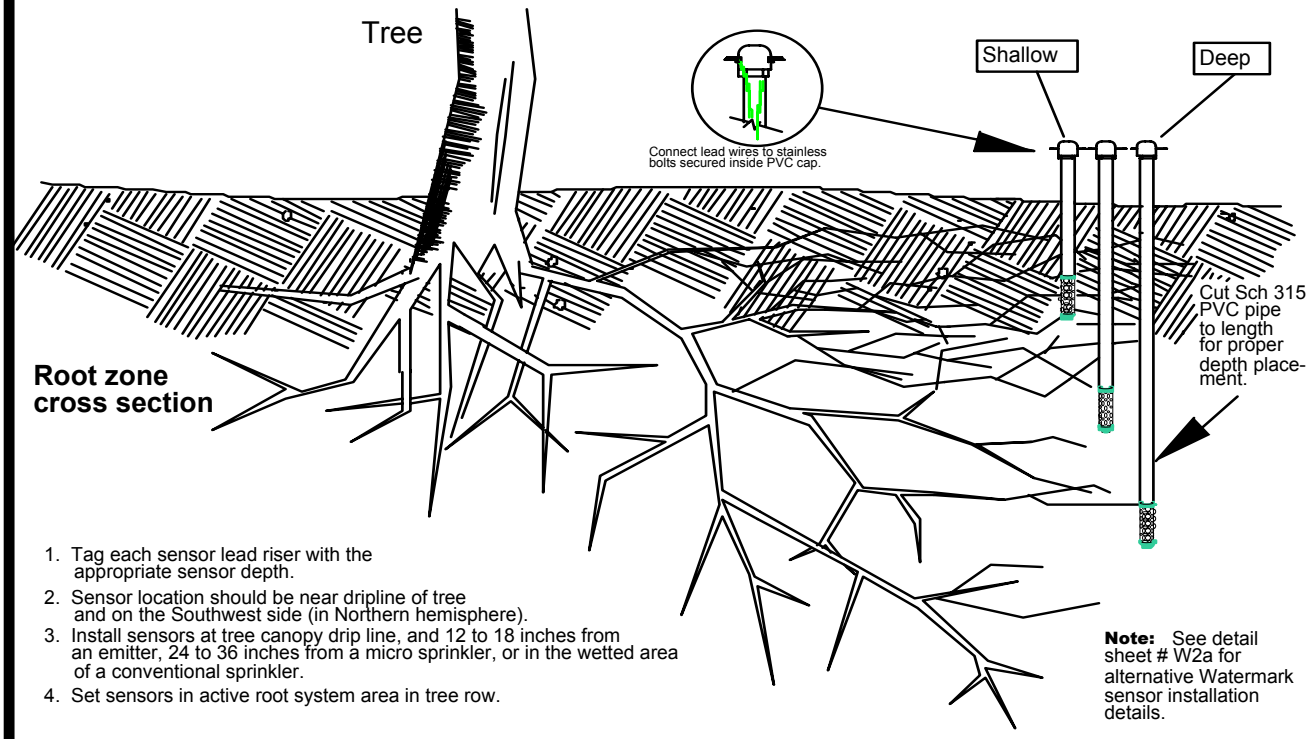
1. Install Irrometers 3 or 4 vines in from the road to avoid traffic damage.
2. Install instruments in the active root zone in the vine row.
3. On larger irrigation blocks, a monitoring location every 15 to 20 acres is recommended.
4. Use short (shallow) and long (deeper) Irrometers on 18" or deeper root systems.

NOTE: Irrometer placement depth is a function of crop root depth.

Irrometer 4 - Vines on Jets or Microsprinklers | 02/25/02

Watermark installation detail - Orchards

NOTE: Watermark placement depth is a function of crop root depth.



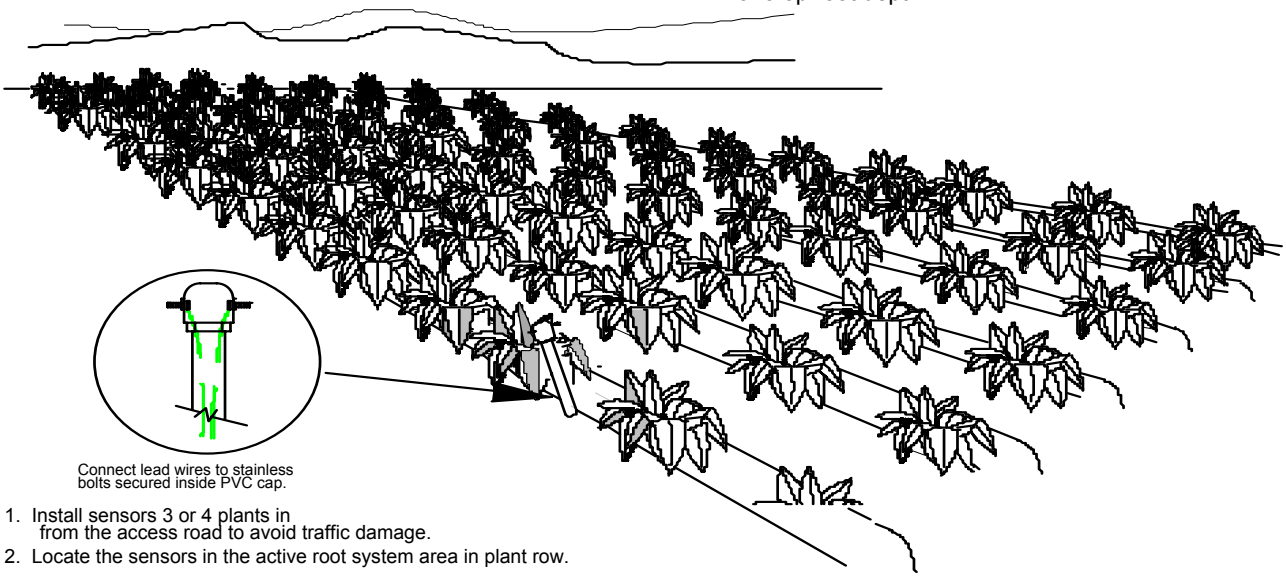
1. Tag each sensor lead riser with the appropriate sensor depth.
2. Sensor location should be near dripline of tree and on the Southwest side (in Northern hemisphere).
3. Install sensors at tree canopy drip line, and 12 to 18 inches from an emitter, 24 to 36 inches from a micro sprinkler, or in the wetted area of a conventional sprinkler.
4. Set sensors in active root system area in tree row.

Note: See detail sheet # W2a for alternative Watermark sensor installation details.

Watermark 1 | 01/30/02

Watermark installation detail - Row Crops

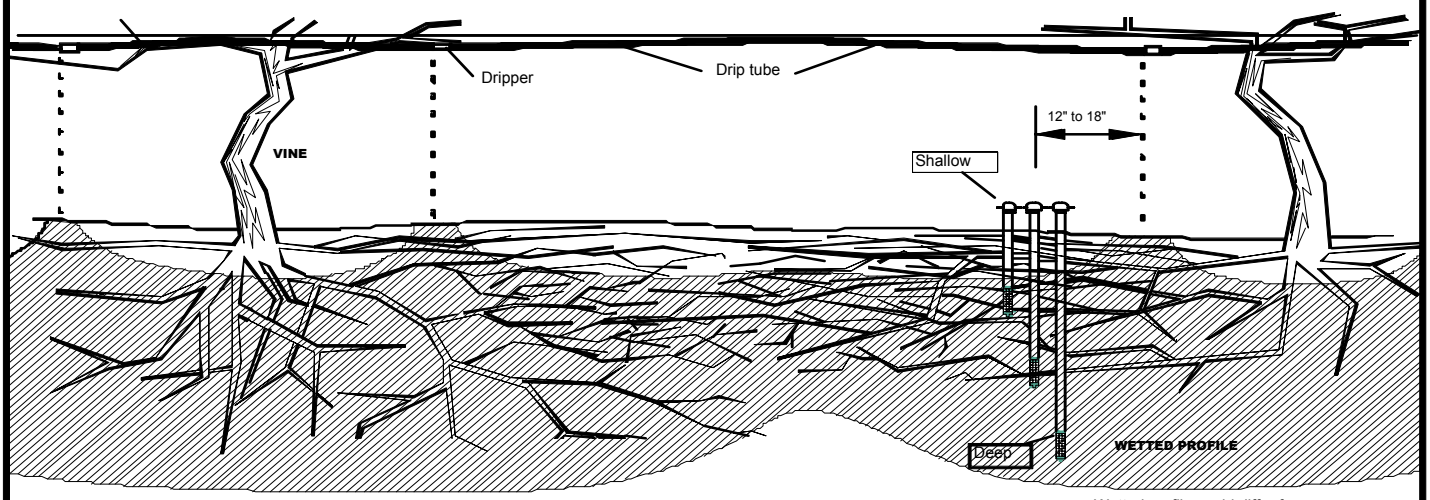
NOTE: Watermark placement depth is a function of crop root depth.



1. Install sensors 3 or 4 plants in from the access road to avoid traffic damage.
2. Locate the sensors in the active root system area in plant row.
3. On larger irrigation blocks, a monitoring location every 15 to 20 acres is recommended.
4. In deeper rooting crops, two or more sensors per location set at shallow and then progressively deeper steps are advised for more accurate monitoring of moisture profile.

Watermark 2 | 03/12/02

Watermark Installation detail - Vines on Drip



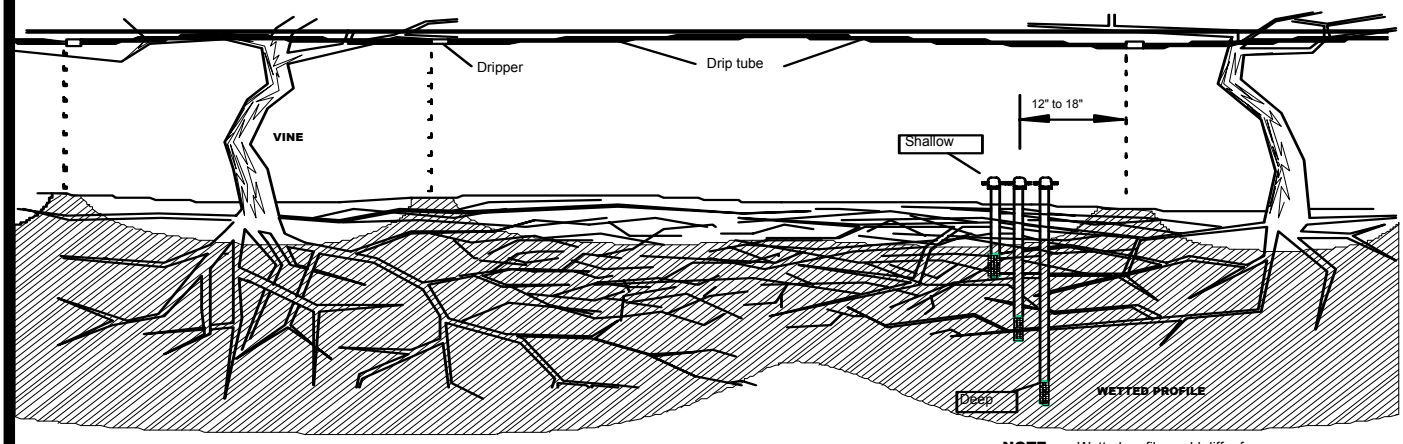
NOTE: Wetted profile could differ from that shown above depending on soil types.

1. Install Watermarks 3 or 4 vines in from the road to avoid traffic damage.
2. Install instruments in the active root zone in the vine row.
3. On larger irrigation blocks, a monitoring location every 15 to 20 acres is recommended.
4. Use short (shallow) and long (deeper) Watermark sensors on 18" or deeper root systems.

NOTE: Watermark placement depth is a function of crop root depth.

Watermark 3 - Vines on Drip | 03/07/02

Watermark Installation detail - Vines on Drip



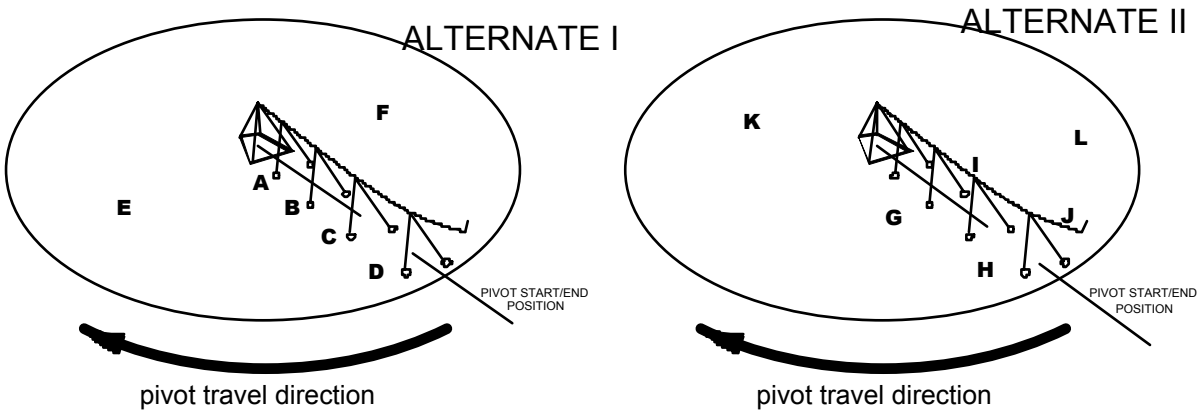
NOTE: Wetted profile could differ from that shown above depending on soil types.

1. Install Watermarks 3 or 4 vines in from the road to avoid traffic damage.
2. Install instruments in the active root zone in the vine row.
3. On larger irrigation blocks, a monitoring location every 15 to 20 acres is recommended.
4. Use short (shallow) and long (deeper) Watermark sensors on 18" or deeper root systems.

NOTE: Watermark placement depth is a function of crop root depth.

Watermark 3 - Vines on Drip | 03/07/02

TYPICAL IRROMETER or WATERMARK PLACEMENT - 130 Ac. CENTER PIVOT



ALWAYS USE TWO (2) IRROMETERS OR WATERMARKS PER LOCATION, ONE SHALLOW AND ONE DEEP.

A = BETWEEN TOWERS 2 AND 3
B = BETWEEN TOWERS 4 AND 5
C = BETWEEN TOWERS 6 AND 7
D = BETWEEN TOWERS 8 AND 9
G = BETWEEN TOWERS 3 AND 4 **(START POSITION)**
H = BETWEEN TOWERS 7 AND 8 **(START POSITION)**
I = BETWEEN TOWERS 3 AND 4 **(FINISH POSITION)**
J = BETWEEN TOWERS 7 AND 8 **(FINISH POSITION)**
E AND K = "HOT SPOT" - LIGHTEST SOIL - QUICKEST TO DRY
F AND L = BEST PRODUCTION AREA IN FIELD

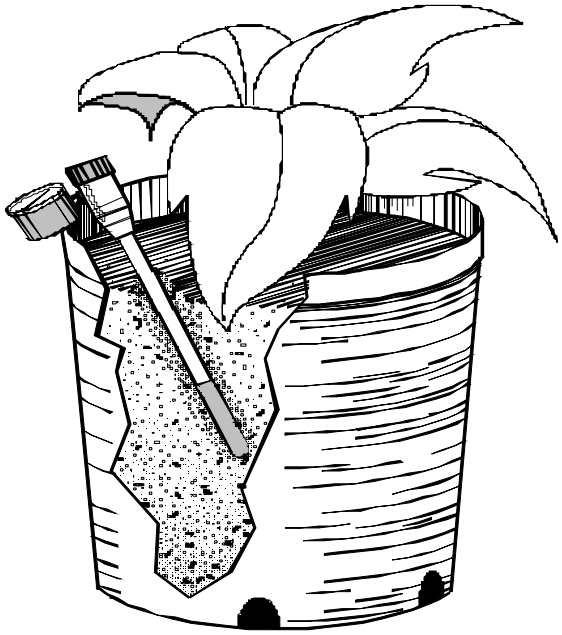
Notes:

- Set shallow sensors at approx. 25% of the crop rooting depth.
- Set deep sensors at approx. 75% of the crop rooting depth.
- Sensors near start and finish positions should be a few sprinkler diameters away from the actual start/finish line.

Irrometers or Watermarks on Center Pivot | 10/24/05

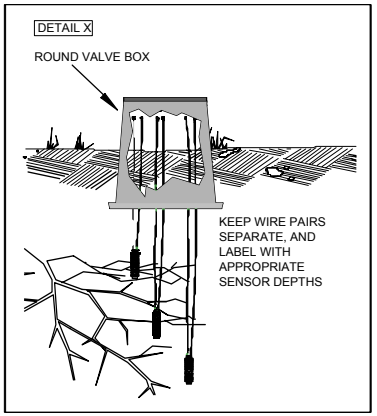
Greenhouse Application

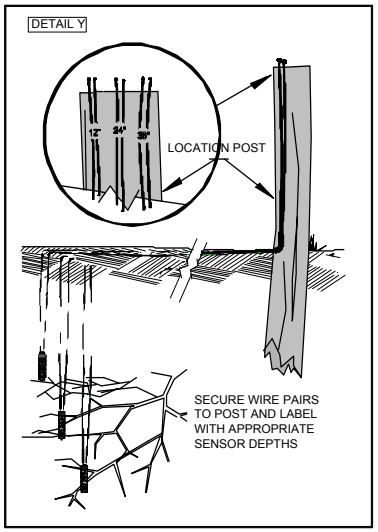
MLT IN CONTAINER

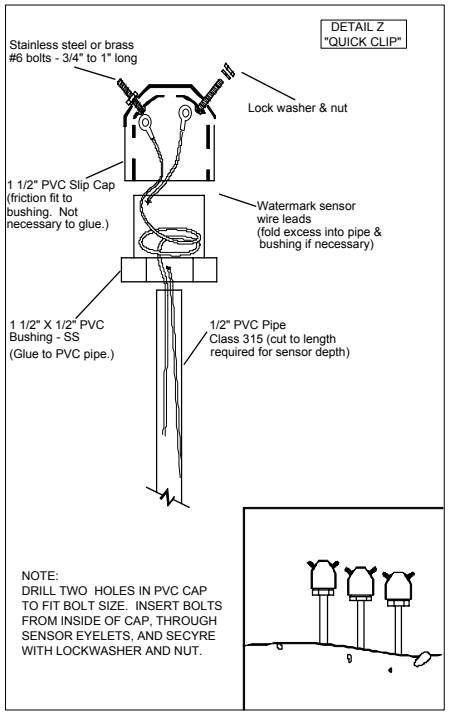


1. **Place tip in root mass area, usually halfway down the pot.**
2. **Angle with gauge downward and resting on container edge for support.**
3. **Select container in drier area of bench.**
4. **"Flag" container being monitored for easy identification.**

Irrometer 5 - Irrometer in Container | 10/24/05

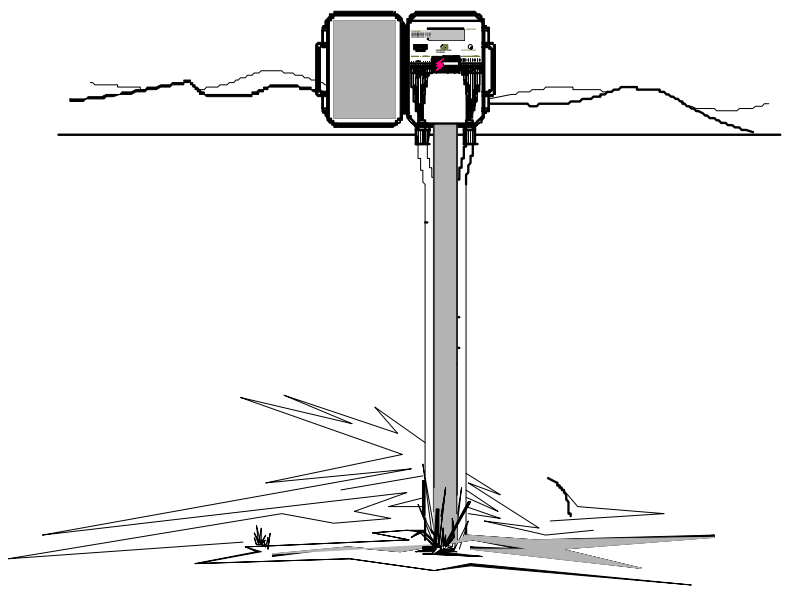






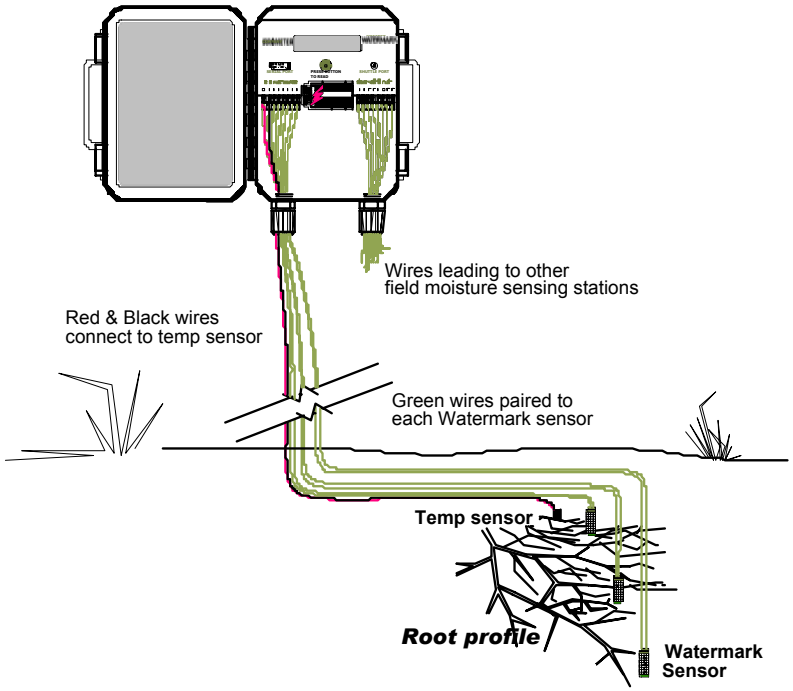
SAMPLE WIRING DETAILS FOR MANUALLY READING WATERMARK SENSORS WITH HANDHELD METER (#30KTCD-NL)

Watermark 5 - Installation Options | 10/20/2005



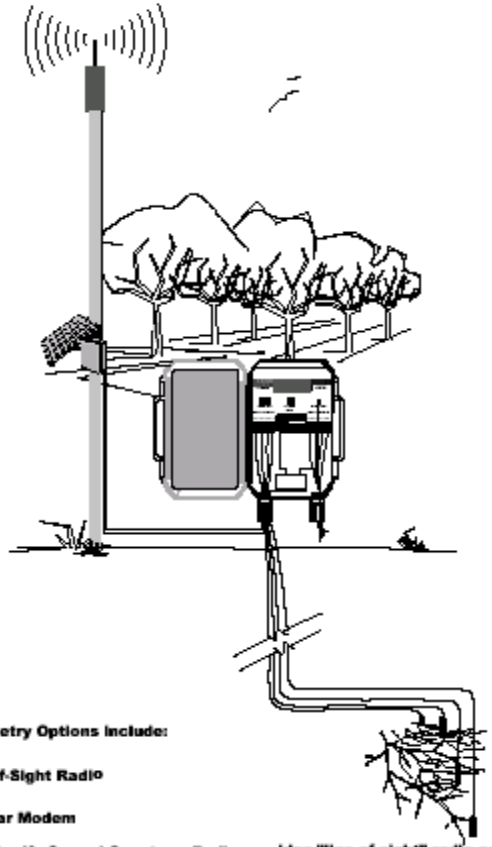
1. **Monitor should be mounted on post at convienient height for easy viewing and operation.**
2. **An optional "table board" may be attached to post for use with a laptop or for note taking.**

Monitor 1 - Field Installation | 10/24/05



1. **Sensor placement depth is a function of crop rooting depth.**
2. **Install sensors in active root zone.**
3. **Program Monitor with appropriate sensor reading interval.**
4. **Install Watermark sensors or Irrometer Model RSU tensiometers as necessary or specified.**
5. **Download Monitor to display graphs of soil moisture history on computor.**

Monitor 2 - wiring connection detail | 10/24/05



Telemetry Options include:

Line-of-Sight Radio

Cellular Modem

1. **900 mHz Spread Spectrum Radio provides "line of sight" radio connection to remotely retrieve data.**
2. **Drawing shows the Monitor with Field radio Module (900FR) installed on mounting post including optional Battery Pack (900BP) supplying power for the radio.**
3. **Field radio must be within line of sight of base station radio, or use of repeater radios may be necessary for long distances or terrain changes.**
4. **Cellular modem also available for field connection, service must be customer provided.**

Monitor 4 - Field Installation with Telemetry and Battery Pack | 10/24/05

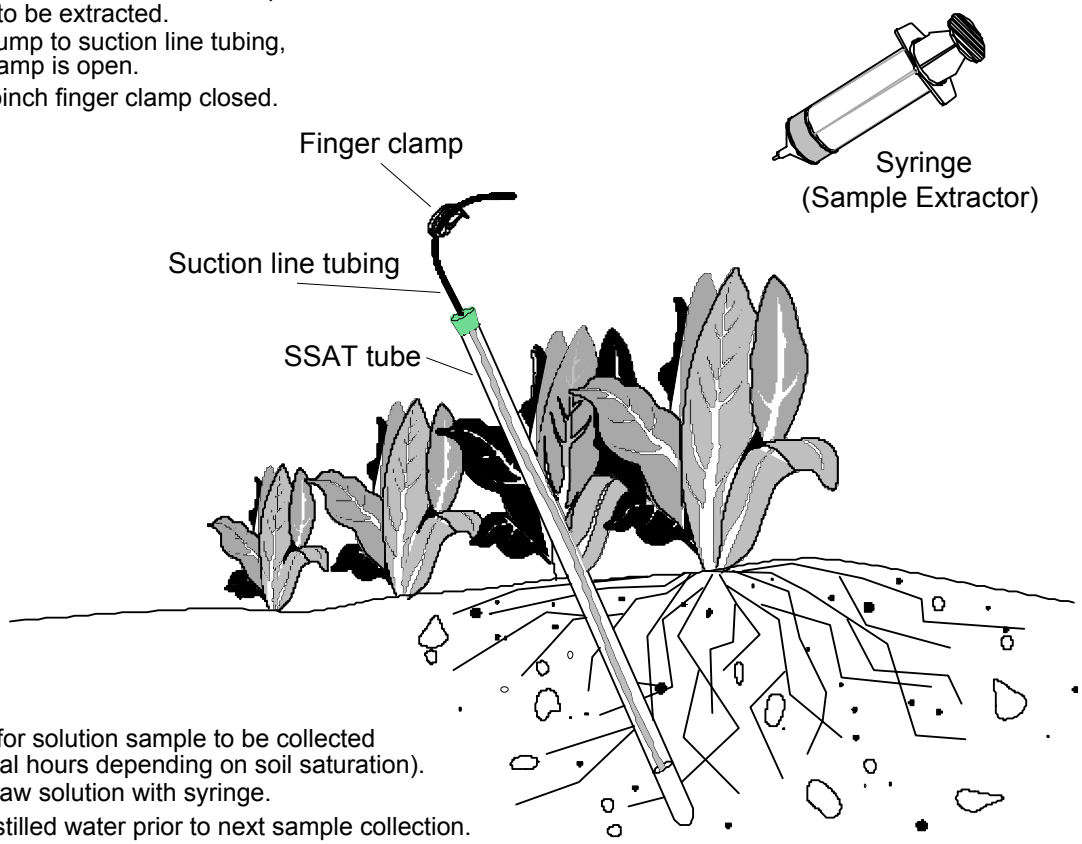
Soil Solution Access Tubes

…for Nutrient Management

Irrometer Soil Solution Access Tubes, SSAT, are used for monitoring the effectiveness of “fertigation” regimes. The process of suction extract analysis uses these tubes to extract actual soil water samples, which can then be analyzed for elements commonly used in fertigation and chemigation. These SSATs, or suction lysimeters, are typically used to obtain samples for the determination of such things as nitrate concentration, EC or salinity levels. Please note: Use for measuring pH is limited, but can be performed utilizing additional procedures, please consult factory for details.

In practice, after the fertigated water has been applied, a vacuum is drawn on the tube with the syringe or a hand vacuum pump, for lengths longer than 12 inches (30 cm). After sufficient time has elapsed for soil water to be drawn into the tube, the collected soil water solution is extracted from the tube with the syringe. Analysis is typically done in the field with portable devices, such as test kits or meters, or sent to a laboratory.

1. Insert SSAT tip into active root zone at the depth where the sample is to be extracted.
2. Connect syringe or pump to suction line tubing, making sure finger clamp is open.
3. Pull a vacuum, then pinch finger clamp closed.



4. Allow adequate time for solution sample to be collected (this could take several hours depending on soil saturation). Open clamp to withdraw solution with syringe.
5. Rinse syringe with distilled water prior to next sample collection.
6. Placement of SSAT's at moisture sensor location helps validate soil saturation status.
7. Use of a longer SSAT provides greater vacuum capacity, thus making sample collection more efficient. For example, using an 18" tube at 8" sampling depth.

SSAT 1 - Soil Solution Access Tube | 03/11/02

Irrometer Pressure Gauges

Irrometer offers pressure gauges designed for the demanding conditions of irrigation service.

Hermetically Sealed for long life and corrosion resistance to provide years of trouble-free service in the toughest field conditions.

Liquid-Filled for applications where vibration is a problem.

Switching Pressure Gauges are also available for applications where a pressure activated switch closure is needed.

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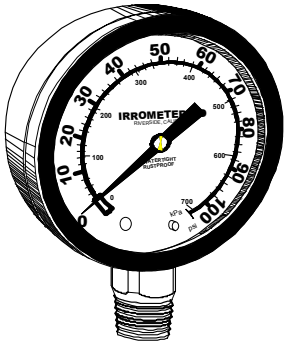
WATER TIGHT
RUST PROOF
DUST PROOF
SHATTER PROOF FACE



THIS DURABLE, SPECIALLY CONSTRUCTED HERMETICALLY SEALED GAUGE IS DESIGNED TO GREATLY LENGTHEN SERVICE LIFE

HERMETICALLY SEALED 2" PRESSURE GAUGE
PRESSURE RANGE(S):
____0-15 PSI
____0-30 PSI
____0-60 PSI
____0-100 PSI
____0-200 PSI
____0-400 PSI

AVAILABLE WITH FACTORY INSTALLED INTERNAL SNUBBER TO HELP ABSORB SURGES (SNUBBER IS REMOVEABLE FOR CLEANING)
____S

ALL GAUGES ARE DUAL SCALE WITH PSI AND kPa
ASME B40.1 GRADE B COMMERCIAL SERIES
1/4" NPT BRASS BOTTOM CONNECTION
INTERNAL COMPONENTS:
BRASS WITH NYLON GEAR AND PHOSPHORUS BRONZE BOURDON TUBE
CLEAR BUTYRATE OUTER FACE AND POLYCARBONATE INTERNAL FACE
THERMO PLASTIC RUBBER (TPR) COVER

12 Irrometer Sealed Pressure Gauge

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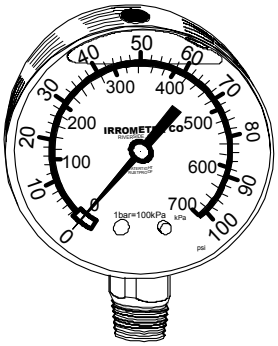
STAINLESS STEEL COVER
LIQUID FILLED



THIS GAUGE PROVIDES SUPERIOR PERFORMANCE IN APPLICATIONS WHERE VIBRATION, PULSATION, MECHANICAL SHOCK AND PRESSURE SPIKES ARE COMMON.

AVAILABLE WITH FACTORY INSTALLED INTERNAL SNUBBER TO HELP ABSORB SURGES (SNUBBER IS REMOVEABLE FOR CLEANING)
____S

LIQUID FILLED 2 1/2" PRESSURE GAUGE
PRESSURE RANGE(S):
____0-60 PSI
____0-100 PSI
____0-200 PSI
____0-400 PSI

ALL GAUGES ARE DUAL SCALE WITH PSI AND kPa
ANSI B40.1 GRADE B COMMERCIAL SERIES
1/4" NPT BRASS BOTTOM CONNECTION
INTERNAL COMPONENTS:
BRASS WITH NYLON GEAR AND PHOSPHORUS BRONZE BOURDON TUBE
304 STAINLESS STEEL CASE WITH BUNA-N VENT PLUG
POLYCARBONATE FACE
GLYCERIN FILLING (0-150° F AMBIENT)

13 Irrometer Liquid Filled Pressure Gauge

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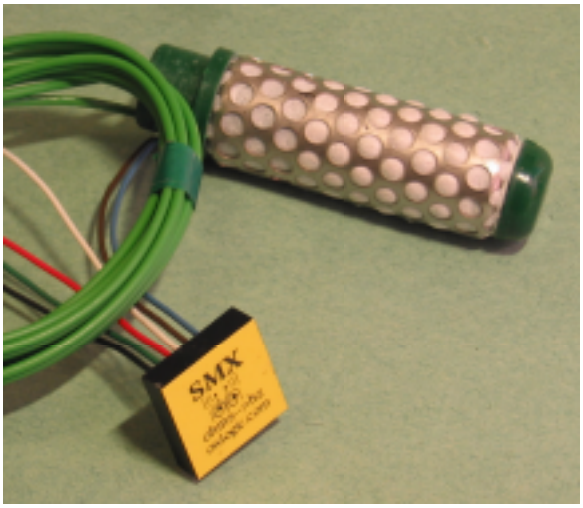
Contributing MEMBER
The Irrigation Association

December 2005

SMX

Electrical Interface for Watermark™ or Gypsum Block Sensors.

Watermark™ sensors are available from Irrometer Company* and their distributors world wide, including EME Systems. These soil moisture sensors are to be buried in intimate contact with soil at root depth, where they will reach equilibrium with the local soil moisture. The measurement correlates well with soil water potential. This is fine for agriculture, because water potential (in units of kilo-Pascal or centibar) best quantifies the work plant roots do to extract moisture from the soil. Of course, plants and soils have their individual characteristics. The bottom line is that the readings are related to plant stress and well being.



The signal is electrical resistance, which decreases with increasing soil moisture (and also temperature, which can be compensated). The sensor construction is ingenious: A perforated stainless steel cylinder supports a permeable membrane, inside which there is a tightly packed sand aggregate, the "granular matrix", and at one end there is a wafer of gypsum, and concentric electrodes, which are attached to wires that emerge to the soil surface. The gypsum wafer serves as a buffer against differences in soil acidity and salinity, so that the electrical resistance between the electrodes depends on moisture and temperature only.

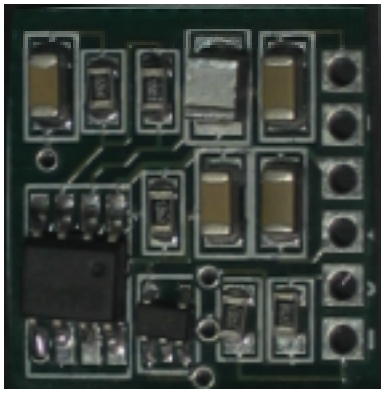
A special circuit is needed to measure the electrical resistance of the Watermark sensor. DC currents must not be allowed to flow through the wet part of the circuit, or else irreversible reactions will occur and spoil the readings. AC excitation avoids these problems, by reversing the polarity of the current many times per second, so that no net reaction takes place at either electrode. The circuit must also isolate the sensor electrodes from galvanic currents in the soil environment. Metal objects such as ground rods or pipes or tanks or other sensors that contact the soil can give rise to underground electrical currents in relation to the electrodes of the Watermark sensor, and those too can spoil the reading and degrade the sensor.

The SMX circuit provides the AC excitation and galvanic isolation required by the Watermark sensor. The output signal is a voltage, or alternatively, from the same module, a current or a frequency, that depends on the AC electrical resistance, from which the soil moisture tension can be calculated by an intelligent data logger or nomograph. Two wires go to the Watermark sensor, and the SMX output is routed to a data logger, controller or meter. The SMX module allows the Watermark sensors to be used with a wide range of general purpose equipment that does not have built in the special circuitry required to read the Watermark AC resistance.

The SMX is available as a module potted in industrial epoxy, with 6 wire leads, suitable for outdoor deplooyment, and the module is also available as an assembled circuit board, suitable for incorporation into custom systems.

* Watermark is a trademark of Irrometer Company, Riverside CA 909/689-1701 <http://www.irrometer.com>

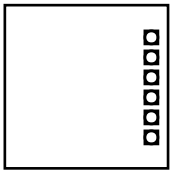
Specifications:



- Supply Voltage: 4–15 VDC
- Voltage output
  0.2 volts dry to 1.0 volts wet typical
  (as high as 1.7 V with sensor short circuit)
- Frequency output 50 hz dry to 7 khz wet
  open collector square wave (needs pullup resistor to read out frequency.)
  (as high as 13 khz with sensor short circuit)
- Current output (also supply current)
  0.2 mA dry to 1.0 mA wet
  (as high as 1.7 ma with sensor short circuit)
- less than 0.01% per Volt supply variation.
- **http://www.emesystems.com**

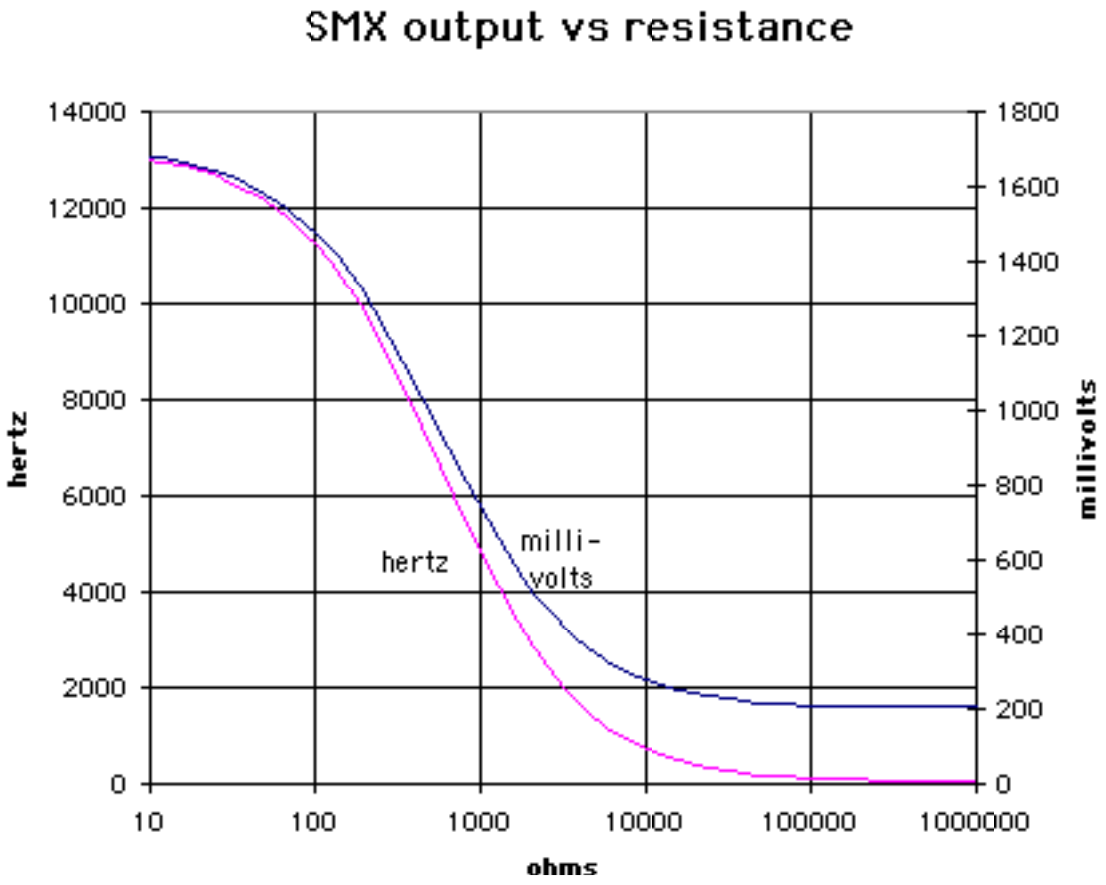
The SMX is a potted module (0.825" sqaure x 0.25" thick) for placement in the field near the sensor. There are two wires for connection to the Watermark or gypsum block sensor, and four wires for connection to the data logger or other equipment.

- connections
  - red: + 5 to 15 volts DC
  - green: signal frequency, needs pull-up to +V
  - white or yelow: voltage signal
  - black: common
  - blue wires: soil moisture block
- Operating Temperature: -0°C to +50°C
  no meaningful signal below 0°C



SMX rev 2, top view (component side)
blue sensor
blue, sensor
yellow, volts out
green, frequency out, open collector
red, power +3.5 to 15 volts
black, common

Figure 1



Wiring the SMX to the data logger

The two blue wires from the module connect to the Watermark sensor terminals, either polarity is okay. Use wire nuts or other standard means of wiring. Insulate the connections, because water or other conductive material between them would give a false signal.

The SMX needs a power supply in the range of 3.5 to 15 volts DC. The SMX draws 1 milliamp or less of supply current, so it is possible to provide power from a switched output pin from a microcontroller. If more than one SMX is to be installed at a single location, power each one of them separately, in order to avoid interactions between the sensors.

Figure 2 shows how to connect the sensor for digital frequency output. The pullup resistor shown (4.7 kohms, value not critical) can pull up to any voltage from 3 to 7 volts DC. The output signal is a square wave, and its frequency varies from 50 hz when the sensor is bone dry, up to 10000+ hertz when the sensor is soaking wet. This output can be measured using a COUNT or PERIOD function on the data logger. Note that the white and the black wires are connected together.

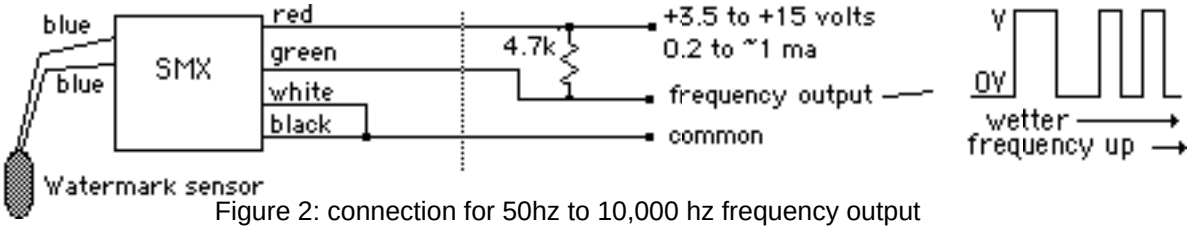


Figure 2: connection for 50hz to 10,000 hz frequency output

Figure 3 shows how to connect the sensor for voltage output. The green wire should be connected to the white wire. The minimum power supply is 4.5 volts in this configuration. The output signal is a voltage that varies from 0.2 volts when the sensor is bone dry, up to 1+ volt when the sensor is soaking wet. For best smoothing of the signal, add a capacitor of 100 µF from the voltage signal line to common. That will smooth out the remaining low frequency ripple.

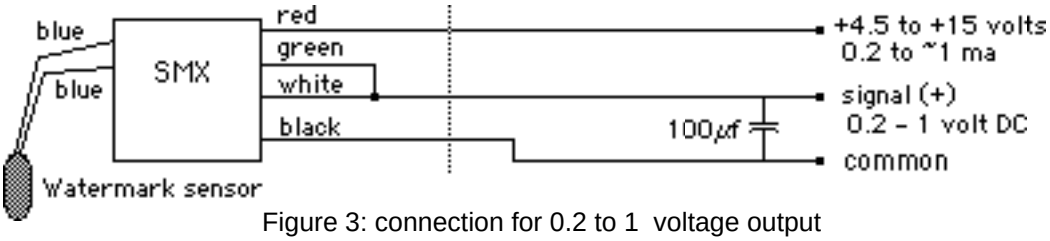
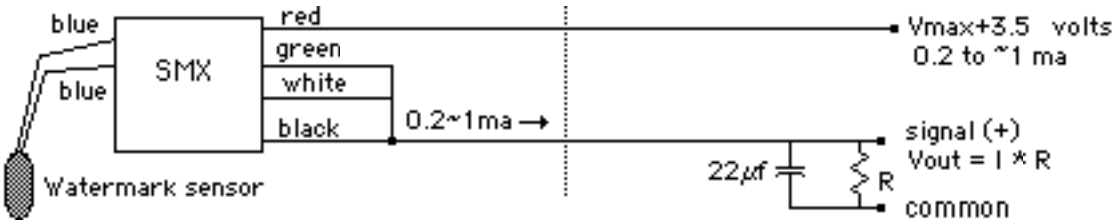


Figure 3: connection for 0.2 to 1 voltage output

Figure 4 shows how to connect the sensor for two wire current output. The black, green and white wires are joined. The output signal is a current that varies from 0.2 milliamp when the sensor is bone dry, up to over 1 milliamp when the sensor is soaking wet. The current on the two wire circuit may be converted to a voltage at the input of the data logger. A 1 kΩ resistor will convert the 0.2–1.0 millamp current into a 0.,2–1 volt signal. The power supply voltage must be a high enough voltage to sustain the maximum expected voltage across that resistor, plus the line loss in the wiring, plus the 3.5 volts required by the SMX module itself. For example, with a 15 volt supply and a 10kohm resistor, it is possible to achieve a signal output of 0 to 10 volts. DC across the resistor. Add a capacitor across the resistor to smooth the residual ripple

Figure 4: connection for two-wire 0.2 to 1 ma current output.



Watermark installation:

"Plant" the sensors, following the Watermark instructions for presoaking. Install the sensors while they and the soil are wet, and maintain good contact with the surrounding soil. Use a slurry as “glue” if necessary.

The sensors will interact with one another slightly if they are planted too close together. Keep them a foot or two apart if possible.

Install a temperature sensor at the same depth as the sensor, in order to implement the temperature compensation.

Lightning protection:

This circuit, like any that is installed in intimate contact with the soil, is subject to danger from lightning This is especially a problem if the soil moisture sensor is installed at a distance from the data logger or readout device that is monitoring the wetness, and the data logger has its own ground connection. If lightning strikes nearby, there can be large differences in ground potential between the two locations and currents will attempt to flow through the interconneting wires and through the sensitive circuit elements. The inputs on the blue and brown wires are protected to ±25 volts, however, this might not be enough in frequent lightning areas. Solutions:

1) Use a TVS (transient voltage suppressor, surge protector) rated at 12 volts across the sensor leads, with the ground of the TVS attached to the cable shield that leads up to the ground terminal on the data logger.

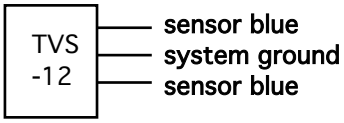
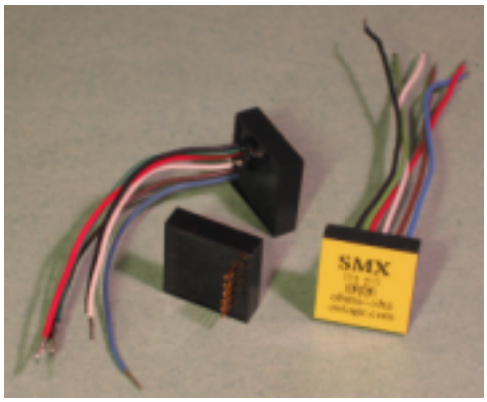


Figure 5: surge protector.

2) power the SMX from a separate battery, and transmit the data as a frequency using optical isolation.

3) install the data logger and the SMX in close physical proximity.



Notes on basic reading of the sensor signal.

Connect the SMX as in figure 2, for frequency output. This program is written in PBASIC for the BASIC Stamp, using the command COUNT to determine the SMX oscillation frequency.

```
' simple test of the SMX operation, count input.
result   var  word
loop:
  count 12,1000,result   ' count on Stamp P12 for 1 second
  debug ? result         ' show the result in counts
goto loop
```

The result should be between 50 Hertz (dry) to 10000 Hertz drenched (550 Ω) or 13000 Hertz with a direct short circuit across the grid.

Alternatively, here is code using the voltage input version. Connect the SMX as in figure 3, for voltage output, and connect the voltage to an analog to digital converter, as for example an analog input of an OWL2e data logger.

```
' simple test of the SMX operation, voltage input.
result   var  word
DO
  GOSUB ADread          ' not shown here
  DEBUG ? result        ' show the result in millivolts
  PAUSE 1000            ' slow it down
LOOP
```

The result should come out between 200 millivolts (dry) to 1000 millivolts (drenched, ~550 Ω), to 1700 millivolts (direct short circuit across the grid). **IMPORTANT:** If two or more sensors are located in close proximity, the power should be turned on to only one at a time, to avoid interaction.

```
' simple test of the SMX operation, voltage input.
result var  word
DO
  HIGH power1           ' turn on power to the 1st SMX module
  PAUSE 1000            ' allow reading to settle
  GOSUB ADread          ' read the value
  LOW power1            ' turn off power to the 1st SMX
  DEBUG ? result        ' show the result in millivolts
  HIGH power2           ' turn on power to the 2nd SMX module
  PAUSE 1000            ' allow reading to settle
  GOSUB ADread          ' read the value
  LOW power2            ' turn off power to the 2nd SMX
  DEBUG ? result        ' show the result in millivolts
LOOP
```

The raw readings above can be used to establish thresholds for irrigation or other actions, based on observation of plant stress and well being. On the other hand, in order to obtain quantitative results that can be compared to the Irrometer tables and advice for use of the Watermark, the raw voltage or raw count can be transformed to resistance, temperature compensated, and converted to moisture units in kilopascals. The following paragraphs describe this procedure, and a reference PBASIC program is listed in the appendix.

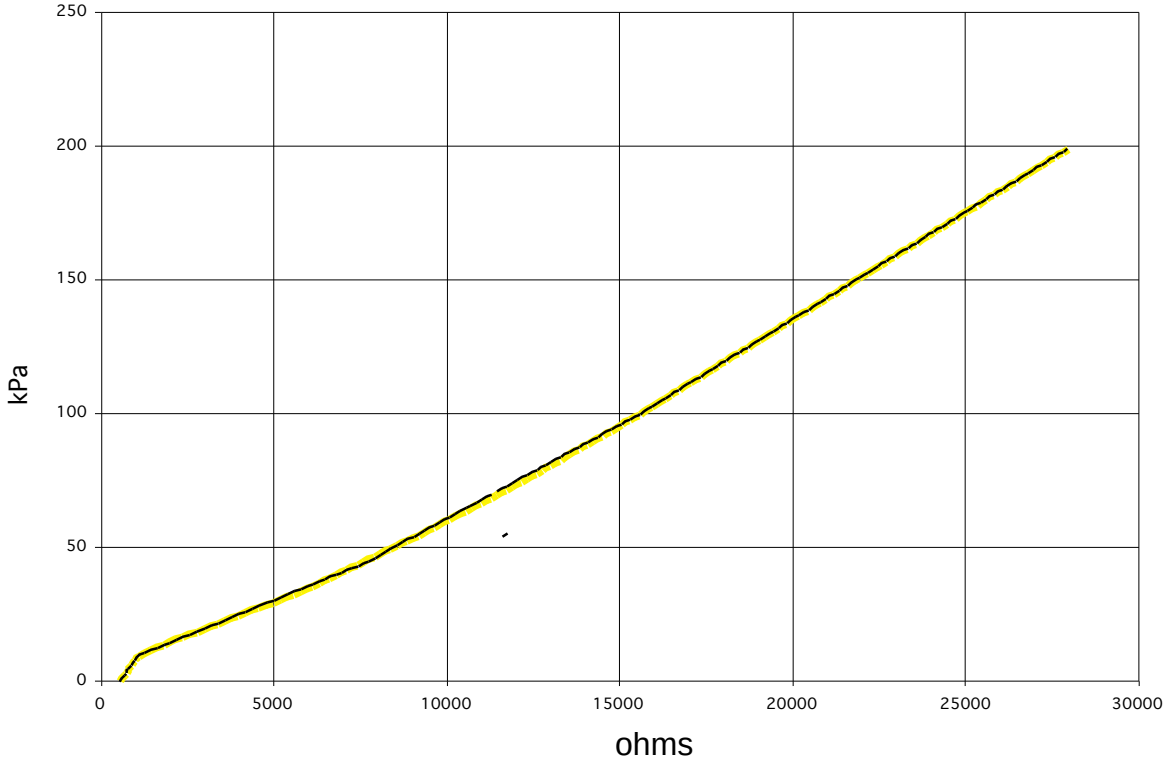
ohms	volts	μ-amps	hertz
0	1707	1707	13233
1	1704	1704	13209
2	1702	1702	13186
3	1699	1699	13162
4	1697	1697	13139
6	1691	1691	13092
8	1686	1686	13047
12	1676	1676	12962
16	1666	1666	12871
24	1645	1645	12708
32	1625	1625	12526
48	1588	1588	12200
64	1552	1552	11893
96	1485	1485	11312
128	1426	1426	10802
192	1320	1320	9882
256	1230	1230	9104
384	1089	1089	7878
512	980	980	6932
768	828	828	5596
1024	726	726	4697
1536	596	596	3557
2048	517	517	2862
3072	427	427	2071
4096	377	377	1623
6144	323	323	1135
8192	295	295	874
12288	265	265	612
16384	250	250	476
24576	234	234	335
32768	226	226	264
49152	218	218	194
65536	214	214	157
98304	210	210	122
131072	208	208	103
196608	206	206	85
262144	205	205	76
10000000	201	201	48

TABLE 1
Table of voltage, current and frequency output by the SMX module, when the given resistance is placed across its input terminals.

Table 2:
Showing the resistance values that correspond to certain levels of soil water potential. Summary of Irrometer "Chart #3", composed of piecewise linear segments. The resistance values are taken or temperature compensated to 75 degrees Fahrenheit (24 degrees Celsius).

SWP kPa	ohms	slope ohms/kPa
0	550	
		50
9	1000	
		100
10	1100	
		180
15	2000	
		200
35	6000	
		160
55	9200	
		150
75	12200	
		135
100	15575	
		125
200	maximum: 28075	

Figure 6: Soil Moisture in kiloPascal vs Watermark resistance in ohms.



Interpret the readings.

Soil moisture tension is given in terms of the electrical resistance of the Watermark sensor. Table 1 on the previous page shows the voltage, current and frequency output of the SMX as a function of resistance across the input. This data is also graphed in figure 1. Table 2 and figure 5 show soil moisture as a function of resistance. The two tables provide means to go from the volts or Hertz reading of the SMX, through resistance, to the corresponding soil moisture in kPa. The microcomputer or the spreadsheet can do this automatically, by a process of interpolation. There is actually one more small step in between table 1 and table 2, and that is that the resistance reading needs to be temperature compensated. The graph

Observe in table 1 that mVolts and µAmps are numerically the same, this being due to the fact that the voltage is determined by the current passed through a precision 1kΩ resistor.

The shape of this curve in table 1,and figure 1,is due to the design of the electrical circuit. It's output is proportional to one over the resistance of the sensor and other resistors that limit the low and high frequency of oscillation. This is by design. (Refer to the appendix 1 for more circuit information.)

The region of the curve in figure 1 that is of interest for irrigation will be the center part, from 500 ohms to 10000 ohms. Incidentally, the relationship of millivolt and current output is linear in relation to frequency. output (R^2>0.999).

Here is another way to express the information in table 2 and figure 6. This frames the relation between kPa and ohms (@75°F) terms of a piecewise linear computation:

kPa = (ohms - 550) / 50	**for 550 <= ohms <= 1000**
kPa = 9 + (ohms - 1000) / 100	**for 1000 <= ohms <= 1100**
kPa = 10 + (ohms - 1100) / 180	**for 1100 <= ohms <= 2000**
kPa = 10 + (ohms - 2000) / 200	**for 2000 <= ohms <= 6000**
kPa = 10 + (ohms - 6000) / 160	**for 6000 <= ohms <= 9200**
kPa = 10 + (ohms - 9200) / 150	**for 9200 <= ohms <= 12200**
kPa = 10 + (ohms - 12200) / 135	**for 12200 <= ohms <= 15575**
kPa = 10 + (ohms - 15575) / 125	**for 15575 <= ohms <= 28078**

The value of ohms on the right side of the equation is the temperature-compensated resistance of the Watermark sensor. At temperatures higher than the standard (75 degrees Fahrenheit), the Watermark sensor will have a lower resistance than it does at the standard temperature. The measured resistance will be multiplied by a correction factor that increases its resistance by 1% per degree F so as to estimate the value of resistance (higher) that it would have at 75 °F.

Use this formula:

$$R_{compensated} := R_{raw} * (1 + 0.01 * (°F - 75))$$

This is embodied in the PBASIC program in appendix 2. The program 1) turns on the power to the SMX module, 2) allows the reading to stabilize for 1 second, 3) reads the raw millivolt value., 4) converts the raw millivolt value to ohms using a lookup table, 5) appliies the temperature correction, and 6) looks up the SWP in kilopascals in a second lookup table. That is the reading that is displayed. There may be an additional step, to average the readings over some period of time to go into the log file.

It is also possible to replace the lookup tables with calculations. The lookup table is better suited to the integer math of the BASIC Stamp. The calculations are better suited to larger computers that have better math libraries. For example, the raw millivolts and temperature can be imported into Excel on a PC and the moisture calculation made there. Appendix 3 shows these calculations.

Background, resistance to soil moisture potential, Irrometer chart #3.

Irrometer Corporation has published a table of electrical resistance values in relation to soil moisture in kPa. (table 2 and figure 5 above are taken from "chart #3") The resistance ranges from 550 ohms in saturated soil, 0.0 kPa, to 27950 ohms in bone dry soil, 199 kPa. That is at 75 degrees Fahrenheit, 24 degrees Celsius. This table is the basis of the readings produced by the Watermark Meter model 30KTCD-NL and for the new Watermark data logger and the Hanson model AM400 soil moisture data logger . Crop irrigation typically takes place in the range of 10 (sandy soils) to 60 (clay soils), depending on the crop and many factors. That is a resistance range of 1000 to 10000 ohms sensor resistance.

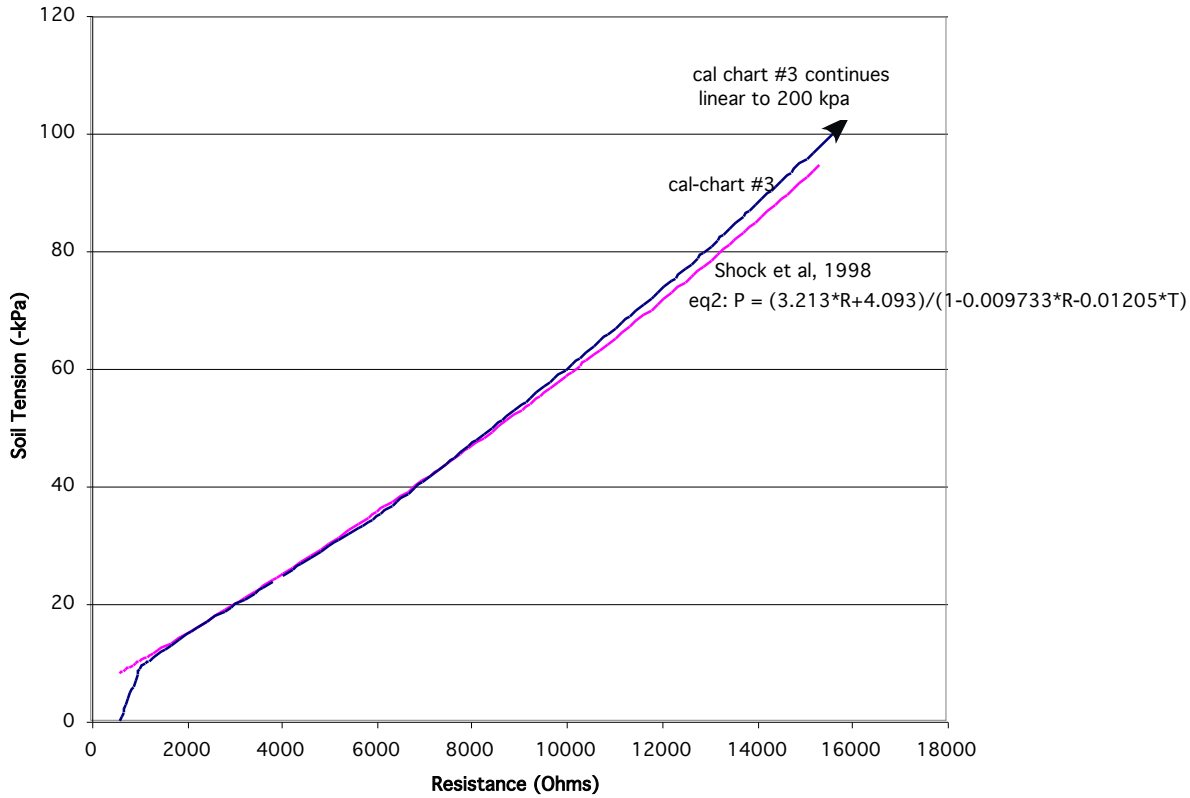
It is informative to understand where this comes from. Irrometer "chart #3" is based on a careful study of the Watermark sensors carried out by Shock, Barnum and Seddigh ("Calibration of the Watermark soil moisture sensors for irrigation management", *Proceedings of the 1998 Irrigation Association Technical Conference*). The study was set up in a temperature controlled environment in a sandy loam soil, with 24 model 200SS Watermarks along with standard tensiometers and temperature sensors. The main part of the Irrometer calibration chart is based those readings, averaged across the 24 sensors for each wetness and temperature. The experiments were done at both 25 degrees C and at 15 degrees C, so that the temperature compensation is validated over that range. The experiments covered the range of roughly -2 to -75 kPa, which is the range of the tensiometers used as the standard.

The range from -10 to -75 kPa is in fact the most important for agriculture, because irrigation schemes typically maintain tension in that range. Shock et al came up with the following equation as the best fit to the data, with the two variables (resistance and temperature) over the -10 to -75 range.

kPa = (3.213 * kohms + 4.093) / {1 - 0.009733 * kohms - 0.01205 * Celsius)

A graph of that function in relation to the Irrometer calibration is also shown on figure 6. It is important to note

Figure 8: Soil Tension vs. Resistance



that the fit outside the -10 to -75 range is bad.

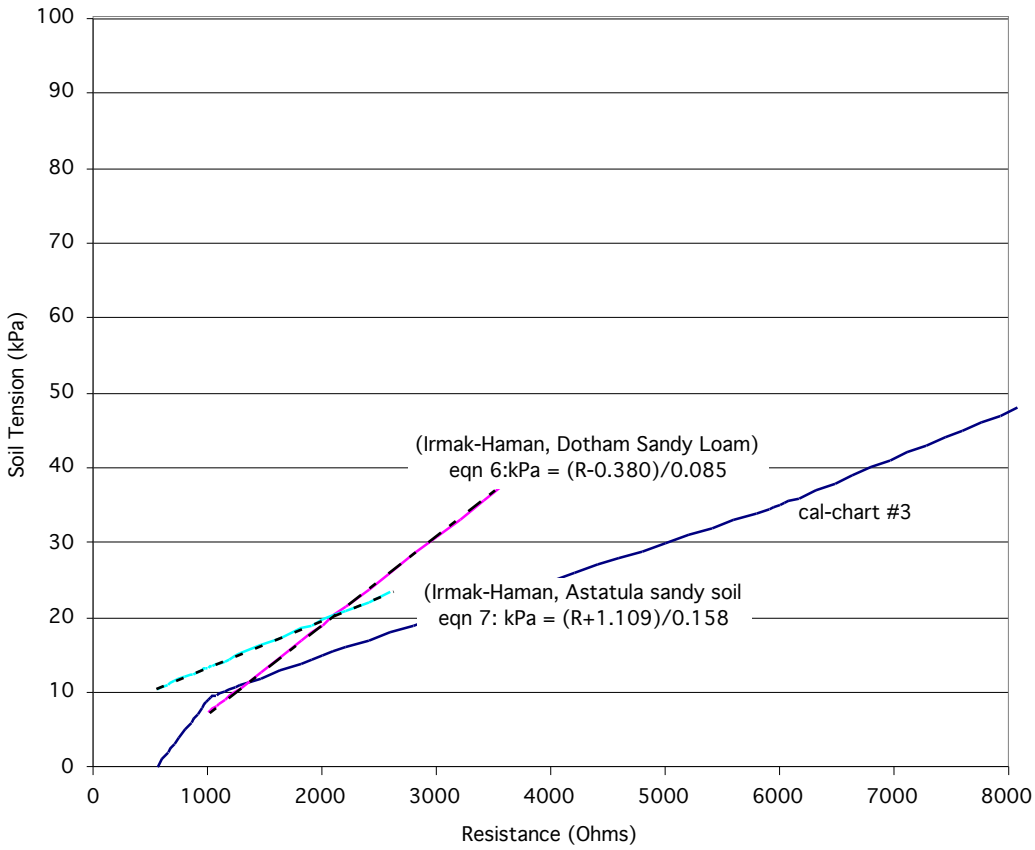
For suction less than -10 kPa (very wet soils), the slope of the empirical graph has a very different slope. A small range of resistance values covers a relatively large range of soil moistures. In terms of soil physics, that is probably due to the falloff in chemical and capillary forces that bond to soil the water as the soil approaches saturation.

The study did not cover higher absolute levels of tension, because tensiometers do not function below about -80 kPa. The Irrometer Watermark calibration chart extends up to -200 kPa. This seems to be a simple extrapolation of the experimental data,

Caveats.

We have to realize that the data in the calibration chart comes from empirical results in a certain type of soil. Fgure 10 below shows results of resistance vs independently measured moisture in a study of sandy soils, instead of the loam. (Irmak & Haman, "Performance of the Watermark Granular Matrix Sensor in Sandy Soils", *Applied Engineering in Agriculture*, 17(6):787-795 2001) This is compared to the Irrometer calibration chart #3. Any given

figure 10: Irmak-HermanGMS vs. Irrometer Cal. Chart #3

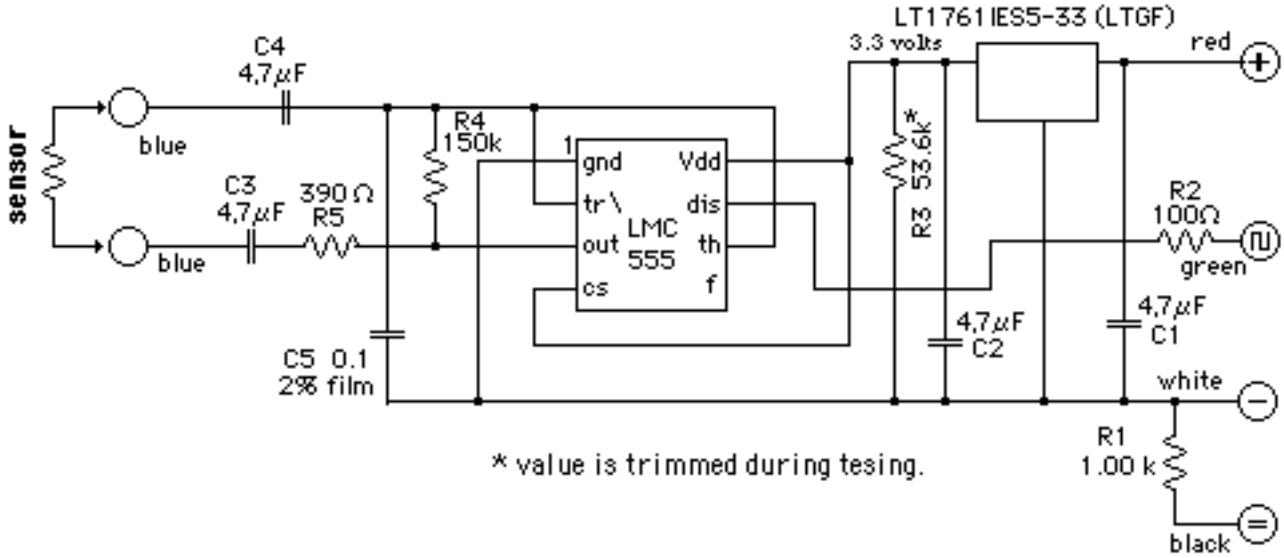


resistance value corresponds to a higher soil tension value than it would in the standard loam soil. This comparison should serve to emphasize how important calibration in locals soils is for the best accuracy.

On-site calibration can be done by comparing the Watermark output to a tensiometer. Over time, this can be developed into a relation between the variables of resistance, temperature, and soil moisture tension, applicable to the local situation. Even a few quick spot checks can fix a few points on the curve. Practical observation of plants establish the critical points for irrigation. Local agricultural extension agents can help with advice about the optimal level of irrigation for productivity and water usage of local crops in local soils.

There is variation from sensor to sensor, due to actual differences in moisture distribution and timing, or due to differences in installation, or due to variation in the Watermark sensors themselves and their aging. * install multiple sensors. • follow the Irrometer instructions for installation. • do reality checks on the sensors and reinstall sensors on a rotating schedule. (

Appendix 1: Technical information:

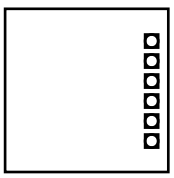


The power supply voltage is regulated at 3.3 volts DC by the micropower regulator. The power supply + input can be as low as 4 volts and as high as 15 volts. Filter capacitors are provided for stability and averaging of the supply current. The LMC555 timer operates in its direct feedback mode, with a square wave on the totem pole output from pin 3 charging or discharging the 0.1 µf polyester film timing capacitor through the network of fixed resistors in series/parallel with the moisture sensor. When the sensor is dry, the 150kΩ resistor sets a minimum oscillator frequency of 50 hertz. When the sensor is wet, or a short circuit, the 390Ω in series with the grid limits the upper frequency to about 13 khz. The current through the sensing grid is AC. Nonpolar ceramic capacitors isolate the circuit from the sensor, to assure that the average current is AC and to forestall galvanic interactions in the soil environment. The output frequency is transmitted to the logger from the open collector DIS output pin, protected from miswiring by the 100 Ω resistor. Normally a pullup resistor will be provided to give voltage transitions at the logger. The current drawn by the circuit varies linearly with the frequency due to the charge and discharge cycles of the 0.1¨F capacitor. The supply current is proportional to wetness, a voltage signal can be taken from across the 1kΩ resistor. The quiescent current is trimmed by R3, the 53..6 kΩ resistor.

There will be a small AC component on the DC output signal, that can be averaged in software. A 10µf capacitor in parallel with the output resistor will reduce the AC component to <5 millivolts.

The brown wire is the low impedance ouput of the oscillator. the blue wire is the high impedance input to the comparator.

There is still an issue about how this circuit measures the resistance of the sensor, in comparison to the Watermark standard meter, and in comparison with the Campbell CR10X + AM416 multiplexer that was used to collect the data used to construct "chart #3". The Watermark meter uses a low frequency AC half-bridge circuit, operating at around 100 hz. The CR10 + AN416 uses low voltage DC pulses a few milliseconds long per reading, in a half bridge, isolated through reed relays. The SMX uses a complex AC waveform at a frequency that varies from 50 hz (dry) to 10000 hz, (wet). We are still investigating how much difference the readout method makes in the result. The sensor is not just a simple resistor, but a chemical system with reactions and mobility of ions to take into account.



SMX rev 2, top view (component side)
blue sensor
blue, sensor
yellow, volts out
green, frequency out, open collector
red, power +3.5 to 15 volts
black, common

Appendix 2: PBASIC Snippets to read the SMX and convert to kPa

```
' ---- routine to service an SMX module ----
' ---- enter with channel number for power and for the signal
' ---- return with the result, and result shown on terminal screen
getkPa1:
  HIGH kPaPwr       ' turn on the power to this SMX
  INPUT kPaCh       ' be sure this channel is an input
  PAUSE 1000        ' allow reading to stabilize
  ADch=kPaCh        ' prepare to read this channel
  GOSUB ADread      ' do it, read voltage
  LOW kPaPwr        ' turn off the power to this SMX
  GOSUB calcOhms    ' calculate ohms from voltage
  GOSUB tcompOhms   ' temperature compensate ohms
  GOSUB calcSWP     ' calculate SWP in kPa from ohms
  GOSUB showdec1    ' show the result with one decimal place
  RETURN

' ---- lookup table, relating ohms to millivolts from SMX
ohms DATA Word 65535, Word 49152, Word 32768, Word 24576
     DATA Word 16384, Word 12288, Word 8192, Word 6144
     DATA Word 4096, Word 3072, Word 2048, Word 1536
     DATA Word 1024, Word 768, Word 512, Word 384
     DATA Word 256, Word 192, Word 128, Word 96
     DATA Word 64, Word 48, Word 32, Word 24
mVs  DATA Word 214, Word 218, Word 226, Word 234
     DATA Word 250, Word 265, Word 295, Word 323
     DATA Word 377, Word 427, Word 517, Word 596
     DATA Word 726, Word 828, Word 980, Word 1089
     DATA Word 1230, Word 1320, Word 1426, Word 1485
     DATA Word 1552, Word 1588, Word 1625, Word 1645

' ---- routine to calculate ohms, given millivolts
' ---- looks up millivolts in the table and interpolates ohms
calcOhms:
  ' enter with millivolts from smx
  IF mV<214 THEN ohms=65535 : RETURN    ' the ohms is greater than 65535, clamp that
  mV =mV MAX 1644                       ' clamp maximum millivolts too
  LOOKDOWN wx                           ' find position of millivolts in category
,<[0,218,226,234,250,265,295,323,377,427,517,596,726,828,980,1089,1230,1320,1426,1485,
1552,1588,1625,1645], cat
  READ (cat-1)*2+mVs,Word ww,Word wz    ' read lower and upper bound of category
  wy = mV - ww                          ' position in catagory
  ww = wz-ww                            ' width of catagory
  FOR ix=7 TO 0                         ' find the BS2 */ multiplier
    wy = wy//ww<<1
    wz0.BIT0(ix) = wy/ww
  NEXT
  READ (cat-1)*2+ohms,Word wy,Word ww   ' read lower and upper bound of ordinate
  wx = wy-((wy-ww)*/wz0)                ' interpolate using */ multiplier
  RETURN
```

```
' ---- temperature compensate the ohms reading
' ---- to the value the SMX would have at 75 degrees F
TcompOhms:
  ' enter with ohms in wx, soil degF in TFsoil
  ' Rx = (1 + 0.01*(TFsoil - 75)) * Rx  Implements this formula
  wx= (TFsoil*/655)-192+256 */ wx
  RETURN


' ---- lookup table, relating SWP to ohms from SMX
' ---- the ohms values adjusted to 75 degrees F
ohms2 DATA Word 550,Word 1000,Word 1100,Word 2000
      DATA Word 6000,Word 9200,Word 12200,Word 15575
      DATA Word 28075
swp   DATA 0,9,10,15
      DATA 35,55,75,100
      DATA 200


' ---- routine to calculate SPW in kPa, given ohms at 75 °F
' ---- looks up ohms in the table and interpolates kPa
calcSWP:
  IF wx<550 THEN kPa=0 : RETURN  ' don't bother, soil is saturated
  ohms =ohms MAX 28074           ' maximum ohms for SWP determination
  LOOKDOWN ohms ,<[0,1000,1100,2000,6000,9200,12200,15575,28075], cat
  READ (cat-1)*2+ohms2,Word ww,Word wz         ' find position in lookup tables
  wy=ohms-ww    ' position in category         ' position of ohms wrt category
  ww=wz-ww    ' width of category
  FOR ix=7 TO 0                                ' find BS2 */ multiplier for wy/wx
    wy=wy//ww<<1
    wz0.BIT0(ix)=wy/ww
  NEXT
  READ (cat-1)+swp,wy,ww  ' span of ordinate   ' width of SWP category
  kPa=wy*2+((ww-wy*2)*/wz0)*5  ' calc to 0.5   ' interpolation using */ multiplier
  RETURN

  END
' ===== end of snippets ====
```

The above program is meant to illustrate the principle, not to be a complete program. There are no variable declarations, nor is there a main program. The variable names and the subroutine names and the comments are chosen to be self-explanatory.

The linear interpolation process on the BASIC Stamp may appear strange, due to the integer math, but the process is really very straightforward.

Please contact Eme Systems or look on the web site for more complete examples using the OWL2pe data logger, and for further tutorial explanation of the integer math.

Appendix 3--Online Resources on Soil Moisture:

www.emesystems.com/smx.htm

www.irrometer.com

http://www.sowacs.com/
The main clearinghouse for all aspects and techniques of soil moisture measurement
http://www.sowacs.com/archives/
Sowacs mail
archive--The mail list covers a wide range of questions and answers.
Moderated by Bruce Metelerkamp
http://www.sowacs.com/archives/98-02/msg00000.html
Resurrecting the Gypsum Block for Soil Moisture Measurement
http://www.sowacs.com/archives/01-02/msg00027.html
Sowacs-mea-gypsum block email

http://www.cropinfo.net/granular.htm
GMS Malheur OSU - Clinton Shock
Malheur experiment station at Oregon State University,
bibliography of experimental research

http://www.kimberly.uidaho.edu/water/swm/Calibration_Watermark2.htm
Watermark calibration
http://www.kimberly.uidaho.edu/water/swm/
Soil Water Management
http://www.kimberly.uidaho.edu/water/swm/WM_Hobo2.htm"
Watermark to HOBO data logger
Articles from Rick Allen at the University of Idaho
http://soil-physics.nmsu.edu/sp/tutorials/

http://www.hwr.arizona.edu/globe/train/smchanges.html
UArizona/GLOBE Soil Moisture Project
University of Arizona educational project on parameters of global environmental importance

http://www.mea.com.au/
Measurement Engineering Australia - Environmental Monitoring Systems
Articles by Andrew Skinner of Measurement Engineering
Australia (MEA), and a link to the company web site.
http://www.Delmhorst.com/
Delmhorst Instrument Company
www.soilmoisture.com
Soil Moisture Corporation
http://www.measure.com/how2measure.html
Remote Measurement Systems - Sensors and Techniques

Soil Moisture Monitoring: Low-Cost Tools and Methods

A Publication of ATTRA - National Sustainable Agriculture Information Service • 1-800-346-9140 • www.attra.ncat.org

By Mike Morris
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Irrigators who monitor soil moisture levels in the field greatly increase their ability to conserve water and energy, optimize crop yields, and avoid soil erosion and water pollution. This publication explains how soils hold water and surveys some low-cost soil moisture monitoring tools and methods, including a new generation of sophisticated and user-friendly electronic devices.

Contents

How Soils Hold Water 2
What Soil Moisture Monitoring Method is Right for You? 3
Direct Inspection..... 4
Meters and Sensors 5
Tips on Placing Moisture Sensors..... 8
Other Tools and Techniques..... 9
Conclusion..... 9
References 10
Further Resources..... 10

While poor irrigation practices cause a host of environmental problems, irrigation can also be a sustainable practice, at times and places where it does not deplete or degrade surface water, groundwater, or soils. In times of high energy and water costs, efficient irrigation is essential to the viability of many farms and ranches. In the next few decades, more efficient irrigation may offer the best hope of feeding the world's growing population. (Postel, 1999)

NCAT photo.

Given the importance of irrigation efficiency, it's unfortunate that irrigation water management is often presented as a series of complicated mathematical calculations that only an engineer could love. Irrigation management is nothing more mysterious than maintaining a suitable environment for growing crops, mainly by keeping soils from becoming too wet or too dry. There are many ways to achieve this goal, including some that require no calculations at all. This publication describes several ways that you can check the soil moisture levels in your fields, using your hands, inexpensive probes, or new electronic devices.

Of course, there's more to irrigation management than just checking soil moisture levels. You should follow general irrigation guidelines for the crops you are growing, and you should track crop water use (evapotranspiration) as the season goes by. These topics are not covered in this publication; your local Natural Resources Conservation Service (NRCS), Extension, or soil and water conservation district office should be able to assist you. You should also know the amount of irrigation water you are applying. (Please refer to the ATTRA publication *Measuring and Conserving Irrigation Water*.)

No one knows as much as you do about your fields, crops, and irrigation system. So adjust, adapt, or reject any suggestion in this publication that doesn't fit your situation or doesn't seem to be working. Use every kind of information you can find about how your soils and crops are responding, proceed cautiously, and test every recommendation with direct observations in the field.

ATTRA - National Sustainable Agriculture Information Service is managed by the National Center for Appropriate Technology (NCAT) and is funded under a grant from the United States Department of Agriculture's Rural Business-Cooperative Service. Visit the NCAT Web site (www.ncat.org/agri.html) for more information on our sustainable agriculture projects.

How Soils Hold Water

The water-holding capacity of a soil depends on its type, organic matter content, and past management practices, among other things.

Soils are classified into one of about a dozen standard *texture classes*, based on the proportions of sand, silt, and clay particles. Sand particles are larger than clay particles, with silt particles falling in between. For example, a soil that is 20 percent clay, 60 percent silt, and 20 percent sand (by weight) would be classified as silt loam. Other texture classes are sand, loamy sand, sandy loam, loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay, and clay.

Coarse-textured soils have a high percentage of sand, and *fine-textured* soils have a high percentage of clay. Fine-textured soils generally hold more water than coarse-textured soils, although some medium-textured soils hold as much or more *plant-available* water than some clay soils.

Besides their texture classification, soils are also classified into *soil types* or *soil series*, based on soil-building factors such as geology, chemistry, age, and location. There are more than 20,000 named soils in the U.S. alone, with names often referring to a town or landmark near where the soil was first recognized. For example, the Houston Black series is a clay soil formed under prairie vegetation in Texas. The Myakka series is a wet sandy soil found in Florida. The full description of a soil series includes a number of layers or horizons, starting at the surface and moving downward.

To identify the soil types or series in your fields, refer to a soil survey. Soil surveys are generally available from your local NRCS or Extension office.

As water infiltrates soil, it fills the pore spaces between the soil particles. When the pores are completely saturated, some of the water — known as *gravitational water* — percolates down through the soil profile and below the root zone. Gravitational water may take a few hours to drain away in sandy soils, or days or even weeks in clay soils.

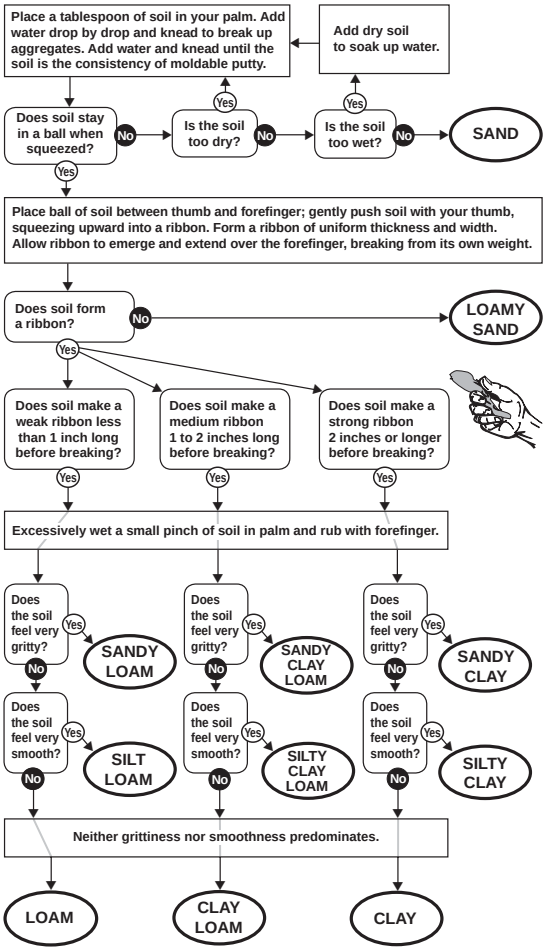
Evaporation at the soil surface pulls water upward through capillary forces, while capillary forces also hold water around the soil particles. When a balance is reached between gravitational and capillary force, water stops moving downward and is held by surface tension in the soil – a condition known as *field capacity*.

Capillary water stored in the root zone is the most important water for crop production, but not all capillary water is available for plants to use. The water-holding force of soil, or *soil water tension*, is affected by soil texture. For example, clay soils have small pores and hold water more tightly than silt soils, with their larger pores. As soil water is depleted, the films of water remaining

Overwatering can

- drown crop root systems, depleting air and encouraging disease
- leach nutrients, especially nitrogen, below the root zone
- send nutrients into groundwater
- reduce root growth by cooling the soil
- cause waterlogging and salt build-up in the root zone
- reduce crop quality and yield
- waste energy and money

Figure 1. Determining Soil Texture by the "Feel Method."



Adapted from *NRCS Irrigation Guide*, USDA Natural Resources Conservation Service, 1997.

around the soil particles become thinner, until they are eventually held in the soil with more tension than plants can overcome, and the plants begin to wilt.

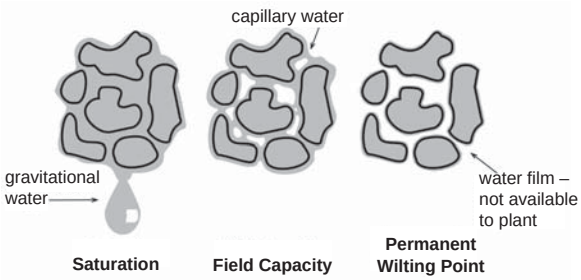


Figure 2. Saturation, Field Capacity, and Permanent Wilting Point.

Available water capacity is the amount of water a soil can make available to plants, generally defined as the difference between the amount of water stored in a soil at field capacity and the amount of water stored in the soil at the permanent wilting point.

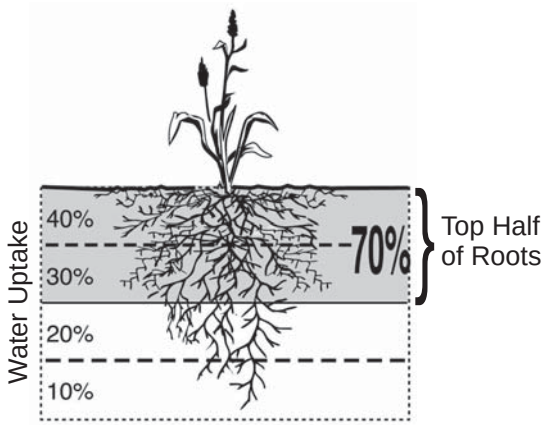


Figure 3. Effective Root Zone: the top half of the actual rooting depth, which supplies about 70% of the crop's water needs.

Plants get most of their water from the upper (shallow) portion of the root zone. The term *effective root zone* refers to about the upper half of the root zone depth, where roughly 70 percent of the plant's water is taken up.

What Soil Moisture Monitoring Method is Right for You?

In deciding when and how much to irrigate (a process sometimes called *irrigation scheduling*), all irrigators should do some kind of soil moisture monitoring. You may be surprised to learn how easy and inexpensive it has become to purchase, install, and use a state-of-the-art monitoring system. More devices are coming on the market all the time, and prices continue to fall.

- Unless you are a scientific researcher, don't get too hung up on accuracy or precision. Methods and devices will give slightly different readings, but almost all will track moisture trends similarly. So choose a method that works for you, take the exact readings with a grain of salt, and pay more attention to the trends and changes you are seeing over time.
- Consider the limitations imposed by your irrigation system, and choose a method that gives you information you can use. As a general rule, the greater your control over the rate and frequency of water applications, the more sophisticated and detailed the information you can use.
- Consider your soils and crops. Some devices work better in coarse soils than in fine soils, some devices work better with annual crops than with perennial crops, and so on. High-value crops will often justify a more expensive monitoring system than low-value crops.
- Consider what's convenient for you. Some devices are portable while others are hard-wired in place. Some devices give you "raw" data, and others do the calculations for you or display readings in a graph. Some devices require cables that may interfere with tillage.
- Be realistic in your expectations. Soil moisture measurement, even with the advent of ever-more-accurate devices, is still an art as much as a science. Soil sensing and measuring devices don't substitute for the judgment, observation, and local knowledge that good irrigators acquire over time.

The methods below are arranged roughly in order of cost, from least expensive to more expensive. All work just fine if they are used properly and diligently.

Related ATTRA Publications

The Montana Irrigator's Pocket Guide

Drought Resistant Soils

Sustainable Soil Management

Soil Management: National Organic Program Regulations

Alternative Soil Amendments

Table 1. Determining Soil Water Content by Feel and Appearance

Coarse	Moderately Coarse	Medium	Moderately Fine and Fine	% of Available Water Capacity (AWC)
Free water appears when soil is bounced in hand.	Free water is released with kneading.	Free water can be squeezed out.	Puddles and free water forms on surface.	Exceeds field capacity – runoff & deep percolation.
Upon squeezing, no free water appears on soil, but wet outline of ball is left on hand.				100% – At field capacity
Tends to stick together, forms a weak crumbly ball under pressure.	Forms weak ball that breaks easily; does not stick.	Forms a ball and is very pliable; sticks readily if relatively high in clay.	Ribbons out between thumb and finger; has a slick feeling.	70 – 80% of AWC
Tends to stick together. May form a very weak ball under pressure.	Tends to ball under pressure, but seldom holds together.	Forms a ball, somewhat plastic; sticks slightly under pressure.	Forms a ball; ribbons out between thumb and finger.	50 – 70% of AWC
For most crops, irrigation should begin at 40 to 60% of AWC. Crop-specific guidelines are available from NRCS or Extension.				
Appears to be dry; does not form a ball under pressure.	Appears to be dry; does not form a ball under pressure.	Somewhat crumbly but holds together under pressure.	Somewhat pliable; balls up under pressure.	25 – 50% of AWC
Dry, loose, single-grained flow through fingers.	Dry, loose, flows through fingers.	Powdery dry, sometimes slightly crusted but easily breaks down into powder.	Hard, baked, cracked; sometimes has loose crumbs on surface.	0 – 25% of AWC

Adapted from *NRCS Irrigation Guide*, USDA Natural Resources Conservation Service, 1997.

Direct Inspection

The least expensive methods rely on digging up soil samples in the field and then inspecting, feeling, or weighing and drying them.

Feel and Appearance Method

Take walnut-sized soil samples from various locations and depths in the field, appropriate to your crop's root zone. Then use the table above to estimate the soil water content of your samples. With practice and diligence, the feel and appearance method can be accurate enough for most irrigation management decisions. A soil probe, auger, or core sampler is far superior to a shovel, especially for retrieving deep soil samples.

Hand-Push Probe

You can use a hand-push probe (sometimes called a *Paul Brown Probe* or *Brown Moisture Probe*) to determine the depth of wetted soil and also to retrieve soil samples. These extremely useful probes cost less than $50 and are among the fastest and easiest ways to check moisture anywhere in your fields.

To determine the depth of wetted soil, push the probe vigorously into the soil by putting your weight on the handle *without turning*. The probe will stop abruptly when it reaches dry soil. (Rocks and gravel will also stop the probe, but these are easily detected by a metallic click.) Check the mark on the probe shaft to determine the depth of the wetted soil.

To obtain a soil sample, twist the probe after pushing it into the ground. The probe will be full of soil when you pull it up. Then use either the "feel and appearance" method or gravimetric weight method to estimate soil moisture.

Figure 4. Soil Sampling Tools

Gravimetric Weight Method

The gravimetric method involves weighing soil samples, drying them in an oven, weighing them again, and using the difference in weight to calculate the amount of water in the soil. While too time consuming to be used for day-to-day management decisions, this highly accurate and low-cost method is often used to calibrate other tools. Your local Extension or NRCS office may be able to provide instructions for this technique, or you can find the instructions on the Internet.

Meters and Sensors

More sophisticated devices measure some physical property that is correlated with soil moisture. Some portable sensing tools are pushed directly into the soil or into an access tube implanted in the soil. Other systems rely on buried sensors that are either hard-wired to a fixed meter or else have long attached wires (electrodes) that are left above-ground and hooked to a portable hand-held meter.

Soil Moisture Blocks

The most common sensors, *electrical resistance blocks*, work on the principle that water conducts electricity. The wetter the soil, the lower the electrical resistance and the better the block conducts electricity. The two most common types of electrical resistance blocks are *gypsum blocks* (with a life of as little as one year but a cost of only $5 to $15 apiece) and *granular matrix sensors* (lasting three to seven years or more and costing $25 to $35 each). Freezing can cause cracking and premature aging in gypsum blocks, but will generally not hurt granular matrix sensors.

Electrical resistance blocks work by absorbing water from the surrounding soil. They need to be buried carefully, with snug soil contact and no air pockets—something that may be difficult to achieve in coarse or gravelly soils. Over the past several years, the National Center for Appropriate Technology (NCAT) has installed hundreds of granular matrix sensors. We have found the number-one problem to be poor soil-to-sensor contact, usually in coarse or gravelly soils.

Gypsum blocks. NCAT photo.

Granular matrix sensor. NCAT photo.

When burying any soil moisture sensing device, minimize soil compaction and disturbance to the surrounding soil and canopy cover. Your goal is to install each sensor in surroundings that are representative of the field.

Electrical resistance blocks may be read either with a data logger (see below) or with a portable hand-held meter. Hand-held meters, costing $150 to $600, generally either give electrical resistance readings in ohms or else convert resistance to *centibars*. (See text box below.)

Hand-held meters have their advantages. You don't need to bury cables in the field. And because the meter is portable, you can check moisture at an unlimited number of sites, wherever your soil moisture blocks are buried.

A disadvantage of hand-held meters, though, is that each monitoring site must be marked in some way, so you can find the electrodes in the field and hook them to the meter.

A common indicator of soil moisture is *soil water tension*

Some soil moisture monitoring instruments give *volumetric* readings — moisture per foot or per inch of soil — while other instruments indicate the level of soil water tension. Soil water tension is usually measured in centibars (cb), where a centibar is 1/100th of a bar, and a bar is roughly equivalent to one atmosphere of pressure. Centibars measure the force that a plant must exert to extract water from the soil. As the plant works harder to remove water, the centibar number increases. So larger centibar numbers mean drier soil.

Soil water tension levels mean different things in different soils and so — unfortunately — there is no simple way to translate centibar readings into water volumes or vice versa. Depending on soil texture, for example, field capacity may be between about 10 and 33 cb. Coarse soils (such as sands and sandy clay loams) have released 50 percent of their available water by the time soils have dried out to 40 to 50 cb. On the other hand, many clay and silty soils still retain more than 50 percent of available water at 80 cb.

Another disadvantage is the challenge of wading through crops (sometimes tall and wet) to your monitoring sites. Also, the meters seem expensive for what they do. For roughly the cost of a hand-held meter you could purchase a sophisticated data logger offering graphical display, automated moisture readings, and many other features.

Considering the high cost of the hand-held meters, you may be tempted (as we were) to measure resistance with an ordinary ohm meter. Unfortunately, this doesn't work. Ohm meters use DC power, which polarizes the soil moisture blocks and causes readings to fluctuate wildly. The meters made specifically for use with soil moisture blocks convert DC power to AC, avoiding polarization and giving stable readings.

Thermal dissipation blocks, a less-common alternative to electrical resistance blocks, work on the principle that dry objects heat up faster than wet objects. These porous ceramic blocks contain small heaters and temperature sensors. They cost $35 to $50 apiece, with meters costing $150 to $600.

Tensiometer. Photo courtesy The Irrometer Company.

Tensiometers

A tensiometer is an airtight, water-filled tube with a porous ceramic tip on the end that is placed in the soil, with a vacuum gauge on the other end that protrudes above the ground. Tensiometers measure soil water tension and display the reading on the vacuum gauge in centibars (cb). These devices work best in the range of 0 to 80 cb, making them better suited to coarse soils than fine soils. A coarse soil at 80 cb might cause severe crop stress, whereas a fine soil such as clay might still contain more than half of its available water capacity at 80 cb.

Tensiometers are fairly easy to use but must be serviced regularly by filling with water and using a pump to pull a vacuum. If the soil becomes too dry, tensiometers can lose soil contact, requiring re-installation. Depending on length—from 6 to 48 inches—they cost $45 to $80. Because they are easy to install and remove, tensiometers are well-suited to cultivated fields and annual crops where buried blocks or cable would be awkward. They are also often used in orchards.

Tensiometers measure moisture tension at the depth where the tip is located. To use two tensiometers as simple irrigation "on-off" indicators, install one at the center of the effective root zone and another one just below the effective root zone (i.e., at approximately one third and two thirds of the total root depth). Use the shallow tensiometer as an indicator to start irrigating and use the deeper one as an indicator to stop irrigating.

Table 2. Irrigation Guidelines Based on Centibar Readings

Reading	Interpretation
0-10 cb	Saturated soil
10-20 cb	Most soils are at field capacity
30-40 cb	Typical range of irrigation in many coarse soils
40-60 cb	Typical range of irrigation in many medium soils
70-90 cb	Typical range of irrigation in heavy clay soils
> 100 cb	Crop water stress in most soils

Adapted from *Watermark Soil Moisture Sensors*, The Irrometer Company, Riverside, CA.

Data Loggers

Soil moisture data loggers are typically battery-operated devices, permanently mounted on a post and hard-wired to buried electrical

resistance block sensors. At regular intervals (generally every several hours), the data logger sends a current through each sensor, measuring electrical resistance. The measurements are converted into soil moisture readings and stored in memory. Data loggers with a graphical display show several days or weeks of readings in a bar graph, allowing you to see recent soil moisture trends at a glance on the screen. Depending on their features, soil moisture data loggers may cost $60 to $500, not including sensors or cable.

The arrival of low-cost soil moisture data loggers on the market in the late 1990s was great news for irrigators. A major advantage of data loggers is that no matter how busy you get, the monitor automatically checks and records your soil moisture. The monitor is normally mounted on a conveniently-located post at the edge of the field or near the control panel of a center pivot, eliminating the need to walk into the field or find electrodes amidst foliage. A disadvantage is that a limited number of sensors (typically 6 to 15) can be connected to the monitor. Installation generally also requires running cable from the data logger to each sensor. When feasible, such as in perennial crops, burying the cable is recommended.

Between 2000 and 2004, NCAT helped install around 100 soil moisture data loggers at farms and ranches in Montana. Data logger installation is not particularly difficult, and the headaches mostly relate to the cable. We saw dozens of faulty splices, cables chewed by livestock and wildlife, cables damaged by machinery during tillage and hay cutting, cables melted when the owner was burning weeds, cables melted by lightning, and (on one memorable occasion) a cable snagged by a passing car.

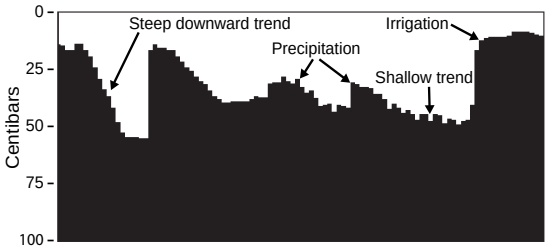


Figure 5. Data Logger Graphical Display.

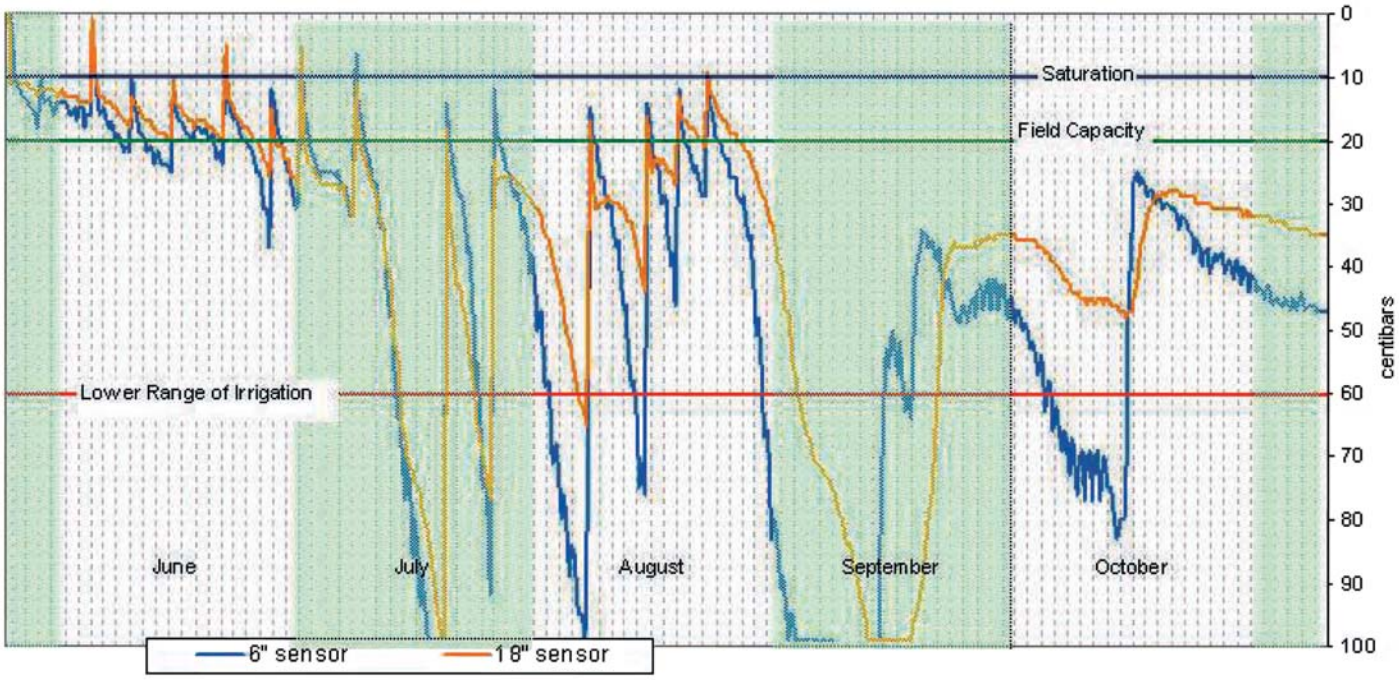
Besides displaying recent moisture readings, soil moisture data loggers store several months or years of data, which may be downloaded and viewed in graph form.

Comments from Data Logger Users

Below are a few representative comments from interviews with NCAT's 2000-2004 soil moisture data logger project participants. (The names are fictitious.)

Jim Clinton intensively grazes grass pasture, which he waters frequently and for short periods. After he installed a soil moisture data logger, he checked it daily and called

Figure 6. Soil Moisture Graph Generated by a Data Logger, Showing an Entire Irrigation Season.



Soil Moisture Data Logger.
NCAT Photo.

it "one of the best things to come along for a long, long time." Jim quickly became convinced that he was overwatering. He had been running five- to six-hour sets through the growing season, switching to eight-hour sets during hot weather. In his second year with the monitor, he ran two-hour sets in the spring, three-hour sets through May, and four- to five-hour sets when it got hot. He told us, "Soil moisture has always been the missing link... The meter said that six hours was all we needed. Even if it started out at 90 centibars, we got down to 10 centibars within six hours."

After Chester Hendricks installed a soil moisture monitor, he looked at it "every day, at least, and sometimes two or three times per day." He told us that he bases most of his decisions on careful observation of the crop, and he called the data logger "a tool to manage the crop along with visual observation of the crop... It's a tool, but so is looking at the crop." Chester believes that the monitor definitely made a difference to his total production. During an exceptionally hot and dry summer, he "didn't let the crop get hurt" by the hot dry weather, and enjoyed excellent yields, "one of our best crops ever." Chester was surprised that evapotranspiration rates skyrocketed once the plants started getting taller. "An 18-inch crop pulls a lot more moisture than when the plants are smaller and younger." He was also impressed by "how much effect wind and humidity make on depletion of soil moisture.... Unbelievable." He saw some tremendous moisture drops take place in just a four to six hour period.

NCAT photo.

George Adams told us that his irrigation practices didn't change much during his first year using a data logger. The device did give him a much better idea, though, how the water was moving down through the soil profile. He said, "The year before I wasn't getting water deep enough. This year I wanted to saturate it then let it go longer between passes to let the water go deeper, by slowing down the pivot. Yield was fantastic." In subsequent years, George has monitored soil moisture in the spring and started irrigating earlier. He told us that he sees the device as useful for limited-water situations: "Instead of trying to water everything, I can set priorities for short water supplies."

Three years of using a soil moisture data logger have not caused John Jefferson to make major changes to his water management methods, but have confirmed his belief that he is not overwatering and is making good use of water. He told us that the monitor has helped him save water during spring rains and late June snowstorms. "We saved two to three days of watering because the ground was wet after a late snow," Jefferson says. At prevailing electricity rates, he saved about $100 in these three days alone.

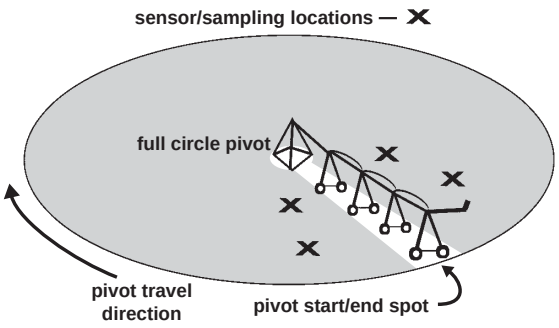
Tips on Placing Moisture Sensors

- It's generally not practical to monitor every part of the field, so install sensors in average soil and slope areas. Avoid field edges and unusually wet or dry areas.
- For mature trees, place sensors well away from the trunk but inside the drip line (canopy diameter).
- The question of how deeply to maintain soil moisture is a management decision, depending on crop and growth stage, soil conditions, and other factors. In general, though, management should focus on the effective root zone; i.e., the upper half, where plants take up most of their water.
- For three-foot or deeper effective root depths, you may want to place sensors at three depths; e.g., in the top,

middle, and deepest third of the total root depth.

- For effective root zones of two feet or less, place sensors at two depths.
- Place a sensor below the root zone for shallow-rooted crops (including grasses), or in the lower quarter of the root zone for deeper-rooted crops, as a way of detecting deep percolation and overwatering.
- For center pivots, monitor a few sprinkler diameters from where you normally start the pivot, in the direction of pivot movement. Also monitor a few sprinkler diameters before the spot where you normally stop the pivot.

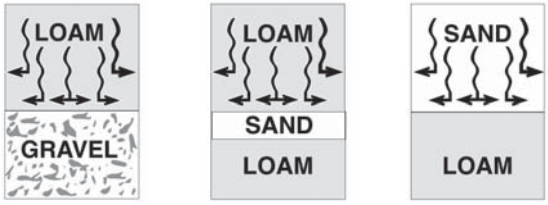
Figure 7. Soil Monitoring Sites Under Pivot.



Changes in soil texture act as a temporary barrier to water movement.

Fine soil overlying a coarse soil, or vice versa, must become very wet before water will move down through the subsoil. Under these conditions, the overlying soil holds up to three times as much water as it would in more uniform soils. If you have distinct layers of soil, you may want to monitor soil moisture in each layer separately.

Figure 8. Water Movement in Stratified Soils.



(Adapted from *NRCS Irrigation Guide*, USDA Natural Resources Conservation Service, 1997.)

- Avoid the inner part of a pivot circle (inside the first tower), which tends to be wetter than the rest of the circle.

Other Tools and Techniques

In 2006, the tools below are generally more expensive and best suited to high-value crops, large farms, and scientific research. In some cases, though, high-tech features are becoming available at affordable prices. It's hard to predict the future of this highly competitive and rapidly changing market.

Remote sensing systems ($1,000 and up) use buried sensors wired to a nearby transmitter that sends readings to a receiver, usually a data logger connected to a computer. These systems are often called "wireless." Although this term is slightly misleading, it's true that the cable connections between the sensors and transmitter are typically quite short. The big advantage of these systems is that they allow large farms to monitor soil moisture in several fields from a single computer, without going into the field.

Time domain reflectometers (TDR) send an electromagnetic wave along two parallel rods or stiff wires inserted in the soil, measuring the "dielectric constant" of the soil. TDR instruments range in price from about $500 to $4,400.

Frequency domain reflectometers ($475 to $900) use high-frequency radio waves pulsed through the soil from a pair of electrodes.

Infrared thermometry is based on the principle that the temperature of a plant's leaves is related to its transpiration rate. *Infrared satellite imagery* to detect crop stress is under research.

Conclusion

Soil moisture monitors, especially the new generation of electronic devices, show you how water is moving through your soils, with a precision and vividness that most irrigators have never seen before. The effect can be startling — almost like having an x-ray machine that allows you to look beneath the surface of the soil. With the cost of sophisticated monitoring systems dropping into the range of a few

hundred dollars, many of these devices are rapidly paying for themselves in the form of crop yield improvements, energy savings, water conservation, and peace of mind.

On the other hand, soil moisture monitors don't "tell you when to irrigate." You'll still need to develop guidelines for your own crops and soils, and there is no substitute for the experience, subtle observations, and judgment that make someone a good farmer.

References

Postel, Sandra. 1999. **Pillar of Sand**. Worldwatch Books, New York. 313 pages.

USDA-Natural Resources Conservation Service. 1997. **NRCS Irrigation Guide**. Natural Resources Conservation Service, Washington, DC. 702 pages.
www.wcc.nrcs.usda.gov/nrcsirrig/irrig-handbooks-part652.html

Further Resources

NCAT Publications

Installing and Using the AM400 Soil Moisture Monitor. 2004. By Mike Morris and Vicki Lynne. National Center for Appropriate Technology, Butte, MT. 17 pages.

Detailed instructions for installing and using the AM400 soil moisture data logger, including maintenance, troubleshooting, downloading data, and advanced settings. To request a free print or electronic copy, call 800-411-3222 (toll-free).

The Montana Irrigator's Pocket Guide. 2003. By Mike Morris, Vicki Lynne, Nancy Matheson, and Al Kurki. National Center for Appropriate Technology, Butte, MT. 161 pages.

A take-to-the-field reference to help irrigators save energy, water, and money, including guidelines for water management, equipment maintenance, and handy conversions and formulas. Get a free printed copy by calling 800-346-9140 (toll-free).

Water and Energy Conservation with the AM400 Soil Moisture Monitor. 2004. By Mike Morris. National Center for Appropriate Technology, Butte, MT. 15 pages.

Summarizes four years of NCAT research on the AM400 soil moisture monitor. To request a free print or electronic copy, call 800-411-3222 (toll-free).

Other Publications

Soil Water Monitoring with Inexpensive Equipment. 2000. By Richard Allen, University of Idaho, Kimberly, ID. [four papers]
www.kimberly.uidaho.edu/water/swm

Reviews and research on low-cost soil moisture monitoring equipment.
Hard copy available from
Kimberly Research and Extension Center
University of Idaho
3793 North 3600 East
Kimberly, ID 83341
208-423-4691

Tensiometer Use in Irrigation Scheduling. 1997. By Mahbub Alam and Danny H. Rogers. Kansas State University Agricultural Experiment Station and Cooperative Extension Service, Manhattan, KS. 6 p.
www.oznet.ksu.edu/library/ageng2/l796.pdf

Tensiometer installation, use, and troubleshooting.
Hard copy available from
Production Services/Distribution
Kansas State University
26 Umberger Hall
Manhattan, KS 66506-3404
785-532-5830

Measuring Soil Moisture. 1998. By Blaine Hanson and Steve Orloff. University of California, Davis, CA. 34 p.
http://gwpa.uckac.edu/05.htm

Good discussion and comparison of soil moisture measuring devices, although slightly dated and does not include data loggers.
Hard copy available from
Cooperative Extension Office
Department of Land, Air and Water Resources
113 Veihmeyer Hall
University of California
Davis, CA 95616
530-752-1130

Web sites

NRCS Irrigation Page
USDA-Natural Resources Conservation Service
www.wcc.nrcs.usda.gov/nrcsirrig

A comprehensive source for irrigation reports, guides, statistics, photos, and links.

The Soil Water Content Sensor discussion group
www.sowacs.com
Moderated by Bruce Metelerkamp

An e-mail discussion list and archives, with discussions and reviews of all kinds of soil moisture monitoring devices, concentrating on automated electronic sensors that can be continuously logged with data loggers.

An Internet search under "soil moisture monitoring" (or similar key words) will yield hundreds of additional Web sites offering products, reviews, and guidelines.

Suppliers

Hundreds of companies make and sell soil moisture monitoring equipment. Listed below are a few representative sources of equipment mentioned in this article.

Art's Manufacturing & Supply, Inc.
105 Harrison Street
American Falls, ID 83211
800-635-7330 (toll-free)
www.ams-samplers.com

Source of soil probes, bucket augers, and other irrigation equipment.

Ben Meadows Company
2589 Broad Street
Atlanta, GA 30341
800-241-6401 (toll-free)
www.benmeadows.com

Campbell Scientific, Inc.
815 West 1800 North
Logan, UT 84321-1784
435-753-2342
www.campbellsci.com

Source of data loggers and weather stations.

Davis Instruments Corp.
3465 Diablo Ave.
Hayward, CA 94545
510-732-9229
www.davisnet.com

Source of weather stations and wireless soil moisture monitoring systems.

Delmhorst Instrument Company
51 Indian Lane East
Towaco, NJ 07082-1025
1-877-DELMHORST (toll-free)
www.delmhorst.com

Source of gypsum blocks and hand-held soil moisture meters.

Gempler's
P.O. Box 44993
Madison, WI 53744-4993
800-382-8473 (toll-free)
www.gemplers.com

Source of soil moisture sensors, probes, tensiometers, and other irrigation equipment.

Irrometer Company, Inc.
P.O. Box 2424
Riverside, CA 92516
909-689-3706
www.irrometer.com

Source of Watermark granular matrix soil moisture sensors, hand-held soil moisture meters, tensiometers, soil moisture data loggers, and other soil moisture monitoring equipment.

Isaacs and Associates, Inc.
3380 Isaacs Ave.
Walla Walla, WA 99362
800-237-2286 (toll-free)
www.isaacstech.com

Source of remote soil moisture monitoring systems.

M.K. Hansen Company
2216 Fancher Boulevard
East Wenatchee, WA 98802
509-884-1396
www.mkhansen.com

Manufacturer of the AM400 soil moisture data logger.

Soil Moisture Equipment Corporation
801 S. Kellog Ave.
Goleta, CA 93117
805-964-3525
www.soilmoisture.com

Source for soil augers, soil moisture sensors and meters, tensiometers, time domain reflectometers, and other soil moisture monitoring equipment.

Soil Moisture Monitoring: Low-Cost Tools and Methods

By Mike Morris
NCAT Energy Specialist
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Robyn Metzger, Production

This publication is available on the Web at:
www.attra.ncat.org/attra-pub/soil_moisture.html
or
www.attra.ncat.org/attra-pub/PDF/soil_moisture.pdf

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NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

IRRIGATION WATER MANAGEMENT

(Ac.)

CODE 449

DEFINITION

The process of determining and controlling the volume, frequency and application rate of irrigation water in a planned, efficient manner.

PURPOSE

This practice may be applied as part of a resource management system to achieve one or more of the following purposes:

- Manage soil moisture to promote desired crop response
- Optimize use of available water supplies
- Minimize irrigation induced soil erosion
- Decrease non-point source pollution of surface and groundwater resources
- Manage salts in the crop root zone
- Manage air, soil, or plant micro-climate
- Proper and safe chemigation or fertigation
- Improve air quality by managing soil moisture to reduce particulate matter movement
- Reduce energy use

CONDITIONS WHERE PRACTICE APPLIES

This practice is applicable to all irrigated lands.

An irrigation system adapted for site conditions (soil, slope, crop grown, climate, water quantity and quality, air quality, etc.) must be available and capable of efficiently applying water to meet the intended purpose(s).

CRITERIA

General Criteria Applicable to All Purposes

Irrigation water shall be applied in accordance with federal, state, and local rules, laws, and regulations. Water shall not be applied in excess of the needs to meet the intended purpose.

Measurement and determination of flow rate is a critical component of irrigation water management and shall be a part of all irrigation water management purposes.

The irrigator or decision-maker must possess the knowledge, skills, and capabilities of management coupled with a properly designed, efficient and functioning irrigation system to reasonably achieve the purposes of irrigation water management.

An “Irrigation Water Management Plan” shall be developed to assist the irrigator or decision-maker in the proper management and application of irrigation water.

Irrigator Skills and Capabilities. Proper irrigation scheduling, in both timing and amount, control of runoff, minimizing deep percolation, and the uniform application of water are of primary concern. The irrigator or decision-maker shall possess or obtain the knowledge and capability to accomplish the purposes which include:

A. General

1. How to determine when irrigation water should be applied, based on the rate of water used by crops and on the stages of plant growth and/or soil moisture monitoring.

2. How to determine the amount of water required for each irrigation, including any leaching needs.
3. How to recognize and control erosion caused by irrigation.
4. How to measure or determine the uniformity of application of an irrigation.
5. How to perform system maintenance to assure efficient operation.
6. Knowledge of "where the water goes" after it is applied considering soil surface and subsurface conditions, soil intake rates and permeability, crop root zones, and available water holding capacity.
7. How to manage salinity and shallow water tables through water management.
8. The capability to control the irrigation delivery.

B. Surface Systems

1. The relationship between advance rate, time of opportunity, intake rate, and other aspects of distribution uniformity and the amount of water infiltrated.
2. How to determine and control the amount of irrigation runoff.
3. How to adjust stream size, adjust irrigation time, or employ techniques such as "surge irrigation" to compensate for seasonal changes in intake rate or to improve efficiency of application.

C. Subsurface Systems

1. How to balance the relationship between water tables, leaching needs, and irrigation water requirements.
2. The relationship between the location of the subsurface system to normal farming operations.
3. How to locate and space the system to achieve uniformity of water application.
4. How to accomplish crop germination in arid climates and during dry periods.

D. Pressurized Systems

1. How to adjust the application rate and/or duration to apply the required amount of water.
2. How to recognize and control runoff.
3. How to identify and improve uniformity of water application.
4. How to account for surface storage due to residue and field slope in situations where sprinkler application rate exceeds soil intake rate.
5. How to identify and manage for weather conditions that adversely impact irrigation efficiency and uniformity of application.

System Capability. The irrigation system must be capable of applying water uniformly and efficiently and must provide the irrigator with adequate control over water application.

Additional Criteria to Manage Soil Moisture to Promote Desired Crop Response

The following principles shall be applied for various crop growth stages:

- The volume of water needed for each irrigation shall be based on plant available water-holding capacity of the soil for the crop rooting depth, management allowed soil water depletion, irrigation efficiency and water table contribution.
- The irrigation frequency shall be based on the volume of irrigation water needed and/or available to the crop, the rate of crop evapotranspiration, and effective precipitation.
- The application rate shall be based on the volume of water to be applied, the frequency of irrigation applications, soil infiltration and permeability characteristics, and the capacity of the irrigation system.

Appropriate field adjustments shall be made for seasonal variations and field variability.

Additional Criteria to Optimize Use of Water Supplies

Limited irrigation water supplies shall be managed to meet critical crop growth stages.

When water supplies are estimated to be insufficient to meet even the critical crop growth stage, the irrigator or decision-maker shall modify plant populations, crop and variety selection, and/or irrigated acres to match available or anticipated water supplies.

Additional Criteria to Minimize Irrigation-Induced Soil Erosion

Application rates shall be consistent with local field conditions for long-term productivity of the soil.

Additional Criteria to Decrease Non-Point Source Pollution of Surface and Groundwater Resources

Water application shall be at rates that minimize transport of sediment, nutrients, and chemicals to surface waters and that minimize transport of nutrients and chemicals to groundwater.

Additional Criteria to Manage Salts in the Crop Root Zone

The irrigation application volume shall be increased by the amount required to maintain an appropriate salt balance in the soil profile.

The requirement shall be based on the leaching procedure contained in NRCS National Engineering Handbook (NEH) Part 623, Chapter 2, Irrigation Water Requirements, and NEH, Part 652, National Irrigation Guide, Chapters 3 and 13.

Additional Criteria to Manage Air, Soil, or Plant Micro-Climate

The irrigation system shall have the capacity to apply the required rate of water for cold or heat protection as determined by the methodology contained in NEH Part 623, Chapter 2, Irrigation Water Requirements.

Additional Criteria for Proper and Safe Chemigation or Fertigation

Chemigation or fertigation shall be done in accordance with all local, state and federal laws.

The scheduling of nutrient and chemical application should coincide with the irrigation cycle in a manner that will not cause excess leaching of nutrients or chemicals below the root zone to the groundwater or to cause excess runoff to surface waters.

Chemigation or fertigation should not be applied if rainfall is imminent. Application of chemicals or nutrients will be limited to the minimum length of time required to deliver them and flush the pipelines. Irrigation application amount shall be limited to the amount necessary to apply the chemicals or nutrients to the soil depth recommended by label. The timing and rate of application shall be based on the pest, herbicide, or nutrient management plan.

The irrigation and delivery system shall be equipped with properly designed and operating valves and components to prevent backflows into the water source(s) and/or contamination of groundwater, surface water, or the soil.

Additional Criteria to Reduce Particulate Matter Movement

Sprinkler irrigation water shall be applied at a rate and frequency sufficient to reduce the wind erodibility index (I Factor) of the soil by one class.

Additional Criteria Applicable to Reduce Energy Use

Provide analysis to demonstrate reduction of energy use from practice implementation.

Reduction of energy use is calculated as average annual or seasonal energy reduction compared to previous operating conditions.

CONSIDERATIONS

The following items should be considered when planning irrigation water management:

- Consideration should be given to managing precipitation effectiveness, crop residues, and reducing system losses.
- Consider potential for spray drift and odors when applying agricultural and municipal waste waters. Timing of irrigation should be based on prevailing winds to reduce odor. In areas of high visibility, irrigating at night should be considered.
- Consider potential for overspray from end guns onto public roads.

- Equipment modifications and/or soil amendments such as polyacrylamides and mulches should be considered to decrease erosion.
- Consider the quality of water and the potential impact to crop quality and plant development.
- Quality of irrigation water should be considered relative to its potential effect on the soil's physical and chemical properties, such as soil crusting, pH, permeability, salinity, and structure.
- Avoid traffic on wet soils to minimize soil compaction.
- Consider the effects that irrigation water has on wetlands, water related wildlife habitats, riparian areas, cultural resources, and recreation opportunities.
- Management of nutrients and pesticides.
- Schedule salt leaching events to coincide with low residual soil nutrients and pesticides.
- Water should be managed in such a manner as to not drift or come in direct contact with surrounding electrical lines, supplies, devices, controls, or components that would cause shorts in the same or the creation of an electrical safety hazard to humans or animals.
- Consideration should be given to electrical load control/interruptible power schedules, repair and maintenance downtime, and harvest downtime.
- Consider improving the irrigation system to increase distribution uniformity or application efficiency of irrigation water applications.

PLANS AND SPECIFICATIONS

Application of this standard may include job sheets or similar documents that specify the applicable requirements, system operations, and components necessary for applying and maintaining the practice to achieve its intended purpose(s).

OPERATION AND MAINTENANCE

The operation and maintenance (O&M) aspects applicable to this standard consist of evaluating available field soil moisture, changes in crop evapotranspiration rates and changes in soil intake rates and adjusting the volume, application rate, or frequency of water application to achieve the intended purpose(s). Other necessary O&M items are addressed in the physical component standards considered companions to this standard.

REFERENCES

USDA-NRCS National Engineering Handbook, Part 623, Chapter 2, Irrigation Water Requirements.

USDA-NRCS, National Engineering Handbook, Part 652, National Irrigation Guide

Mendocino County 2012 Crop Report

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COUNTY OF MENDOCINO
DEPARTMENT OF AGRICULTURE
890 N BUSH STREET
UKIAH, CALIFORNIA 95482

MS. KAREN ROSS, SECRETARY
CALIFORNIA DEPARTMENT OF FOOD AND AGRICULTURE
and
THE HONORABLE BOARD OF SUPERVISORS OF MENDOCINO COUNTY

Dear Secretary and Board Members,

In accordance with Section 2279 of the California Food and Agricultural Code, I am pleased to submit the 2012 annual crop report for Mendocino County. **This report reflects the gross value of agricultural commodities produced in the county and not the net returns for producers.**

The **total gross agricultural value** for all commodities produced in 2012 was **$216,550,651,** which represents an increase of 24% compared to the 2011 value of $174,492,400. The leading agricultural commodity continues to be wine grapes, which posted a record value of $**102,305,700.** Agricultural production, excluding timber, was valued at **$144,962,700.** Timber represents the second highest value commodity, with a gross "at mill" value of **$71,587,951**. Mendocino County ranked 4th in the state in timber volumes and produced roughly 9% of the states total timber harvest in 2012.

The increase in the overall gross value for 2012 resulted primarily from increases in wine grapes and timber. Most notably, favorable growing conditions in 2012 allowed for a 23% increase in wine grape yields and with higher prices being realized for nearly all varietals, the overall value of wine grapes was 43% greater than the previous year. The increase in timber values resulted from increases in the total board feet harvested and increased logging and hauling costs, resulting in an "at mill" value that was 21% higher compared to 2011.

Both the pear industry and cattle operations posted respectable gains compared to 2011 values. The pear industry realized good production yields and market prices which were improved over 2011. Cattle returns were higher based on good market prices and a subsequent reduction in inventory to take advantage of the up market. Total milk valuation dropped significantly on slightly less production and a 9% reduction in the price paid to producers. The nursery industry showed a 22% reduction based primarily on the loss of production acreage and greenhouses.

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I would like to extend my gratitude and appreciation to all of our agricultural producers who furnish the necessary information that make this report possible. I would also like to thank the University of California Cooperative Extension and my outstanding staff, particularly Jennifer Krauss, for their invaluable assistance and contributions to this report.

Respectfully submitted,

Chuck Morse

Chuck Morse
Agricultural Commissioner/Sealer

MENDOCINO COUNTY
DEPARTMENT OF AGRICULTURE

ANNUAL CROP REPORT FOR 2012

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MENDOCINO COUNTY BOARD OF SUPERVISORS

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Department of Agriculture

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SEASONAL INSPECTORS

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Sam Upton
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Amanda Ekstrand
Bill Kubran

FRUIT AND NUT CROPS

COMMODITY	YEAR	BEARING ACREAGE	TONS PER ACRE	PRODUCTION IN TONS	$ PER TON	VALUE
APPLES, TOTAL	**2012**	**230**	**6.7**	**1,541**	**$ 610**	**$ 880,900**
	2011	227	10	2,270	$ 432	$ 987,900
Fresh	**2012**			**724**	**$ 938**	**$ 679,100**
	2011			704	$ 974	$ 685,700
Other	**2012**			**817**	**$ 247**	**$ 201,800**
(Dried, Juice, etc.)	2011			1,566	$ 193	$ 302,200
WINE GRAPES, TOTAL	**2012**	**16,750**	**4.2**	**71,095**	**$ 1,439 (4)**	**$ 102,305,700**
	2011	16,679	3.4	57,383	$ 1,237	$ 71,595,800
White	**2012**	**6,143**	**5.1**	**31,087**		
Varieties	2011	6,110	4	24,375		
Red	**2012**	**10,607**	**3.8**	**40,008**		
Varieties	2011	10,569	3.1	33,008		
PEARS, TOTAL (1)	**2012**	**1,339**	**19.1**	**25,599**	**$ 470**	**$ 12,041,400**
	2011	1,355	20.5	27,718	$ 415	$ 11,505,700
Bartlett (2)	**2012**	**1,178**	**20**	**23,537**	**$ 420**	**$ 9,894,400**
	2011	1,183	20.6	24,425	$ 347	$ 8,477,900
Canning	**2012**			**17,352**	**$ 293**	**$ 5,084,100**
	2011			16,665	$ 239	$ 3,982,900
Fresh (2)	**2012**			**5,032**	**$ 930**	**$ 4,682,600**
	2011			5,582	$ 769	$ 4,292,500
Other	**2012**			**1,150**	**$ 111**	**$ 127,700**
(Baby Food	2011			2,178	$ 93	$ 202,500
Dried, Paste)						
Bosc (2)	**2012**	**104**	**13.0**	**1,347**	**$ 855**	**$ 1,151,700**
	2011	105	22.1	2,321	$ 789	$ 1,831,300
Red (2)	**2012**	**57**	**12.5**	**715**	**$ 1,392**	**$ 995,300**
	2011	67	14.5	972	$ 1,231	$ 1,196,500
MISC. TOTAL (3)	**2012**	**234**				**$ 1,100,000**
	2011	222				$ 1,250,000
TOTALS	**2012**	**18,553**				**$ 116,328,000**
	2011	18,483				$ 85,339,400

(1) Does not include misc./other pears. See (3)

(2) The fresh values listed for pears are FOB values. The actual average prices paid per ton to the growers (farm gate values) for 2012 were: Bartlett $320, Bosc $488, and Reds $471.

for 2011 were: Bartlett $249, Bosc $265, and Reds $363.

(3) Miscellaneous includes berries, cherries, chestnuts, olives, other pears, peaches, persimmons, pistachios and walnuts

(4) Weighted average

Some Values throughout this report may not compute exactly due to computational rounding.

FRUIT, NUT, AND GRAPEVINE ACREAGE

CROP	ACRES BEARING	ACRES NON-BEARING	TOTAL
APPLES	254	0	254
WINE GRAPES, TOTAL	16,885	373	17,258
Red	10,665	211	10,876
White	6,220	162	6,382
OLIVES	107	6	113
PEARS, TOTAL	1,358	10	1,368
Bartlett	1,178	7	1,185
Red	57	0	57
Bosc	104	0	104
Other	19	3	22
WALNUTS, ENGLISH	38	0	38
MISCELLANEOUS*	70	0	70
TOTALS	**18,712**	**389**	**19,101**

*Miscellaneous includes: Berries, cherries, chestnuts, guava, peaches, persimmons, pistachios, plums, and table grapes.

LIVESTOCK INVENTORIES

COMMODITY	2012	2011
All Cattle and Calves	**18,100**	18,800
Beef Cows and Heifers, 2 years and older	**8,500**	8,800
Milk Cows	**1,110**	1,425
Sheep and Lambs, all	**9,000**	9,200
Swine	**1,450**	1,500

LIVESTOCK PRODUCTION

COMMODITY	YEAR	NO. OF HEAD	TOTAL CWT** LIVE WT.	$ PER	$ VALUES
CATTLE AND CALVES	**2012**	**9,400**	**65,800**	**$129**	**$8,488,200**
	2011	9,100	63,700	$118	$7,516,600
SHEEP AND LAMBS	**2012**	**3,100**	**2,697**	**$159**	**$428,800**
	2011	3,500	2,905	$158	$459,000
SWINE	**2012**	**750**	**1,215**	**$69**	**$83,700**
	2011	800	1,256	$67	$83,500
MISCELLANEOUS*	**2012**				**$750,000**
	2011				$800,000
TOTALS	**2012**				**$9,750,700**
	2011				$8,859,100

*Miscellaneous includes goats, pigeons, poultry, rabbits, turkeys, bison and aquaculture (fish farms).

**CWT= 100 lbs.

LIVESTOCK AND POULTRY PRODUCTS

COMMODITY	YEAR	PRODUCTION IN LBS.	PER UNIT	$ VALUE
MILK	**2012**	**192,833 CWT.**	**$19.00**	**$3,663,800**
	2011	236,752 CWT.	$20.85	$4,936,800
WOOL	**2012**	**31,200 LB.**	**$1.92**	**$59,900**
	2011	32,400 LB.	$2.05	$66,400
MISCELLANEOUS*	**2012**			**$1,800,000**
	2011			$1,950,000
TOTALS	**2012**			**$5,523,700**
	2011			$6,953,200

*Miscellaneous includes apiary, eggs, emus, cheese, manure, and ostriches.

NURSERY PRODUCTION

COMMODITY	YEAR	GREENHOUSE SQUARE FEET	FIELD ACRES	$ VALUES
Nursery*	**2012**	**96,769**	**31**	**$1,611,900**
	2011	152,049	52	$2,087,000
Christmas Trees	**2012**	N/A	N/A	**$15,000**
	2011	N/A	N/A	$18,000
TOTALS	**2012**	**96,769**	**31**	**$1,626,900**
	2011	152,049	52	$2,105,000

*Includes turf and cut flowers

VEGETABLE CROPS

COMMODITY	YEAR	ACRES	$ VALUES
Miscellaneous Vegetables*	**2012**	**320**	**$900,000**
	2011	320	$900,000

*Includes beans, sweet corn, garlic, herbs, melons, peas, potatoes, squash, tomatoes, etc.

FIELD CROPS

COMMODITY	YEAR	ACRES	YIELD/ ACRE	TOTAL YIELD	PER AUM	$ VALUES
IRRIGATED PASTURE	**2012**	**6,000**	9.00 AUM*	**54,000**	**$20.00**	**$1,080,000**
	2011	6,000	9.00 AUM*	54,000	$19.00	$1,026,000
PASTURE, other (grassland, coast bench)	**2012**	**365,000**	**1.03 AUM***	**376,000**	**$11.10**	**$4,173,600**
	2011	365,000	1.08 AUM*	394,200	$11.10	$4,375,600
RANGE	**2012**	**355,000**	**.71 AUM***	**252,100**	**$8.25**	**$2,079,800**
	2011	355,000	.74 AUM*	262,700	$7.80	$2,049,000
MISCELLANEOUS**	**2012**					**$3,500,000**
	2011					$3,800,000
TOTALS	**2012**					**$10,833,400**
	2011					$11,250,600

*AUM means Annual Unit Month (food required to feed a 1,000 pound steer for one month).

**Miscellaneous includes alfalfa, barley, beans, corn, hay and oats.

FOREST PRODUCTS

TIMBER	2012	2011
Log Production (board feet)	**121,850,000**	89,795,000
Total Stumpage Value, net	**$28,940,451**	$25,761,584
Total Value at Mill, gross	**$71,587,951**	$59,085,110

1) Calendar year 2012 showed a slight increase in timber harvest activity when compared to 2011.

2) The modest increase in harvest yields for Mendocino County from the previously reported year is the result of a slight increase in stumpage values. The harvest activity in Mendocino County represents 100% extraction from private lands.

3) The average price for stumpage based on the information provided by the Board of Equalization is approximately $237/mbf for the timber harvested within Mendocino County.

4) The combined value of delivered value at the mill includes both stumpage ($237/mbf) and logging and hauling costs (approx. $350/mbf) for a total value of $587/mbf=$71,587,951.

5) Mendocino County produced approximately 9% of the total timber produced in the state in 2012.

6) Mendocino County ranked 4th in the state in timber volumes for 2012. The top ranking counties in 2012 were Humboldt, Shasta, Siskiyou, Mendocino, and Lassen.

Data based on information from Gregory A. Giusti, U.C. Cooperative Extension.

10 YEAR COMPARISON (LOG PRODUCTION)

YEAR	Log Production (Board Feet)	Value at Mill (Gross)
2012	**121,850,000**	**$71,587,951**
2011	89,795,000	$59,085,110
2010	94,724,000	$57,673,418
2009	43,801,000	$25,448,400
2008	92,652,000	$67,004,000
2007	103,031,000	$74,594,400
2006	110,168,000	$86,481,900
2005	120,841,000	$89,441,000
2004	109,548,000	$66,605,200
2003	112,568,000	$68,496,100

SUSTAINABLE AGRICULTURE

ORGANIC ACRES

CROPS	ACRES
Wine grapes	4,132
Fruits & Nuts	274
Vegetables	33
Herbs	107
Pasture/Forage/Grain	5,672
Nursery & Cut Flowers	6
TOTAL	**10,224**

PEST EXCLUSION

Parcel Post & Truck Shipment Inspections

SHIPMENTS INSPECTED	EXOTIC PESTS INTERCEPTED	SHIPMENTS REJECTED
1928	5	10

BIOLOGICAL CONTROL

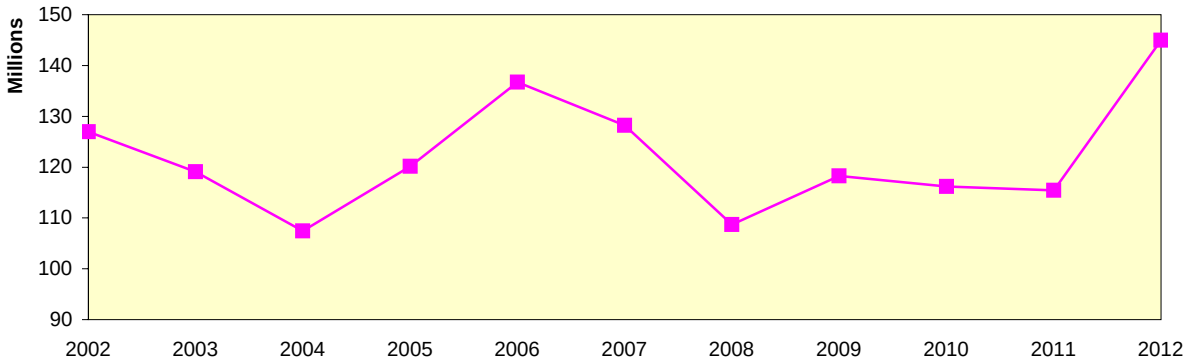
BIO-CONTROL AGENT	SCOPE OF PROGRAM
Bull Thistle Gall Fly	3 Sites
Gorse Weevil	Generally Distributed
Gorse Spider Mite	Generally Distributed
Italian Thistle Seed Head Weevil	Widely Distributed
Klamath Weed Beetles	Widely Distributed
Klamath Weed Root Borers	Widely Distributed
Puncture Vine Seed Weevil	Generally Distributed
Puncture Vine Stem Weevil	Generally Distributed
Tansy Ragwort Cinnabar Moth	Established
Tansy Ragwort Flea Beetle	Established
Yellow Starthistle Seed Head Weevil	Widely Distributed
Yellow Starthistle Gall Forming Fly	Widely Distributed
Yellow Starthistle Hairy Weevil	Generally Distributed
Yellow Starthistle Peacock Fly	Widely Distributed

Yellow Starthistle Hairy Weevil

Tansy Ragwort Cinnabar Moth

Photos taken by and courtesy of Mark Schwarzlander, University of Idaho, bugwood.org

VALUE OF MENDOCINO COUNTY AGRICULTURE (EXCLUDING TIMBER)
2002 - 2012

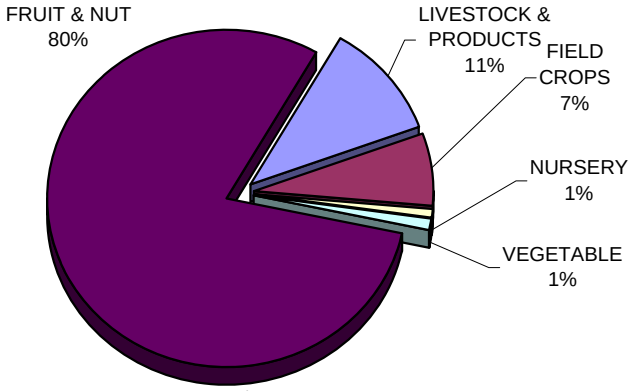


MILLION DOLLAR CROPS

WINE GRAPES	$	102,305,700
TIMBER	$	71,587,951
BARTLETT PEARS	$	9,894,400
CATTLE & CALVES	$	8,488,200
PASTURE	$	4,173,600
MILK	$	3,663,800
NURSERY	$	1,626,900
BOSC PEARS	$	1,151,700
PASTURE, IRRIGATED	$	1,080,000

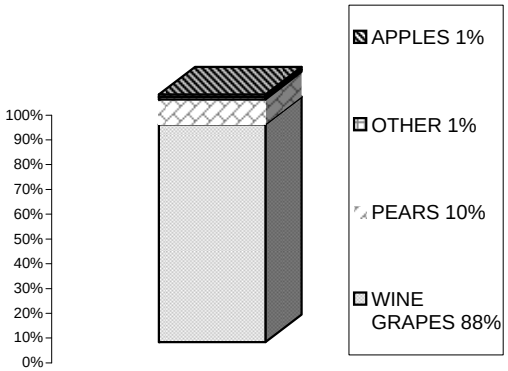
SHARES OF AGRICULTURAL VALUE

ALL AGRICULTURE (EXCLUDING TIMBER)



TOTAL $ 144,962,700

FRUIT & NUT CROPS



TOTAL $116,328,000

SUMMARY OF PRODUCTION

COMMODITY		2012		2011
FRUITS AND NUTS	**$**	**116,328,000**	$	85,339,400
LIVESTOCK PRODUCTION	**$**	**9,750,700**	$	8,859,100
LIVESTOCK AND POULTRY PRODUCTS	**$**	**5,523,700**	$	6,953,200
NURSERY PRODUCTION	**$**	**1,626,900**	$	2,105,000
VEGETABLE CROPS	**$**	**900,000**	$	900,000
FIELD CROPS	**$**	**10,833,400**	$	11,250,600
FOREST PRODUCTS	**$**	**71,587,951**	$	59,085,110
TOTALS	**$**	**216,550,651**	$	174,492,410

SUPPLEMENT TO CROP REPORT: COMMERCIAL FISH CATCH

COMMODITY	TOTAL LBS	TOTAL VALUE
CRAB, DUNGENESS	1,939,398	$ 6,829,698
SALMON, CHINOOK	604,619	$ 2,798,353
SEA URCHIN, RED	3,197,470	$ 2,555,719
SABLEFISH	672,640	$ 1,842,791
SOLE, DOVER	975,525	$ 436,785
ROCKFISH, CHILIPEPPER	342,447	$ 233,671
SOLE, PETRALE	128,438	$ 178,137
THORNYHEAD, LONGSPINE	334,162	$ 168,053
ROCKFISH, GROUPSLOPE	159,449	$ 111,575
SWORDFISH	24,922	$ 99,716
MICELLANEOUS	504,959	$ 425,759
TOTALS	8,884,029	$ 15,680,257

COMMERCIAL FISH CATCH TEN YEAR VALUE COMPARISON

YEAR	POUNDS	VALUE
2012	**8,884,029**	**$ 15,680,257**
2011	8,187,209	$ 12,438,515
2010	7,784,183	$ 7,691,243
2009	8,172,353	$ 7,434,164
2008	7,203,296	$ 7,112,954
2007	5,931,839	$ 7,038,220
2006	5,468,557	$ 5,763,048
2005	6,603,170	$ 6,615,121
2004	7,058,011	$ 7,941,313
2003	9,615,994	$ 10,993,736

Source - State of California Department of Fish and Game
All figures are rounded - figures are preliminary

UKIAH 100 YEAR RAINFALL DATA
(FROM UKIAH FIRE DEPARTMENT RECORDS)

SEASON	TOTAL
1911-12	25.73
1912-13	33.40
1913-14	54.85
1914-15	49.28
1915-16	34.80
1916-17	30.23
1917-18	23.43
1918-19	37.23
1919-20	19.05
1920-21	47.94
1921-22	28.74
1922-23	30.35
1923-24	16.19
1924-25	47.44
1925-26	26.33
1926-27	47.32
1927-28	34.94
1928-29	24.44
1929-30	31.08
1930-31	20.06
1931-32	27.67
1932-33	24.71
1933-34	25.21
1934-35	33.05
1935-36	37.83
1936-37	29.24
1937-38	55.13
1938-39	22.86
1939-40	41.01
1940-41	56.92
1941-42	48.21
1942-43	40.41
1943-44	26.19
1944-45	31.74
1945-46	36.11
1946-47	25.90
1947-48	32.93
1948-49	27.53
1949-50	29.75
1950-51	42.28

SEASON	TOTAL
1951-52	47.74
1952-53	45.06
1953-54	35.74
1954-55	25.63
1955-56	51.09
1956-57	32.36
1957-58	58.87
1958-59	26.42
1959-60	32.60
1960-61	34.89
1961-62	31.46
1962-63	44.45
1963-64	24.96
1964-65	50.84
1965-66	35.46
1966-67	43.16
1967-68	32.95
1968-69	51.28
1969-70	48.71
1970-71	38.31
1971-72	25.61
1972-73	42.09
1973-74	57.09
1974-75	38.60
1975-76	18.75
1976-77	14.20
1977-78	53.66
1978-79	30.23
1979-80	44.79
1980-81	26.82
1981-82	55.82
1982-83	70.19
1983-84	43.76
1984-85	27.40
1985-86	48.68
1986-87	25.25
1987-88	30.22
1988-89	31.48
1989-90	26.91
1990-91	26.00

SEASON	TOTAL
1991-92	31.38
1992-93	50.49
1993-94	23.73
1994-95	58.88
1995-96	44.10
1996-97	39.07
1997-98	63.95
1998-99	34.77
1999-00	33.81
2000-01	26.68
2001-02	31.74
2002-03	49.70
2003-04	38.99
2004-05	41.46
2005-06	60.39
2006-07	26.15
2007-08	31.64
2008-09	22.68
2009-10	40.51
2010-11	42.78
2011-12	23.50

FISCAL YEAR DATA

FIVE YEAR VALUE COMPARISON

****ALL COMMODITIES****

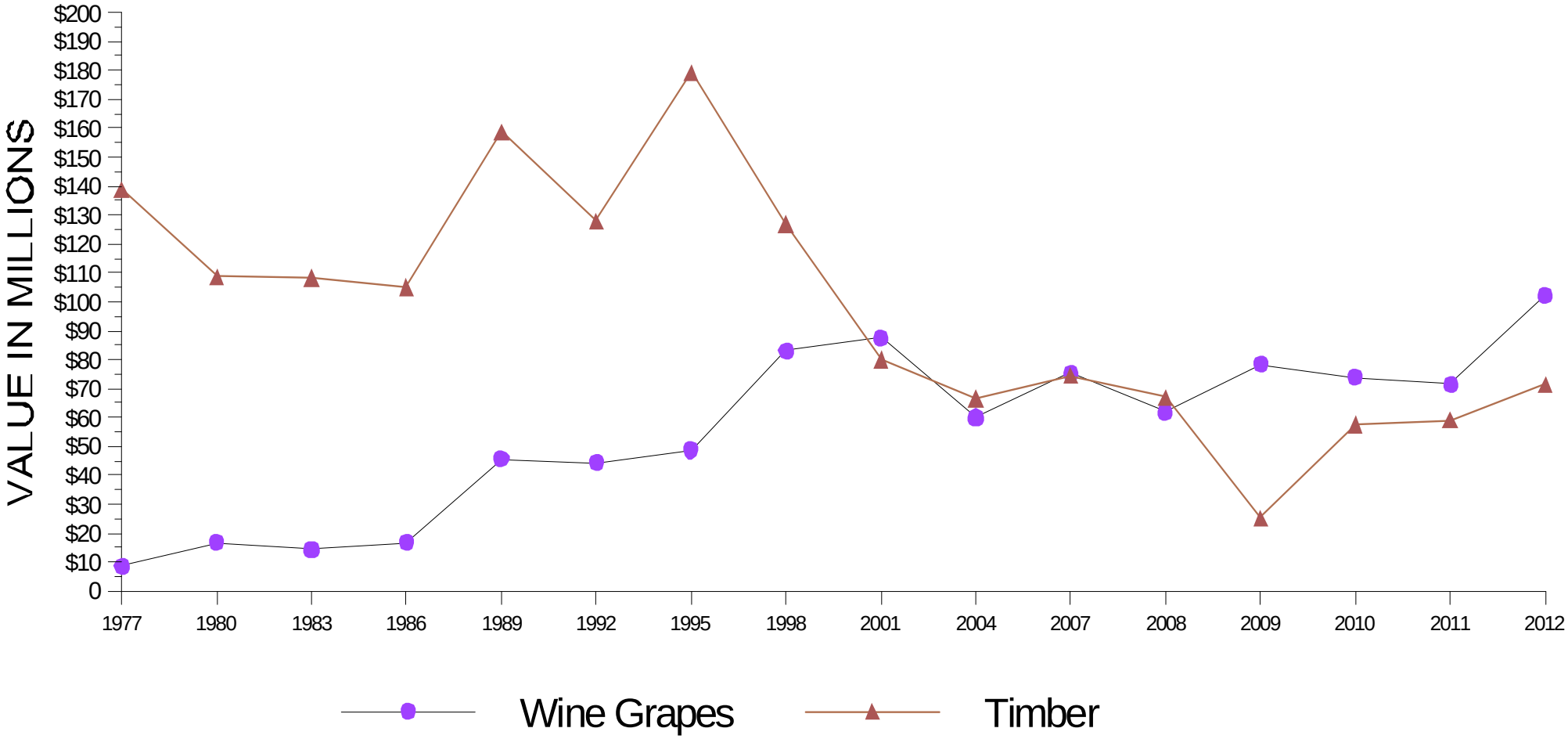
YEAR	FRUIT/ NUTS	LIVESTOCK PRODUCTION	LIVESTOCK AND POULTRY PRODUCTS	NURSERY PROD.	VEG PROD.	FIELD CROPS	TOTAL
2012	**$ 116,328,000**	**$ 9,750,700**	**$ 5,523,700**	**$ 1,626,900**	**$ 900,000**	**$ 10,833,400**	**$ 144,962,700**
2011	$ 85,339,400	$ 8,859,100	$ 6,953,200	$ 2,105,000	$ 900,000	$ 11,250,600	$ 115,407,300
2010	$ 87,134,900	$ 7,718,300	$ 6,043,700	$ 3,187,000	$ 1,200,000	$ 10,907,500	$ 116,191,400
2009	$ 91,537,300	$ 7,229,500	$ 5,973,900	$ 2,900,000	$ 1,000,000	$ 9,509,000	$ 118,149,700
2008	$ 80,760,400	$ 7,179,700	$ 8,153,500	$ 3,704,600	$ 900,000	$ 7,993,200	$ 108,691,400

TOP TEN GRAPE VARIETY VALUES

VARIETY	Acres Bearing	Acres Total	TONS	VALUE PER TON	TOTAL VALUE
Chardonnay	4691	4840	24,447.9	$1,272.72	$31,115,331
Pinot Noir	2601	2636	8,657.4	$2,704.18	$23,411,167
Cabernet Sauvignon	2428	2547	8,249.3	$1,589.23	$13,110,035
Zinfandel	1936	1962	8,151.2	$1,443.08	$11,762,833
Merlot	1550	1550	7,066.2	$1,176.19	$8,311,194
Sauvignon Blanc	745	757	3,251.5	$1,180.98	$3,839,956
Syrah	698	698	2,602.1	$1,263.88	$3,288,742
Petite Sirah	559	562	2,036.4	$1,444.22	$2,941,010
Gewurtzraminer	218	218	1,030.8	$1,172.01	$1,208,108
Carignane	355	355	1,150.4	$1,005.60	$1,156,842

MENDOCINO COUNTY

WINE GRAPE VALUE VS TIMBER VALUE



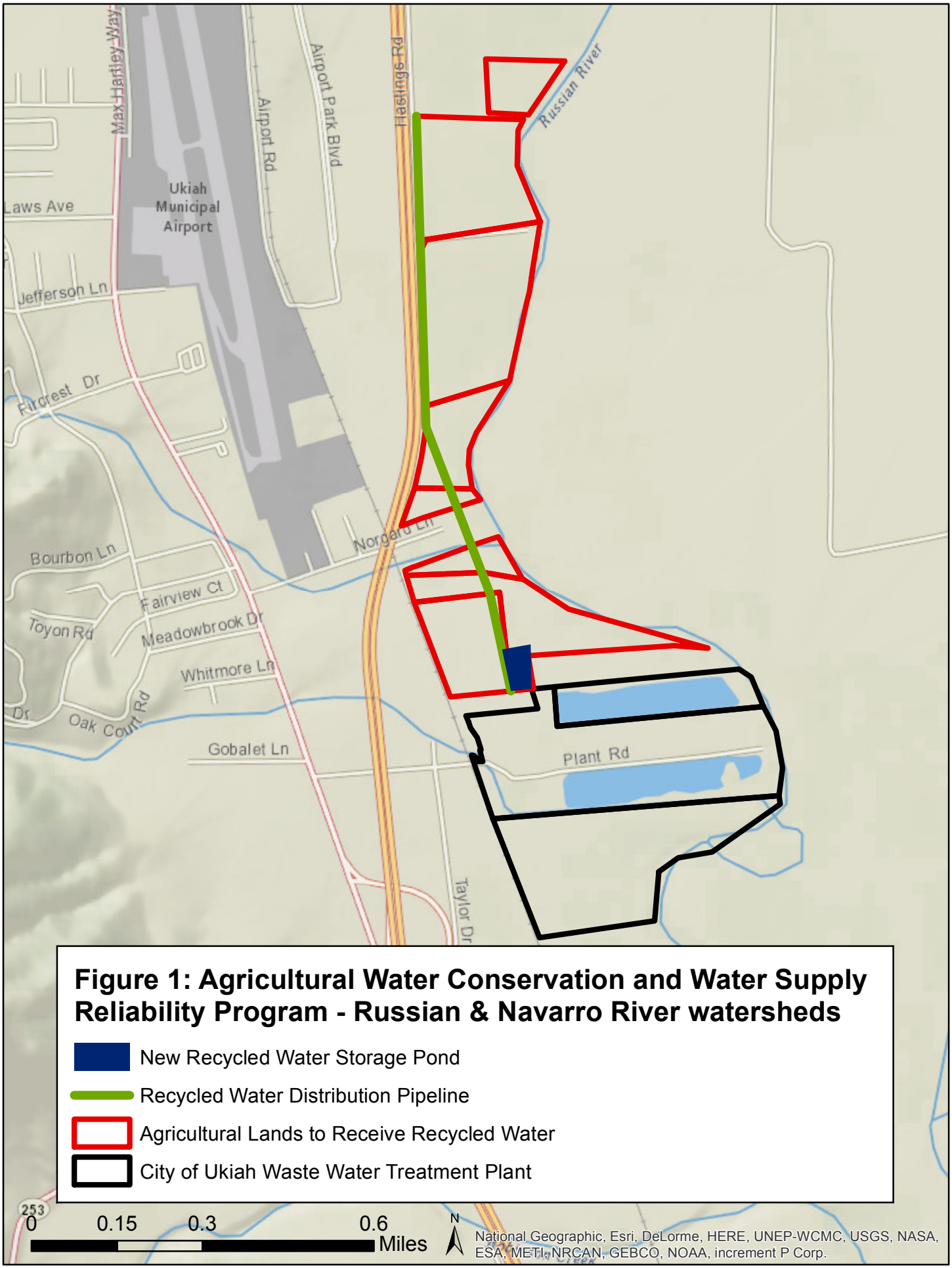


Figure 1: Agricultural Water Conservation and Water Supply Reliability Program - Russian & Navarro River watersheds

- New Recycled Water Storage Pond
- Recycled Water Distribution Pipeline
- Agricultural Lands to Receive Recycled Water
- City of Ukiah Waste Water Treatment Plant

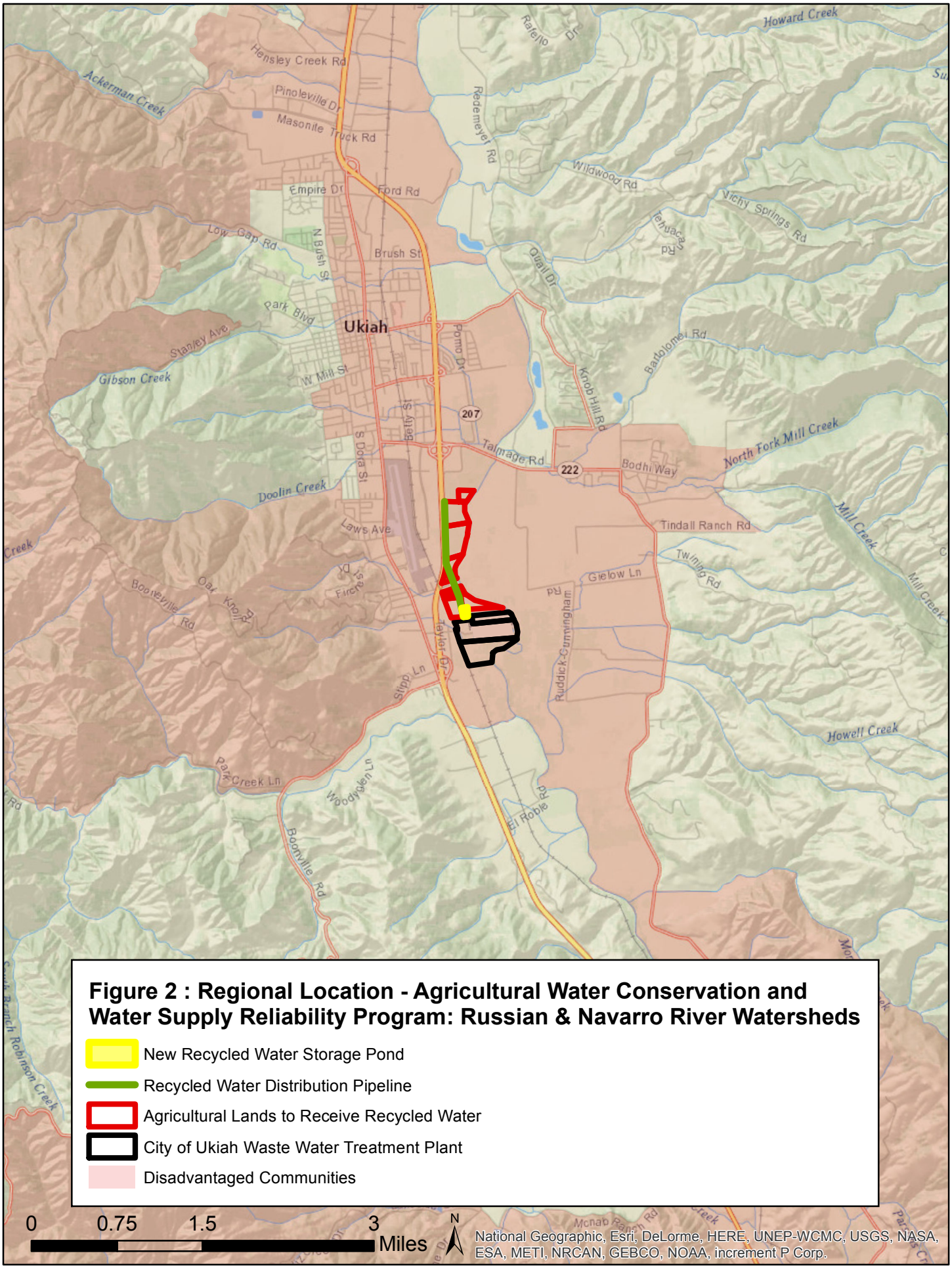


Figure 2 : Regional Location - Agricultural Water Conservation and Water Supply Reliability Program: Russian & Navarro River Watersheds

- New Recycled Water Storage Pond
- Recycled Water Distribution Pipeline
- Agricultural Lands to Receive Recycled Water
- City of Ukiah Waste Water Treatment Plant
- Disadvantaged Communities

NORTH COAST RESOURCE PARTNERSHIP

2014 IRWM Drought Project Grant Application

ATTACHMENT 3:

Project Justification Appendix

Integrated Regional Water Management Program
Applicant: Humboldt County

North Coast Resource Partnership 2014 IRWM Drought Project Grant

Attachment 3. Project Justification Appendix

Supporting Documentation

1. Seismic Assessment of Elevated Water Tank
2. Elevated Tank Inspection Report
3. Repair and recoating quote
4. Geotechnical Investigation

InfraTerra, Inc.
5 3rd Street
Suite 220
San Francisco, CA 94103
www.infratrerra.com

August 5, 2013
Pittsburg Tank & Tower
Maintenance Co., Inc.,
P.O. Box 1849
Henderson, KY 42419-0913
Attention: Mr. Patrick Heltsley
Vice President Specialty Projects

Dear Mr. Heltsley:

Report
Seismic Assessment
50,000 Elevated Water Tank
Wonder Stump Road and Highway 101
for
City of Crescent City

InfraTerra, Inc. (InfraTerra) is pleased to submit our seismic assessment of the 50,000 gallon Crescent City tank located near the intersection of Wonder Stump Road and Highway 101 in Crescent City, California.

We have enjoyed working on this project and look forward to our continued association. If you have any questions on this report please contact us at (510) 684-6306.

Very truly yours,

INFRATERRA, INC.

Ahmed Nisar, P.E.

Principal Engineer

Cc: File

Report

Seismic Assessment

50,000 Gallon Elevated Water Tank

City of Crescent City

900 10th Street

Crescent City, CA

August 5, 2013

Prepared by:
InfraTerra, Inc.
For Pittsburg Tank & Tower Maintenance Co., Inc.

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5.1 CONCLUSIONS 21

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1.0 INTRODUCTION

InfraTerra, Inc. (InfraTerra) is pleased to submit this report to Pittsburg Tank & Tower Co., Inc. (PT&T). This report presents seismic assessment of a 50,000 gallon elevated steel tank owned by the City of Crescent City.

1.1 SITE LOCATION

The tank is located near the intersection of Wonder Stump Road and Highway 101, Crescent City, California (Figure 1). Approximate coordinates for the tank site are:

Latitude: 41°50'18.30"N

Longitude: 124°8'38.73"W

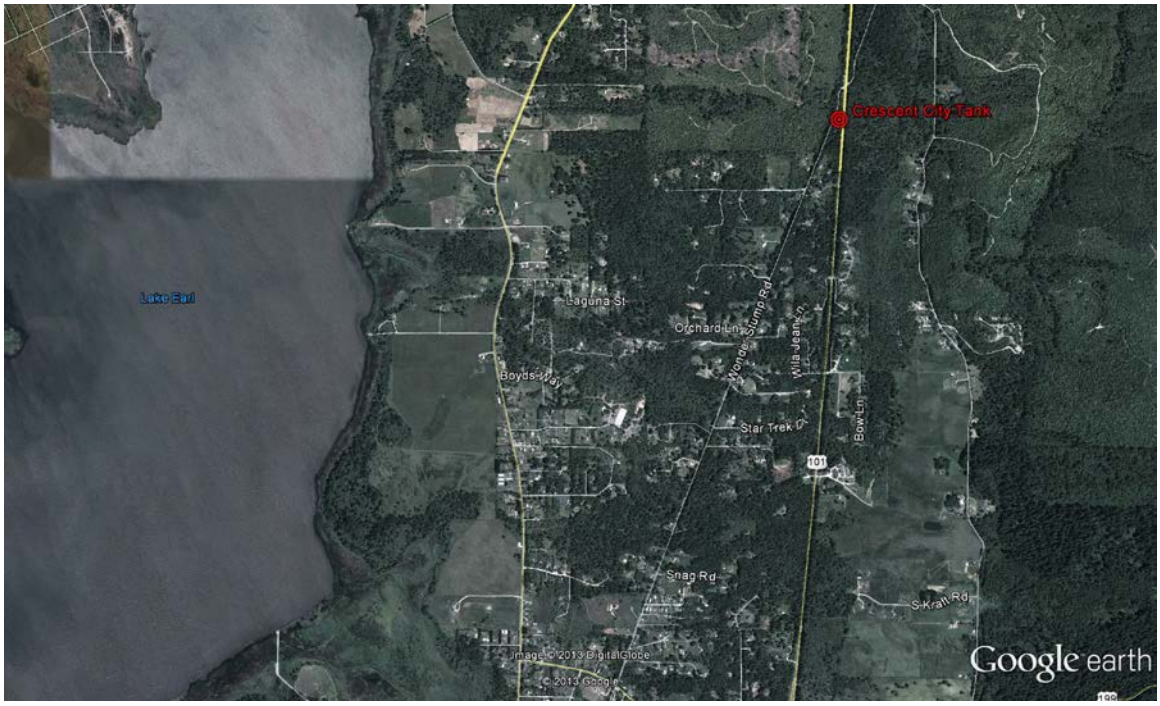

Figure 1: Site Location (© 2013 Google)

1.2 PURPOSE AND SCOPE OF WORK

The purpose of this study is to perform a desktop evaluation of the elevated tank for earthquake loading. The study was limited to the assessment of the supporting tower under seismic shaking. Our scope of work did not include a site visit or an assessment of earthquake induced ground deformations resulting from fault rupture, liquefaction, lateral spread or landslides. For our assessment we relied on information provided by PT&T as described in the following section.

1.3 AVAILABLE DATA

The following data was provided by PT&T for the assessment of the tank:

- Summary report documenting as-built conditions of the tank (PT&T, 2013).
- Photographic documentation of PT&T's site visit to the tank site (PT&T, 2013).
- Specifications for the construction of the tank (Roy M. Trotter & Associates, 1958).
- Draft geotechnical investigation report for an adjacent new tank (Taber Consultants, 2006).

2.0 ASSESSMENT METHODOLOGY

Structural assessment of the tank to seismic loading was performed using the approach described in American Water Works Association (AWWA) D-100. Seismic analysis of the tower was performed using both the AWWA D-100 equivalent lateral force (ELF) and response spectrum analysis (RSA) procedures.

For the ELF procedure, the AWWA D-100 provides simplified equations for the computation of earthquake base shear coefficient as a function of the period of vibration of the structure. The earthquake base shear (static base shear coefficient times the mass of the structure including water) is applied to the center of mass of the tank and the forces in the supporting tower calculated. In the RSA procedure, dynamic analysis is performed by applying design response spectrum at the base of the tower.

Both procedures require the computation of the fundamental period of vibration of the structure. AWWA D-100 allows the use of dynamic analyses to compute the period of vibration. However, the code also provides a simplified but conservative methodology for computing the period of vibration. This simplified methodology generally leads to the fundamental period falling at the peak of the response spectrum, which results in higher seismic loads. For the purpose of this assessment both approaches were used for the calculation of fundamental period of vibration.

To account for ductility and energy dissipation during earthquake shaking, the code allows the use of a ductility factor Ri of 3.0 for such tanks. AWWA D-100 recommends Importance Factor I=1.5 for tanks that provide direct service to facilities that are deemed essential for post-earthquake recovery, life, health and safety of public including post-earthquake fire suppression.

A finite element model of the tank and its supporting structure was developed in using SAP2000 structural analysis software. The purpose of the model was to compute the period of vibration in addition to the code based conservative method and to compute member forces in structural members of tower. The tower legs and braces were modeled using beam elements. Due to tension only nature of the braces, they were assigned zero compression limits in the analysis. The tank was modeled using shell elements; however, for simplicity all degrees of freedom were constrained to treat the tank and water as a single lumped mass system.

The typical approach for including the mass of water in the analysis for a ground supported flat bottom tank is to divide the water mass in the impulsive and

convective components. The former is described as the portion of the mass of water that moves in unison with the tank while the latter describes the sloshing wave component of the enclosed water. The impulsive and convective components are a function of tank geometry. For example, the impulsive component is significantly greater than the convective component for tall narrow tanks and vice a versa for broad and squat tanks. The period of vibration of sloshing wave tends to be several seconds long and falls on the falling branch of the response spectrum whereas the period of vibration of impulsive mode tends to fall near the peak of the spectrum. To be conservative, the code requires that elevated tanks be analyzed by considering only the impulsive loads. The impulsive mass of water was modeled as uniformly distributed along all tank nodes in the finite element model with the tank nodes constrained for all degrees of freedom the water was modeled as a lumped mass that moves in unison with the tank.

The code refers to the American Society of Civil Engineers ASCE-7 for computation of seismic loading in terms of the design response spectrum to be used in the design and analysis of the tanks.

3.0 TANK DETAILS

3.1 STRUCTURAL CONFIGURATION

The Crescent City Tank is cylindrical welded steel tank with ellipsoidal roof and bottom supported on a cross braced steel tower. Figure 2 shows the as-built drawing for the tank provided by PT&T. It is our understanding that the drawing was prepared using field measurements by PT&T during a recent site visit.

Based on the information shown in Figure 2, the total tank height including the tower is estimated to be a little more than 80 feet with the overflow height at 79.83 feet. The tank has a diameter of 22 feet and a height of 18.83 feet from the base to the overflow.

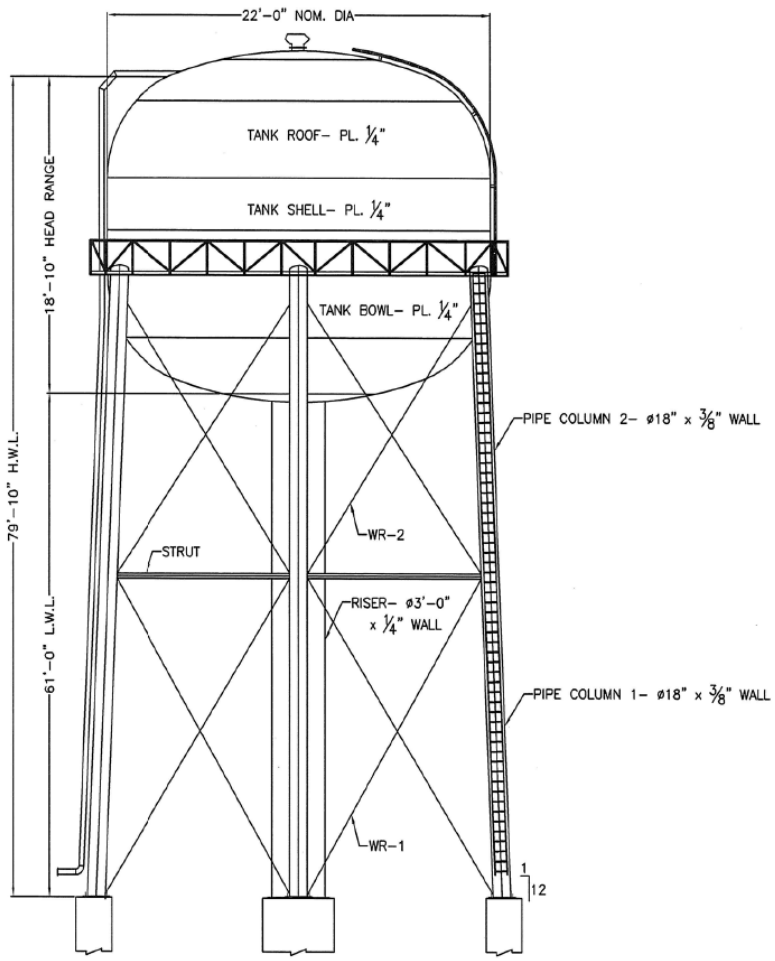

Figure 2: Tank Configuration (from PT&T)

The tank is supported on braced frame with four legs and two levels. Each leg of the tower consists of an 18-inch diameter steel pipe section with 3/8-inch wall thickness. Figure 3 shows a general view of the tank. Based on information provided by PT&T,

diagonal distance between each leg at the base is approximately 33 feet. The tower has tension rod bracing that consists of 1-1/4-inch square rods at both levels (Figure 4). The braces are fitted with a turnbuckle to make them taut (Figure 4). It does not appear that the turnbuckle is used for pre-stressing. The horizontal struts consist of a two channel combination section with a horizontal channel (C6x8.2) welded to the top flange of a vertical channel (C7x9.8) as shown in Figure 5.

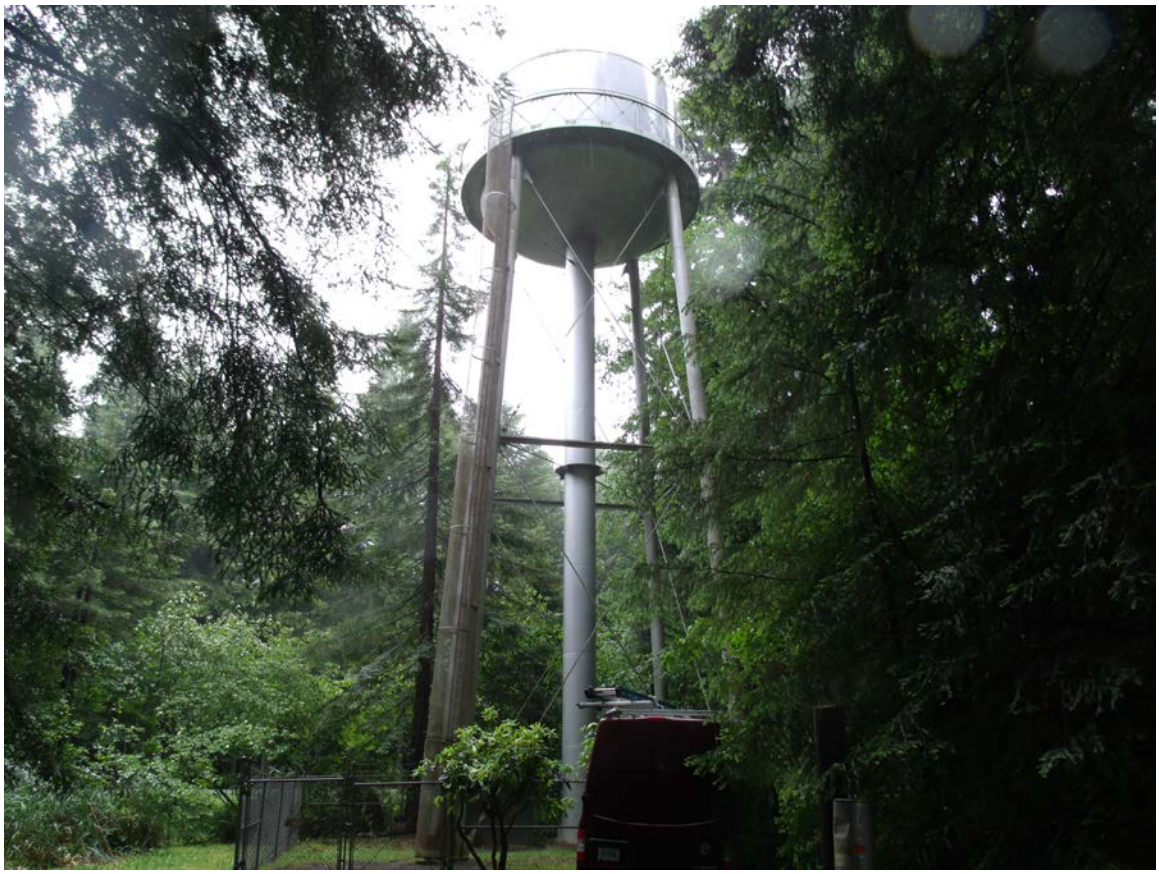

Figure 3: General View of the Tank (from PT&T)

According to Section 12-04 of the construction specifications (Roy M. Trotter & Associates, 1958), all structural steel and anchor bolts use ASTM A7-39 steel. The ASTM A7 steel had minimum yield strength of 33 ksi and was discontinued in 1967 (Gustafson, 2007).

The tank has a central riser that contains inlet/outlet piping. The riser is 3 feet in diameter with ¼ inch wall thickness (Figure 6).

Based on discussion with Mr. Patrick Heltsley of PT&T we understand that the tank is supported on piles but the number, length and type of piles is unknown. The tower legs are anchored into a concrete pier using a two 1¾-inch diameter anchor bolt with a hex nut at the top (Figure 7). The anchorage condition and length of the bolt within

the concrete pier is unknown. Each pier at the ground surface is 3 feet square and 5 feet tall supported on a 4.33 feet square and 1.5 feet thick pile cap.

Figure 4: Tension Rod Bracing with Turnbuckle and Anchor Bolt (from PT&T)

Figure 5: Horizontal Strut Connection to the Column (from PT&T)

Figure 6: Central Riser Base Connection (from PT&T)

Figure 7: Anchor Bolt at Column Base (from PT&T)

3.2 SUBSURFACE CONDITIONS

Construction specifications (Roy M. Trotter & Associates, 1958) for the Crescent City tank refer to soil investigations by Porter, Urquhart, McCreary & O'Brien, which state that the foundations can be designed for 6,000 psf dead load and 9,000 psf dead plus live load. The allowable bearing pressure values were presented at a depth of 6 feet below ground surface.

Recently, Taber Consultants (Taber, 2006) performed geotechnical investigations for a proposed 150,000 gallon elevated tank located immediately to the north of the existing 50,000 gallon tank. According to the Taber report, the top 23 to 24 feet of the site is underlain by semi-compact to compact silty sand (referred to as Unit I soils in Taber report). The silty sand layer is underlain by dense silty sand and very stiff clay (referred to as Unit II soils in Taber report). Shallow ground water was encountered at a depth of about 1.5 feet during the investigations.

Based on the geotechnical investigations, Taber conclude that Unit I soils are susceptible to liquefaction. Liquefaction is a process whereby strong ground shaking during an earthquake transforms granular material from a solid state into a nearly liquefied state, resulting in a reduced ability to support structures and overlying soil layers. Taber also conclude that Unit II soils not susceptible to liquefaction and are capable of supporting the tank foundation without excessive settlement. Several recent earthquakes such as the 1989 Loma Prieta, California, 1994 Northridge, California, 1995 Kobe, Japan, 1999 Duzce, Turkey, 2001 Bhuj, India and 2010/2011 Christchurch, New Zealand earthquakes have shown damaging effects of liquefaction.

Liquefaction as a phenomenon was not as well understood in 1958 (date of construction of the tank) as it is now. Therefore, if based on the original design the foundations for the tank do not extend beyond the top 23 to 24 feet of liquefiable material, the tank is susceptible to damage that could lead to collapse.

4.0 SEISMIC ANALYSIS

Figure 8 shows the finite element model of the structure. For the analysis nominal material and section properties were assumed (i.e. section properties were not reduced to account for corrosion). The model was developed as described in Section 2.0.

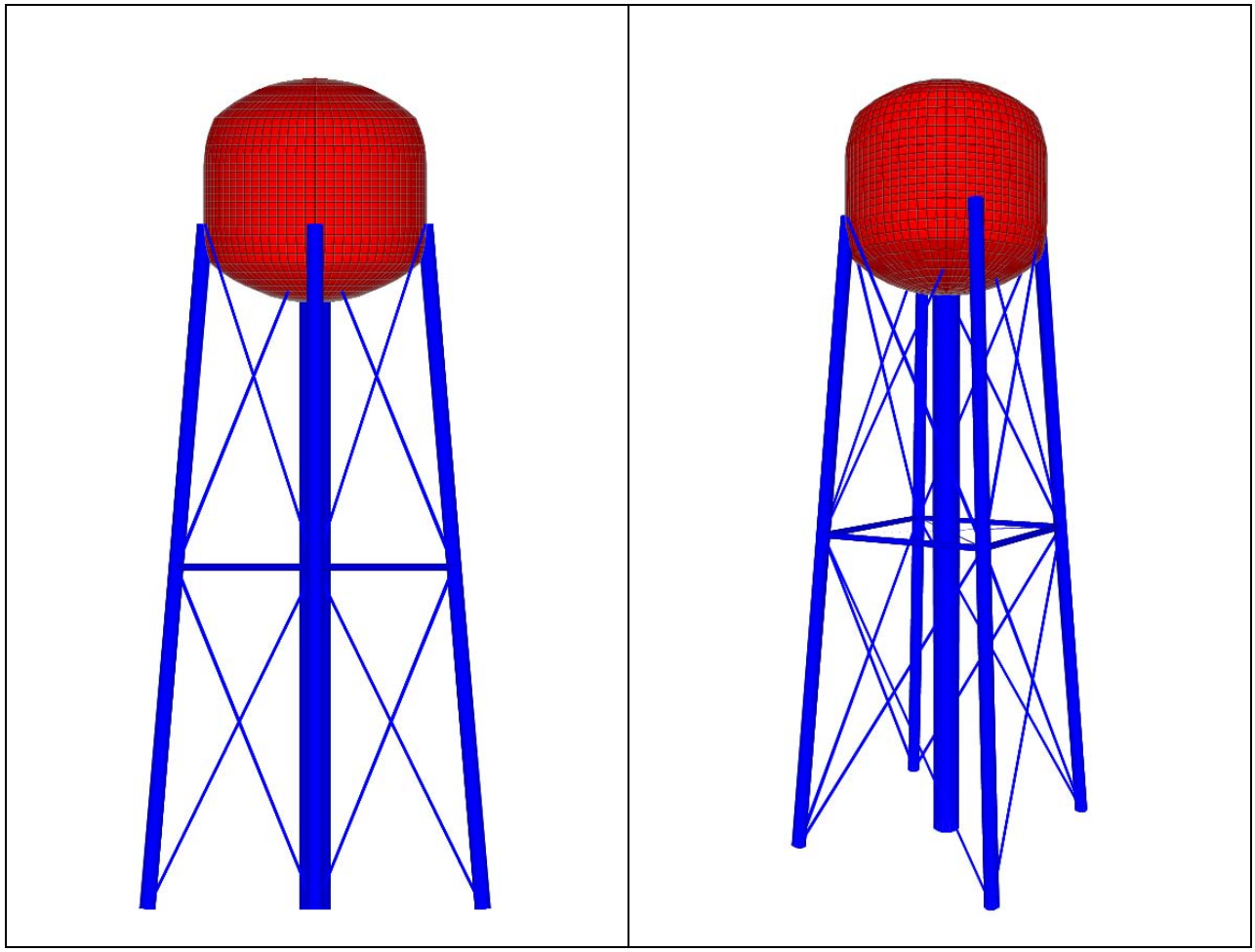

Figure 8: SAP2000 Finite Element Model of the Crescent City Tank

4.1 COMPUTATION OF PERIOD OF VIBRATION

Dynamic analysis was performed to compute the period of vibration of the structure. The fundamental modes of vibration along the two orthogonal horizontal directions were identical due to symmetric configuration of the structure and computed to be 1.03 seconds. The computed period of the vertical mode of vibration was 0.12 seconds. Contributing mass associated with the horizontal modes of vibration was 99% while that for the vertical mode of vibration was 100%. The deformed shapes associated with the horizontal and vertical modes of vibration are shown in Figure 9.

Vibration period of the structure was also computed using the simplified approach presented in the AWWA D-100 standard. According to this approach the structure is modeled as a guided cantilever. The computed period of vibration using this approach is 0.2 seconds.

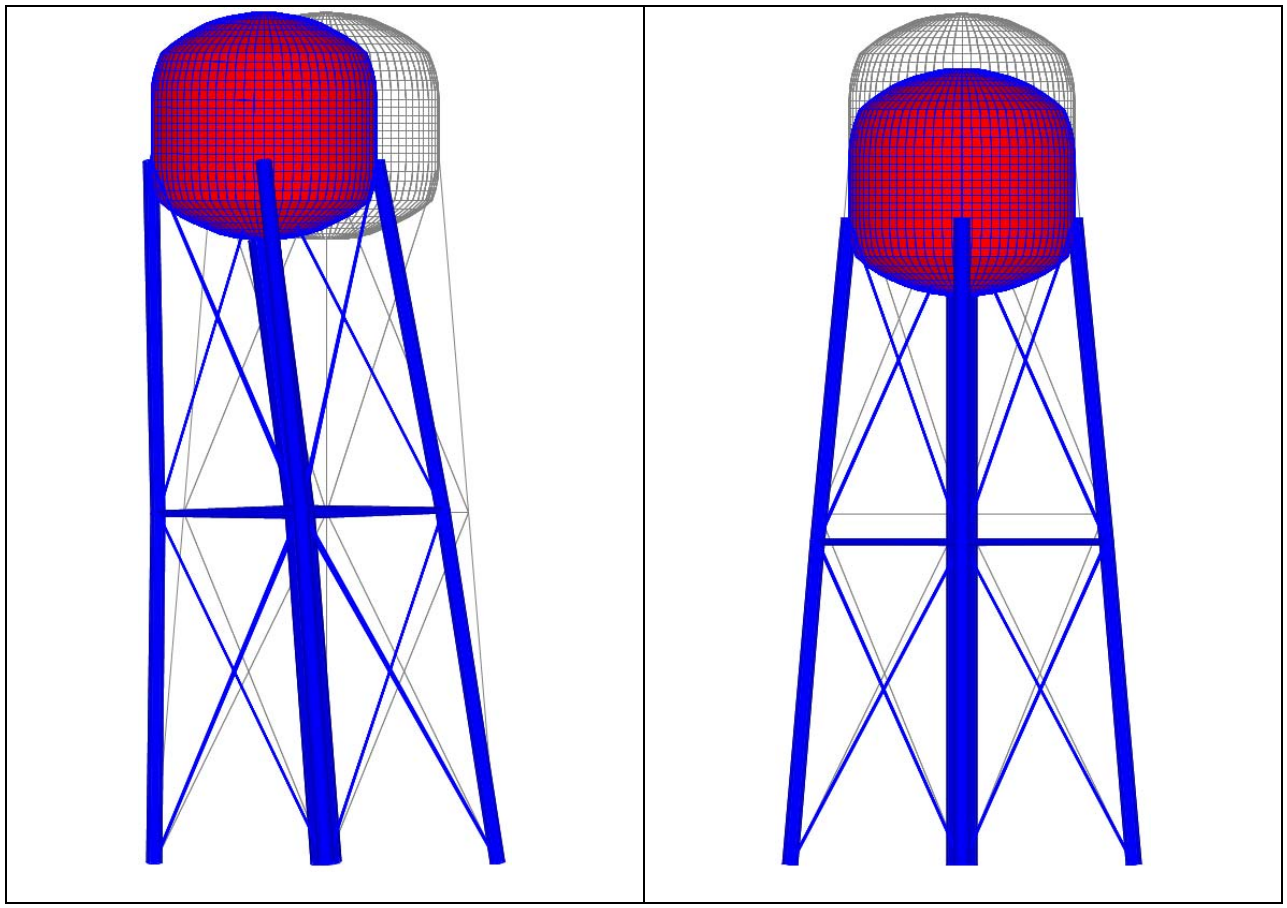

Figure 9: Horizontal (T=1.03 seconds) and Vertical (T=0.12 seconds) Modes of Vibration

4.2 DESIGN RESPONSE SPECTRUM

The design response spectrum for the Crescent City Tank site is shown in Figure 10 and represents ground motions for the 2012 IBC for Site Class D (Stiff Soil) and Occupancy Category IV (essential facility). The response spectrum was obtained from the online design maps utility developed by the United States Geological Survey (USGS). Site Class D was assumed based on the description of soil provided in the Taber report. This site class designation assumes that liquefaction mitigation has been performed at the site.

As shown in Figure 10 the spectral acceleration associated with the period computed from dynamic analysis (1.03 seconds) to be 0.64g and 0.90g for the period computed using the simplified AWWA D-100 approach (0.2 seconds). Using these period values

the static base shear coefficient of 0.23 and 0.32 were computed using the formula provided in AWWA D-100 (using Ri=3.0 and I=1.5), respectively.

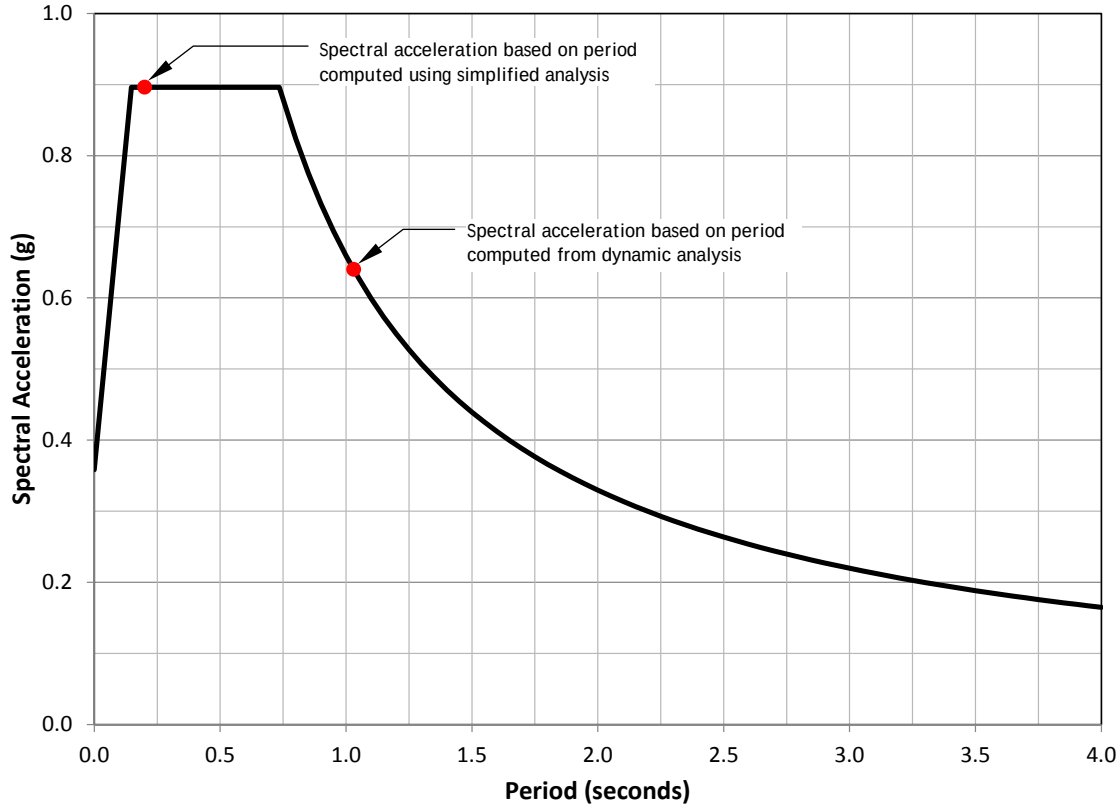

Figure 10: CRC1-T1 Design Response Spectrum

4.3 SEISMIC ANALYSIS

Results of seismic analysis using both AWWA D-100 equivalent lateral force procedure and response spectrum analysis are provided below.

4.3.1 Equivalent Lateral Force Analysis

Equivalent lateral force based analyses were performed by applying static base shear (static base shear coefficient times the mass of the structure including water) to the center of mass of the tank. The base shear was applied along the x-axis of the model; however, due to the random orientation of earthquake loading and symmetric nature of the tower, results of the analysis are applicable for different earthquake loading directions. Deformed shape of the tower for this analysis is shown in Figure 11.

Results of the analysis showing demand to capacity ratios (DCR) for the structural members of the tower are presented in Figure 12 for base shear coefficient of 0.23

(based on period computed from dynamic analysis) and for base shear coefficient of 0.32 (based on period computed using AWWA D-100 simplified procedure). The results show that for the analysis with base shear coefficient of 0.23 DCRs of several braces exceeding 1.0 with a maximum value of 1.4. For the analysis with base shear coefficient of 0.32, DCRs of all braces acting in tension significantly exceed 1.0 with the values ranging from 1.3 to 1.9.

Although the results show not all of the tower braces to be overstressed, however, because of the random nature of the direction of earthquake loading, all tower braces are vulnerable to earthquake damage. Therefore, all braces will require strengthening.

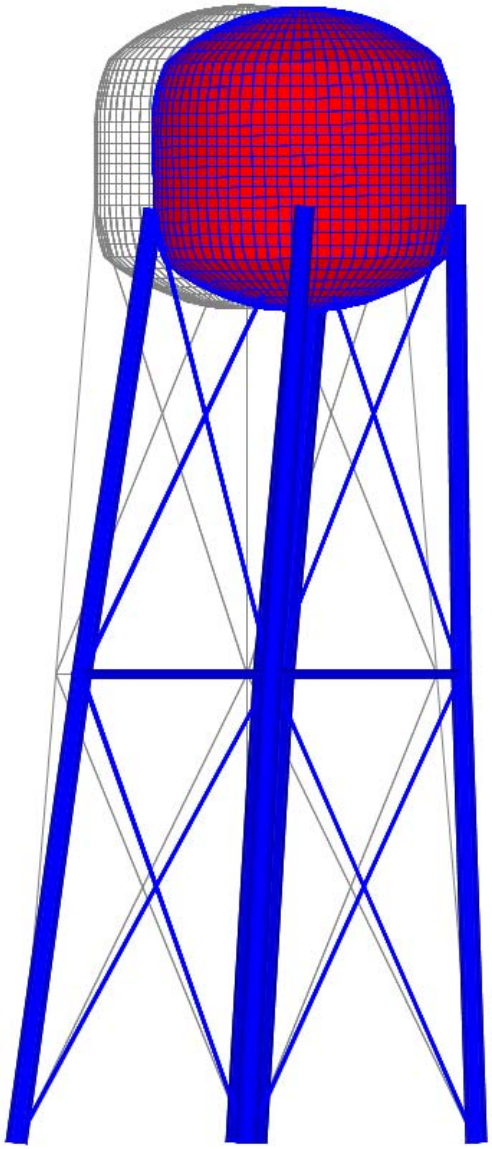

Figure 11: Deformed Shape Static Analysis

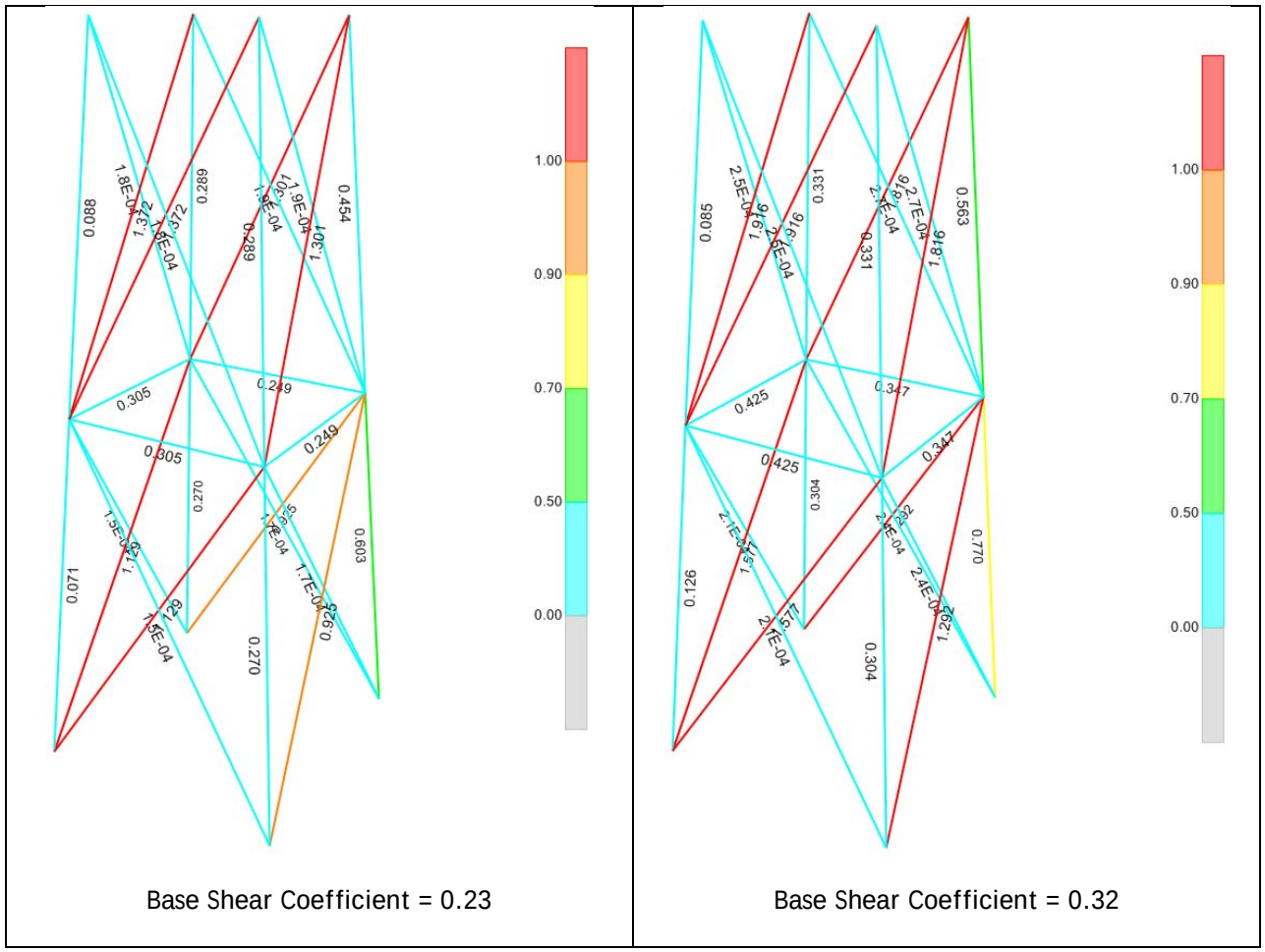

Figure 12: Demand to Capacity Ratios (DCR) – ELF Analysis

4.3.2 Response Spectrum Analysis

Following the static analyses, a response spectrum analysis was performed. For this analysis tension only braces were used. DCRs from the response spectrum analysis are shown in Figure 13. The results of this analysis also show DCRs greater than 1.0 (ranging from 1.1 to 1.4) for six of the eight braces acting in tension.

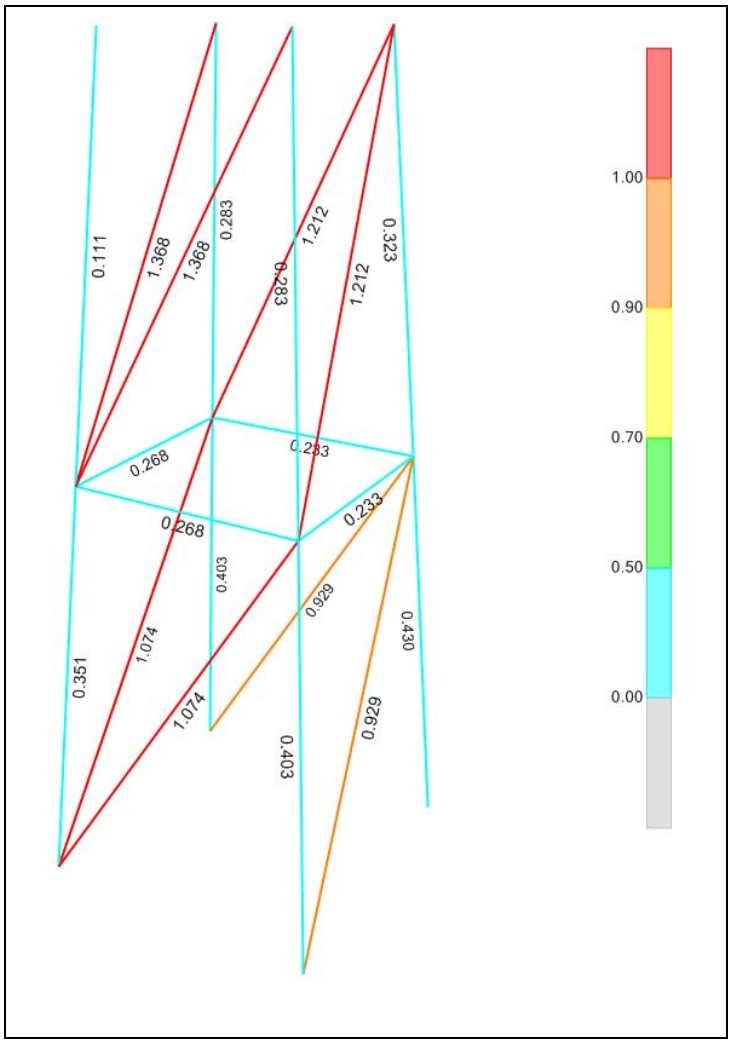

Figure 13: Demand to Capacity Ratio (DCR) Based on Response Spectrum Analysis (only braces in tension shown)

4.4 PRELIMINARY TANK RETROFIT ANALYSIS

4.4.1 Tower Retrofit

Analyses were performed to evaluate potential retrofit options. The results show that the DCR of less than 1.0 in the braces can be achieved by replacing all of the existing cross braces by two L3x3x3/8 angle sections (Figure 14). Other structural shapes such as channel sections can be used if they provide the additional area equivalent to 2L3x3x3/8.

Dynamic analyses of the tank were performed by replacing the existing braces by two L3x3x3/8 angle sections. The results of the analysis show that the horizontal period of vibration is reduced from 1.03 to 0.73 seconds and the vertical period of vibration

is reduced from 0.12 seconds to 0.11 seconds due to increased stiffness of the structure (Figure 15). The reduction in fundamental period of vibration results in higher spectral acceleration and the resulting base shear coefficient. This increase in base shear coefficient is still less than the value computed using the simplified code approach. Figure 16 shows DCR of less than 1.0 for the retrofitted tank. Table 1 shows the steel area required for the conceptual retrofit scheme. The retrofit and steel requirements were developed only to provide planning level estimates. The conceptual retrofit scheme shown in Figure 14 and Table 1 requires approximately 4 tons of steel for the main structural members. It should be noted that conceptual retrofit scheme shown in Figure 14 and Table 1 cannot be implemented without additional design calculations and detailing such as modification of gusset plates (wing plates), connection details of new braces with the gusset plates, anchor bolts and anchor chairs.

Table 1: Conceptual Level Retrofit Requirements

Level	Member	Number	Approx. Length (ft.)	Existing Section	Conceptual Retrofit			
					Retrofitted Section		Cross-Sectional Area (in^2)	Weight (tons)[1]
Level 1	Brace	8	36	1¼ sq. rod	2L3x3x3/8	subst.	4.2	2.1
Level 2	Brace	8	31	1¼ sq. rod	2L3x3x3/8	subst.	4.2	1.8

Note 1: Increase steel area by 25% to account for miscellaneous items such as gusset plates, anchor bolts and anchor bolt chairs etc.

The conceptual retrofit requirements in the table above are based on a preliminary assessment of retrofit requirements to develop planning level cost estimates. These requirements are not final design and should not be used for actual design purposes. The final retrofit design may result in different steel sections based on design calculations and required construction details. For budgeting purposes, the total steel area is estimated to be 4.9 tons.

4.4.2 Foundation Assessment

For the retrofitted tank, the controlling dead, live and earthquake load combination case results in a total base shear of 148 kips and an overturning moment of 10,804 kip-feet at the foundation. For an individual footing, the maximum shear is 76 kips,

and the maximum tension and compression forces are 278 kips and 392 kips, respectively.

Assuming 33 ksi steel (based on A7 designation) tensile yield capacity of each anchor bolt is calculated to be approximately 70 kips. Each leg of the tower is anchored to concrete footing using two 1¾ inch diameter bolts. Total tensile yield capacity of two anchor bolts (140 kips) is significantly less than the imposed tensile demand of 278 kips. Furthermore, photographic documentation from the site visit performed by PT&T show that the anchor bolts are significantly corroded. Based on these results, additional anchorage against uplift will also be required as part of any retrofit scheme.

Due to lack of information on pile foundation, an assessment of column foundations cannot be performed. If no piles are assumed, the calculated bearing stress is many times higher than the allowable value given in the construction specifications.

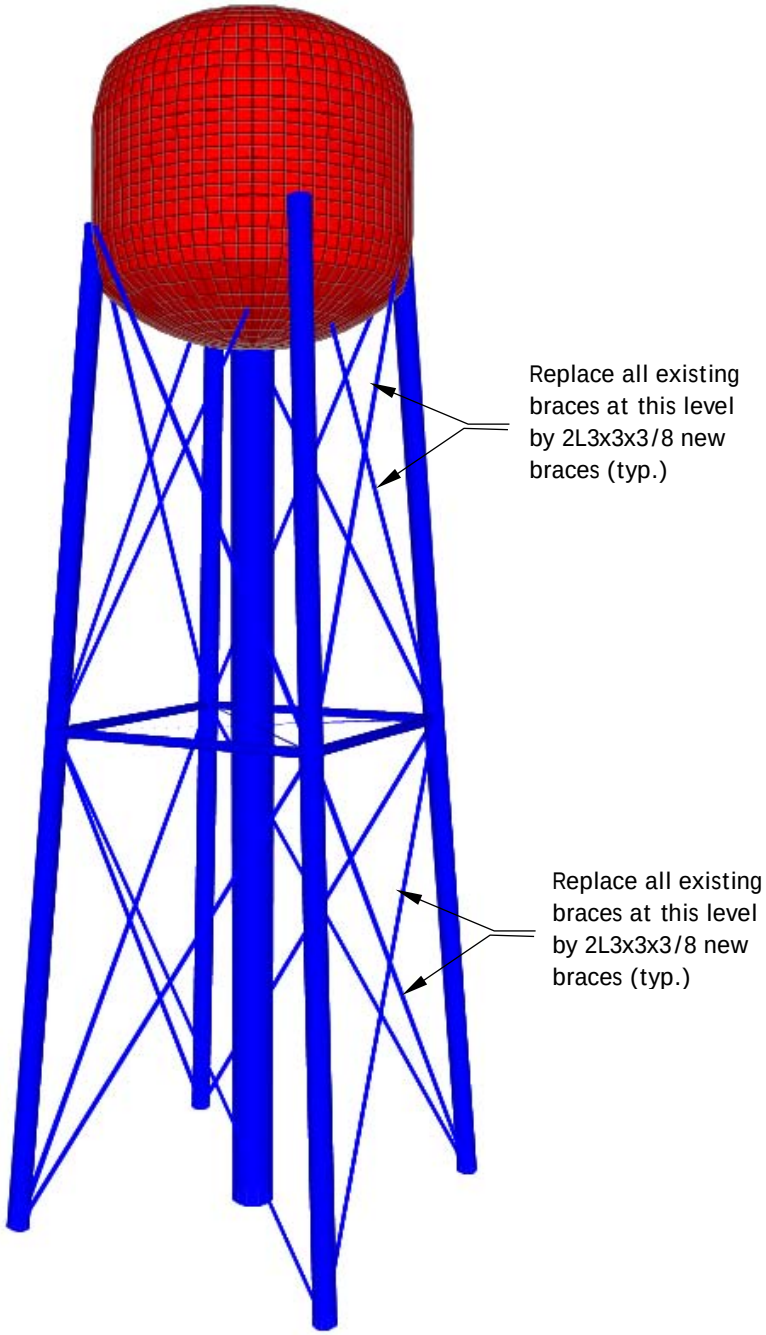

Figure 14: Retrofitted Model

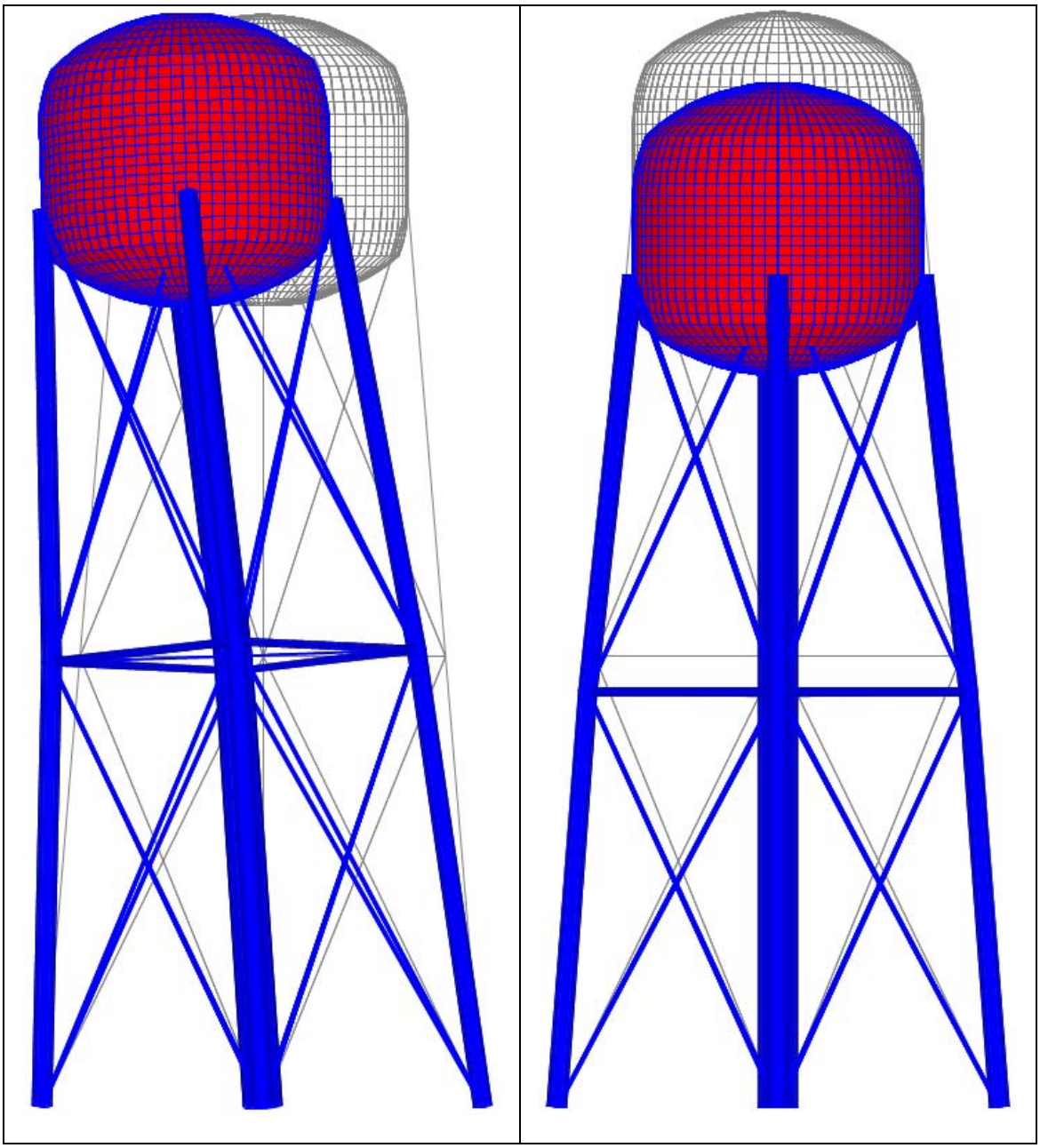

Figure 15: Horizontal (T=0.73 sec) and Vertical (T=0.11 sec) Vibration Modes, Retrofitted Model

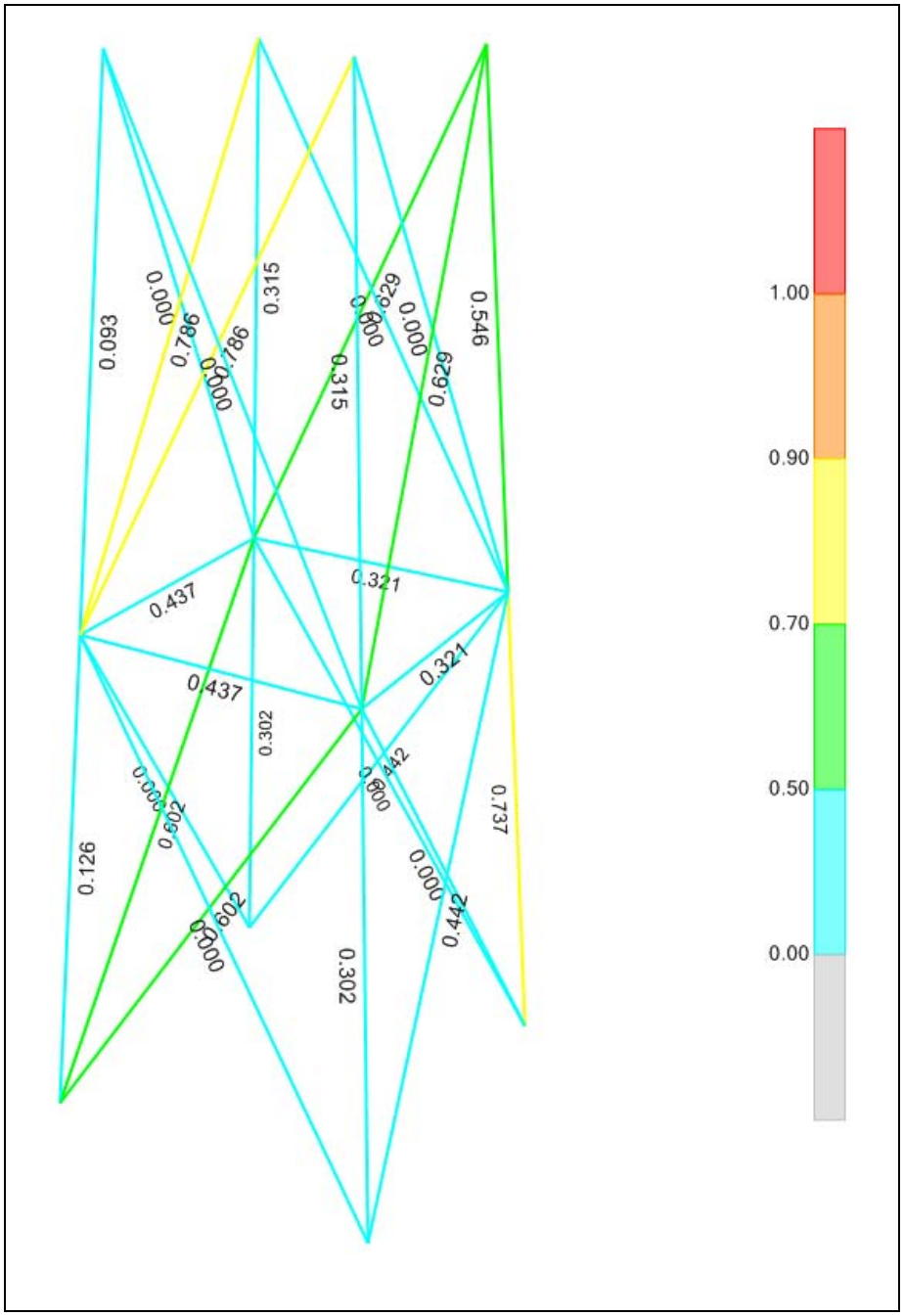

Figure 16: Retrofitted Model - DCRs

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

Results from the seismic assessment of the Crescent City tank show the following:

- Structural analysis using equivalent static force procedures show that the tower braces and do not meet the code requirements and that the tank is unstable under seismic loading. Similar results are obtained using the response spectrum analysis.

- Photographic documentation by PT&T show significant corrosion of structural members of the tank including the anchor bolts at the base of the columns (Figure 17 through Figure 22).

- Analyses were performed assuming Seismic Use Group III with an importance factor of 1.5. This was based partly on the critical nature of water supply but also on the catastrophic consequences of failure.

- There is a significant difference period of vibration of the tank computed using the simplified approach of AWWA D-100 and that from finite element model of the tank. The former results in a base shear coefficient of 0.32 while the later results in a base shear coefficient of 0.23. Based on linear elastic analysis member forces computed using the former approach are significantly greater.

- Based on results presented in the Taber geotechnical report, the potential of liquefaction at the site is high.

- Preliminary analyses suggest that the tank can be retrofitted by replacing the existing braces with two L3x3x3/8 angles. Although the results show not all of the braces to be overstressed, however, because of the random nature of the direction of earthquake loading, all tower legs are vulnerable to earthquake damage. Therefore, all braces will require strengthening. Approximately 4.9 tons of steel are required for this conceptual retrofit scheme.

- Field observations from PT&T's show that the tower is supported on pile foundations, however, no information on pile foundation (size, number and type of piles and their load carrying capacity) is available. If it is assumed that the tower legs are supported on shallow spread footing by ignoring the piles, the structural assessment shows that the foundation bearing stress is many times higher than the allowable bearing pressure. Possible options for foundation assessment include:

- Obtain as-built information or foundation design drawings. It is our understanding that this information is not available.
- Perform load tests to estimate load carrying capacity of the foundation.
- Perform foundation retrofit by adding new piles.

- Tensile loads in the columns are significantly higher than the capacity of anchor bolts. Furthermore, photographic documentation from the site visit shows that the anchor bolts are highly corroded.

Figure 17: Significant Corrosion of the Anchor Bolt

Figure 18: Significant Corrosion of the Anchor Bolt

Figure 19: Corrosion of Tie-Rod Connecting Central Riser to Exterior Columns (from PT&T)

Figure 20: Corrosion of Tie-Rod Connecting Central Riser to Exterior Columns (from PT&T)

Figure 21: Corrosion in Tank Shell (from PT&T)

Figure 22: Damaged Coating at Tank Shell (from PT&T)

5.2 RECOMMENDATIONS

The following is recommended:

- Finite element analysis of the Crescent City tank was performed to assess its seismic vulnerability. The assessment was performed using ground shaking estimates at the tank site developed by the United States Geological Survey (USGS) as part of their National Seismic Hazard Mapping Program, and also as cited in other current codes, including the California Building Code, and the American Water Works Association (AWWA) Standard D-100 for water storage tanks. The results of the analyses show that the earthquake demand on the tower bracing is substantially greater than the available capacity. As a result, the tank is vulnerable to damage and potential collapse during strong earthquake ground shaking predicted for this site by the USGS from future earthquakes. Collapse of the tank is a potential life safety concern. Seismic retrofit of the tank to current seismic design standards is recommended.

- Obtain as-built data on the tower foundation. Re-assess the foundation based on as-built conditions. If the data cannot be obtained and if the allowable capacity of existing foundation cannot be assessed through other means such as load testing, then perform seismic retrofit of foundation to

carry compressive and uplift loads. Based on discussions with PT&T, it appears that adding new piles to carry the anticipated loads might be more cost effective compared to performing load testing to assess foundation capacity, because the latter may still result in capacity that is less than demand thereby still requiring a foundation retrofit.

- For liquefiable sites, the code designation is site class F, which requires site specific analysis to compute design response spectrum. Seismic analyses of the tank were based on an assumption of site class D assuming ground improvement will be performed to mitigate liquefaction hazard as recommended in Taber report.

- Structural elements of the tank and tower are showing excessive corrosion. All corroded elements should be immediately replaced or repaired to maintain their full structural integrity.

6.0 TECHNICAL REFERENCES

AWWA D100-05, 2006, American Water Works Association, AWWA Standard D100-05, Welded Carbon Steel Tanks for Water Storage, Effective May 1, 2006.

Gustafson, K., 2007, Evaluation of Existing Structures, Steel Solutions Center, Steelwise, Modern Steel Construction, February 2007.

Roy M. Trotter & Associates, Consulting Engineers, Berkeley, California, 1958, Specifications for the Construction of Elevated Steel Water Equalizing Tank for the City of Crescent City Del Norte County, California, Job No. 1563, September 1958.

Petersen, M.D., A.D. Frankel, S.C. Harmsen, C.S. Mueller, K.M. Haller, R.L. Wheeler, R.L. Wesson, Y. Zeng, O.S. Boyd, D.M. Perkins, N. Luco, E.H. Field, C.J. Wills, & K.S. Rukstales (2008), "Documentation for the 2008 Update of the United States National Seismic Hazard Maps," U.S. Geological Survey Open-File Report 2008-1128, 61 p.

http://earthquake.usgs.gov/hazards/products/conterminous/2008/update_201001/grids/

Pittsburg Tank & Tower Maintenance Co., Inc., 2013, City of Crescent City 900 10th Street, Crescent City, CA 95531, RE: Wonder Stump Road & 10150,000 Gallon G.S.T. April 12, 2013, Tom Romesberg, Utilities Manager (661) 333-4134 Job No. 313142-C.

Taber Consultants, 2006, Draft Geotechnical Investigations, Proposed Elevated Water Tank, Wonder Stump Road near Highway 101, Crescent City, California, 1P1/306/043, 41124-G2:322N;050W.

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City of Crescent City
900 10th Street
Crescent City, CA 95531
RE: Wonder Stump Road & 101
50,000 Gallon G.S.T.
April 12, 2013
Tom Romesberg, Utilities Manager
(661) 333-4134
Job No. 313142-C

If you would like to speak with Patrick Heltsley concerning this report, call (270) 826-9000, Ext. 253.
For additional copies of this report call (270) 826-9000 Ext. 253.

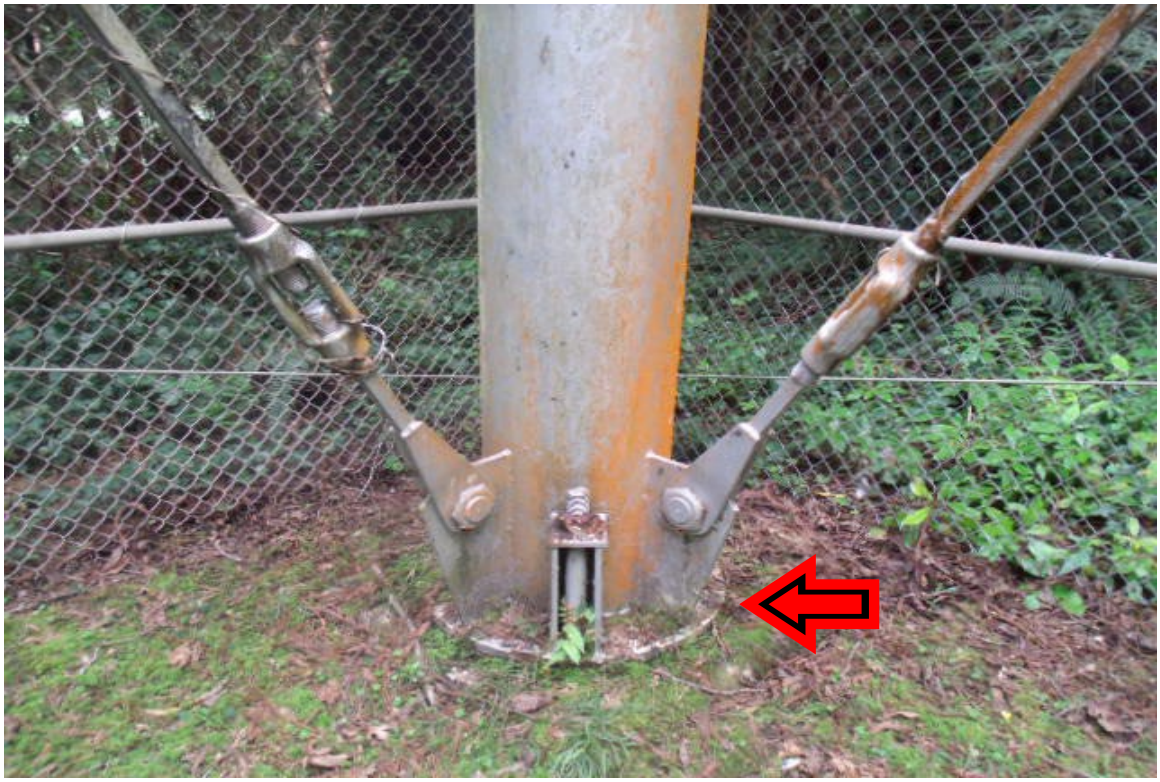


Photo shows the condition of the foundations. AWWA D100-11; 12.7.1: Foundations, states "the top of the piers shall be 6" above the finished grade." This work should be done by a local excavating company.

We then recommend removing all dirt, debris and loose gravel from the foundations, repairing any cracks and spalling in the concrete with a commercial non-shrinking grout and sealing the foundations with sealant.

We also recommend the tank be electrically grounded for lightning protection as required by OSH Act 29 CFR 1926, Subpart K.

Photo shows the exposed condition of the foundations.

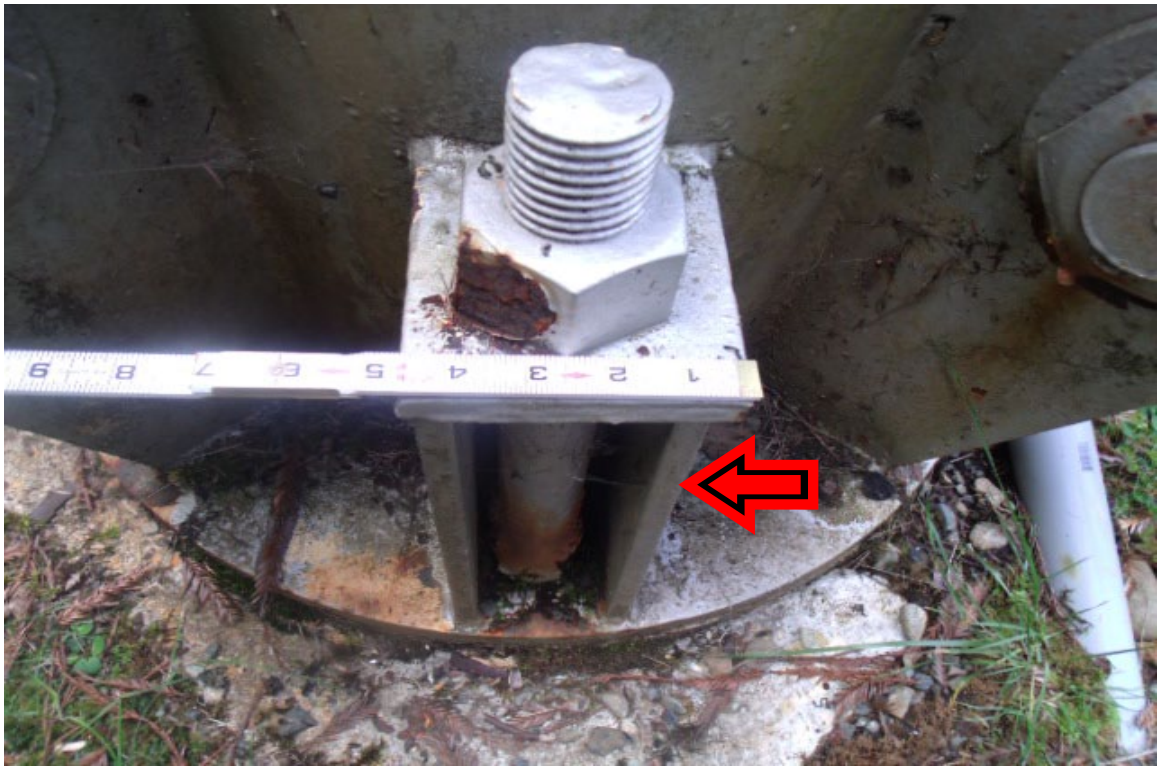


Photo shows the condition of the anchor bolts. The structural integrity of the anchor bolts should be maintained to withstand 100 m.p.h. winds blowing from any direction as required by AWWA D100-11; 3.8: Foundation bolts. We recommend cleaning the area around the anchor bolts, welding around the circumference of the bolt to nut and nut to base plate connections to reinforce, then weld steel plates, complete with grease fittings, over the anchor chair openings and fill the area around the anchor bolts with grease to prevent deterioration of the exposed portion of the anchor bolts.

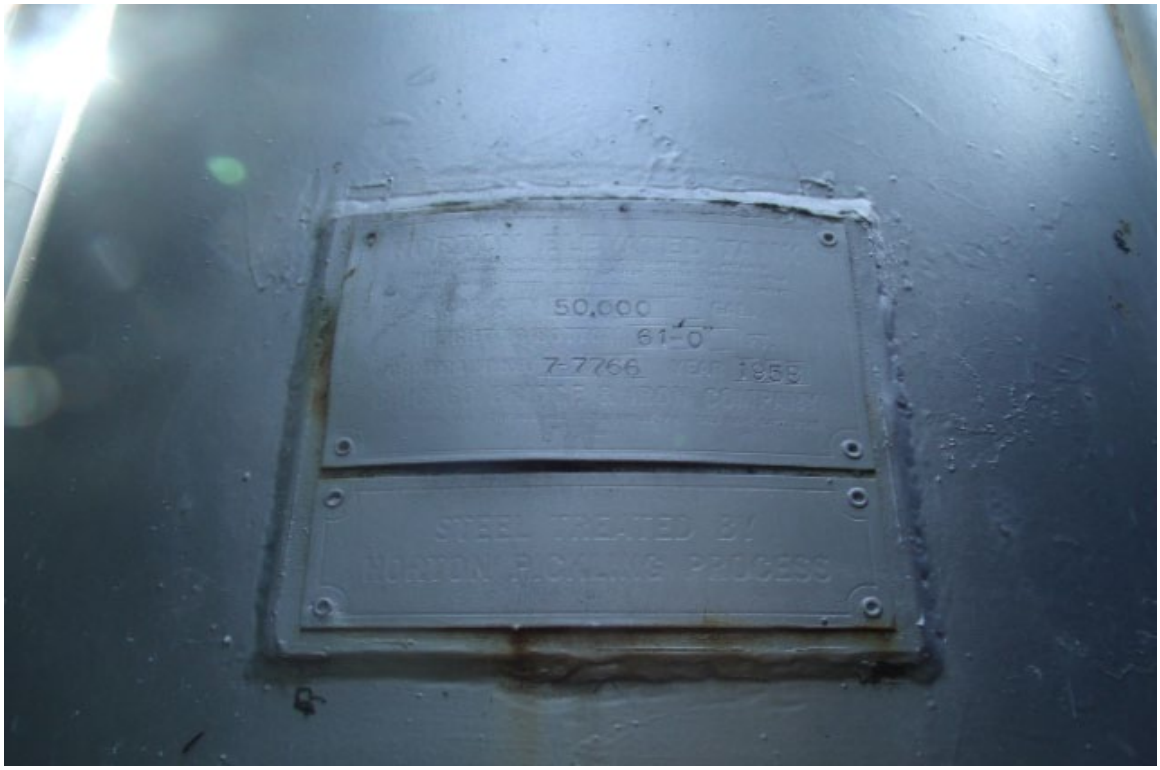


Photo shows the tank name plate. We recommend removing the name plate, cleaning the face of the plate, cleaning and repainting the area behind the plate, and remounting it.

Photo shows the base of the riser pipe. Currently there is no riser drain valve. A drain valve performs two functions it allows the tank to be drained and it is used as a blowout to remove silt and scale from the lower portion of the tank. We recommend installing a frost proof drain valve, complete with a locking device to prevent unauthorized draining of the tank and a splash pad to direct water away from the foundation.

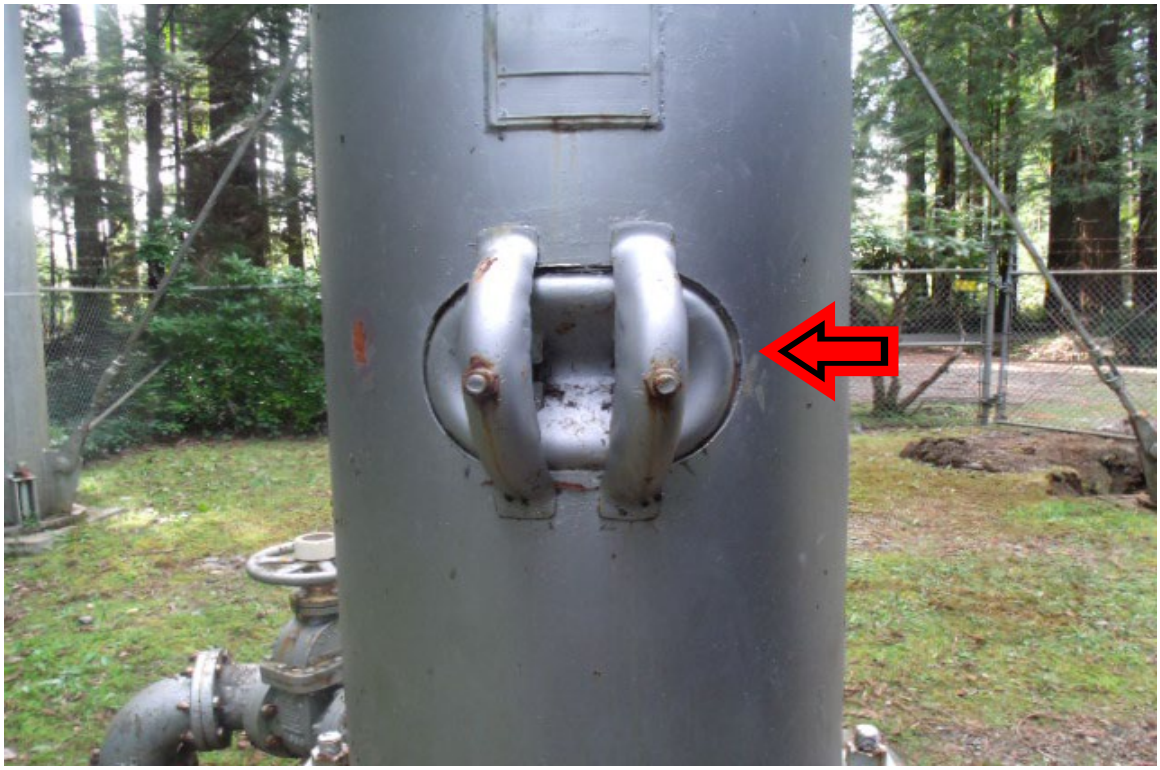


Photo shows the condition of the 16" X 12" riser manway. This manway would restrict entry in an emergency. We recommend replacing the existing riser manway with an AWWA D100-11; 5.4.4, approved 24" manway, complete with a davit arm, a **Confined Space Entry** sign and maintenance free galvanized steel bolts.

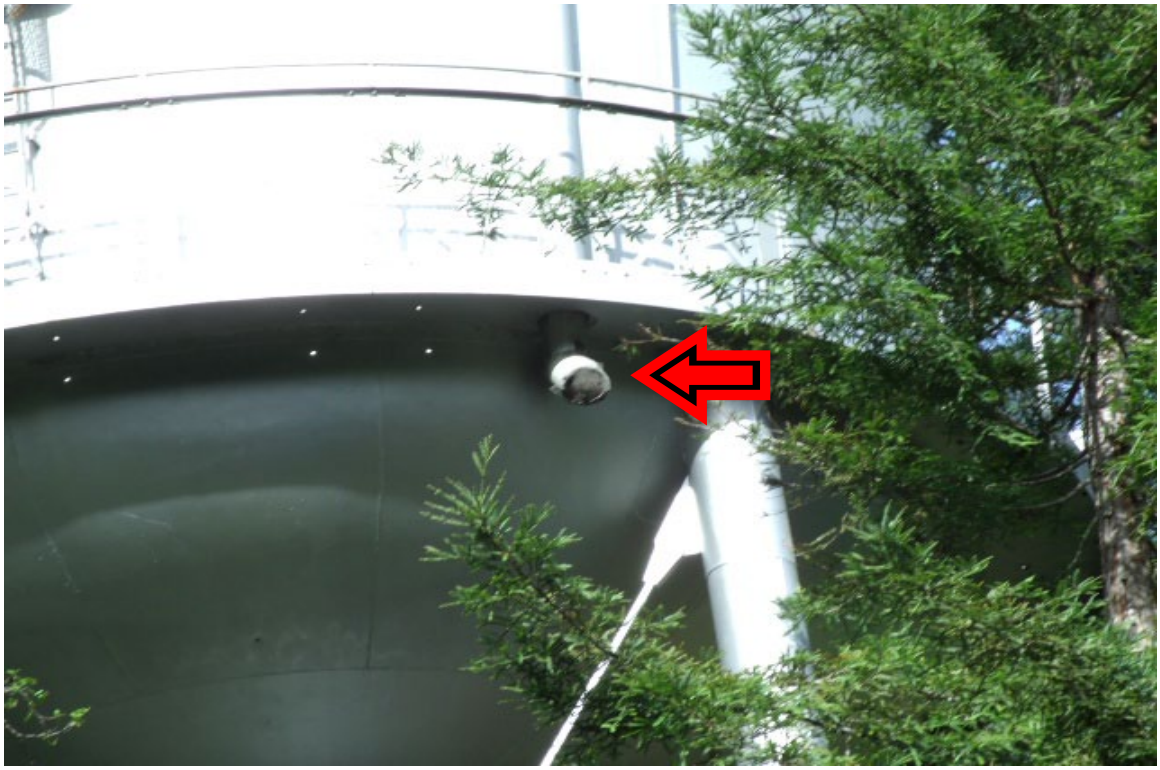


Photo shows the condition of the stub overflow pipe. The overflow pipe is not equipped with a flapper valve. We recommend extending the overflow down the exterior to grade with 8" pipe, complete with standoffs every 10' on center, an elbow at the base fitted with a flapper valve,and a new screen to prevent the ingress of contaminants into the water supply and a splash pad to direct water away from the foundation.

Photos show the tower access ladder is equipped with anti-skid rungs, but is only 13" wide. OSHA 19.27 Ladders states: "Minimum clear distance between the sides of individual rung/step ladders and between the side rails of other fixed ladders must be 16 inches (41 cm)." We recommend installing an approved tower access ladder complete with standoffs every 12' on center, a cable type ladder safety device, a lockable ladder guard to prevent unauthorized access and posting a **Fall Protection Required** sign.

Photos show the tower access ladder. OSHA 29 CFR 1926.1050-1060 states: "Fixed ladders with structural defects- such as broken or missing rungs, cleats or steps, broken or split rails or corroded components- must withdrawn from service until repaired." We recommend tagging out the tower access ladder on an emergency basis until it can be replaced by installing an approved, anti-skid rung equipped, access ladder, complete with standoffs every 12' on center, a lockable ladder guard, a cable type ladder safety device and posting a **Fall Protection Required** sign. **This replacement is an emergency repair.**

Photo shows the condition of the windage rods. The windage rods are in tune and appear to be properly adjusted.

Photo shows the condition of the strut end connections. We recommend reinforcing the strut ends by welding.

Photo shows the riser pipe and bowl connection which appears to be in good condition.

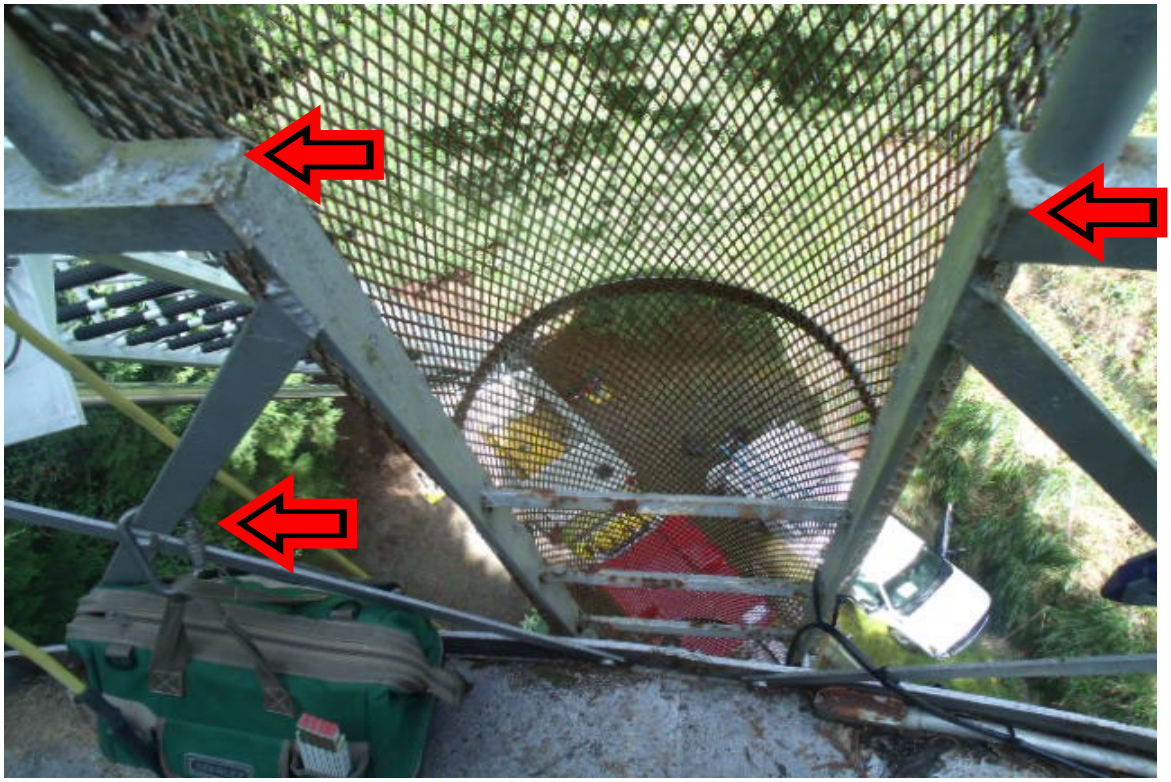
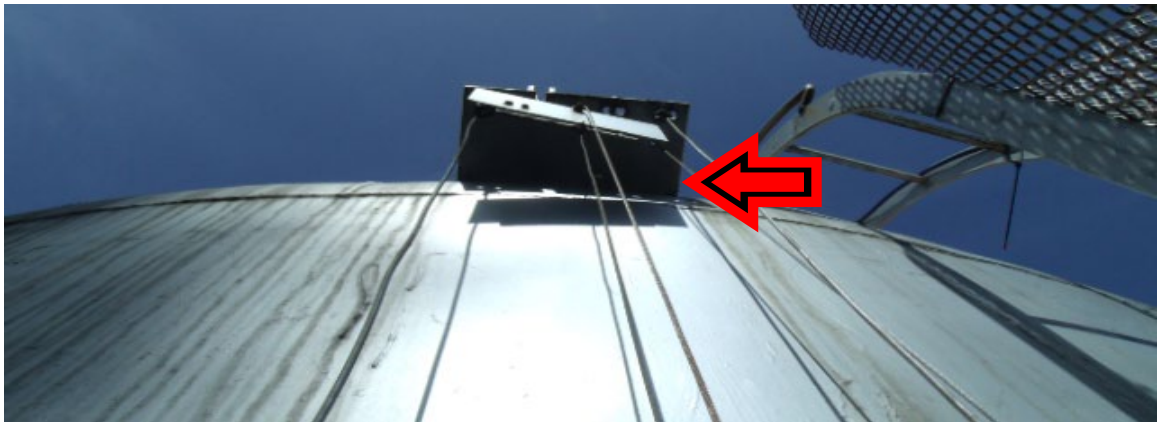
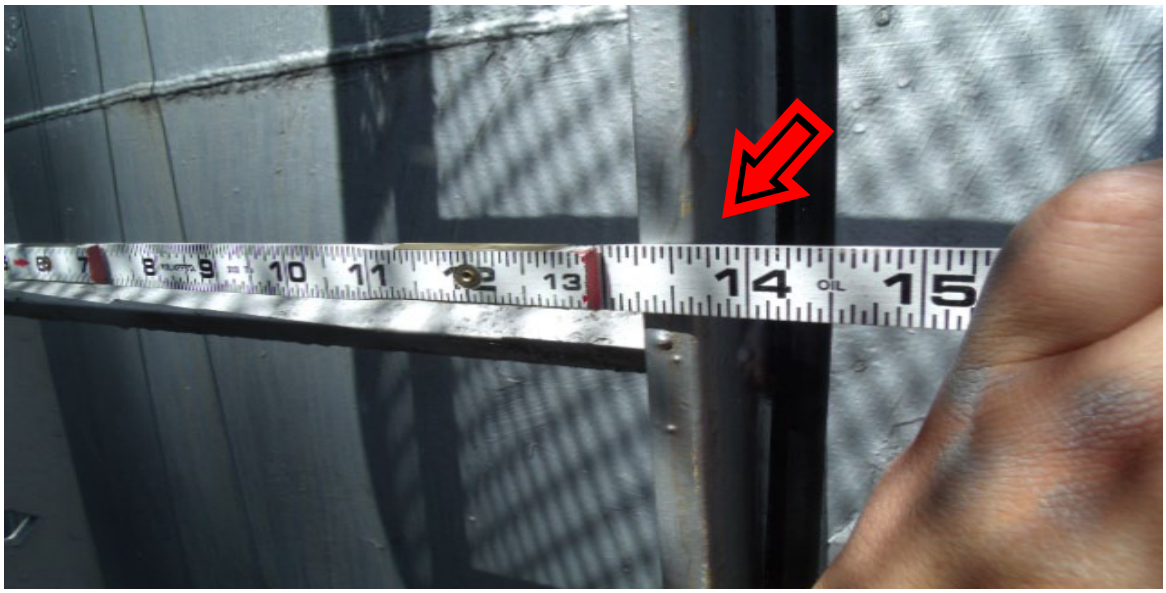


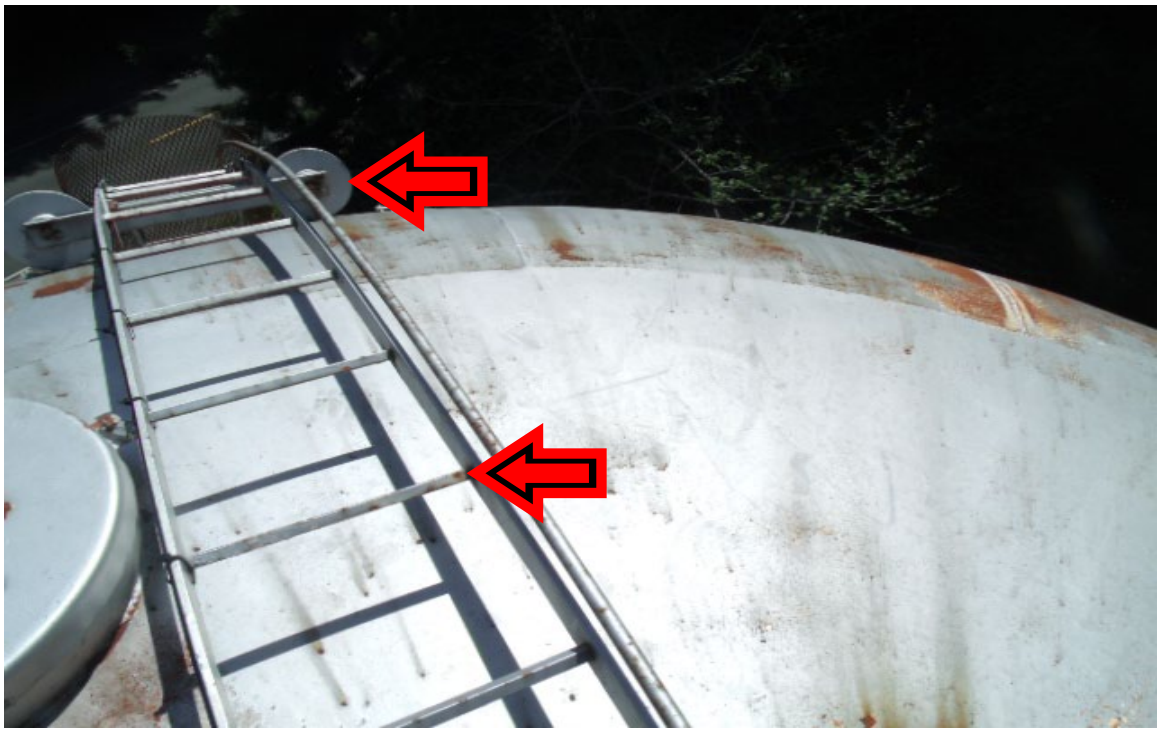
Photo shows the condition of the existing handrail system. The handrail is 48" tall but non-compliant with OSHA 29 CFR 1910.23(e)(1) due to absence of a mid-rail. We recommend installing a mid-rail and a stainless steel gate chain at the opening in the handrail at the junction of the tower access ladder and structural girder.

Photo shows the condition of the balcony floor. The arrow is pointing to show where water is ponding, causing deterioration of the paint and steel. We recommend drilling additional weep holes in the balcony floor to prevent ponding of water.



Photos show the condition of the liquid level indicator. We recommend cleaning and lubricating all moving parts on the liquid level indicator for preventative maintenance then adjusting and calibrating the unit.





Photos show the shell/roof access ladder is equipped with anti-skid rungs, but is only 13" wide and a roll-a-round type. OSHA 19.27 Ladders states: "Minimum clear distance between the sides of individual rung/step ladders and between the side rails of other fixed ladders must be 16 inches (41 cm)." We recommend installing an approved shell/roof access ladder complete with standoffs every 10' on center and a cable type ladder safety device.

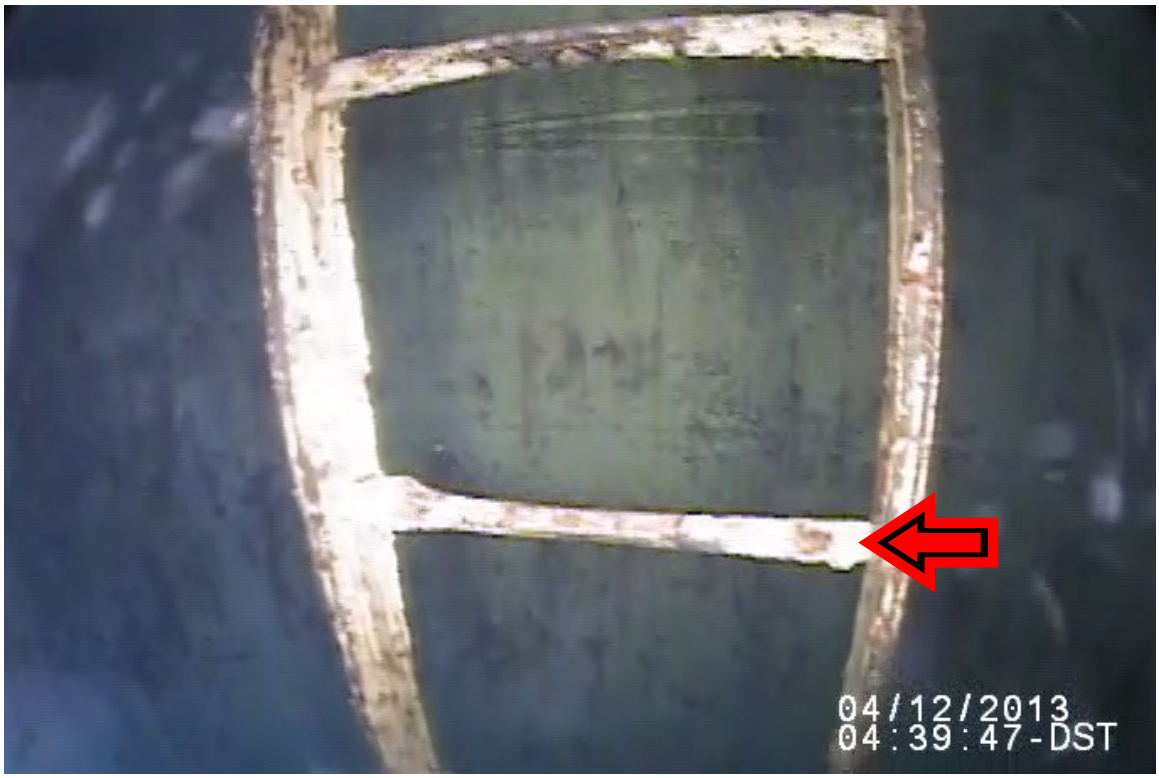
Photo shows the roof manway is compliant with AWWA D100-11; 5.4.3.1.roof openings. Roof openings on this tank require the following to be in compliance with OSHA 29 CFR 1910.23(a)(1).

We recommend:

Post a **Confined Space Entry** sign on roof manway
Install handrails around all roof openings
Install new lock on existing roof manway

Photos show the condition of the existing roof vent and screen. We recommend replacing the existing roof vent with a vacuum-pressure vent and screen.

Photos show the tank exterior coating system. We recommend pressure washing the tank exterior with biodegradable detergent injection (minimum 3,500 psi at 3.0 gpm) then remove all loose rust and scale with wire brushes and hand scrapers in accordance with SSPC#2 (hand tool cleaning), spot prime and apply one (1) finish coat of alkyd enamel.

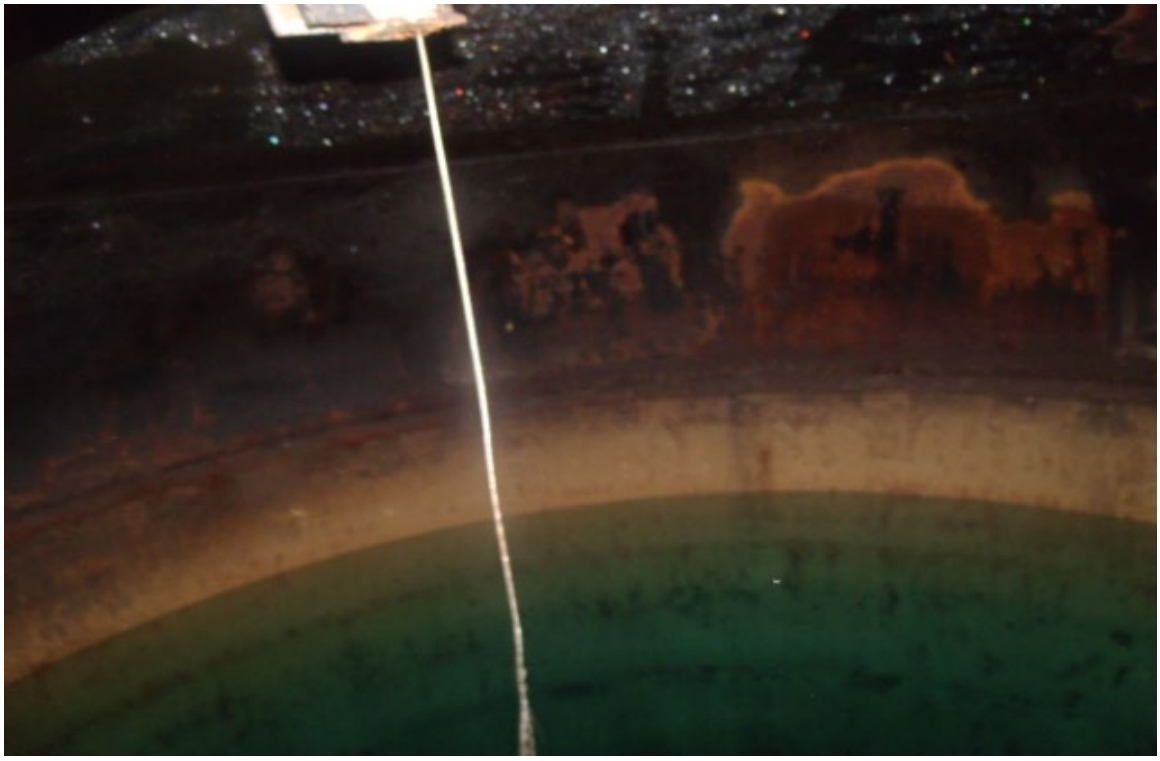


Interior access ladder in above photo is equipped with anti-skid rungs, but is only 13" wide. OSHA 19.27 Ladders states: "Minimum clear distance between the sides of individual rung/step ladders and between the side rails of other fixed ladders must be 16 inches (41 cm)." We recommend installing an approved interior access ladder complete with standoffs every 10' on center and a cable type ladder safety device.

Photo shows sediment and debris in the tank. We recommend that cleaning be performed in order to prevent contamination issues associated with excessive sedimentation buildup.

We also recommend installing a passive cathodic protection system on the interior of the tank.

Photo shows the condition of the riser pipe opening. The riser opening is not equipped with a safety grating in accordance with AWWA D100-11; 5.1.1 Safety grill and OSHA 29 CFR 1910.23(a)(1). We recommend installing an approved safety grating, designed for fall protection, over the riser opening.



Photos show the condition of the interior liner. We recommend sandblasting all the tank interior surfaces to an SSPC #10 (near white blast) condition, stripe coating all seams and welds, then applying an epoxy liner to achieve 8-10 mils of dry film thickness.

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ELEVATED TANK INSPECTION REPORT

JOB NO: 313142-C INSPECTOR: Shawn Potoka (JF)

TANK OWNER: City of Crescent City

OWNER'S REPRESENTATIVE: Tom Romesberg TITLE: Utilities Manager

MAILING ADDRESS: 900 10th Street

PHYSICAL ADDRESS: 900 10th Street

E-MAIL ADDRESS: tromesberg@crescentcity.org

CITY, STATE: Crescent City, CA ZIP: 95531

COUNTY TANK IS LOCATED IN: Del Norte

TELEPHONE: (661) 333-4134 CELL: (661) 333-4134

LOCATION OF TANK: Wonder Stump Road and 101

City of Crescent City
900 10th Street
Crescent City, CA 95531
April 12, 2013
Tom Romesberg,
Utilities Manager
(661) 333-4134

ORIGINAL CONTRACT NO: 7-7766 YEAR BUILT: 1958

ORIGINAL MANUFACTURER: CBI CAPACITY: 50,000 Gallon

DATE OF LAST INSPECTION: unknown TYPE: Potable

DIAMETER: 22'-0" HIGH WATER LEVEL: 79'-0"

LOW WATER LVL: 61'-0" HEAD RANGE: 28'-0"

TYPE CONSTRUCTION: WELDED: X RIVETED: _____ BOLTED: _____

ACCOUNT EXECUTIVE: Patrick Heltsley/M. Hoffman

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ELEVATED WATER STORAGE TANK CODE UPDATES

Item	Deficiency	Not-Applicable	Codes as Applicable
Lightning Protection	X		NFPA 780-2011 OSH Act 29 CFR 1926, Subpart K
Riser Manway	X		AWWA D100-11; 5.4.4
Manway Davit(s)		X	AWWA D100-11; 5.4.4
Confined Space Entry Signs	X		TSS Sec. 7 7.0.12 Safety OSHA 1910. Confined spaces
Tower Access Ladder	X		AWWA D100-11; 5.4.2.4 OSHA 1926.1053(a)
Safety Climb Devices	X		AWWA D100-11; 5.4.1 OSHA 29.CFR 1926.502
Standoffs on 10' Centers	X		AWWA D100-11; 5.4.1 OSHA 29.CFR
Structural Girder Handrails		X	AWWA D100-11; 5.4.2.5 OSHA 29 CFR 1910.23(a)(1)
Safety Chain in Handrail Opening	X		AWWA D100-11; 5.4.4.2.5 OSHA 29.CFR 1910.23(a)(1)
Screen on Overflow		X	AWWA D100-11; 5.3
Vent		X	AWWA D100-11; 5.5
Roof Manway		X	AWWA D100-11; 5.4.3
Interior Shell Ladders	X		AWWA D100-11; 5.4.2.6 OSHA 1926.1053(a)
Handrails Around Roof Openings	X		AWWA D100-11; 5.4.1 OSHA 29.CFR 1910.23(a)(1)
Safety Grating Over Riser	X		AWWA D100-11; 5.1.1 OSHA 29.CFR 1910.146, 1910.23(a)(1)

RECOMMENDATIONS

NUMBERS REFER TO PAGE NUMBERS

2. Remove all dirt, debris and loose gravel from the foundations, repair any cracks and spalling in the concrete with a commercial non-shrinking grout and sealing the foundations with sealant

   Electrically ground the tank for lightning protection

4. Clean the area around the anchor bolts, weld around the circumference of the bolt-to-nut and nut-to-anchor chair connections to reinforce, then weld steel plates, complete with grease fittings, over the anchor chair openings and fill the area around the anchor bolts with grease

5. Remove the tank name plate, clean the face of the plate, clean and repaint the area behind the plate, then remount it

6. Install a frost proof drain valve, complete with a locking device and a splash pad

7. Replace the existing riser manway with an AWWA, approved 24" manway, complete with davit arm, **Confined Space Entry** sign and maintenance free galvanized steel bolts

8. Extend the overflow down the exterior to grade, complete with stand-offs every 10' on center, install a flapper valve, and a new screen and a splash pad

9. Install an approved, anti-skid rung equipped, tower access ladder complete with stand-offs every 12' on center
   Install a cable type ladder safety climb device
   Install an aluminum lockable ladder guard to prevent unauthorized access
   Post a **Fall Protection Required** sign

10. Tag out deteriorating tower access ladder on an emergency basis

12. Weld the strut end connections to reinforce

14. Install installing a midrail and a stainless steel gate chain at the tower access ladder to catwalk entrance

RECOMMENDATIONS

NUMBERS REFER TO PAGE NUMBERS

15. Drill additional weep holes in balcony floor

16. Clean and lubricate all moving parts on the liquid level indicator, then adjust and calibrate the unit

17. Install an approved, anti-skid rung equipped, shell/roof access ladder complete with standoffs every 10' on center
    Install a cable type ladder safety climb device

18. Post a **Confined Space Entry** sign on roof manway
    Install handrails around all roof openings
    Install new lock on existing roof manway

19. Replace the existing roof vent with a vacuum/pressure vent and screen

21. Install an approved, anti-skid rung equipped, interior access ladder complete with standoffs every 10' on center
    Install a cable type ladder safety climb device

22. Clean tank out
    Install a passive cathodic protection system on the interior of the tank

23. Install an approved safety grating over riser opening

20. EXTERIOR COATING SYSTEM: Pressure wash the tank exterior with biodegradable detergent injection (minimum 3,500 psi at 3.0 gpm) then remove all loose rust and scale with wire brushes and hand scrapers in accordance with SSPC#2 (hand tool cleaning), spot prime and apply one (1) finish coat of alkyd enamel

RECOMMENDATIONS

NUMBERS REFER TO PAGE NUMBERS

24. INTERIOR COATING SYSTEM: Sandblast all the tank interior surfaces to an SSPC #10 (near white blast) condition, stripe coating all seams and welds, then applying an epoxy liner to achieve 8-10 mils of dry film thickness

Pittsburg Tank & Tower can perform all work recommended in this report.

BASED ON THE NUMBER OF ITEMS ACCEPTED, PRICES MAY VARY.
All prices are in USD
If union labor or prevailing wage is required please advise
For additional copies of this inspection report call (270) 826-9000, Ext. 253.

The inspection report and comments reflect the general condition of the tank. However, we can not guarantee that additional deficiencies may not become apparent during the cleaning, repair or paint process of the tank.

This tank may not be consistent with seismic zone requirements for this type of structure in this zone. Consideration should be given to performing a structural analysis to determine if any changes are needed to meet design requirements.

The handling, removal and/or disposal of hazardous or contaminated materials such as asbestos, lead, chemical or any like substance that requires special handling is not included in the price submitted for work herein. Paint prices do not include logo, lead abatement or containment.

Client Sample Results

Client: Pittsburg Tank &Tower Maintenance Co Inc
Project/Site: City of Crescent City

TestAmerica Job ID: 490-25473-1
SDG: 313142, Crescent City, CA

2

Client Sample ID: INT-50,000 EWT

Date Collected: 04/12/13 09:15
Date Received: 04/30/13 08:30

Lab Sample ID: 490-25473-1
Matrix: Paint Chip

Method: 6010B - Metals (ICP)

Analyte	Result	Qualifier	RL	MDL	Unit	D	Analyst	Analyzed	Dil Fac
Lead	2.14		0.00996		Percent		KJ	05/02/13 09:29	10

Client Sample ID: EXT-50,000 EWT

Date Collected: 04/12/13 11:50
Date Received: 04/30/13 08:30

Lab Sample ID: 490-25473-2
Matrix: Paint Chip

Method: 6010B - Metals (ICP)

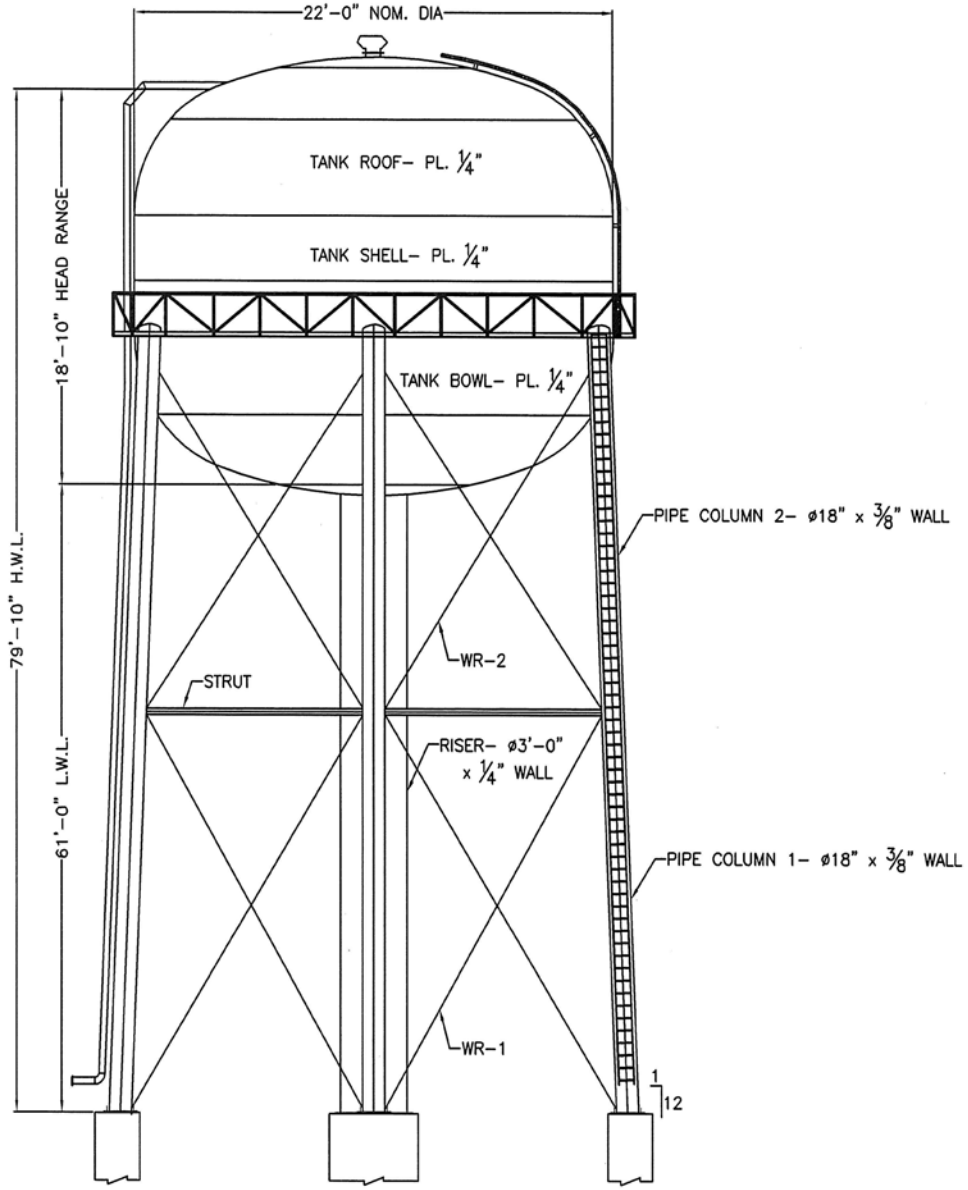
Analyte	Result	Qualifier	RL	MDL	Unit	D	Analyst	Analyzed	Dil Fac
Lead	19.3		0.00996		Percent		KJ	05/02/13 09:33	100

RECEIVED
MAY 11 2013
Pittsburg Tank & Tower

Lead Test	Interior	Exterior
	POSITIVE	POSITIVE
Adhesion Test		
Exterior	A3 @ 10.8 mils	
Interior	A1 @ 2.3 mils	

Mil-T Paint Thickness Test

Roof	9.1	9.0			Riser	11.0	8.1	14.5			
	16.8	9.5				12.5	14.3	12.6			
	12.1	10.3	13.2			19.9	9.4				
	13.3	17.3	7.1								
	17.1	6.5	6.8								
	10.2	6.9	6.0								
Course											
Shell 2	20.2	19.2	25.2	18.3	18.1	18.1	20.9	24.4	20.6	23.0	
Shell 1	25.1	15.5	23.8	23.1	22.4	18.9	15.4	18.4	15.9	19.5	
Columns	1			2			3			4	
	12.7	12.2		19.1	12.5		16.7	15.1		10.3	10.8
	10.1	13.5		10.3	15.0		11.3	13.9		11.1	13.6
	11.1	10.2		14.3	13.8		13.8	13.4		10.5	10.8
	11.0	8.2		14.1	10.4		12.7	16.8		11.9	13.3



DRAWING INDEX	
DRAWING NO,	DRAWING NAME
OV	TANK OVERVIEW
WRD	WINDAGE ROD DETAIL
SD	STRUT DETAIL
CPD	CONNECTION PLATE DETAIL
FND	COLUMN FOUNDATION DETAIL

REVISION BLOCK			
NO.	DATE	BY	REVISION

TANK OVERVIEW

DRAWN BY:	MW
DATE:	5/1/13
CHECKED BY:	MW
APPROVED BY:	

CITY OF CRESCENT CITY
50,000 GALLON E.W.T.
CRESCENT CITY, CA

JOB NO:	313142
PROJ. MGR.:	PH
DWG. NO.:	OV
SCALE:	NONE

SINCE 1919

PITTSBURG TANK & TOWER
MAINTENANCE CO, INC.
HENDERSON, KENTUCKY

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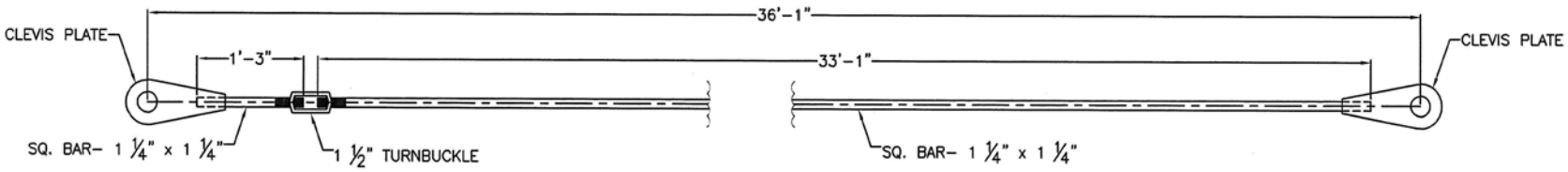
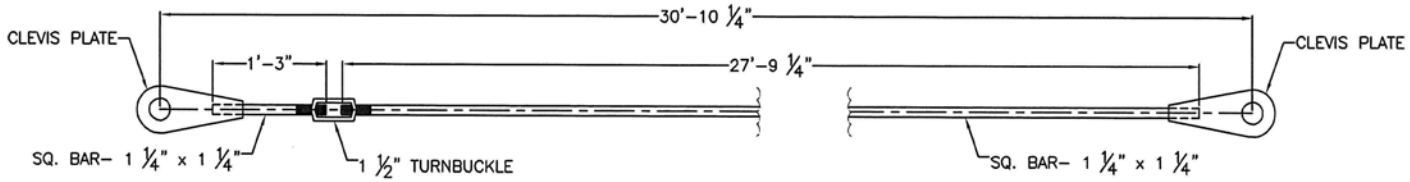


WR-1



WR-2

REVISION BLOCK			
NO.	DATE	BY	REVISION

WINDAGE ROD DETAIL	
DRAWN BY:	MW
DATE:	5/1/13
CHECKED BY:	MW
APPROVED BY:	

CITY OF CRESCENT CITY 50,000 GALLON E.W.T. CRESCENT CITY, CA	
JOB NO:	313142
PROJ. MGR.:	PH
DWG. NO.:	WRD
SCALE:	NONE

SINCE 1919

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MAINTENANCE CO, INC.
HENDERSON, KENTUCKY

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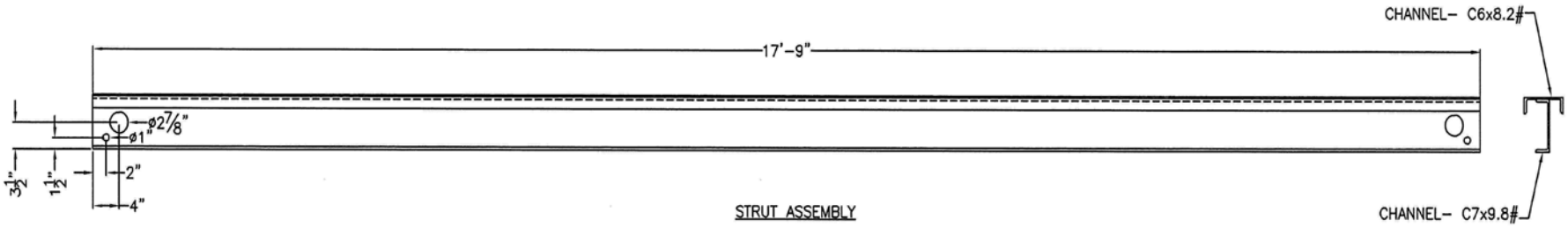

STRUT ASSEMBLY

REVISION BLOCK			
NO.	DATE	BY	REVISION

STRUT DETAIL		CITY OF CRESCENT CITY, CA 50,000 GALLON E.W.T. CRESCENT CITY, CA	
DRAWN BY:	MW	JOB NO:	313142
DATE:	5/1/13	PROJ. MGR.:	PH
CHECKED BY:	MW	DWG. NO.:	SD
APPROVED BY:		SCALE:	NONE

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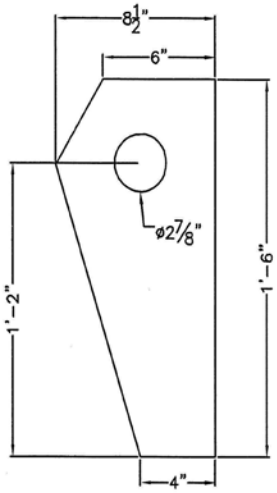
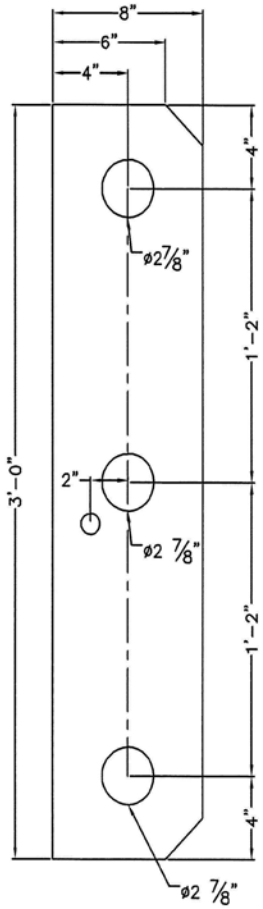
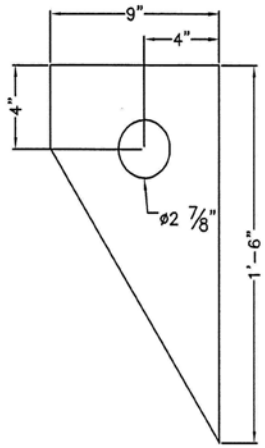


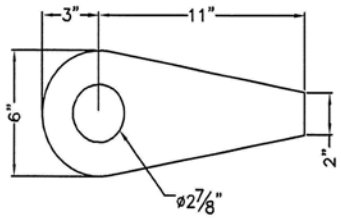
LOWER WING PLATE
PL- ½" THK.



INTERMEDIATE WING PLATE
PL- ½" THK.



UPPER WING PLATE
PL- ½" THK.



CLEVIS PLATE
PL- ½" THK.

REVISION BLOCK			
NO.	DATE	BY	REVISION

CONNECTION PLATE DETAIL

DRAWN BY:	MW
DATE:	5/1/13
CHECKED BY:	MW
APPROVED BY:	

CITY OF CRESCENT CITY
50,000 GALLON E.W.T.
CRESCENT CITY, CA

JOB NO:	313142
PROJ. MGR.:	PH
DWG. NO.:	CPD
SCALE:	NONE

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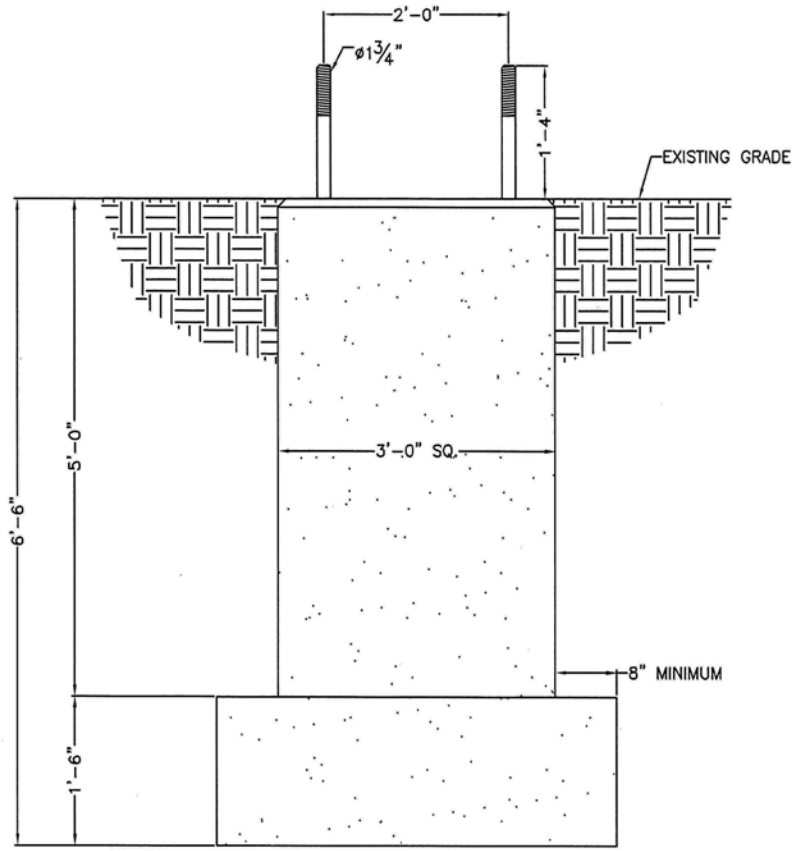

TYPICAL COLUMN FOUNDATION

REVISION BLOCK			
NO.	DATE	BY	REVISION

CONNECTION PLATE DETAIL

DRAWN BY: MW	JOB NO: 313142
DATE: 5/1/13	PROJ. MGR.: PH
CHECKED BY: MW	DWG. NO.: CPD
APPROVED BY:	SCALE: NONE

CITY OF CRESCENT CITY
50,000 GALLON E.W.T.
CRESCENT CITY, CA

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http://www.watertank.com Email: sales@watertank.com

May 16, 2014 **Revision 1**

Mr. Tom Romesberg
Utilities Manager
City of Crescent City
900 10th Street
Crescent City, CA 95531
661-333-4132
661-333-4134 Cell
tromesberg@crescentcity.org

Tom,

We are pleased to provide you with a quotation to repair and recoat one (1) 50,000 gallon elevated storage tank located at Wonder Stump Road and 101 – Tank C.

Pittsburg has been serving the nation's tank needs for more than ninety years and our fully equipped and experienced crews specialize in all the services listed above in our letterhead. **We are a veteran owned company.**

We will furnish ten million dollars ($10,000,000) worth of insurance for our mutual protection.

To accept our proposal, just sign and return one (1) copy to our Henderson, Kentucky office.

Respectfully,
Pittsburg Tank & Tower Maintenance Co., Inc.

Patrick Heltsley
VP of Specialty Projects
270-826-9000 ext 253
270-748-1325 Cell
pheltsley@watertank.com

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http://www.watertank.com Email: sales@watertank.com

DATE: May 16, 2014 **Revision 1**

TO: City of Crescent City
900 10th Street
Crescent City, CA 95531
EMAIL: tromesberg@crescentcity.org

ATTN: Mr. Tom Romesberg
Utilities Manager
PHONE: 661-333-4132
CELL: 661-333-4134

In accordance with price, terms and conditions quoted below, we propose to furnish all labor, material, equipment and insurance necessary to complete the following to **one (1) 50,000 gallon elevated storage tank located at Wonder Stump Road and 101 – Tank C:**

SCOPE OF WORK

$2,400	Electrically ground the tank for lightning protection
$2,800	Install a frost proof drain valve, complete with a locking device and a splash pad
$6,450	Replace the existing riser manway with an AWWA approved 24" manway, complete with davit arm, **Confined Space Entry** sign and maintenance free galvanized steel bolts
$15,800	Extend the overflow down the exterior to grade, complete with standoffs every 10' on center, install a flapper valve, a new screen and a splash pad
$14,750	Tag out deteriorating tower access ladder on an **EMERGENCY** basis Install an approved, antiskid rung equipped, tower access ladder complete with standoffs every 12' on center Install a cable type ladder safety climb device Install an aluminum lockable ladder guard to prevent unauthorized access Post a **Fall Protection Required** sign
$3,000	Weld the strut end connections to reinforce
$5,600	Install a mid-rail around circumference of catwalk handrail and a stainless steel gate chain at the tower access ladder to catwalk entrance
$2,000	Drill additional weep holes in balcony floor
$1,000	Clean and lubricate all moving parts on the liquid level indicator, then adjust and calibrate the unit
$8,800	Install an approved, antiskid rung equipped, shell/roof access ladder complete with standoffs every 10' on center Install a cable type ladder safety climb device
$8,200	Post a **Confined Space Entry** sign on roof manway Install handrails around all roof openings Install new lock on existing roof manway

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$6,800	Replace the existing roof vent with a vacuum/pressure vent and screen
$7,200	Install an approved, antiskid rung equipped, interior access ladder complete with standoffs every 10' on center Install a cable type ladder safety climb device
No Charge W/ Interior Coating System	Clean tank out
$8,500	Install a passive cathodic protection system on interior of the tank
$3,400	Install an approved safety grating over riser opening
$52,400	EXTERIOR COATING SYSTEM: Pressure wash the tank exterior with biodegradable detergent injection (minimum 3,500 psi at 3.0 gpm) then remove all loose rust and scale with wire brushes and hand scrapers in accordance with SSPC#2 (hand tool cleaning), spot prime and apply one (1) full intermediate coat of epoxy mastic and one (1) full finish coat of polyurethane
$50,500	INTERIOR COATING SYSTEM: Sandblast all tank interior surfaces to an SSPC#10 (near white blast) condition, stripe coating all seams and welds, then applying an epoxy liner to achieve 8-10 mils of dry film thickness

The following are seismic upgrades with BUDGET pricing:

$115,000	Wing plate modifications/ anchor bolts with anchor chairs/ strut welding/ angled bracing.
$80,000-$140,000	New foundation modifications

DEPENDING ON THE NUMBER OF ITEMS ACCEPTED PRICES MAY VARY.

IN THE EVENT INTERIOR AND/OR EXTERIOR COMPLETE TANK REPAINTING IS NOT INCLUDED IN THIS SCOPE OF WORK, ALL NEW TANK APPURTENANCES FURNISHED AND INSTALLED BY PITTSBURG TANK & TOWER MAINTENANCE CO. INC AS PART OF THIS SCOPE OF WORK SHALL BE FIELD PRIMED AND FINISH COATED TO MATCH EXISTING COATING SYSTEM(S). COLOR TO MATCH AS CLOSE AS POSSIBLE.

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CONTRACTOR FURTHER AGREES

- If needed a pressure release valve will be furnished during the cleaning and painting operation.
- Handling, removal, and/or disposal of hazardous or contaminated material (e.g., asbestos, lead, chemicals, etc.) requiring special handling or transportation to a specific disposal site are not included in the submitted quotation for work.
- This quote does not provide for the shrouding or containment of blast media and paint.
- If necessary, Customer will be required to clear/move vehicles and equipment a safe distance from the job site to prevent damage and place physical barricades around the perimeter to restrict access.
- Owner understands and agrees any Federal, State, and Municipal taxes imposed on Contractor with respect to the outlined work are additional expenses not included in the contract and further assumes the obligation of paying said additional costs incurred by Contractor.
- This contract is governed by the laws of the Commonwealth of Kentucky and any claims should be filed with the Commonwealth of Kentucky.
- Warning: Do not attach any additional loading to your tank/tower unless structural integrity is known to be sufficient. For analysis call Pittsburg Tank & Tower Maintenance Co., Inc.

QUALITY CONTROL

- All labor will be provided by mechanics skilled in their trade.
- All workmanship is guaranteed for twelve (12) months after completion.
- No paint shall be applied during wet, damp, or inclement weather.
- All paint will be delivered to the job site in original containers with contents identified by the manufacturer.

INSURANCE

Prior to start of work, Owner will be furnished a certificate of insurance covering Workman's Compensation, Occupational Disease, Employer's Liability, and Public Liability.

TERMS

50% With Order; Balance Upon Completion OR Mutually Agreed Payment Terms

MasterCard, Visa and American Express are accepted

The parties approving this contract certify that they are fully authorized to do so, and that all legal requirements have been complied with. You are hereby authorized to furnish all labor, material, equipment and insurance required to complete the work mentioned in the above proposal, for which the undersigned agrees to pay the amount mentioned in said proposal and according to the terms thereof. In the event purchaser fails to abide by the terms and conditions of the contract requiring Pittsburg Tank & Tower Maintenance Co, Inc to collect on amounts due and owing, purchaser agrees to pay all attorney fees and all costs incurred by Pittsburg Tank & Tower Maintenance Co, Inc to secure said payments from purchaser.

ALL QUOTATIONS SUBJECT TO ACCEPTANCE WITHIN 60 DAYS

Accepted: _____, 20_____ **Respectfully Submitted by:**

City of Crescent City, CA **PITTSBURG TANK & TOWER MAINTENANCE CO, INC.**

By:_____ **By: _____**

Title: _____ **Don Johnston, President**

Please visit our web site at www.watertank.com

3911 West Capitol Avenue
West Sacramento, CA 95691-2116
(916) 371-1690
(707) 575-1568
Fax (916) 371-7265
www.taberconsultants.com

DRAFT GEOTECHNICAL INVESTIGATION

Proposed Elevated Water Tank
Wonder Stump Road near Highway 101
Crescent City, California

City of Crescent City
Client

1P1/306/043
41124-G2:322N;050W

June 2006

Ta bee Consultants
Engineers and Geologists

DRAFT GEOTECHNICAL INVESTIGATION

Since 1954

Proposed Elevated Water Tank
Wonder Stump Road near Highway 101
Crescent City, California

1P1/306/043

Introduction

A study of subsurface materials and conditions has been completed at the above site in accordance with the agreement between the City of Crescent City and Taber Consultants. The purpose of this study is to provide geotechnical criteria for use in design and construction of the proposed elevated water tank.

This report is submitted as a draft. We expect to incorporate subsequent design development and review comments in a "final" report. Limitations of this study are discussed herein and in the attached "General Conditions."

Site Description

The site is located about 50 feet east of Wonder Stump Road about 250 feet south of the intersection with Highway 101 north of Crescent City, California. The USGS $7^1/2$' "Crescent City" topographic quadrangle (see Figure-1) shows the site location; typical natural ground surface near the site is relatively level and is shown at elev. 120±. At the request of Mr. Wier with the city of Crescent City, an assumed elevation of 100.0 ft is to be assumed at the southwest corner of the concrete pad beneath the northwest support column of the existing elevated tank at the site. All elevation references below are based on this assumed datum.

The existing tank and associated small equipment shed are surrounded by a chain-link fence; these features will be removed during/after construction of the proposed tank. We understand the existing tank and pipes need to remain in service until construction of the new tank is completed. The project site was relatively level as crushed rock and gravelly fill materials had been placed by the City to facilitate drill rig access to the boring locations at the proposed tank site. A shallow (less than 2±ft in depth) seasonal drainage swale was noted immediately north of the project site. The site is located in a wooded area with no other above-grade structures in the immediate project vicinity.

Project Description

We understand that the major element of the proposed project is a new pre-engineered, metal, 150,000 gallon elevated water tank. The proposed tank will be located immediately to the north of the existing elevated 50,000 gallon water tank and equipment shed. Dimensions of the proposed tank are currently unknown. The tank is reportedly to be supported on four support columns (legs), similar to the existing tank.

Based on the loading information provided by Mr. Wier, we understand a total dead+live load of approximately 1,800 kips (about 450 kips/leg). Grading is anticipated to be limited (typically less than 2±feet cut/fill) — sufficient to construct a relatively level pad with positive drainage away from the proposed structure/improvements near elev. 100±ft. Consideration will reportedly be made to retain the referenced drainage feature through the site, either by routing it around the proposed tank or using a buried pipe to transport water across the site.

Exploration and Testing

Information on the nature and distribution of subsurface materials and conditions was obtained for this study by means of three sampled auger/rotary drilled test boring penetrating to maximum depth 59±ft below ground surface (to elev. 40±).

Soil samples were recovered by means of 2.0-inch OD "standard penetration" (per ASTM D1586) and 2.5-inch I.D. "split-spoon" samplers advanced with standard 350 ft-lb hammer to provide a field estimate of soils consistency. Sampler penetration resistance can be correlated to soil strength and bearing characteristics. Bulk soil samples were also obtained from auger cuttings.

The boring was logged and earth materials field-classified by an engineer as to consistency, color, gradation and texture on the bases of sampler penetration resistance, examination of samples and observation of drill cuttings. Groundwater observations were made in borings during drilling operations. At completion of field

study, the test boring was backfilled with lean cement grout per Del Norte County Environmental Health requirements.

Portions of drive samples were retained in moisture-proof containers for laboratory testing and reference. Laboratory testing on selected samples included engineering classification, moisture content-dry density, corrosivity, compressibility, unconfined compressive and direct shear strength determinations.

The test borings were performed at/near the locations identified by the City of Crescent City (Figure-2). Details of the borings and results of tests are shown on the attached Figures 3 and 4. R. E. Loutzenhiser was the engineer for this field study.

Earth Materials and Foundation Conditions

Soils encountered in the test borings can be divided into two generalized units considered significant to proposed structure.

Native near-surface Unit I soils consist mostly of semicompact to compact silty sand, overlain by about 2±ft of crushed rock and silty/clayey gravel fill. The base of Unit I soils was found at about elev. 76-77± (23-24±ft depth). Soil strength varies significantly in Unit I materials. In general, Unit I soils are considered weak and compressible under more than nominal loading. Some Unit I soils are also in the range of texture and consistency considered to be potentially liquefiable in an earthquake.

Underlying Unit soils were penetrated to the maxi-mum depth -explored of 59±ft (elev. 40±) and predominantly consist of dense silty sand and very stiff clay, with a 5±ft thick soft clay layer noted in boring B-1 at a depth of about 33±ft (elev. 66±). A similar clay layer with very stiff consistency was encountered in boring B-2 at a similar elevation. Subject to the limitations of the soft to stiff clay layer, Unit II soils are considered to be capable of developing support for planned foundation loading without excessive settlement.

Free groundwater level was measured in boring B-1 at about elev. 97.5 (1.5± ft depth). Laboratory moisture-density test results indicate that soils are saturated for the

entire depth of exploration. Borings for this investigation were performed late in a wet season and groundwater depth could vary seasonally. Groundwater level data from the Department of Water Resources website (http://wdl.water.ca.gov/gw/ as accessed on 4/4/06) for several wells in the general project vicinity shows groundwater varying from about 0.5 to over 15 ft below existing site grade.

Corrosivity

Laboratory testing in accordance with CTM 643, CTM 422 and CTM 417 indicates soil pH of 5.9 to 6.4; minimum resistivities of 5,360 ohm-cm to 18,490 ohm-cm; chloride content of 6.9 ppm to 14.7 ppm and sulfate content of 1.9 ppm to 27.0 ppm. Test results are shown on Figure-4. These results indicate a "non-corrosive" soils environment for both concrete and steel foundations in contact with the ground (per Caltrans "Corrosion Guidelines", September 2003).

Seismicity

The site is located within 2001 California Building Code (CBC) Seismic Zone 4 with the nearest fault >15 km from the site. The 2001 CBC near-source factors for Zone 4, Soils Profile Type SD with the nearest fault >15 km from the site are $N_a=N_v=1.0$, with the corresponding seismic coefficients of $C_a=0.44$ and $C_v= 0.64$.

The American Water Works Association's "AWWA Standard for Welded Steel Tanks for Water Storage" (ANSI/AWWA D100-96) recommends a Zone Coefficient (Z) of 0.40 for a site in Seismic Zone 4 and a Site Amplification Factor (S) of 1.5 based on a conservative selection of "C" for the Soil Profile Type.

Deterministic assessment performed using the EQFAULT computer program indicates a mean peak horizontal site acceleration of about 0.45g is likely from a nearby maximum magnitude event.

A probabilistic ground motion value determination for the site was obtained from the USGS website (http://eqint.cr.usgs.gov/eq-men/html/lookup-2002-interp-06.html as accessed on 6/8/06). An interpolated peak ground acceleration of about 0.27g is

anticipated based on a 10% probability of exceedance, (PE), in 50 years (a return period of 475 years). The probabilistic zero period peak ground acceleration was also calculated using the attenuation relationship developed by Sadigh, et. al. (1997). Calculation was performed in the FRISKSP (Version 4.00) computer program (Blake, 2000) and yielded an acceleration of 0.39g.

Copies of the EQFAULT, USGS website and FRISK outputs are attached. We recommend the use of the AWWA code values for tank design, as they appear to coincide fairly well with the deterministic and probabilistic values.

Liquefaction & Ground Stability

Unit I soils are in the range of texture and consistency considered liquefiable (predominantly semicompact saturated sand). The amount of Unit I materials which could liquefy in a seismic event would correspond to the groundwater elevation at the time of the event. Liquefaction is unlikely in Unit II materials due to soil texture and consistency.

Sandy soils that liquefy in an earthquake (or come close to liquefaction) will lose strength and bearing capacity, resulting in loss of foundation support. Such soils can also be expected to densify and/or form sand boils, which can result in settlement and differential settlement at ground level. Liquefaction analysis indicates that unimproved Unit I materials may settle as much as 3±inches in a major seismic event (peak ground acceleration of about 0.40g) with differential settlement on the order of 2±inches. Preliminary calculations suggest that lateral spreading of native soils would probably not occur in the event of a major seismic event.

Improvement of Unit I materials during construction (full-depth overexcavation and recompaction, deep soil mixing, compaction grouting) could essentially eliminate the potential for liquefaction beneath the tank in Unit I materials and allow for structure support on shallow foundations. A lower level of mitigation that could permit severe distress at this hazard level without collapse is assumed to be unacceptable for this facility.

Alternatively, the use of a deep foundation system (driven piles, geopiers) would help transfer the structure loads to competent (non-liquefiable) soils without requiring extensive earthwork operations.

Conclusions

The site is considered adequately stable with soil support available for proposed structure by implementing the recommendations in this report. We expect seismic loading conditions to control foundation design. Given the high groundwater level at the site, proximity of the adjacent existing improvements, and probable high mobilization cost for soil mixing/grouting operations, implementation of ground improvement options appear problematic. Therefore, we anticipate that deep foundations will be used to support the proposed water tank. Recommendations for driven piles are provided below.

Driven piling for this project could take the form of displacement (precast concrete or timber) piles or friction (steel pipe or "H") piles. Given the dense sandy soils present at approximate 37±ft depth (elev. 62±, below the soft-stiff silty clay layer), we recommend the use of precast concrete displacement piles to generate support through end-bearing as well as friction. We would recommend the use of a "standard" Caltrans pile to reduce cost and increase pile availability. Recommendations are provided for 14-inch square precast prestressed concrete piles. Recommendations for alternate pile sections and loads are available based on data available in-hand.

We would anticipate that compacted/rammed aggregate piers (geopiers) could be a technically feasible option and would need to extend to a depth of about 20-25±ft (elev. 75-80±). If desired, specific recommendations for geopier design and construction can be obtained from a contractor proficient in geopier installation.

Cast-in-drilled-hole (CIDH) piling is also a technically feasible foundation alternative at this site, however the presence of groundwater and caving soils would be expected to require the use of "wet" installation methods such as casing, slurry, and tremie pour.

The use of a pile foundation would not require excavation and replacement or other improvement of the existing soils, however such earthwork would improve lateral resistance (passive soil pressure) at piles and pile caps/footings and is recommended.

Recommendations

Precast Concrete Piles

Design (service) loads for 14-inch square precast prestressed concrete (Class 100, Alternative "X" per Caltrans) piles penetrating into Unit II materials are given in the table below. No specific tensile demands have been indicated (and are not anticipated for static loading conditions), however such piles are capable of developing significant tensile resistance under seismic loading conditions (as noted). A 1/3 increase in axial (compression) loading capacity for wind and/or seismic loading is allowable.

No lateral loading conditions have been provided. If piles are battered, use the vertical component of the batter for axial capacity calculation (i.e., for a 3:1 (V:H) batter use 95% of vertical pile capacity for a pile with the same Specified Tip Elevation). Horizontal capacity in this instance (3:1 batter) would be about 31% of the axial capacity.

The free-head pile stiffness (K) is estimated as 24 kips/inch for the 14-inch square section given above for the non-liquefied condition. This value is based on a

---

maximum deflection of 1 inch. This is a conservative approach based on loose sand conditions in Unit I materials. For liquefied Unit I materials, very little lateral support would be available for the piles and free-head pile stiffness of 4 kips/inch is estimated. More detailed "p-y curve" analysis of pile response to lateral loading can be developed based on a defined pile layout and loading conditions.

We assume that pile caps will be on the order of 3±ft thick (bottom of pile cap at elev. 97±). A passive soil resistance based on 425 pcf for engineered fill may be used for pile cap design. Minimal, if any, passive soil resistance would be available during a seismic event in the loose native sand if earthwork is not performed. No base friction

component is available for pile caps/foundations due to the potential for soil settlement during a seismic event.

Piles should have a minimum spacing of three pile diameters (center-to-center) to reduce the possibility for a "group effect" on lateral pile capacity.

Based on the foregoing, the following table has been developed. This office should be consulted in the event that changes in pile type, cut-off elevation and/or loading are required or if tensile and/or lateral loads need additional consideration.

Type	Design Loading	(allowable load)	Specified Tip
	Compression	Tension	Elevation
14" square Class 100 precast concrete	100 tons	34 tons	55

All piles should be specified to penetrate to or below Specified Tip Elevation and should exhibit required "ultimate" bearing per the Gates formula at final penetration. For implementation of the Gates Formula on this project, an "ultimate" driving resistance value of 700 kips should be used for "100 ton" piles.

Assuming adequate materials and workmanship, piling meeting effective "refusal" within 3-ft above STE may be considered acceptable without specific review by this office. For this purpose, "refusal" may be considered as at least twice required formula bearing in the last foot or three times the required bearing within the last 3- inches of driving.

Predrilling is not required or recommended due to the presence of very loose to loose sandy Unit I materials and shallow groundwater. Some hard driving may be encountered in the upper 8-10 feet of Unit II materials (elev. 67-75±) but is not expected to prevent driving the piles to the given Specified Tip Elevation given appropriate hammer selection.

Settlement and differential settlement under service and seismic loads is expected to be less than 1/2-inch for a pile foundation system.

Earthwork

All earthwork should be performed in accordance with applicable codes and the attached "Guide Specification" as modified below.

The areas to be graded should be stripped of all structures, debris, and any organic material. Debris, organic material, and otherwise unsuitable materials should be disposed off site. All existing fill and disturbed soils (Le. from utility removal, etc.) should be removed to full depth. Subexcavation should be performed to at least 6-inches beneath the bottom of the pile cap and extend horizontally past the pile cap limits a distance equal to twice the depth of the pile cap. To provide uniform support, overexcavation should be made to a uniform depth throughout the structure footprint. The surfaces exposed should be field reviewed by the soils engineer to affirm exposure of firm, undisturbed native soil. Disturbed, soft, or otherwise unsuitable soil at the base of excavation should be removed and replaced with engineered fill.

The upper surface of intact native soil exposed by stripping and subexcavation should be scarified, moisture conditioned to over-optimum moisture content and compacted to at least 90% relative compaction (per ASTM D 1557).

A minimum of 6-inches of compacted aggregate base should be placed beneath the pile caps/grade beams. On-site soils (less debris or organic material) are considered acceptable for use as compacted fill and should be placed to at least 90% relative -compaction at over optimum moisture content per ASTM D1557. ----------

Supplemental Services

Final grading and building plans and specifications (insofar as they rely on this report) should be submitted to this office for review and comment as they become available to verify consistency with the recommendations contained herein. Such review is considered a condition of our recommendations.

In addition, foundation excavations, earthwork construction, and/or piledriving performed on the site should be observed and tested by this office. If construction observation is performed by others, they should review this report and either accept the

conclusions and recommendations herein as their own or provide alternative recommendations. If conditions differing substantially from those stated herein are found, appropriate recommendations should be requested from us at that time.

TABER CONSULTANTS

Ronald E. Loutzenhiser
R.C.E. 64089

REGISTERED PROFESSIONAL ENGINEER
RONALD ERIC L TZENHISER
No. 64089
EXP. 9-06
CIVIL
STATE OF CALIFORNIA

June 23, 2006
Attachments: "General Conditions"
"Guide Specification"

Figure-1 "Vicinity Map"
Figure-2 "Location of Field Tests"
"Boring Legend"
Figure-3 "Test Boring Logs"
Figure-4 "Laboratory Test Results"

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Appendix EQFAULT " Deterministic Site Parameters"
"USGS Interpolated Probabilistic Ground Motion Values"
FRISK "Pseudo-absolute Acceleration" tables
LIQUEFY2 "Liquefaction Analysis Summary"

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1P1/306/043

GENERAL CONDITIONS

The conclusions and recommendations of this study are professional opinion based upon the indicated project criteria and the limited data described herein. It is recognized there is potential for sufficient variation in subsurface conditions that some modification of conclusions and recommendations might emerge from further, more detailed study.

This report is intended only for the purpose, site location and project description indicated and assumes design and construction in accordance with applicable codes.

As changes in appropriate standards, site conditions and technical knowledge cannot be adequately predicted, review of recommendations by this office for use after a period of two years is a condition of this report.

A review by this office of any foundation and/or grading plans and specifications or other work product insofar as they rely upon or implement the content of this report, together with the opportunity to make supplemental recommendations as indicated therefrom is considered an integral part of this study and a condition of recommendations.

Subsequently defined construction observation procedures and/or agencies are an element of work that may affect supplementary recommendations.

Should there be significant change in the project, or should earth materials or conditions different from those described in this report be encountered during construction, this office should be notified for evaluation and supplemental recommendations as necessary or appropriate.

Opinions and recommendations apply to current site conditions and those reasonably foreseeable for the described development--which includes appropriate operation and maintenance thereof. They cannot apply to site changes occurring, made, or induced, of which this office is not aware and has not had opportunity to evaluate.

The scope of this study specifically excluded sampling and/or testing for, or evaluation of the occurrence and distribution of hazardous substances. No opinion is intended regarding the presence or distribution of any hazardous substances at this or nearby sites.

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GUIDE SPECIFICATION

for

PREPARATION OF FILL FOUNDATION and PLACEMENT OF ENGINEERED FILL

A. Site Preparation

1. All trees, brush, logs and other debris shall be removed from the area to be filled. The area to receive fill shall be free of all roots and other organic material. Underground structures shall be removed or otherwise abandoned in accordance with public agency requirements and as determined by the Soils Engineer. The fill foundation shall be stripped exposing firm foundation material capable of achieving specified compaction. For fills to be placed on sloping surfaces, adequate fill foundation shall be exposed to the toe of fill slope extended to base of stripping level, unless otherwise specified or permitted by the Soils Engineer.

2. The exposed fill foundation shall be favorably field-reviewed by the Soils Engineer, then scarified to a depth of at least 6-inches. Where fills are to be placed on hillslopes, scarifying shall be to depths adequate to provide bond between fill and fill foundation. Where considered necessary by the Soils Engineer, the fill foundation surface shall be stepped or benched to achieve this bond. Vertical dimension of required benches shall be determined by the Soils Engineer, based upon location, degree and condition of hillslope.

1 The exposed and scarified fill foundation shall be watered as necessary and compacted to not less than 90% of maximum dry density per ASTM D1557 unless otherwise specified.

B. Fill Material

1. All materials proposed for use in the fill shall be favorably reviewed by the Soils Engineer prior to placement. Review may include laboratory testing.

2. Fill materials shall be free from organic matter and other deleterious substances and shall not contain rocks or lumps larger than 4-inch maximum dimension.

GUIDE SPECIFICATION (CONTINUED)

C. Placement of Fill

1. Fill material shall be spread in uniform layers not exceeding 6-inches compacted thickness. Water shall be added to the fill, or the fill allowed to dry, and mixed as necessary to obtain a moisture content which is uniform and which is adequate to achieve compaction as specified.

2. Each layer of fill shall be compacted to not less than 90% of maximum dry density per ASTM D1557 unless otherwise specified. Compaction shall be by sheepsfoot roller, multiple-wheel pneumatic roller or other acceptable equipment of such design that the fill can be compacted as specified.

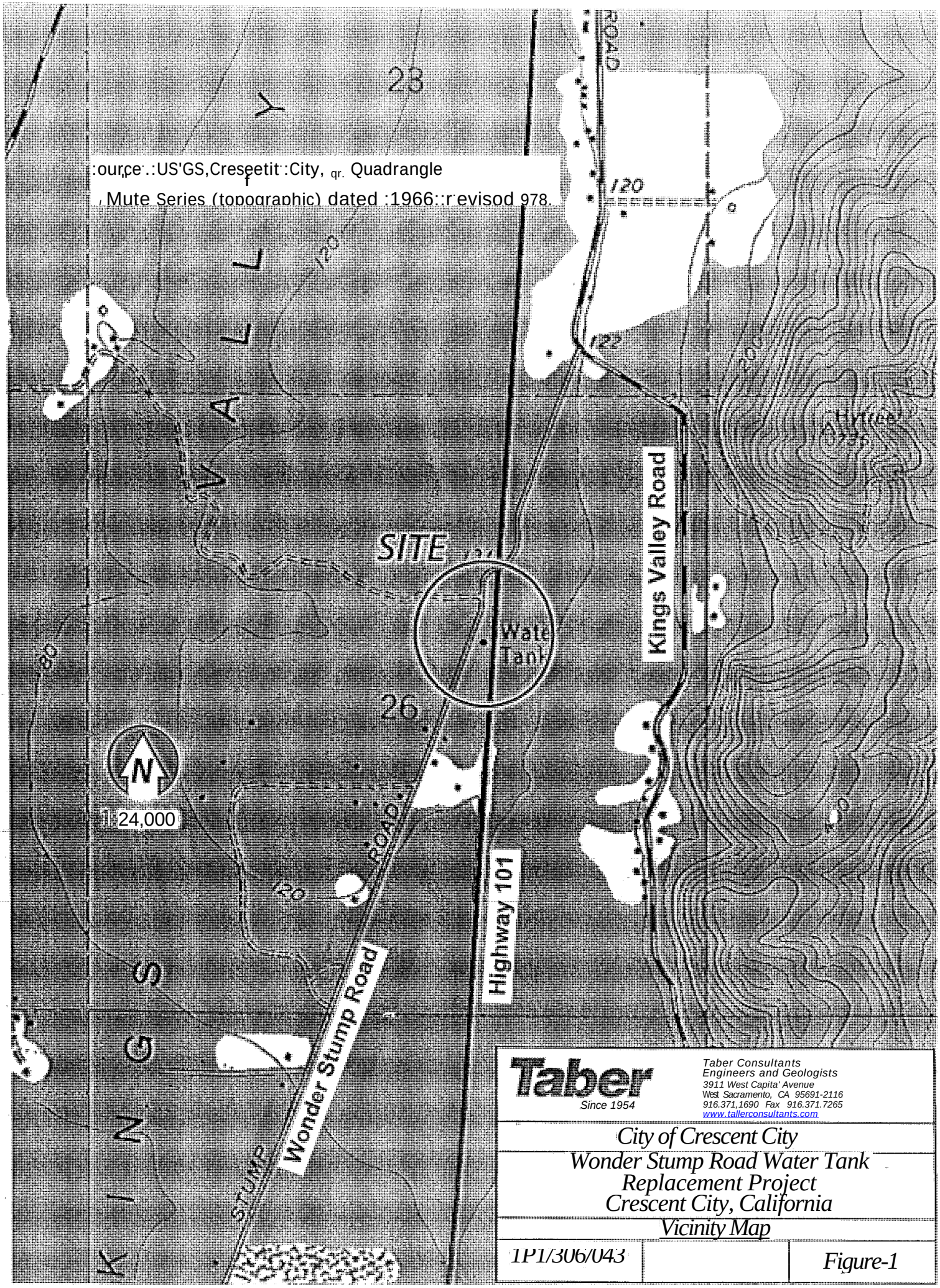
3. Work that has been suspended by weather, scheduling or for any other reason, shall be protected against the effects of such weather or other conditions. Grading which has been considered acceptable but which has been subsequently damaged shall be re-worked to meet the requirements of the specifications.

D. Observation and Testing

1. A minimum of 24-hours notice shall be given the Soils Engineer by the superintendent of grading prior to commencing or recommencing any grading operations; additional time may be required for review/testing of materials proposed for fill. No fill shall be placed prior to favorable field review of fill foundation or previously graded surface by the Soils Engineer.

2. Preparation of fill foundation and placement of fill shall be observed by the Soils Engineer so that he can render a professional opinion as to the conformance of the completed fill to the specifications.

Field density tests shall be made at locations determined by the Soils Engineer. Sufficient tests shall be made to adequately support a professional opinion of the Soils Engineer that the required compaction has been achieved throughout the fill. When tests indicate that the specified compaction has not been achieved, that portion of the fill shall be re-worked until the required density has been attained.



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City of Crescent City
Wonder Stump Road Water Tank
Replacement Project
Crescent City, California
Vicinity Map

1P1/306/043 | Figure-1

TABER CONSULTANTS
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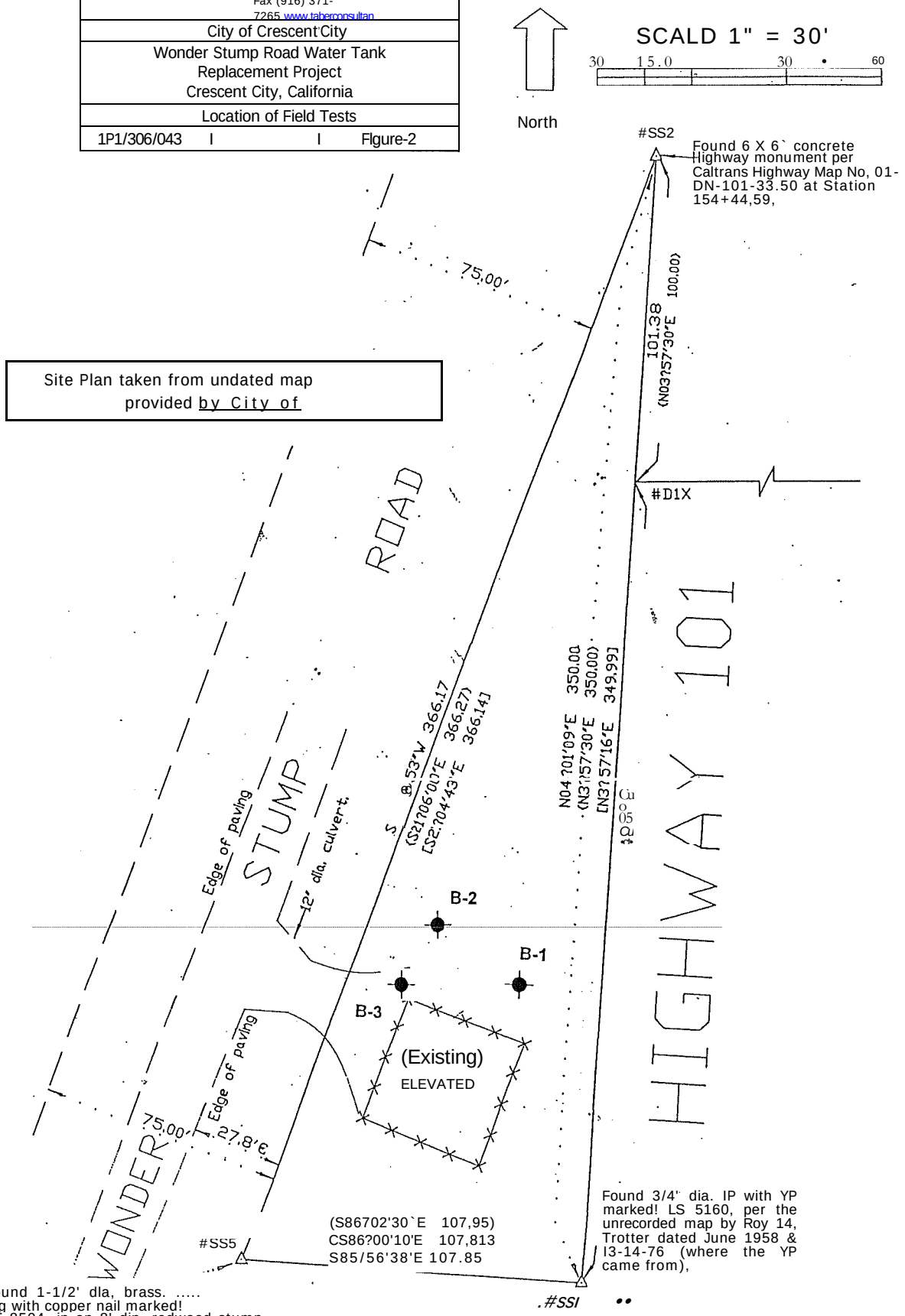
City of Crescent City
Wonder Stump Road Water Tank Replacement Project Crescent City, California
Location of Field Tests
1P1/306/043 I I Flgure-2



WATER TANK

SITE

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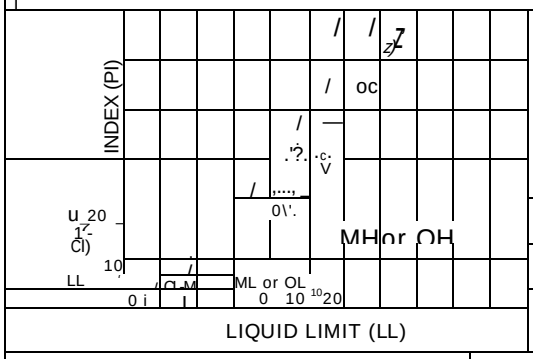
UNIFIED SOIL CLASSIFICATION SUMMARY

(ASTM 0 2487-93)

Pt	OH	CH	MH	OL	CL	ML	SC	SM	SP	SW	GC	GM	GP	GW
Highly organic soils	Silts and clays Liquid limit 50 or more			Silts and clays Liquid limit less than 50			Sands with fines >12% fines		Clean sands < 5% fines		Gravels with fines > 12% fines		Clean gravels < 5% fines	
							Sands-50% or more of coarse fraction is smaller than No 4. Sieve				Gravels—more than 50% of coarse fraction Is larger than No. 4 sieve			
Fine grained soils (50% or more Is smaller than No. 200 sieve)							Coarse grained soils (More than 50% is larger than No. 200 sieve)							



LABORATORY CLASSIFICATION CRITERIA

GW and SW — Cu > 4 for GW and 6 FOR SW; 1 < Cc < 3

GP and SP—Clean gravel or sand not meeting requirements for GW and SW.

GM and SM—Atterberg limits of fines below "A" line or P.I. less than 4.

GC and SC—Atterberg limits of fines above "A" line with P.I. greater than 7.

Fines (silt or clay)	Sand			Gravel		Cobbles	Boulders
	Fine	Medium	Coarse	Fine	Coarse		
Sieve sizes	200	40	10	4	3/4"	3"	10"

0 Classification of earth materials shown on the test boring logs is based on field inspection and should not be construed to imply laboratory analysis unless so stated.

MATERIAL SYMBOLS

- Gravel
- Sand
- Silt
- Clay
- Sandy clay or clayey sand
- Sandy silt or silty sand
- Silty clay or clayey silt
- Peat and/or organic matter
- Fill material
- Igneous rock
- Sedimentary rock
- Metamorphic rock

CONSISTENCY CLASSIFICATION FOR SOILS

Pteannetgon "N "—Value*	Granular	Cohesive
0-5	Very loose	Very soft
6-10	Loose	Soft
11-20	Semicompact	Stiff
21-35	Compact	Very stiff
36-70		Hard
> 70	Very dense	Very hard

* According to the Standard Penetration Test (ASTM D 1586) Blow count of 50/0.5 indicates for 0.5 feet. penetration test Where standard consistencies been performed, on logs are estimated. parenthesis)

KEY TO "OTHER TESTS"

LABORATORY

- A — Atterberg Limits
- C — Consolidation
- CR — Corrosivity
- E — Expansion Index
- G — Gradation
- H — Hydrometer
- M — Maximum Dry Density
- P — Permeability
- R — Resistance Value
- S — Direct Shear
- SE — Sand Equivalent
- SG — Specific Gravity
- T — Triaxial Shear

LEGEND O

Bulk Sample

Drive 5

Sample

Casing set 10

15

Conformable material change

Date

A_p_proximate material change

Date

Unconformable material change

Bottom of borin _____

N TEST

11
15
24
35 12
27
30
11
17
27
33

Vows per foot (using 140 lb. hammer with 30" drop)

Nr
Date
V
Date
10

Gaphoepsent of driving
1 4("/
1_,
1

rate
surface
Groundwat r

20 4 60
Blows per foot

First encountered groundwater

rev. 09/99 newboringlegend.dwg fit L

Boring Legend

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TEST BORING LOG

Job No. 1P113061043

TYPE: 4-INCH AUGER/94MM WIRELINE

ELEVATION: 99

BORING NO 1

UNCONFINED COMPRESSIVE STRENGTH (tsf)	OTHER TESTS	DRY DENSITY (lbs/cu.ft)	Moisture (%)	BLOWS/FOOT 350 ft-lb	SAMPLE SIZE (inches)	SAMPLE No.	Bulk	Bag	SYMBOL	MATERIAL DESCRIPTION
									GM	(Semicompact-compact) SILTY/CLAYEY crushed ROCK with GRAVEL, moist to wet (Fill)
								\A		Loose orange-brown SILTY fine SAND, wet
0.7	CR	96	28	7	1.4				SM	
		97	27	27	2.5	2				Semicompact-dense brown to orange-brown SILTY fine SAND, moist-wet
		102	22	17	1.4					
		104	22	39	2.5				SM	
		109	22	19	1.4					
		118	17	38	1.4					Dense brown to orange-brown SILTY fine SAND, moist-wet
		116	19	44	1.4				SM	
1.8	CR	110	20	8	1.4				CL	Soft gray to green SILTY CLAY with SILTY fine SAND lenses, wet
									SM	Dense-very dense dark gray SILTY fine SAND, wet
										--CONTINUED--

Depth scale: 1, 0, 15, 20, 25, 30, 35, 40

THE BORING LOGS SHOW SUBSURFACE CONDITIONS AT THE DATES AND LOCATIONS INDICATED AND IT IS NOT WARRANTED THAT THEY ARE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES.

LOGGED BY: REL | DATE: 03-20-2006

LOG OF BORING (SOILS ONLY) 1P1 306 043 WATER TANK.GPJ LIBRARY.GLB DATATEMPLATE.GDT 6/7/06

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She 7954
Ma Sacramento, CA 95691-2116
916-371-1690 Fax: 916-371-7265

TEST BORING LOG

Job No. 1P1/306/043

BORING NO 1

ELEVATION: 99

TYPE: 4-INCH AUGER/94MM WIRELINE

UNCONFINED COMPRESSIVE STRENGTH (tsf)	OTHER TESTS	DRY DENSITY (lbs/cu.ft)	Moisture (%)	BLOWS/FOOT 350 ft-lb	SAMPLE SIZE (inches)	SAMPLE No.	DEPTH	MATERIAL S	UNIFIED	
		106	20	35	1.4					Dense-very dense dark gray SILTY fine SAND, wet
		118	16	86	1.4	10	45		SM	
		26	159	49	1.4	11	50	1		Wood in sampler
		107	21	63	1.4	12	55			
		122	12	90	1.4	13				
							60			Bottom of hole at 59.0 feet.
							65			
							70			
							75			
							80			

THE BORING LOGS SHOW SUBSURFACE CONDITIONS AT THE DATES AND LOCATIONS INDICATED AND Ills NOT WARRANTED THAT THEY ARE REPRE-SENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES.

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TEST BORING LOG

Job No. 1P1/306/043

TYPE: 94-MM WIRELINE

ELEVATION: 100

BORING NO 2

UNCONFINED COMPRESSIVE STRENGTH (tsf)	OTHER TESTS	DRY DENSITY (lbs/cu. ft.)	Moisture (%)	BLOWS/FOOT 350 ft-lb	SAMPLE SIZE (inches)	SAMPLE No.	Depth	SYMBOL	MATERIAL	Classification	Description
										GM	0.5' crushed ROCK over brown SILTY/CLAYEY GRAVEL, moist to wet (Fill)
											Semi-compact to compact orange-brown SILTY fine SAND, wet
0.8	3,1A	90	32	12	1.4	1					
		102	22	24	2.5	2	10			SM	Grades brown to gray-brown
		107	21	20	1.4		15				
		110	19	19	1.4		20				
											Dense brown to gray-brown SILTY fine SAND, wet
		120	16	47	1.4		25			SM	
		116	17	48	1.4		30				
										/CL	Very stiff brown CLAY with SILTY fine SAND lenses,
		110	24	22	2.5					CL	Very stiff blue-green SILTY CLAY, moist
										SM	Compact-dense gray SILTY fine SAND with trace wood fragments @ 41', wet
							40				--CONTINUED--

THE BORING LOGS SHOW SUBSURFACE CONDITIONS AT THE DATES AND LOCATIONS INDICATED AND IT IS NOT WARRANTED THAT THEY ARE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES.

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TEST BORING LOG

Job No. 1P1/306/043

TYPE: 94-MM WIRELINE

ELEVATION: 100

BORING NO 2

		106	22	28	1.4	8				SM	Compact-dense gray SILTY fine SAND with trace wood fragments @ 41, wet
		115	18	55	1.4	9	45				
							50				Bottom of hole at 46.5 feet.
							55				
							60				
							65				
							70				
							75				
							80				

THE BORING LOGS SHOW SUBSURFACE CONDITIONS AT THE DATES AND LOCATIONS INDICATED AND IT IS NOT WARRANTED THAT THEY ARE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES.

LOGGED BY: REL DATE: 03-21-2006

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TEST BORING LOG

Job No. 1P1/306/043

TYPE: 94-MM WIRELINE

ELEVATION: 100

BORING NO 3

UNCONFINED COMPRESSIVE STRENGTH (tsf)	OTHER TESTS	DRY DENSITY (lbs/cu. ft.)	Moisture (%)	BLOWS/FOOT 350 ft-lb	SAMPLE SIZE (inches)	SAMPLE No.		MATERIAL SYMBOL	UNIFIED SOIL CLASS	
									GM	0.5' crushed ROCK over brown SILTY/CLAYEY GRAVEL, moist (Fill)
										Semicompact to compact brown to orange-brown SILTY fine SAND with trace GRAVEL, moist-wet
0.5	5	98	25	14	1.4					
							10			
		101	22	18	1.4					
							15		SM	
		107	20	19	1.4					
							2			
		102	22	24	1.4					
							0			
									SM	Dense brown to orange-brown SILTY fine SAND, moist
		114	18	35	1.4					5
							2			Bottom of hole at 27.0 feet.
							5			
							30			
							35			
							40			

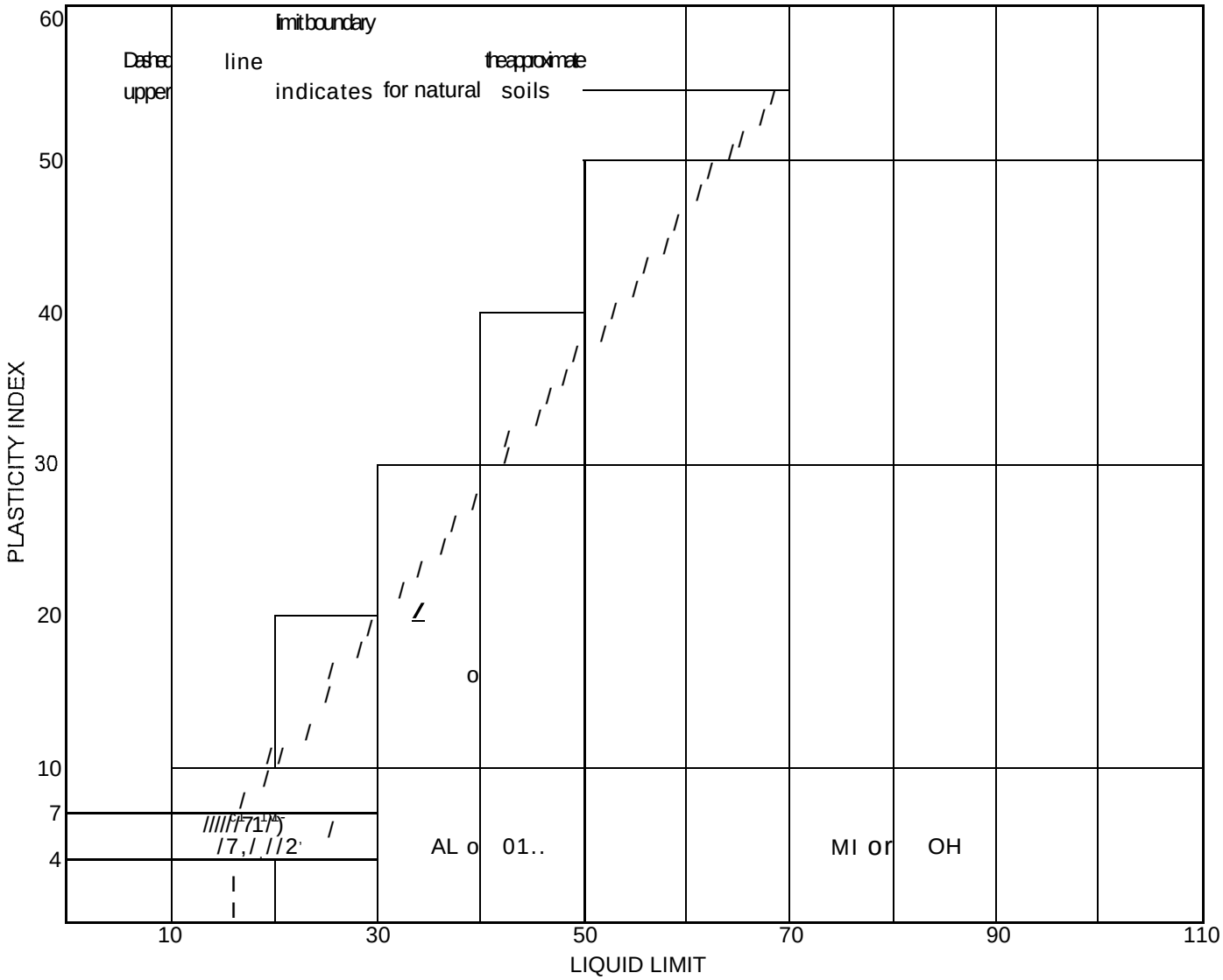
THE BORING LOGS SHOW SUBSURFACE CONDITIONS AT THE DATES AND LOCATIONS INDICATED AND IT IS NOT WARRANTED THAT THEY ARE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES.

LOGGED BY: REL

DATE: 03-21-2006

LOG OF BORING (SOILS ONLY) 1P1 306 043 WATER TANK.GPJ LIBRARY.GLB DATATEMPLATE.GDT 6/7/06

LIQUID AND PLASTIC LIMITS TEST REPORT



SOIL DATA								
SYMBOL	SOURCE	SAMPLE NO.	DEPTH (ft.)	NATURAL WATER CONTENT (%)	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	USCS
•		2/1	4.5-6.5'		27	30	3	SM

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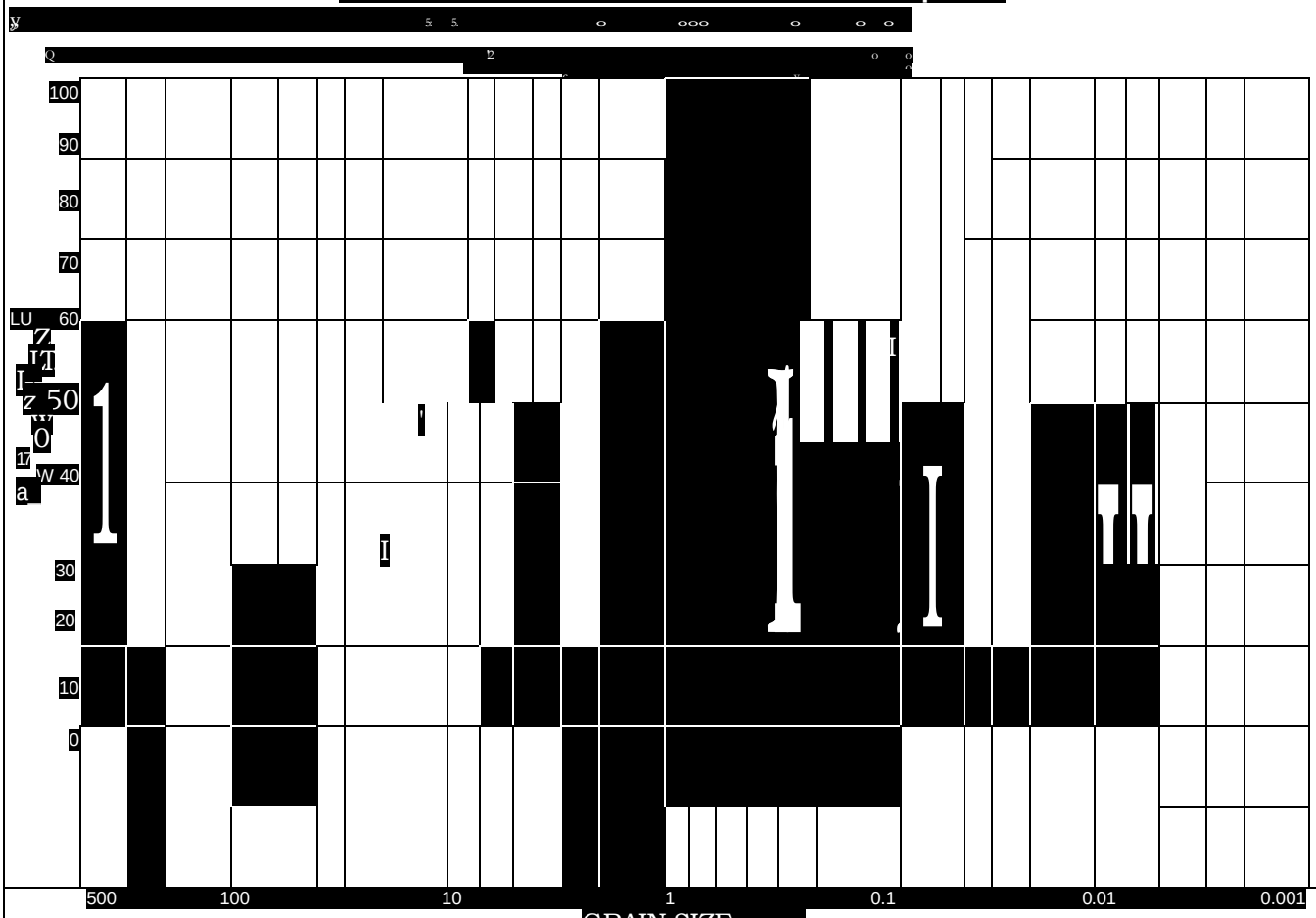
Client: City of Crescent City
Project: Wonder Stump Water Storage Tank

Project No.: 1P1/306/043

Figure 4

Particle Size Distribution Report



% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
0.0	0.0	86.5	13.5	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#20	100.0		
#40	93.6		
#200	13.5		

Material Description

Atterberq Limits

PL= LL= PI=

Coefficients

D85=0.308 D8o=0.171 D5o= 0.141
030=0.0992 015=0.0769 D10=
C_u= C_c=

Classification

USCS= AASHTO=

Remarks

* (no specification provided)

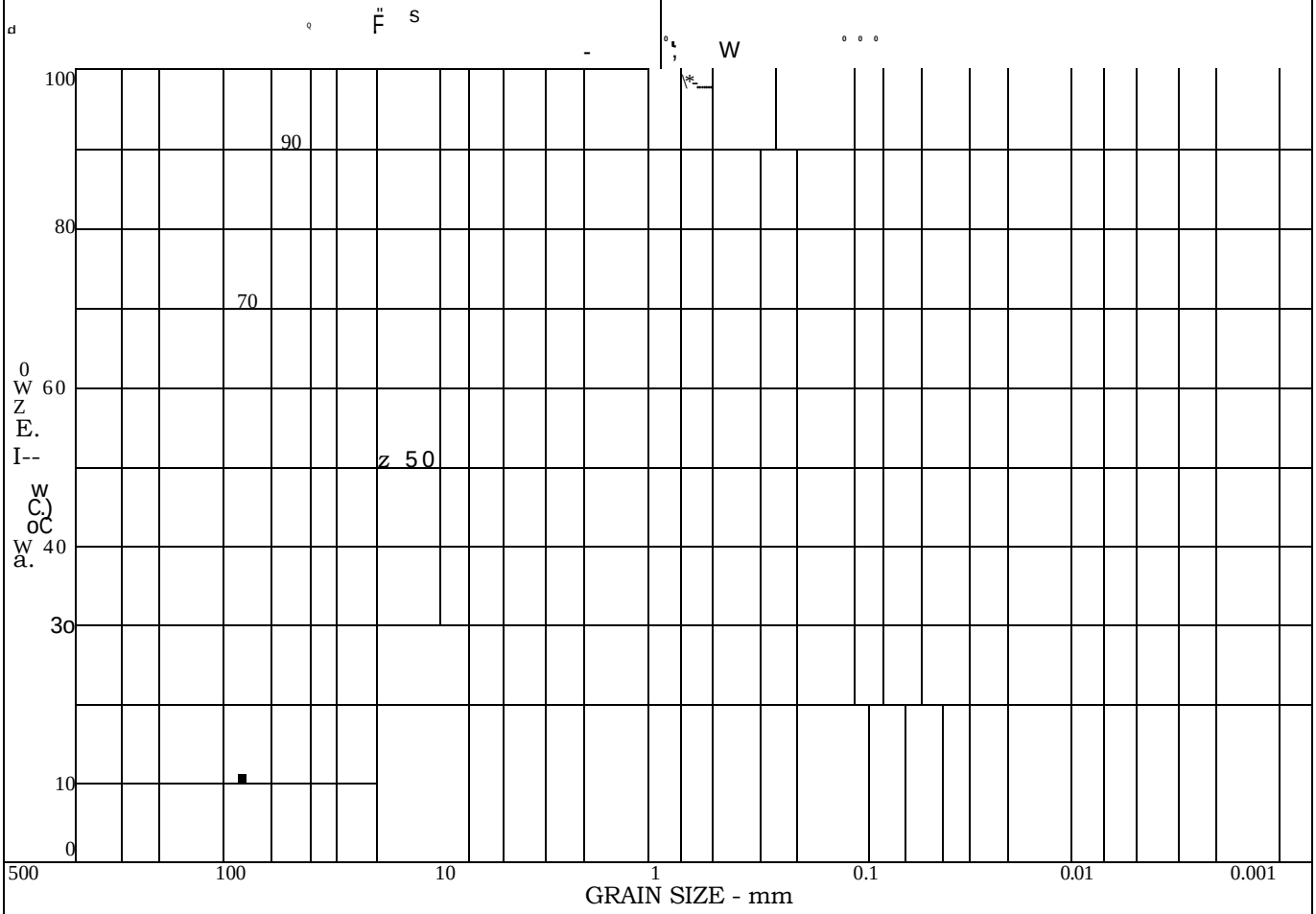
Sample No.: 1/3+1/4+1/5comp. Source of Sample: Date: 4/26/06
Location: Boring 1 Depth: 10-22'

Taber Project:
Since 1954

Client: City of Crescent City
Wonder Stump Water Storage Tank

Project No: 1P1/306/043 Figure

Particle Size Distribution Report



% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
0.0	0.0	86.2	13.8	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#2	100.0		
0	97.6		
#40	13.8		
#200			

Material Description

Atterberq Limits

PL= LL= Pl=

Coefficients

D85= 0.327 D60= 0.195 D50= 0.159
D3o= 0.105 Di 5= 0.0769 D10=
C_u= C_c=

Classification

USCS= AASHTO=

Remarks

* (no specification provided)

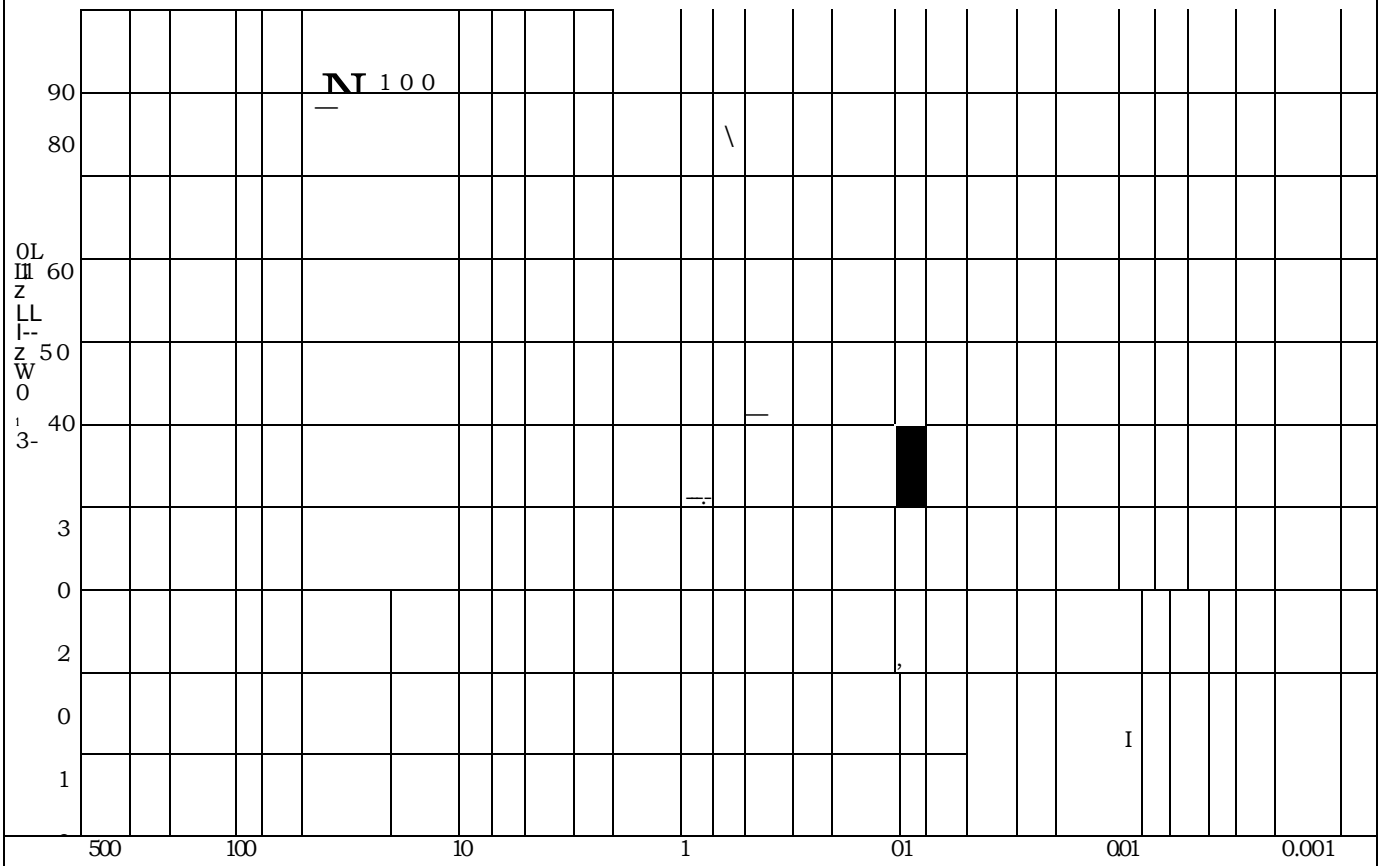
Sample No.: 1/9+1/10+1/11 comp. Source of Sample: Date: 4/26/06
Location: Boring 1 !Depth: 40-52'

Taber Project:
Since 1954

Client: City of Crescent City
Wonder Stump Water Storage Tank

Project No: 1P1/306/043 Figure 4

Particle Size Distribution Report



% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
0.0	0.0	54.0	46.0	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#20	93.3		
#40	84.6		
#200	46.0		

Material Description

Silty sand

Atterbern Limits

PL= 27 LL= 30 PI= 3

Coefficients

D85= 0.436 D80= 0.131 D5o= 0.0878
D30= D15= D10=
C_u= C_c=

Classification

USCS= SM AASHTO=

Remarks

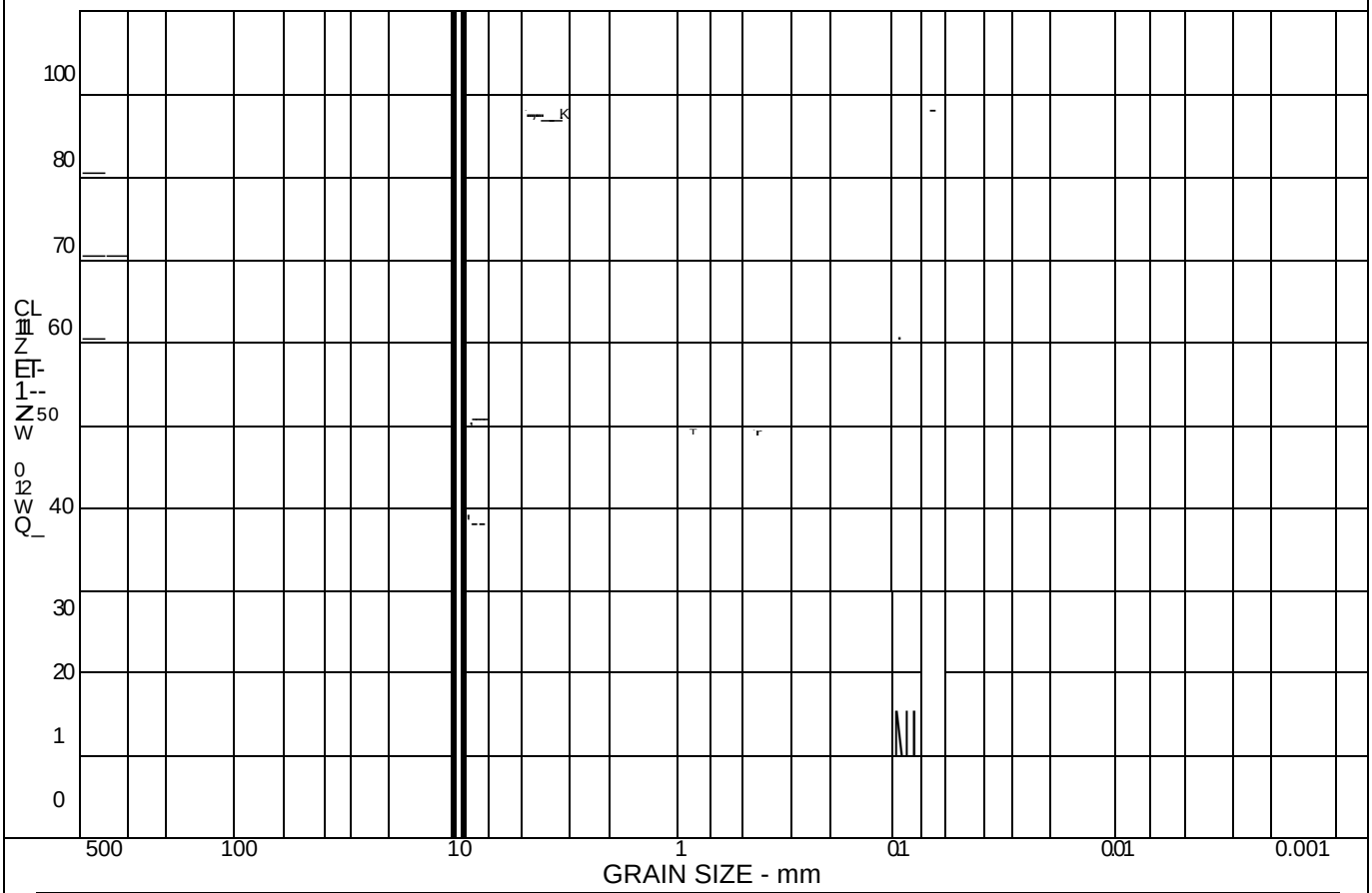
* (no specification provided)

Sample No.: 2/1 Source of Sample: Date: 4/26/06
Location: Boring 2 Depth: 4.5-6.5'

a'r
Since 1954

Client: City of Crescent City
Project: Wonder Stump Water Storage Tank
Project No: 1P1/306/043 Figure

Particle Size Distribution Report



% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
0.0	13.4	72.9	13.7	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.75 in.	100.0		
#4	86.6		
#10	85.1		
#20	84.4		
#40	78.3		
#200	13.7		

Material Description

Atterberq Limits

PL = LL = PI =

Coefficients

D85= 1.84 Deo= 0.217 D5o= 0.167
D30= 0.106 D15= 0.0771 D10=
Cu= Cc=

Classification

USCS= AASHTO=

Remarks

* (no specification provided)

Sample No.: 3/3 Source of Sample: Date: 4/26/06
Location: Boring 3 Depth: 15-17'

a· r
Since 1954

Client: City of Crescent City
Project: Wonder Stump Water Storage Tank
Project No: 1P1/306/043 Figure

B
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Since 1954

1P1/306/043

LABORATORY TEST RESULTS

Summary of Remolded Direct Shear Tests

Boring/ Sample	Test Condition	Normal Stress	Peak Values		Ultimate Values	
			Shear Stress	Displacement	Shear Stress	Displacement
		(psf)	(psf)	(ins)	(psf)	(ins)
B-1/2	3	1,000	615	0.160	548	0.250
	3	2,000	2,345	0.250	2,345	0.250
	3	3,500	3,335	0.250	3,335	0.250
B-2/2	3	1,500	798	0.250	798	0.250
	3	2,500	1,932	0.250	1,932	0.250
	3	3,500	2,720	0.250	2,720	0.250
B-1/2+B-3/1	3, 4	500	644	0.140	519	0.250
	3,4	1,500	1,403	0.110	1,192	0.250
	3, 4	3,000	2,403	0.250	2,403	0.250

ALL SAMPLES SHEARED - - SPECIMEN TEST CONDITION AS NOTED - -
IN STANDARD CIRCULAR SHEAR BOX UNDER STRAIN CONTROL = 0.025 INS/MIN.

Test Condition Notation

1. Natural moisture, unconsolidated
2. Submerged, unconsolidated
3. Saturated, consolidated at test load
4. Remolded to 90% relative compaction (ASTM D 1557)

Taber
Since 1954

1P1/306/043

LABORATORY TEST RESULTS

Surcharged Volume Change Tests

(2.5" diameter X 1" thick specimen; 24-Hour Saturation at indicated surcharge)

Boring/ Sample	Surcharge	Initial Dry Density	Initial Moisture	Final Moisture	Compression(-) Expansion(+)
	(psf)	(pcf)	(%)	(0/0)	(%)
B-1/2	1,000	94	27.2	29.3	+0.1
	2,000	95	27.2	27.0	-1.8
	3,500	97	27.2	26.5	-2.0
B-2/2	1,500	97	21.5	23.5	+0.1
	2,500	100	21.5	21.7	-1.5
	3,500	100	21.5	20.3	-2.3
B-1/2+B-3/1	500	101	13.5	22.7	+0.5
	1,500	101	13.5	22.3	+0.3
	3,000	102	13.5	21.4	-1.0

Taber
Since 1954

1P1/306/043

Corrosivity Test Results

Boring/Sample	Depth (feet)	Minimum Resistivity (ohm-cm) (CTM 532/643)	i	Chloride (ppm) (CTM 422)	Sulfate (ppm) (CTM 417)
B-1/1	2.5-4.5	18,490	5.9	14.7	1.9
B-118	35-37	5,360	6.4	6.9	27.0

APPENDIX

EQFAULT SUMMARY

DETERMINISTIC SITE PARAMETERS

ABBREVIATED FAULT NAME	DISTANCE mi	(km)	MAXIMUM EARTHQUAKE MAG. (Mw)	PEAK SITE ACCEL. g	ESTIMATED MAX. INTENSITY MOD.MERC.
BIG LAGOON - BALD MTN.FLT.ZONE	10.7	(17.3)	7.3	0.332	IX
CASCADIA (all)	12.2	(19.6)	9.0	0.454	X
CASCADIA SUBDUCTION ZONE	12.2	(19.6)	8.3	0.430	X
TRINADAD	25.5	(41.0)	7.3	0.162	VIII
McKINLEYVILLE	46.2	(74.3)	7.0	0.066	VI
MAD RIVER	46.9	(75.5)	7.1	0.070	VI
LITTLE SALMON (Offshore)	49.8	(80.1)	7.1	0.065	VI
FICKLE HILL	53.6	(86.3)	6.9	0.050	VI
TABLE BLUFF	68.1	(109.6)	7.0	0.039	V
LITTLE SALMON (Onshore) I	70.8	(113.9)	7.0	0.037	V
RATE FOR NE CA I	98.2	(158.0)	7.3	0.023	IV

****

-END OF SEARCH- 11 FAULTS FOUND WITHIN THE SPECIFIED SEARCH RADIUS.

THE BIG LAGOON - BALD MIN.FLT.ZONE FAULT IS CLOSEST TO THE SITE.
IT IS ABOUT 10.7 MILES (17.3 km) AWAY.

LARGEST MAXIMUM-EARTHQUAKE SITE ACCELERATION: 0.4538 g

LOCATION 41.8383 Lat. -124.1442 Long.
The interpolated Probabilistic ground motion values, in %g,
at the requested point are:

	10%PE in 50 yr	2%PE in 50 yr
PGA	27.04	60.09
0.2 sec SA	63.21	146.08
1.0 sec SA	25.78	70.77

SEISMIC HAZARD: Hazard by Lat/Lon 2002

cr_cityl.TBL

JOB NUMBER: 1P1/306/043

DATE: 06-21-2006

JOB NAME: Wonder Stump Tank

EXPONENTIAL EQUATION TO INTERPOLATE PSEUDO-ABSOLUTE ACCELERATION VALUES

FORM OF EQUATION:

PSA(T) = c(T)

where: c & k are constants from table below
PSA(T) is pseudo-absolute acceleration (g) at period-T (sec)

AVERAGE RETURN PERIOD: 72 years

BEGIN PERIOD (sec)	END PERIOD (sec)	BEGIN PSRV (ft/sec)	END PSRV (ft/sec)	BEGIN ACCEL. (g)	END ACCEL. (g)	COEF.	COEF.
0.01	0.03	0.0061	0.0180	0.1183	0.1174	0.114	-0.008
0.03	0.08	0.0180	0.0787	0.1174	0.2050	0.992	0.609
0.08	0.10	0.0787	0.1216	0.2050	0.2375	0.772	0.512
0.10	0.20	0.1216	0.3106	0.2375	0.3033	0.535	0.353
0.20	0.30	0.3106	0.4417	0.3033	0.2875	0.245	-0.131
0.30	0.40	0.4417	0.5172	0.2875	0.2525	0.167	-0.451
0.40	0.50	0.5172	0.5636	0.2525	0.2201	0.144	-0.615
0.50	0.75	0.5636	0.6453	0.2201	0.1680	0.139	-0.666
0.75	1.00	0.6453	0.6672	0.1680	0.1303	0.130	-0.884
1.00	1.50	0.6672	0.6534	0.1303	0.0851	0.130	-1.052
1.50	2.00	0.6534	0.5944	0.0851	0.0580	0.146	-1.329
2.00	3.00	0.5944	0.5002	0.0580	0.0326	0.156	-1.426
3.00	4.00	0.5002	0.4096	0.0326	0.0200	0.210	-1.695

JOB NUMBER: 1P1/306/043

DATE: 06-21-2006

JOB NAME: Wonder Stump Tank

EXPONENTIAL EQUATION TO INTERPOLATE PSEUDO-ABSOLUTE ACCELERATION VALUES

FORM OF EQUATION:

PSA(T) = c(T)

where: c & k are constants from table below
PSA(T) is pseudo-absolute acceleration (g) at period-T (sec)

AVERAGE RETURN PERIOD: 100 years

BEGIN PERIOD (sec)	END PERIOD (sec)	BEGIN PSRV (ft/sec)	END PSRV (ft/sec)	BEGIN ACCEL.	END ACCEL. (g)	COEF.	COEF.
0.01	0.03	0.0078	0.0229	0.1515	0.1491	0.141	-0.015
0.03	0.08	0.0229	0.0993	0.1491	0.2585	1.226	0.601
0.08	0.10	0.0993	0.1486	0.2585	0.2902	0.733	0.402
0.10	0.20	0.1486	0.3931	0.2902	0.3839	0.735	0.403
0.20	0.30	0.3931	0.5732	0.3839	0.3731	0.343	-0.070
0.30	0.40	0.5732	0.6779	0.3731	0.3309	0.226	-0.417
0.40	0.50	0.6779	0.7497	0.3309	0.2928	0.200	-0.549
0.50	0.75	0.7497	0.8813	0.2928	0.2295	0.193	-0.601
0.75	1.00	0.8813	0.9292	0.2295	0.1815	0.181	-0.816
1.00	1.50	0.9292	0.9429	0.1815	0.1228	0.181	-0.964
1.50	2.00	0.9429	0.8868	0.1228	0.0866	0.201	-1.213
2.00	3.00	0.8868	0.7703		0.0501	0.220	-1.347
3.00	4.00	0.7703	0.6373	0.0501	0.	0.310	-1.659

JOB NUMBER: 1P1/306/043

DATE: 06-21-2006

JOB NAME: Wonder Stump Tank

EXPONENTIAL EQUATION TO INTERPOLATE PSEUDO-ABSOLUTE ACCELERATION VALUES

FORM OF EQUATION:

PSA(T) = c(T)

where: c & k are constants from table below
PSA(T) is pseudo-absolute acceleration (g) at period-T (sec)

AVERAGE RETURN PERIOD: 200 years

BEGIN PERIOD (sec)	END PERIOD (sec)	BEGIN PSRV (ft/sec)	END PSRV (ft/sec)	BEGIN ACCEL. (g)	END ACCEL. (g)	COEF.	COEF.
0.01	0.03	0.0123	0.0379	0.2392	0.2466	0.272	0.028
0.03	0.08	0.0379	0.1566	0.2466	0.4078	1.691	0.549
0.08	0.10	0.1566	0.2267	0.4078	0.4426	0.853	0.285
0.10	0.20	0.2267	0.6372	0.4426	0.6222	1.372	0.491
0.20	0.30	0.6372	0.9560	0.6222	0.6223	0.623	0.000
0.30	0.40	0.9560	1.1702	0.6223	0.5713	0.435	-0.297
0.40	0.50	1.1702	1.3221	0.5713	0.5164	0.377	-0.453
0.50	0.75	1.3221	1.6386	0.5164	0.4267	0.373	-0.471
0.75	1.00	1.6386	1.7862	0.4267	0.3488	0.349	-0.700
1.00	1.50	1.7862	1.9236	0.3488	0.2504	0.349	-0.817
1.50	2.00	1.9236	1.8842	0.2504	0.1840	0.387	-1.072
2.00	3.00	1.8842	1.7310	0.1840	0.1127	0.425	-1.209
3.00	4.00	1.7310	1.4954	0.1127	0.0730	0.591	-1.509

JOB NUMBER: 1P1/306/043

DATE: 06.21.2006

JOB NAME: Wonder Stump Tank

EXPONENTIAL EQUATION TO INTERPOLATE PSEUDO-ABSOLUTE ACCELERATION VALUES

FORM OF EQUATION:

PSA(T) = c(T)

where: c & k are constants from table below
PSA(T) is pseudo-absolute acceleration (g) at period-T (sec)

AVERAGE RETURN PERIOD: 475 years

BEGIN PERIOD (sec)	END PERIOD (sec)	BEGIN PSRV (ft/sec)	END PSRV (ft/sec)	BEGIN ACCEL. (g)	END ACCEL. (g)	COEF.	COEF.
0.01	0.03	0.0200	0.0580	0.3914	0.3774	0.336	-0.033
0.03	0.08	0.0580	0.2429	0.3774	0.6323	2.721	0.563
0.08	0.10	0.2429	0.3838	0.6323	0.7495	2.922	0.591
0.10	0.20	0.3838	1.0136	0.7495	0.9897	1.887	0.401
0.20	0.30	1.0136	1.5718	0.9897	1.0232	1.130	0.082
0.30	0.40	1.5718	1.9721	1.0232	0.9628	0.793	-0.211
0.40	0.50	1.9721	2.2843	0.9628	0.8922	0.704	-0.341
0.50	0.75	2.2843	2.9363	0.8922	0.7646	0.685	-0.381
0.75	1.00	2.9363	3.2941	0.7646	0.6433	0.643	-0.600
1.00	1.50	3.2941	3.6912	0.6433	0.4806	0.643	-0.719
1.50	2.00	3.6912	3.7137	0.4806	0.3626	0.715	-0.979
2.00	3.00	3.7137	3.5404	0.3626	0.2305	0.787	-1.118
3.00	4.00	3.5404	3.1267	0.2305	0.1527	1.111	-1.432

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JOB NUMBER: 1P1/306/043

DATE: 06-21-2006

JOB NAME: Wonder Stump Tank

EXPONENTIAL EQUATION TO INTERPOLATE PSEUDO-ABSOLUTE ACCELERATION VALUES

FORM OF EQUATION:

PSA(T) = c(T)

where: c & k are constants from table below
PSA(T) is pseudo-absolute acceleration (g) at period-T (sec)

AVERAGE RETURN PERIOD: 100 years

BEGIN PERIOD (sec)	END PERIOD (sec)	BEGIN PSRV (ft/sec)	END PSRV (ft/sec)	BEGIN ACCEL. (g)	END ACCEL. (g)	COEF.	COEF.
0.01	0.03	0.0255	0.0769	0.4970	0.5008	0.513	0.007
0.03	0.08	0.0769	0.3162	0.5008	0.8234	3.357	0.543
0.08	0.10	0.3162	0.4863	0.8234	0.9497	2.978	0.496
0.10	0.20	0.4863	1.3464	0.9497	1.3147	2.797	0.469
0.20	0.30	1.3464	2.1133	1.3147	1.3757	1.574	0.112
0.30	0.40	2.1133	2.6828	1.3757	1.3098	1.120	-0.171
0.40	0.50	2.6828	3.1399	1.3098	1.2263	1.000	-0.295
0.50	0.75	3.1399	4.1065	1.2263	1.0692	0.970	-0.338
0.75	1.00	4.1065	4.6746	1.0692	0.9129	0.913	-0.550
1.00	1.50	4.6746	5.3453	0.9129	0.6959	0.913	-0.669
1.50	2.00	5.3453	5.4253	0.6959	0.5297	1.022	-0.948
2.00	3.00	5.4253	5.2395	0.5297	0.3411	1.125	-1.086
3.00	4.00	5.2395	4.6486	0.3411	0.2270	1.616	-1.416

L I Q U E F Y 2

Version 1.50

****i *,l.**4..**,l-********-**4..*

EMPIRICAL PREDICTION OF
EARTHQUAKE-INDUCED LIQUEFACTION POTENTIAL

JOB NUMBER: 1P2/306/043 DATE: 06-08-2006

JOB NAME: Wonder Stump

SOIL-PROFILE NAME: WS tank.LDW

BORING GROUNDWATER DEPTH: 2.00 ft

CALCULATION GROUNDWATER DEPTH: 2.00 ft

DESIGN EARTHQUAKE MAGNITUDE: 9.00 Mw

SITE PEAK GROUND ACCELERATION: 0.454 g

BOREHOLE DIAMETER CORRECTION FACTOR: 1.00

SAMPLER SIZE CORRECTION FACTOR: 1.00

N60 HAMMER CORRECTION FACTOR: 1.00

MAGNITUDE SCALING FACTOR METHOD: Idriss (1997, in press)

Magnitude Scaling Factor: 0.627

rd-CORRECTION METHOD: Seed (1985)

FIELD SPT N-VALUES ARE CORRECTED FOR THE LENGTH OF THE DRIVE RODS.

Rod Stick-Up Above Ground: 3.0 ft

CN NORMALIZATION FACTOR: 1.044 tsf

MINIMUM CN VALUE: 0.6

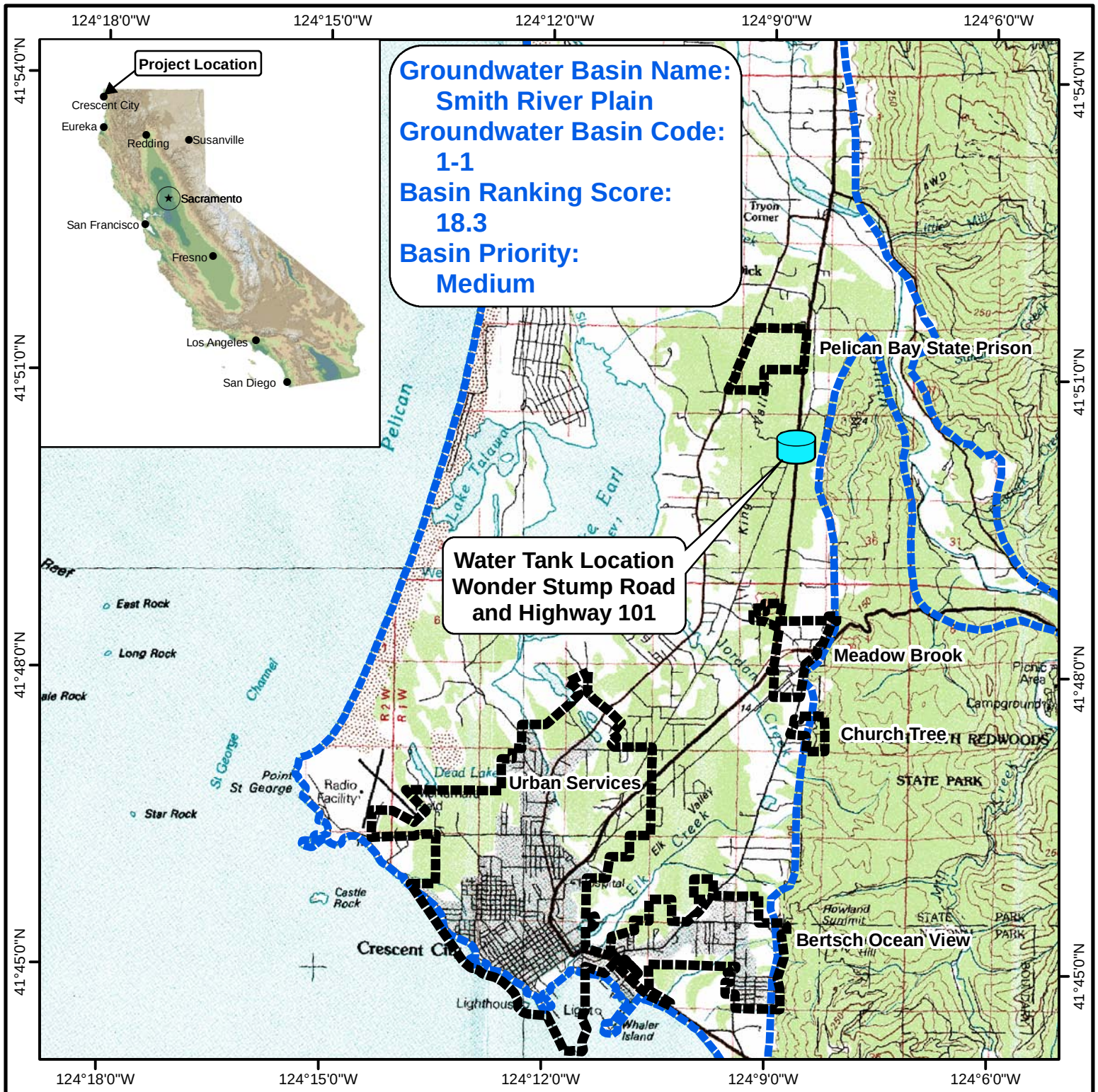
NCEER [1997] Method LIQUEFACTION ANALYSIS SUMMARY PAGE 1

File Name: WS_tank.OUT

SOIL NO.	CALC. DEPTH (ft)	TOTAL STRESS (tsf)	EFF. STRESS (tsf)	FIELD N (B/ft)	FC DELTA N1_60	CORR. (N1)60 (B/ft)	LIQUE. RESIST RATIO	r d	INDUC. STRESS RATIO	LIQUE. SAFETY FACTOR
1	0.251	0.0151	0.0151	14	3.091	*	*			
1	0.751	0.0461	0.0461	14	3.091	*	*			
1	1.251	0.0771	0.0771	14	3.091		*			
1	1.751	0.1081	0.1081	14	3.091	*	*			
1	2.251	0.1381	0.1311	14	3.091	2.000	24.1	0.2711	0.9971	0.3121 0.55
1	2.751	0.1691	0.1461	14	3.091	2.000	24.1	0.2711	0.9961	0.3411 0.50
1	3.251	0.2001	0.1611	14	3.091	2.000	24.1	0.2711	0.9941	0.3651 0.47
1	3.751	0.2311	0.1761	14	3.091	2.000	24.1	0.2711	0.9931	0.3841 0.44
	4.251	0.2611	0.1911	14	3.091	2.000	24.1	0.2711	0.9921	0.4001 0.42
1	4.751	0.2921	0.2061	14	3.091	2.000	24.1	0.2711	0.9911	0.4141 0.41
1	5.251	0.3231	0.2211	14	3.091	2.000	24.1	0.2711	0.9901	0.4261 0.40
1	5.751	0.3541	0.2371	14	3.091	2.000	24.1	0.2711	0.9891	0.4361 0.39
1	6.251	0.3841	0.2521	14	3.091	2.000	24.1	0.2711	0.9871	0.4451 0.38
1	6.751	0.4151	0.2671	14	3.091	2.000	24.1	0.2711	0.9861	0.4531 0.38
1	7.251	0.4461	0.2821	14	3.091	2.000	24.1	0.2711	0.9851	0.4601 0.37
1	7.751	0.4771	0.2971	14	3.091	2.000	24.1	0.2711	0.9841	0.4661 0.36
2	8.251	0.5071	0.3121	18	3.181	1.640	26.1	0.3061	0.9831	0.4711 0.41
2	8.751	0.5381	0.3281	18	3.181	1.640	26.1	0.3061	0.9821	0.4761 0.40
2	9.251	0.5691	0.3431	18	3.181	1.640	26.1	0.3061	0.9811	0.4801 0.40
2	9.751	0.6001	0.3581	18	3.181	1.640	26.1	0.3061	0.9801	0.4841 0.40
2	10.251	0.6301	0.3731	18	3.181	1.640	26.1	0.3061	0.9791	0.4881 0.39
2	10.751	0.6611	0.3881	18	3.181	1.640	26.1	0.3061	0.9781	0.4911 0.39
2	11.251	0.6921	0.4031	18	3.181	1.640	26.1	0.3061	0.9771	0.4941 0.39
2	11.751	0.7231	0.4181	18	3.181	1.640	26.1	0.3061	0.9761	0.4971 0.39
2	12.251	0.7531	0.4341	18	3.181	1.640	26.1	0.3061	0.9741	0.5001 0.38
2	12.751	0.7841	0.4491	18	3.181	1.640	26.1	0.3061	0.9731	0.5021 0.38
3	13.251	0.8161	0.4641	19	3.181	1.382	26.2	0.3071	0.9721	0.5041 0.38
3	13.751	0.8481	0.4811	19	3.181	1.382	26.2	0.3071	0.9711	0.5051 0.38
3	14.251	0.8801	0.4971	19	3.181	1.382	26.2	0.3071	0.9701	0.5061 0.38
3	14.751	0.9121	0.5141	19	3.181	1.382	26.2	0.3071	0.9691	0.5071 0.38
3	15.251	0.9441	0.5301	19	3.181	1.382	26.2	0.3071	0.9681	0.5081 0.38
3	15.751	0.9761	0.5461	19	3.181	1.382	26.2	0.3071	0.9671	0.5091 0.38
3	16.251	1.0081	0.5631	19	3.181	1.382	26.2	0.3071	0.9661	0.5101 0.38
3	16.751	1.0401	0.5791	19	3.181	1.382	26.2	0.3071	0.9651	0.5111 0.38
3	17.251	1.0721	0.5961	19	3.181	1.382	26.2	0.3071	0.9641	0.5121 0.38
3	17.751	1.1041	0.6121	79	3.181	1.382	26.2	0.3071	0.9631	0.5121 0.38
4	18.251	1.1351	0.6281	24	3.371	1.218	30.9	Infin	1.0961	0.5131 NonLiq
4	18.751	1.1661	0.6431	24	3.371	1.218	30.9	Infin	1.0960	0.5141 NonLiq
4	19.251	1.1961	0.6581	24	3.371	1.218	30.9	Infin	1.0959	0.5141 NonLiq
4	19.751	1.2271	0.6731	24	3.371	1.218	30.9	Infin	1.0958	0.5151 NonLiq
4	20.251	1.2581	0.6881	24	3.371	1.218	30.9	Infin	1.0956	0.5161 NonLiq
4	20.751	1.2891	0.7041	24	3.371	1.218	30.9	Infin	1.0955	0.5161 NonLiq
4	21.251	1.3191	0.7191	24	3.371	1.218	30.9	Infin	1.0954	0.5171 NonLiq

File Name: WS tank.OUT

SOIL' NO.1	CALC.1 DEPTH1 (ft)	TOTAL' STRESSI 1 (tsf)1	EFF. STRESSI (tsf)1	'FIELD N (B/ft)1	EC 1 'DELTA' N1_601	C N	CORR.I 1(N1)601 1(B/ft)I	LIQUE.1 RESISTI RATIO'	r d	LIQUE. INDUCH ISTRESS1 1	SAFETY RATIO1FACTOR
4	21.751	1.3501	0.7341	24	3.3711.2181		30.9	lInfin	10.9521	0.5171	NonLiq
4	22.251	1.3811	0.7491	24	3.3711.2181		30.9	lInfin	10.9511	0.5171	NonLiq
4	22.751	1.4121	0.7641	24	3.3711.2181		30.9	lInfin	10.9491	0.5181	NonLiq
5	23.251	1.4441	0.7811	35	3.8111.0951		41.8	lInfin	10.9481	0.5171	NonLiq
5	23.751	1.4771	0.7991	35	3.8111.0951		41.8	lInfin	10.9461	0.5171	NonLiq
5	24.251	1.5111	0.8171	35	3.8111.0951		41.8	lInfin	10.9451	0.5161	NonLiq
5	24.751	1.5441	0.8341	35	3.8111.0951		41.8	lInfin	10.9431	0.5151	NonLiq
5	25.251	1.5781	0.8521	35	3.8111.0951		41.8	lInfin	10.9411	0.5141	NonLiq
5	25.751	1.6111	0.8701	35	3.8111.0951		41.8	lInfin	10.9391	0.5131	NonLiq
5	26.251	1.6451	0.8881	35	3.8111.0951		41.8	lInfin	10.9381	0.5121	NonLiq
5	26.751	1.6781	0.9061	35	3.8111.0951	I	41.8	lInfin	10.9361	0.5111	NonLiq
5	27.251	1.7121	0.9241	35	3.8111.0951		41.8	lInfin	10.9341	0.5101	NonLiq
5	27.751	1.7451	0.9421	35	3.8111.0951		41.8	lInfin	10.9311	0.5091	NonLiq



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LEGEND

Urban Services Boundaries

Smith River Plain

Base Image Data Source:
1:24,000 Digital Raster Graph Mosaic of
Del Norte County, California

ALL LOCATIONS APPROXIMATE

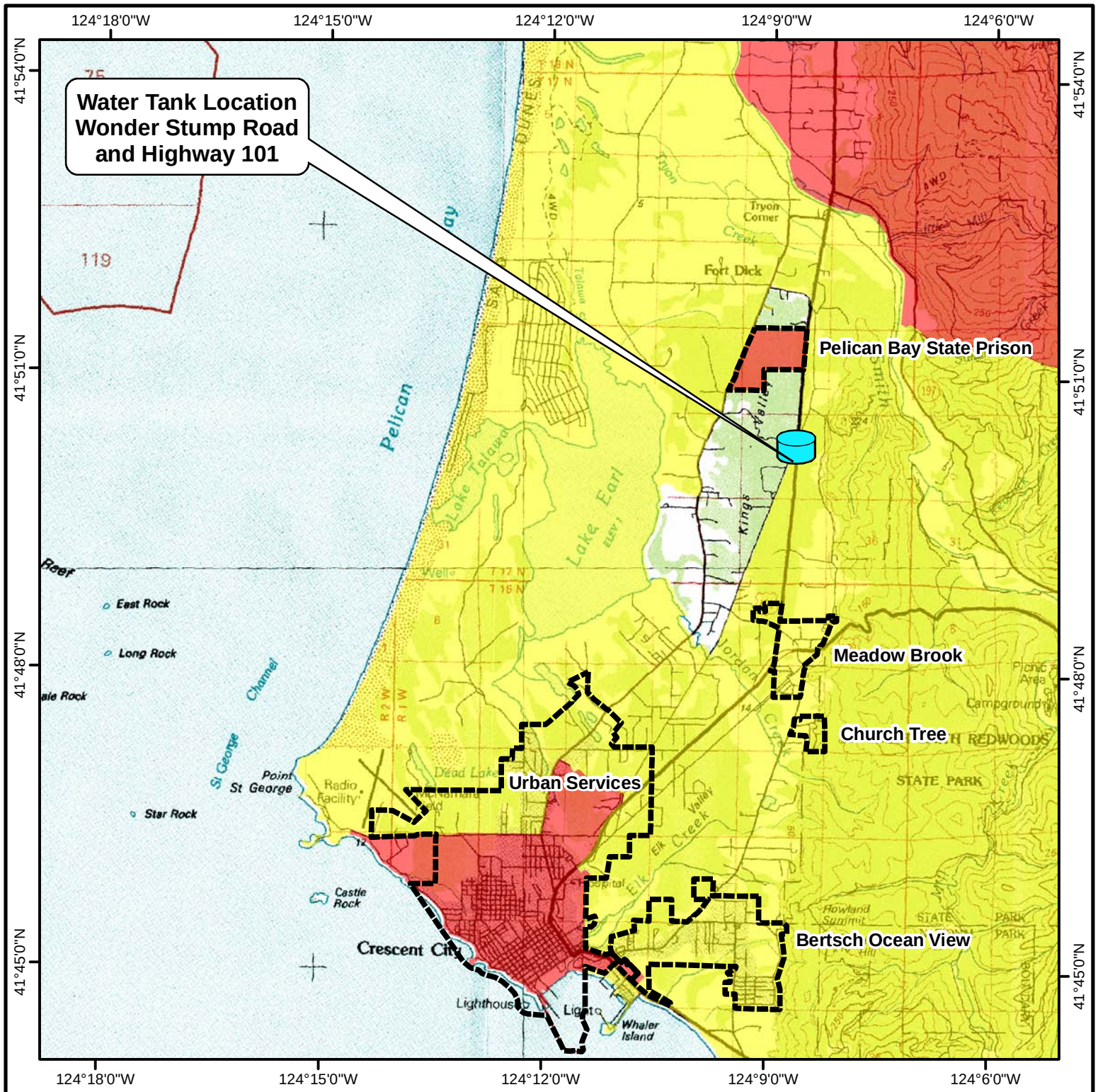
Crescent City
Water Tank Project

Figure 1
Site Location Map

Freshwater Environmental Services

Date: 7-2-14

By: SJT



LEGEND

Urban Services Boundaries

DAC Area

SDAC Area

Base Image Data Source:
1:24,000 Digital Raster Graph Mosaic of
Del Norte County, California
ALL LOCATIONS APPROXIMATE

Crescent City
Water Tank Project

Figure 2
DAC and SDAC Areas

Freshwater Environmental Services

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