Programmatic Operations and Management Technical Report for Micro-Irrigation of Vineyards in the Healdsburg Area

Appendix A

Reference Documents

2012 Middle Reach Russian River Vineyard Irrigation Demonstration Project

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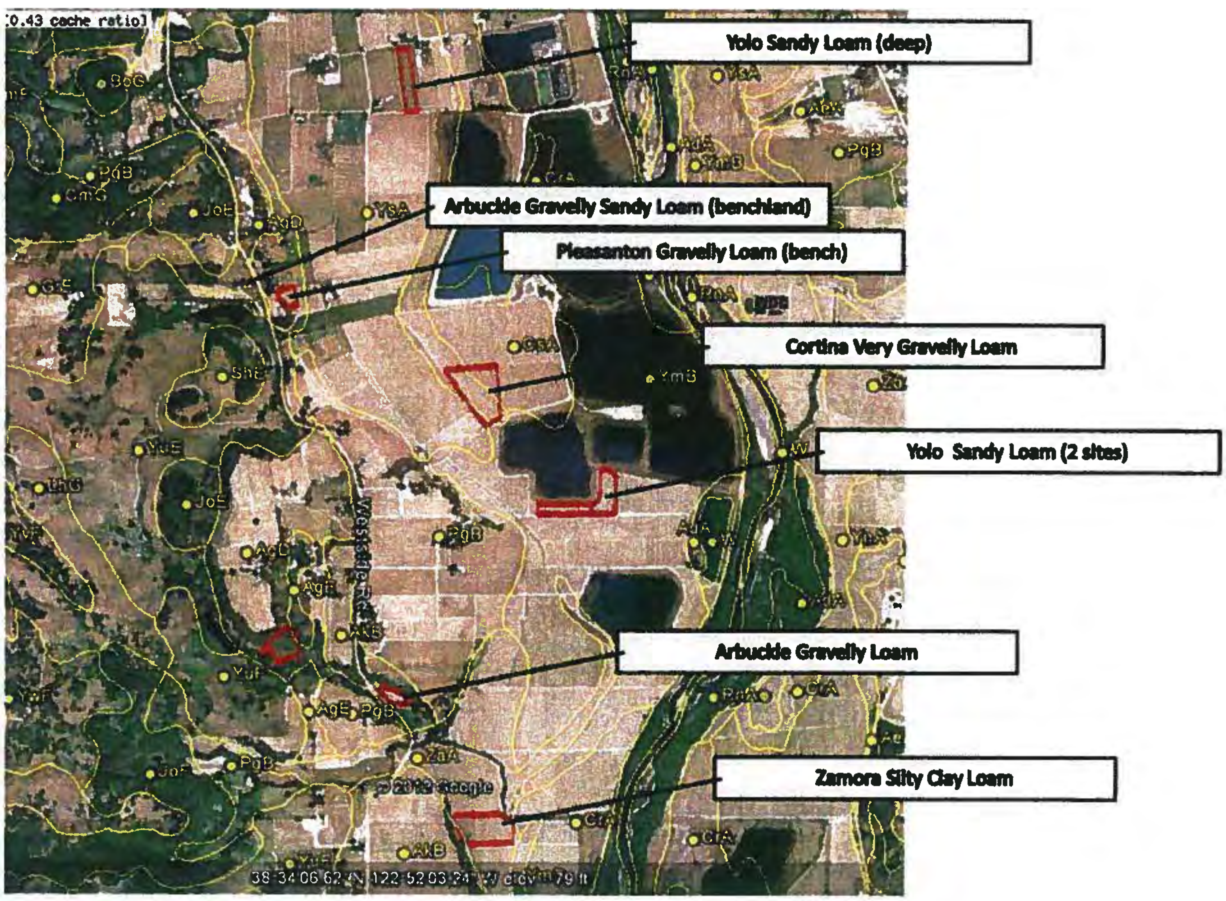
2012 Middle Reach Russian River Vineyard Irrigation Demonstration Project

Project Objectives:

- Determine and demonstrate a methodical, yet relatively simple approach to vineyard irrigation management that achieves good viticultural results with sustainable use of a scarce resource.
- Make general recommendations regarding irrigation volume and intervals for these soils that avoid excessive vine stress and avoid deep percolation of water, thereby reducing potential groundwater contamination.
- Demonstrate a set of tools to growers to provide information and assurance about moisture reserves in the soil so that irrigation can be applied when needed and in an efficient and non-wasteful manner.

Project Methods

A demonstration project was conducted during the 2012 growing season at eight locations in the middle reach region of the Russian River basin. The eight sites were chosen to provide representation from the major soil series in the region and to capture a spectrum of soils from gravelly loams to clay loams.



At each site, continuous-monitoring soil moisture profile sensors were installed that measured soil moisture at 6 depths (from 8" to 48" at 8" intervals) every 30 minutes (see appendix for photographs of equipment). Also, pressure switches were installed in the irrigation lines and connected to data loggers to capture irrigation events. Weekly visits to each site were made during early afternoons, during which vine water status was measured. Leaf water potential was measured with a pressure chamber and stomatal conductance was measured with a leaf porometer. Soil and plant water status were provided to growers on a weekly basis for feedback.

All sites chosen had white winegrape varieties grown, which do not benefit from water stress the way that red varieties do. Nevertheless, very mild stress on grapevines controls vegetative vigor and improves the water use efficiency of the vines.

Soil pits were dug in early August after irrigation had begun in most of the sites. Observations of rooting depths, soil stratifications and irrigation wetting patterns (if applicable) were noted.

Irrigation scheduling was determined by growers, and suggestions were provided weekly by Advanced Viticulture. To extrapolate the total irrigation volume to other growers and to other seasons, a comparison of irrigation volume used at each site to CIMIS evapotranspiration (ET) values was made. The Windsor CIMIS weather station was used as a reference site. Crop ET (ETc) was estimated from reference ET (ETo) using crop coefficients taken from Larry Williams[1] of 0.6 for VSP trellis (at all sites other than Yolo Silt Loam) and 0.8 for the Lyre trellis (at the Yolo Silt Loam site).

To provide an indication about whether minerals (primarily nitrate) may be moving below the vines' root zone, soil pore water samples (a.k.a. suction lysimeters) were installed at two of the sites. A company, AGQ laboratories, was contracted to perform the measurements and analysis. Unfortunately, their performance was poor, and very little information was gained from their participation. For one, their deepest sampling depth was 24". We observed that essentially all of the vineyard sites had root systems below 24". To produce some meaningful results, we installed our own soil pore water samplers at depths of 24" and 48" in triplicate replications. This was done at the end of the season to capture soil pore water after the first rainfall events had occurred. Note that we had installed them at different locations prior to that, and while the data are shown, the water capture rate was poor, as the devices do not work well when soils are too dry.

Participating entities included the Sotoyome Resource Conservation District (RCD), Syar Industries, the Westside Association to Save Agriculture and Advanced Viticulture, Inc. Participating growers are acknowledged for their participation: Dennis Hill, Judith Olney / Marc Bommersbach, Bob Salisbury, an anonymous grower and Syar Vineyards.

[1] Larry Williams. Irrigation of Winegrapes in California. Practical Winery and Vineyard. November/December 2001.

Results

The following pages are site-by site descriptions of measurements and observations at each site. One or more soil profile photo is shown. In those photos, a blue curve was drawn to indicate the approximate wetted zone from the most recent irrigation. Not all vineyards had been irrigated, at least in close time proximity to the observation, so those photos do not have indications of wetting patterns. Red lines on the photos indicate strongly-defined boundaries between soil strata. This is a key feature of the findings of this project with regard to moisture percolation through the soil profile. Note that we found that many of these profiles did not match the ones described by the NRCS soil survey. This was not unexpected as it is often the case that the soil survey is only an approximation of the actual soils of the region and boundaries between soil series are only approximate.

Following the photos and comments are charts of soil moisture for the site. The first chart has six lines, which indicate soil moisture at the six measured depths. This chart may be used to illustrate the depth to which irrigation percolated. Abrupt rises in soil moisture indicate that the wetting front passed by that particular level. On the other hand, a more gradual rise, usually delayed in time relative to the abrupt rise in upper layers, indicates that the wetting front did not reach that level, but redistribution during and after the irrigation application allowed moisture to wick into that soil depth by soil matrix forces.

The second soil moisture chart shows the summation of all six sensors, and provides a good picture of total soil moisture in the profile (to 4 feet). A declining long-term trend indicates deficit irrigation, where the irrigation is insufficient to keep up with demand by the vines as they extract soil moisture. This can be used as a benefit for wine quality, but mainly for red varieties, and most white varieties are best managed with only minimal water stress. The total soil moisture "signal" may be used as an indicator for irrigation scheduling. A "full point" may be designated by a reference line and a "refill point" may be designated as well. The reference lines are determined iteratively, using plant water status levels as a guideline as to how much stress to allow for the refill point and the practicality of irrigation depth needs to be taken into consideration in determining the full point. This interactive irrigation scheduling method takes much of the guesswork out of irrigation, provides the grower with assurances of adequate soil moisture conditions as well as warnings of low soil moisture conditions.

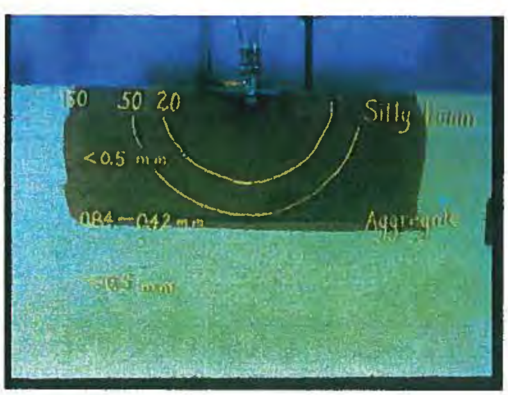
The vine water status measurements are shown in groups of four sites each after the discussions of the individual sites. Note that the green shaded areas represent the ideal target levels of those measurements.

The irrigations were made by the vineyard manager, with suggestions from the consultant. In most cases, other factors (e.g. water supply challenges, operator error, etc.) were involved in the irrigation applications and irrigations did not usually match the ideal applications being recommended. Nevertheless, the actual irrigations and consequences thereof were documented for reference to allow for guidelines of irrigation in this region.

One important result should be discussed at this point, since it applied to several of the sites. It is often assumed that irrigation in gravelly or sandy soils will cause water to percolate downward quickly through the profile with the possible consequence of deep leaching. On the other hand, heavier soils are thought to resist percolation, with their wetting zones developing more horizontally than vertically. In fact, this is not the case for low rate drip irrigation, as is practiced here, and the results were very illustrative of that effect.

With more conventional forms of irrigation, such as flood and furrow, the wetting front (moist zone that moves downward (and perhaps horizontally) into the soil profile is largely saturated at the edge because of the high rate of water application to the surface. With drip irrigation, however, this is not the case, as water is applied at a very low rate to a point on the soil surface. Within the first few inches (varies with soil texture and structure), the wetting zone is saturated, but as the moisture travels deeper and the wetted bulb expands, the fringe of the wetting zone is no longer saturated, but is pulled outwared by matrix forces and downward by both matrix and gravitational forces. Matrix forces are strong, as the adhesive property of water is strong. At the interface of a discontinuity in soil texture, as was seen in many of the soils in this study, water percolation is often disrupted in the vertical dimension. This can occur with a lighter soil layer overlying a heavy, clayey soil. In that case, the low hydraulic conductivity of the clay may prevent percolation of water downward. More commonly in the soils studied here, a heavier soil overlies a coarser-textured soil (see discussions below). In that case, the matrix forces within the heavier soil are stronger than the matrix plus gravitational forces in the underlying layer and moisture tends to spread laterally when that interface is reached. Hence, it becomes difficult to practically impossible to force water to deeper depths when a strong stratification of this type exists.

An illustration can be seen in the following laboratory photo (provided by Rhonda Smith of UC Cooperative Extension), where a coarse layer of "soil" was placed between two finer-textured "soils". The moisture clearly hits the discontinuity and spreads laterally instead of vertically. Soils in the Russian River Basin frequently feature such



stratifications in soil texture, and many situations are illustrated below. The soil profile above was not part of this study, but is from an alluvial soil in Alexander Valley and represents a strongly-stratified soil. The discontinuities in the soil tends to cause higher root densities at the boundaries of the interfaces (as can be seen at about 14 inches and 36 inches in the profile. That is because roots cannot easily grow through these interfaces and tend to turn horizontally when encountering these boundaries.

The restriction of water percolation across soil strata does not apply to rainfall. Rainfall or sprinkler irrigation wets soil as point sources from droplets, but over time, the soil becomes wetted uniformly in the horizontal dimension. That prevents gradients of soil matrix potential from developing in the horizontal dimensions and water is allowed to saturate at the interface between soil layers. Hence, soil profiles are filled back up sometime during the rainy season, thereby allowing roots to take up moisture from all levels during the springtime.

Coarse soils without strong stratification will not hamper moisture percolation, but the coarse particles (rocks, gravel, sand), tend to cause water to fan out from the point of water application. In non-saturated flow, water moves in films along these particles and does not fill the soil pores. The coarse particles cause water to be diverted horizontally, which tends to form a wider wetted bulb than would occur under a high-rate water application in the same soil. Hence, moisture does not simply "run through" a light-textured soil as many believe.

On the contrary, water moves much more readily in the vertical dimension in heavier, more uniform soils. As will be seen in the results, the only site where a normal irrigation reached 48 inches depth was the heavier, more uniform Zamora Silty Clay Loam soil.

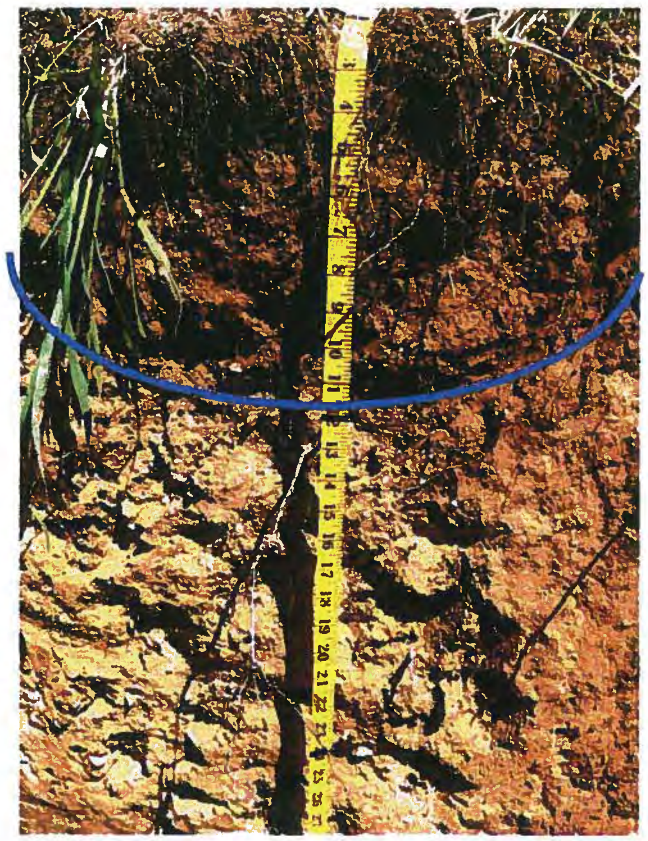
What are the consequences of these findings and theory? It was feared that excessive irrigation could cause deep percolation of moisture below the root zone, potentially below the depth at which roots could extract moisture. This could cause contamination of the groundwater by leaching of contaminants within the irrigation water or by fertilizers or possibly pesticides that have been applied with the irrigation water. However, this is unlikely to be the case in many of these soils, at least those of coarse texture and/or those with strong soil stratification. Nevertheless, even though the leaching is unlikely to occur in those soils due to drip irrigation, rainfall, typically on the order of 35 to 40 inches per season, that occurs following the season may leach out any leachable contaminants (such as nitrate), if present in the soil after the vines enter dormancy. Hence, though leaching does not appear to be an immediate concern from irrigation alone, leaching from the high amounts of rainfall typically experienced in this region may threaten groundwater and possibly streams if high residues of leachable materials are present in the soil.

Land stewardship to maintain soil and water quality would indicate that residues of potential mineral contaminants should not be present in the soils after vines become dormant in the fall and can no longer extract such minerals.

Summary of observations and conclusions by site:

Arbuckle Gravelly Sandy Loam

Sandy loam to 24" over decomposed sandstone PM. Wetted soil to 13" deep and 20" wide about 10" from emitter. Few gravels only at surface. Very porous and little stratification. Downhill runoff from emitter. Mottling at 36" and below.

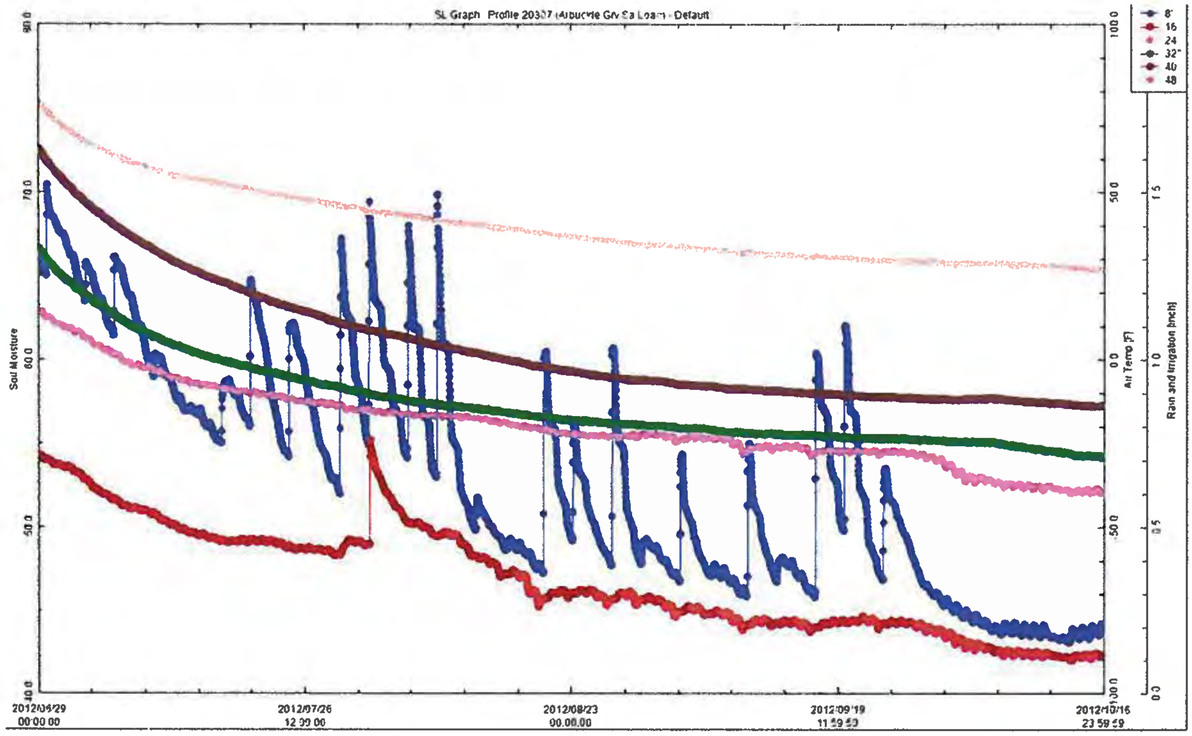


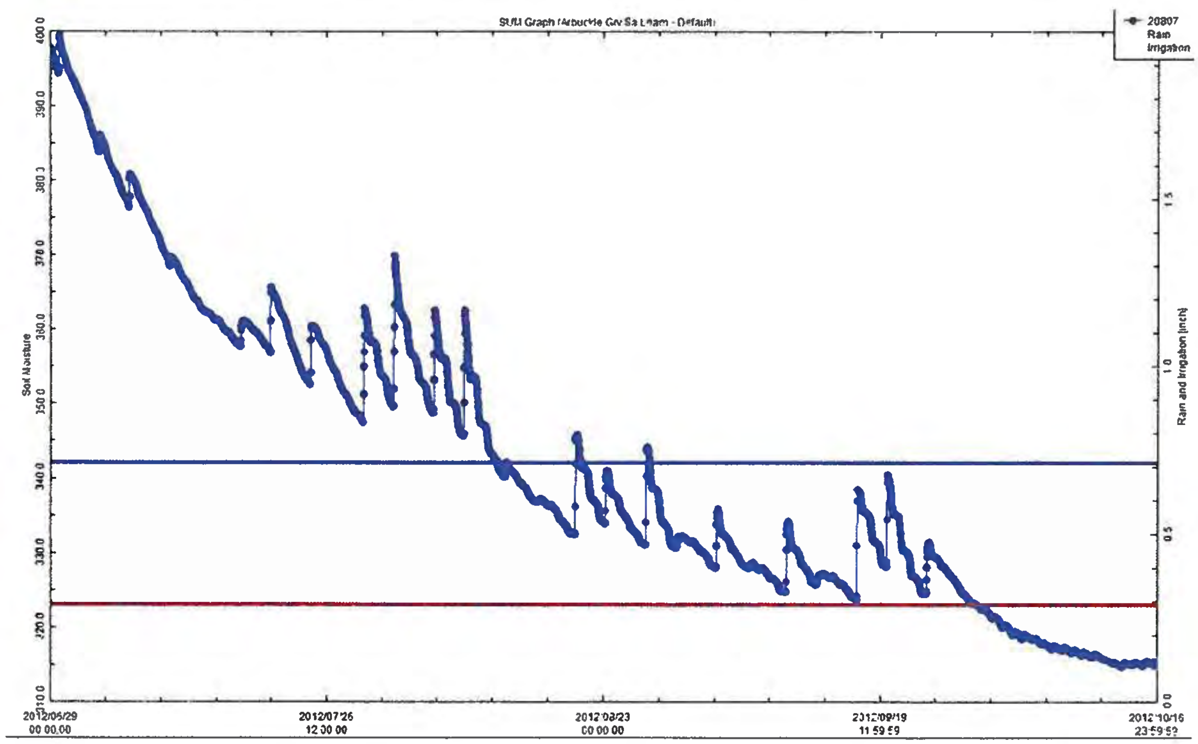
- Viognier
- 1.6 inches total irrigation
- 13% of full ETc (June 29 – Oct. 15)
- Runoff was a problem, so short irrigations best
- Vines were not stressed during the season

This site featured a soil profile that was fairly uniform. If this vineyard was on relatively level ground, percolation of water to deep levels would have likely been possible. However, the vineyard is slightly sloped with partial terraces. Water ran off the surface into the wheel tracks during irrigations. Hence, a low-volume irrigation application was necessary, which necessitated frequent applications of water. The soil moisture chart illustrates how moisture did not usually percolate past the 8" level, only moving to 16" on one occasion. Water supply was limiting at this site, so irrigations, which should have been applied twice per week, did not always get applied at that frequency. As a result, the total soil moisture trended downward during most of the season, though some irrigations at the end of the season

(September) arrested the decline temporarily. Nevertheless, vines were able to extract moisture from deeper soil levels and by doing so, did not reach high levels of water stress.

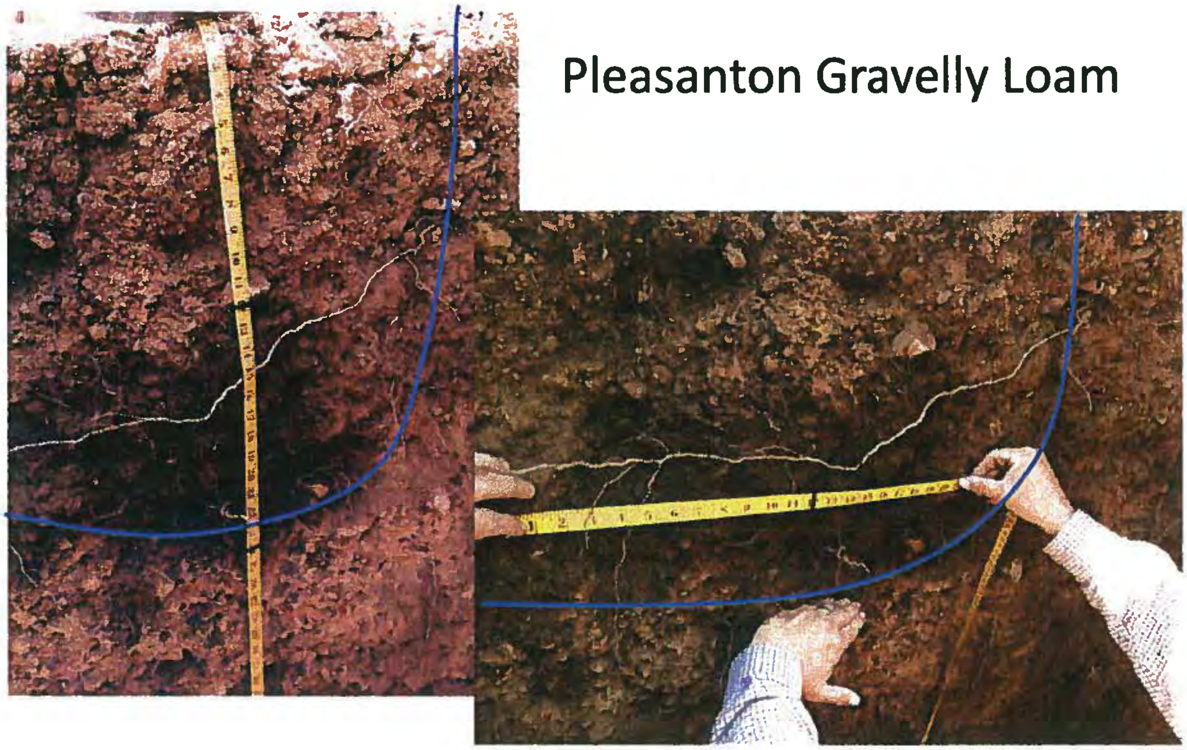
A total of 1.6 inches were applied to the vineyard until October 15, amounting to only 13% of full ETc.





Soil moisture information collected during the irrigation season of 2012 at the Arbuckle Gravelly Sandy Loam site. The upper chart shows relative soil moisture content at 6 depths, from 8" to 48" in 8" increments. The lower chart shows a summation of the soil moisture from each level, to indicate the relative water content of the entire profile. The blue line indicates an ideal "full point" and the red an ideal "refill point", as referenced in the text.

Pleasanton Gravelly Loam



Very gravelly. Loosely consolidated loam with large pores. Strong stratification to coarse gravel at 23". Wetted bulb down to 23" deep and 21" wide at 10" from emitter drop. Gravel to at least 48". Prolific rooting in mid row to 34".

- Chardonnay
- Erratic irrigation due to system problems
- 2.6 inches total irrigation
- 22% of full ETc (June 29 – Oct. 15)
- Irrigation did not percolate below 22" due to soil stratification
- Vines were very slightly water stressed late in the season

This site, although on a toe slope above the river basin, had some strong soil strata that limited water percolation. The major stratification is at 23 inches depth, where coarse gravel underlies a loam textured soil. That interface was wavy, probably due to soil preparation before vineyard planting. The soil excavation revealed that moisture reached to 22 inches, approximately, from which it appeared to spread horizontally. Note in the soil moisture graph below that the 32 inch level was never affected by irrigations, only rising at the end of the period because of rainfall.

Irrigation at this site was erratic due to an unknown problem with the irrigation system hydraulics. Irrigation was slightly more frequent than necessary during most of the season and transitioned to daily irrigations towards the end of the season (due to the system problem), where daily irrigation applications were made. Nevertheless, looking at the soil moisture summation curve, the overall soil moisture pattern showed that the applied irrigation did not result in a deficit of soil moisture during August and September and the daily irrigations in October resulted in overall moisture level increases.

Vines were at a good stress level for much of the season, at least with regard to stomatal conductance. However, stomatal conductance did dip slightly below the target levels on a few occasions indicating that a slightly higher refill point is needed. However, taking in to account the excess irrigation at the end of the season, the amount applied is probably a reasonable quantity. 2.6 inches were applied, which constitutes only 22% of full ETc.

Vineyard close to harvest

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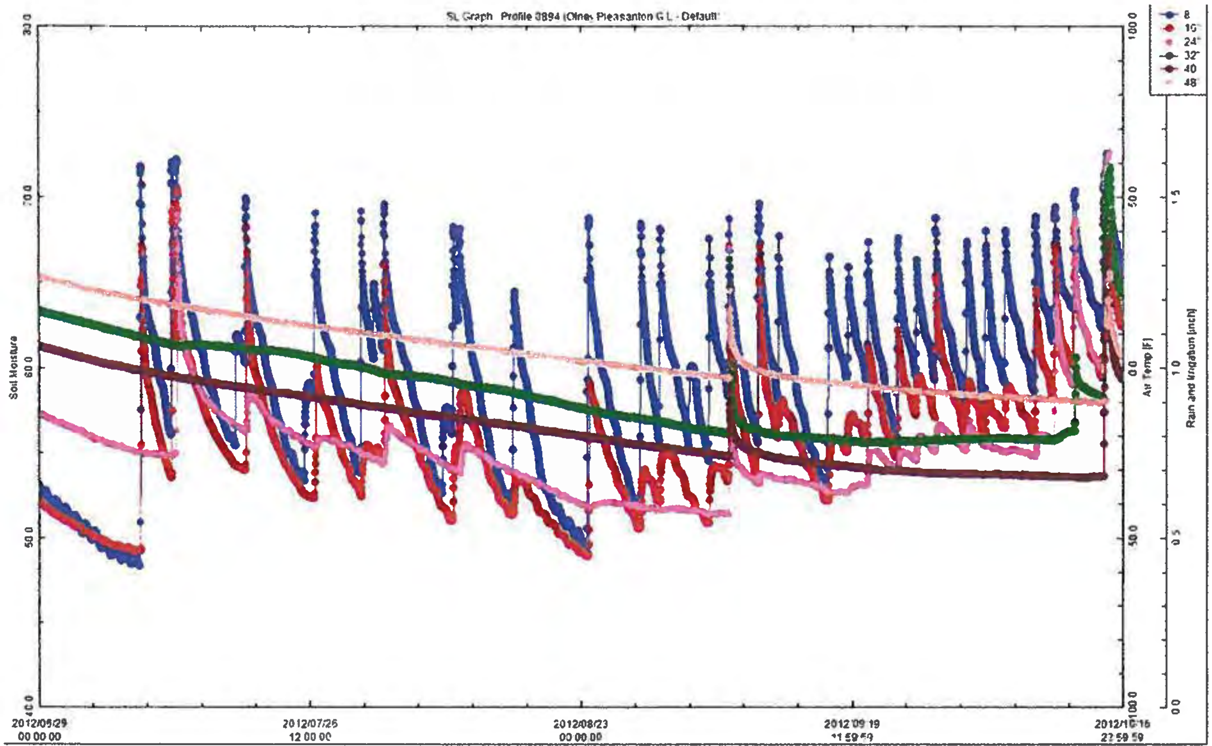
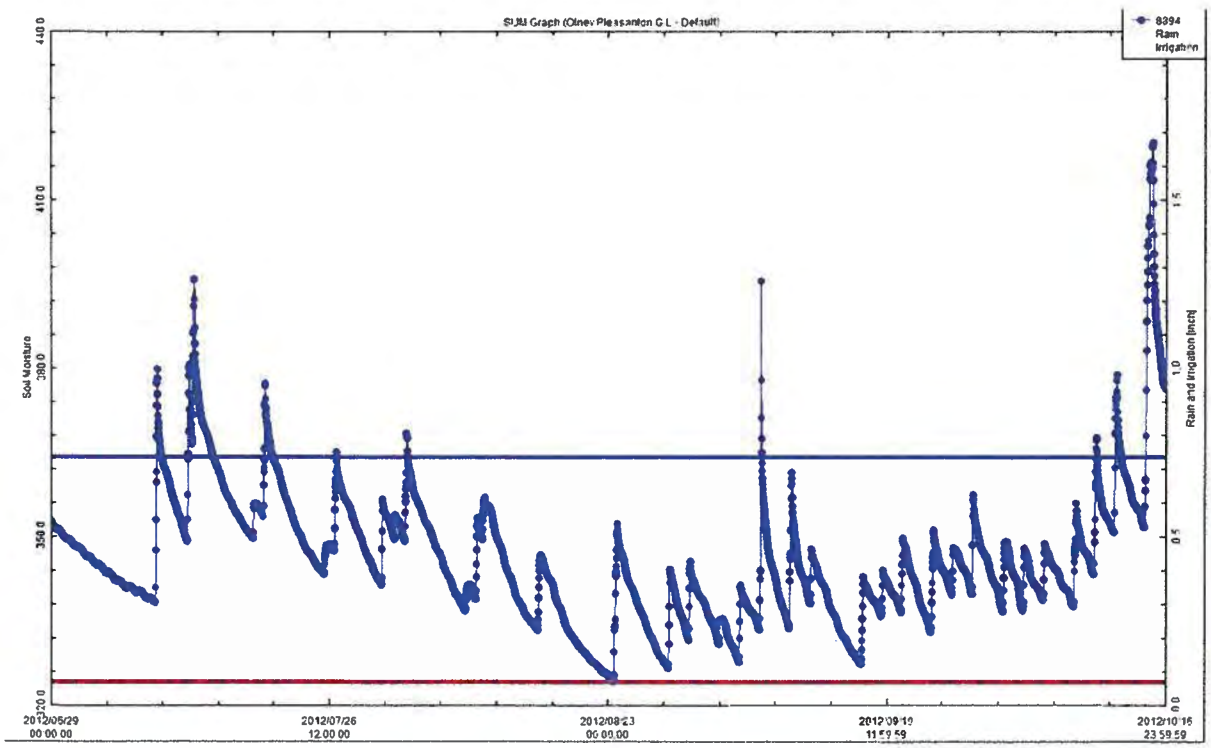
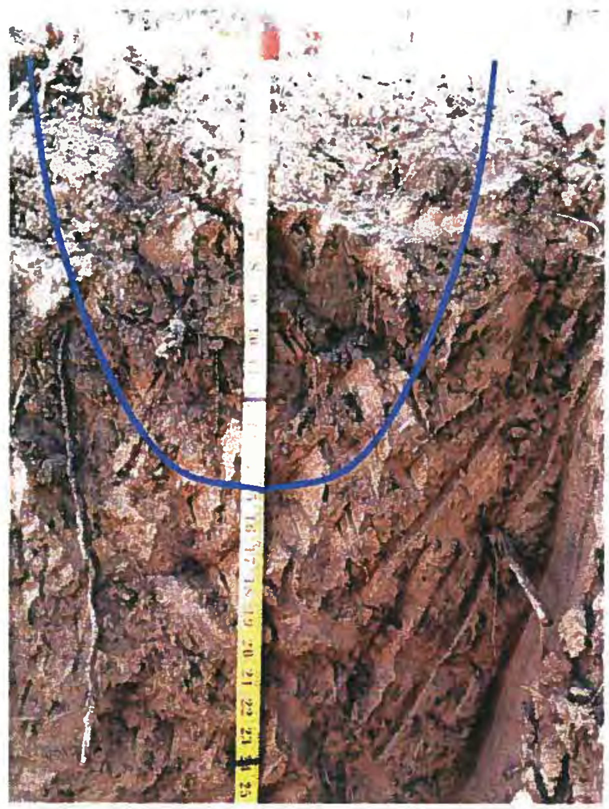




Soil moisture information collected during the irrigation season of 2012 at the Pleasanton Gravelly Loam site. The upper chart shows relative soil moisture content at 6 depths, from 8" to 48" in 8" increments. The lower chart shows a summation of the soil moisture from each level, to indicate the relative water content of the entire profile. The blue line indicates an ideal "full point" and the red an ideal "refill point", as referenced in the text.

Yolo Silt Loam (deep)



Uniform texture to at least 3'. Wetting bulb to about 15" deep and same width at 14" from emitter drop. Loose soil top 6" then uniform soil to 32" over more compact soil to bottom and below. Prolific large roots at bottom of pit. Many roots under dripper.

- Gewürztraminer, Lyre Trellis
- Very little irrigation needed. Extra given.
- 1.7 inches total irrigation
- 11% of full ETc (June 29 – Oct. 15)
- Irrigation did not percolate below 32" though some movement to 40"
- Vines attained healthy stress level late in the season. Leaf scorch not due to water stress.

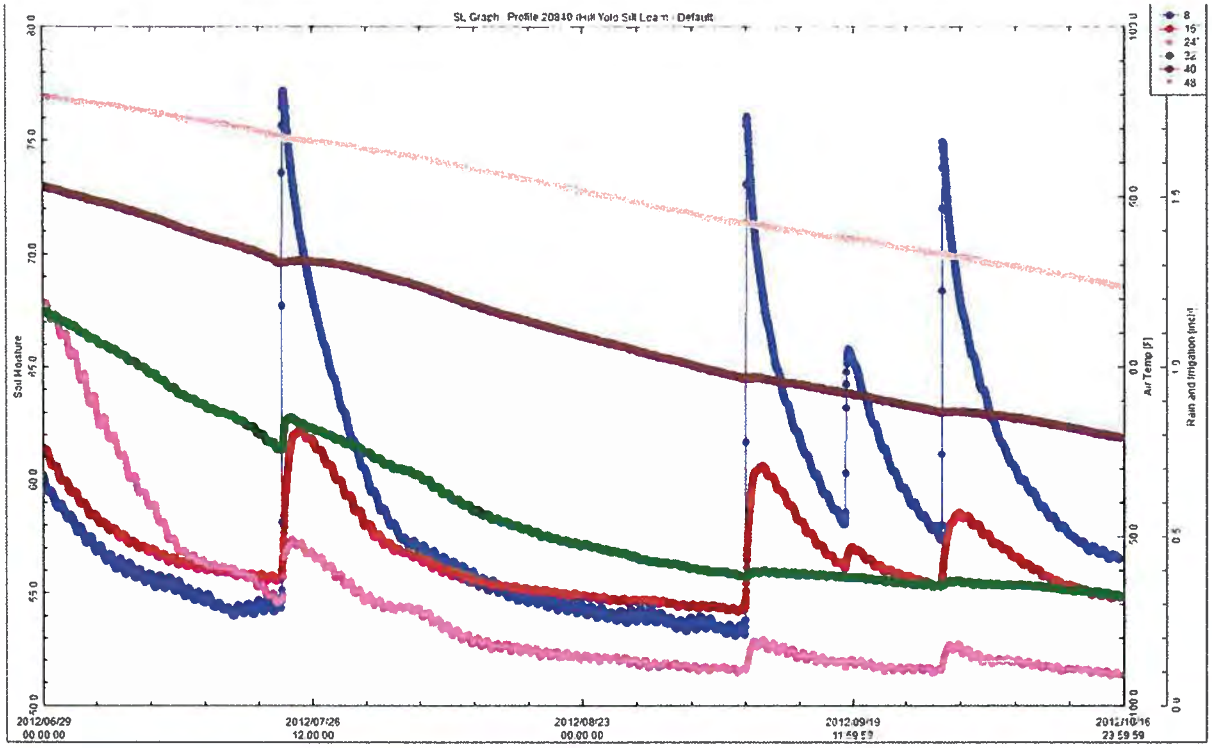
This soil was very deep, though only observed to about 4 feet. Soil was very uniform without strong stratification of soil textures. The recent irrigation had only penetrated to about 15 inches, but was rather wide, with a radius of about 14 inches. While this soil did not exhibit stratification, the coarse texture of the soil (due to silt content) caused the wetted bulb to be wide and not deep. If the irrigation volume had been larger, it would probably have gone deeper, but that large an application may have over-stimulated vegetative growth of the vines. This site did not require much irrigation at all, though some preventative irrigation applications were applied prior to heat events. Roots were found deep in the profile and it can be assumed that the root system extends further than we measured, as there did not appear to be a limiting factor for root penetration in this soil.

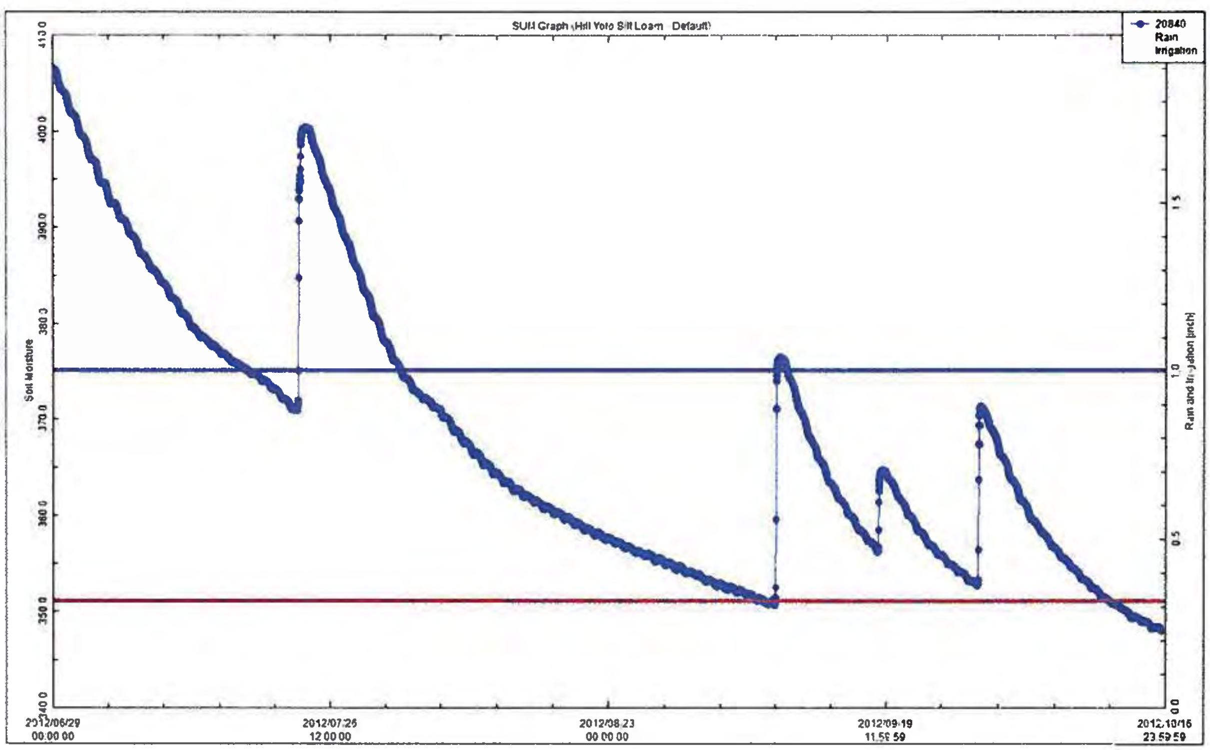
The first irrigation did not reach the 32 inch depth, but did redistribute to that depth, but only slightly raised the soil moisture down there. Subsequent smaller irrigations did not reach the 24 inch depth to a great degree.

Steady moisture depletions can be seen at both 40 and 48 inch depth, indicating an ample water supply to the vines down deep, suggesting that irrigation could have been reduced from the actual applied amount. However, the deficit in soil moisture was halted by late August, which may have been desirable, as water stress is not beneficial for a white variety, even with slight pigmentation such as with Gewürztraminer. Leaf water potential levels were well below stressed levels, though stomatal conductance levels indicated a very good moderate stress level in the vines, which would have improved the water use efficiency of this vineyard.

Overall, the vineyard had 1.7 inches of irrigation, which equated to 11% of full ETc. Note that this was the only vineyard with a divided, Lyre type, trellis, which employed a higher crop coefficient in the ETc model than the other VSP trellis systems.

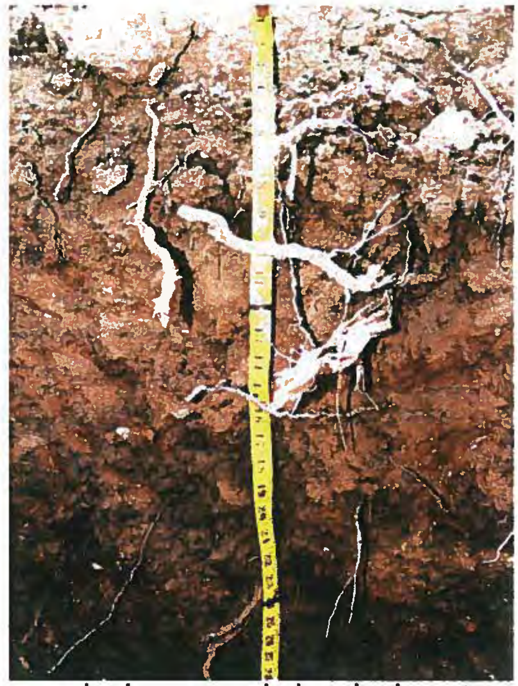
Vineyard close to harvest.





Soil moisture information collected during the irrigation season of 2012 at the Yolo Silt Loam (deep) site. The upper chart shows relative soil moisture content at 6 depths, from 8" to 48" in 8" increments. The lower chart shows a summation of the soil moisture from each level, to indicate the relative water content of the entire profile. The blue line indicates an ideal "full point" and the red an ideal "refill point", as referenced in the text.

Zamora Silty Clay Loam



14 inches of brown clay loam over darker clay loam to 31" over matrix of clay and gravel. Roots primarily to 31". Root system extends into vine row to 26". No irrigation yet. Weak stratification at 14" unlikely to affect percolation because similarly textured.

- Chardonnay
- Very little, if any irrigation needed. Irrigated twice.
- 0.6 inches total irrigation
- 5% of full ETc (June 29 – Oct. 15)
- Uniform, heavy soil allowed water to percolate to 48" depth – only soil in this study that did
- Vines were not stressed at all, suggesting that vines may have been fine without irrigation

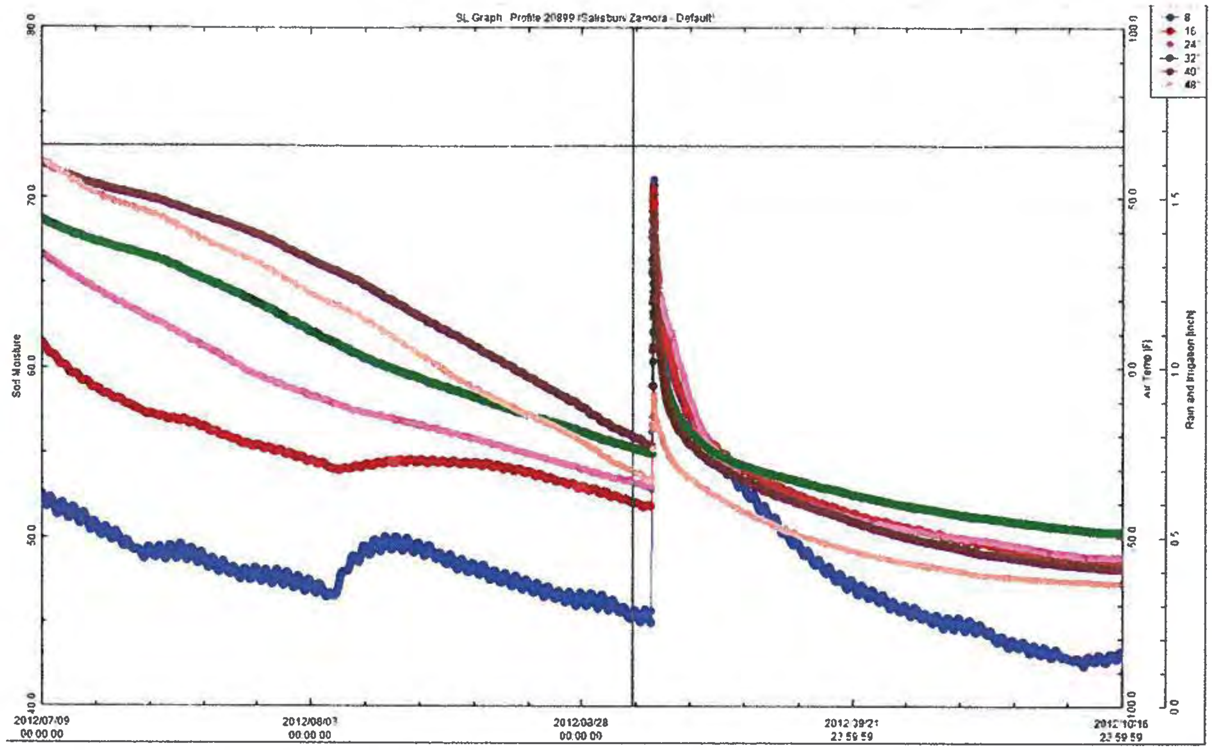
This site was chosen to represent one of the heaviest soils of the region. The soil was heavy, but quite uniform without any strong stratifications, except for a change from the loam texture to a clay/gravel matrix at 31 inches.. Soil was fairly moist at the time of observation and the block had not yet been irrigated (so no visible wetting patter could be identified. This vineyard required very little irrigation, but the grower decided to make two irrigation applications. The first one did not get sensed by the soil probe because water had run down the drip hose away from the soil moisture sensor (this vineyard had embedded emitters unlike all of the others). This points out the importance of proper sensor placement.

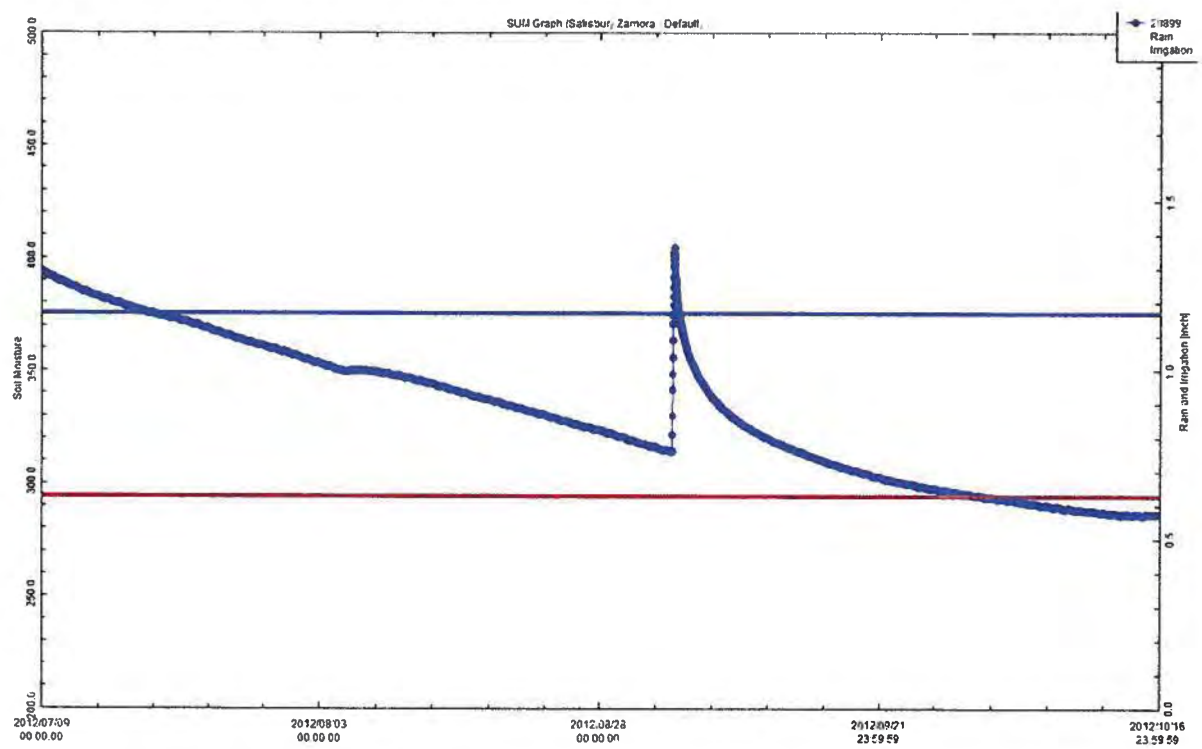
Because this soil is heavy, the wetted plume was not wide, so irrigation about 18 inches away from the drip point did not reach to within the sensing zone of the probe (which only has a radius of influence of about 2-3 inches). The problem was fixed and the subsequent irrigation was sensed clearly by the probe. In fact, this was the only site where the irrigation clearly reached the 48" depth during a normal irrigation. Refer to the discussion above for an explanation of this phenomenon.

Note that the depletion patterns indicate that moisture was steadily being depleted throughout the profile at all levels until late in the season, where the shapes of the curves indicate that depletion had slowed. Vines were not stressed during the season, and leaf water potential was high (less negative), suggesting ample water supply. Likewise, stomatal conductance was high throughout the season. This vineyard appears to be able to get by (at least in a mild year such as this one) on only one or two irrigation applications. There is no incentive to do so, but it could possibly be dry-farmed in mild seasons.

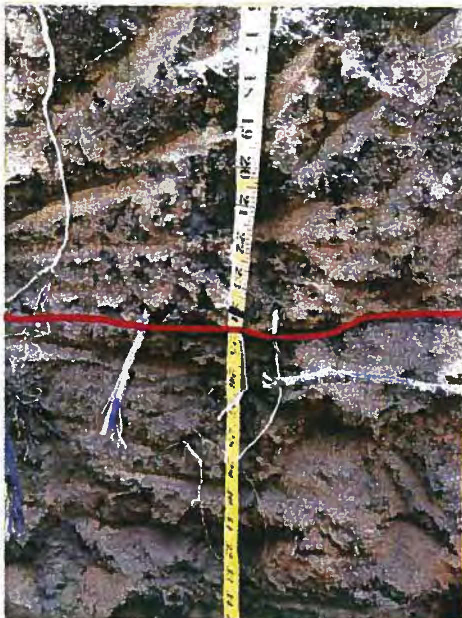
The vineyard had only 0.6 inches of water applied, comprising 5% of full ETc.

Vineyard close to harvest

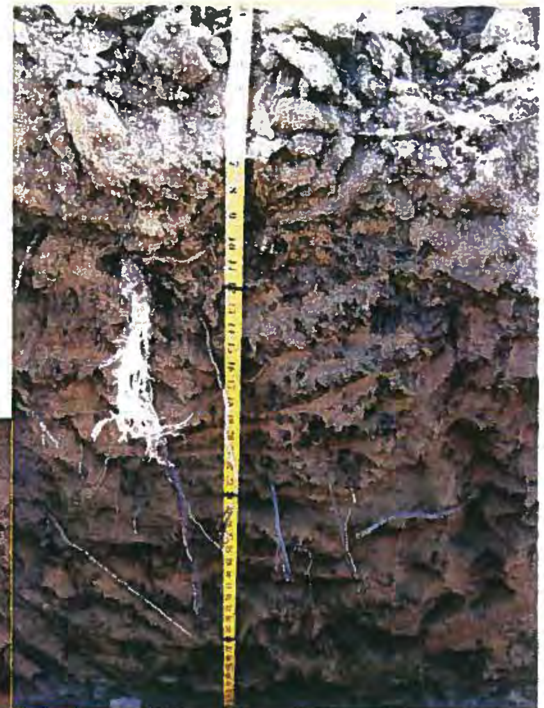




Soil moisture information collected during the irrigation season of 2012 at the Zamora Silty Clay Loam site. The upper chart shows relative soil moisture content at 6 depths, from 8" to 48" in 8" increments. The lower chart shows a summation of the soil moisture from each level, to indicate the relative water content of the entire profile. The blue line indicates an ideal "full point" and the red an ideal "refill point", as referenced in the text.



Cortina
Very
Gravelly
Loam



Sandy loam to 21" over abrupt boundary change to sand to 41" over abrupt coarser unconsolidated sand and gravel.

Wetting zone is not well-defined, but width of wetting zone is 26" deep observed 12" from dripper. Roots to 40".

- Chardonnay
- Irrigation necessary. More erratic scheduling than ideal. Excess application made late in season resulted in second-highest water application of all sites
- 4.1 inches total irrigation
- 34% of full ETc (June 29 – Oct. 15)
- Stratification at 24" depth. Percolation below 24 inches not possible until excessive irrigation was made.
- Vines got a bit moisture stressed late in the season. More regular irrigation applications may have reduced water stress.

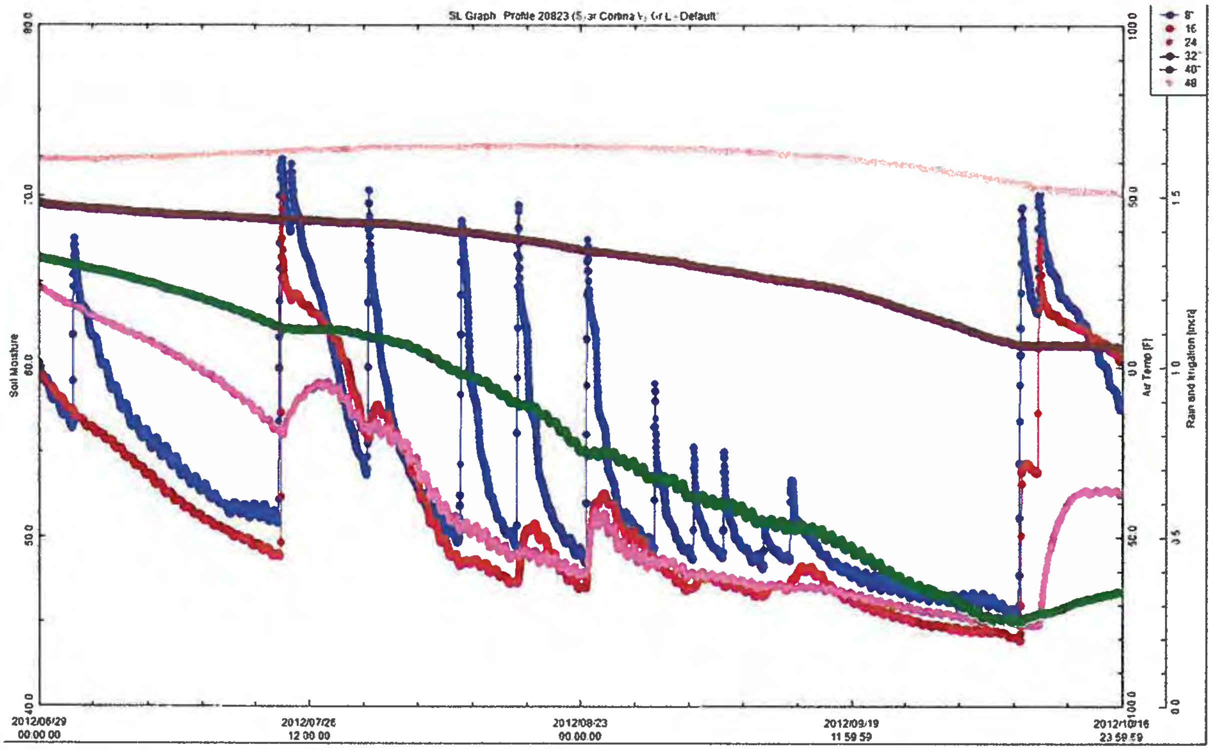
This vineyard was chosen because it was on the coarsest soil in the region, according to the NRCS soil survey. The concern for this site was that heavy irrigation would drive moisture through and below the profile, potentially contaminating groundwater. We did not find this to be the case. There was a stratification at about 21 inches depth, with a sandy loam textured soil overlying a coarse sand/gravel layer. Another stratification occurred at about 41 inches, where an unconsolidated layer of sand and gravel laid under a sandy loam soil. Roots tended to proliferate at those interfaces, suggesting their importance. In fact, we did find that moisture did not readily percolate to the 24 inch depth. Some of the irrigations did redistribute moisture to that depth early in the season, but most of the irrigations wetted only to the 16 inch sensor depth.

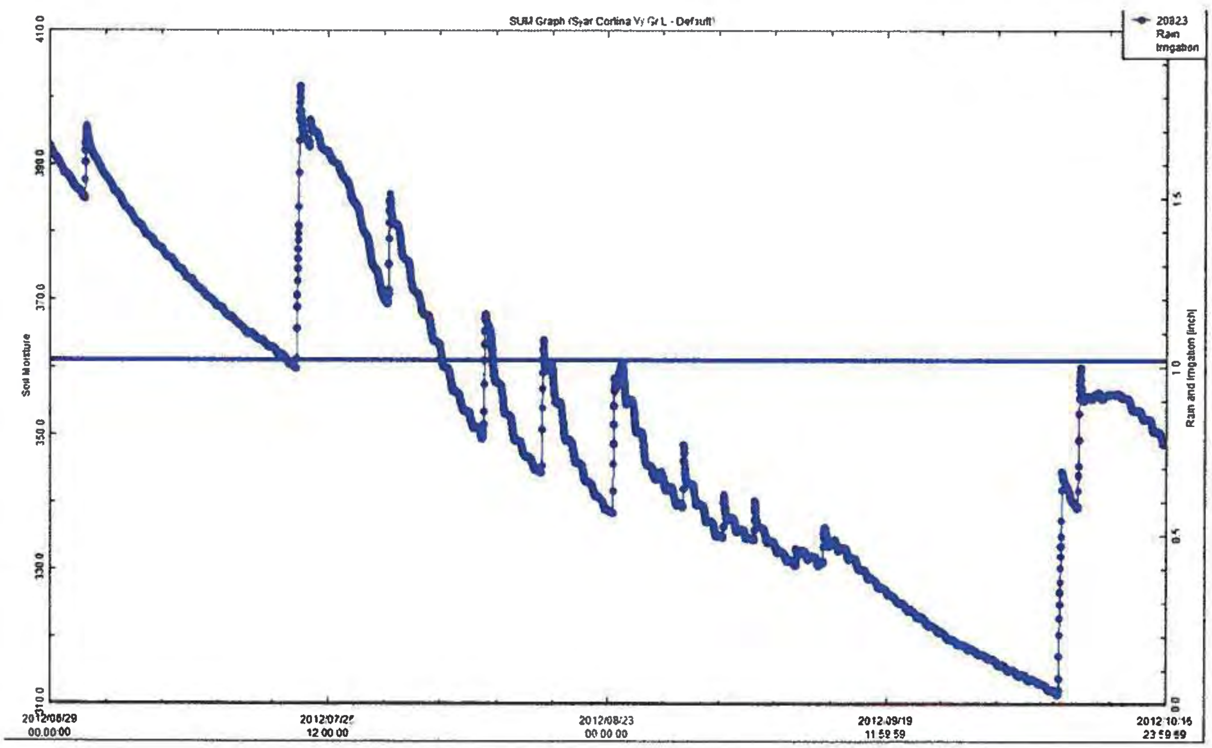
The relatively flat soil moisture curves at 48 inches and to a lesser extent 40 inches indicates that deep soil moisture was not being utilized by the vines.

The irrigation regime was insufficient to prevent a marked soil moisture deficit. Vines became water stressed throughout much of the month of August. After a long period without irrigation (which was not advised), a large irrigation application was made on October 6 (11 hours followed by 8 hours two days later). This amount of moisture was sufficient to raise soil moisture at 24 inches and only slightly at 32 inches – but not any further. There was visible water ponding at the surface which persisted for days following the second irrigation.

Including the large irrigations in early October, total amount of water applied was 4.1 inches, or 34% of full ETc.

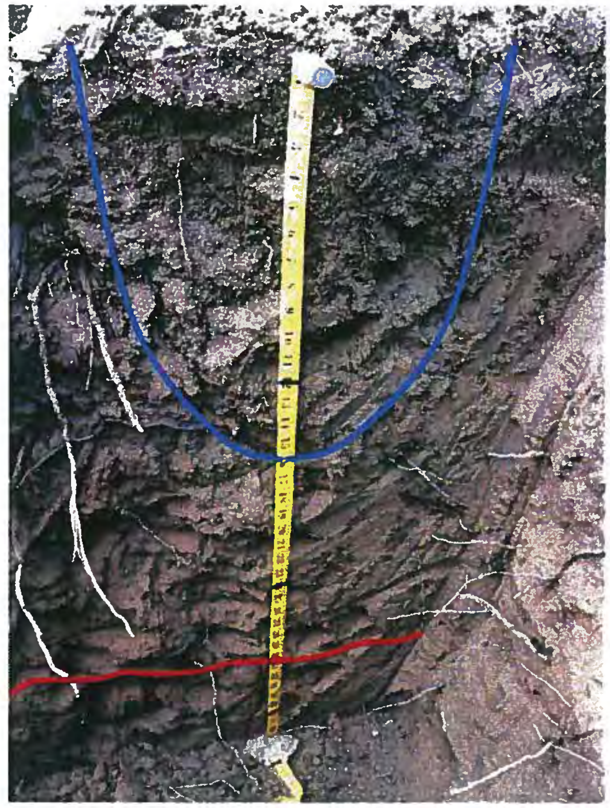
Block at the end of the growing season





Soil moisture information collected during the irrigation season of 2012 at the Cortina Very Gravelly Loam site. The upper chart shows relative soil moisture content at 6 depths, from 8" to 48" in 8" increments. The lower chart shows a summation of the soil moisture from each level, to indicate the relative water content of the entire profile. The blue line indicates an ideal "full point" and the red an ideal "refill point", as referenced in the text.

Yolo Sandy Loam ("gravelly")



Uniform silt loam to 30" over weakly structured sand/gravel. Few small gravels at surface primarily. Water has run off into edge of tillage in row. Wetting bulb to 16" depth 12" wide as seen 8" from dripper. Roots to 30" where gravel starts.

- Chardonnay
- Not as gravelly a soil as expected – gravel primarily on surface.
- Vines needed irrigation, but irrigation scheduling was erratic. Excess application late produced highest irrigation application of the study sites.
- 4.7 inches total irrigation
- 40% of full ETc (June 29 – Oct. 15)
- Stratification at 30" depth, but percolation to 24" was difficult during normal irrigation. Large, application late in the season allowed for deep percolation and ponding on surface indicated excess irrigation.
- Vines were not moisture stressed at all, suggesting that irrigation volume could have been reduced.

This site was noted to be a gravelly site. However, we observed very little gravel within the profile, except for some at the surface and relatively deep in the profile. There was a strong stratification of finer to coarser textured soil at about 30 inches. Roots did not grow into the coarse layer below 30 inches. However, depletions of soil moisture at 40 and 48 inches, suggest that there are either roots down at those levels or moisture is being utilized by roots above them by capillary action (matrix forces) within the soil. A closer look at the soil moisture dynamics (not shown) indicates that the diurnal uptake pattern is seen at 40 inches, but not at 48 inches. This indicates that there are roots nearby the sensor at 40 inches, but not at 48 inches.

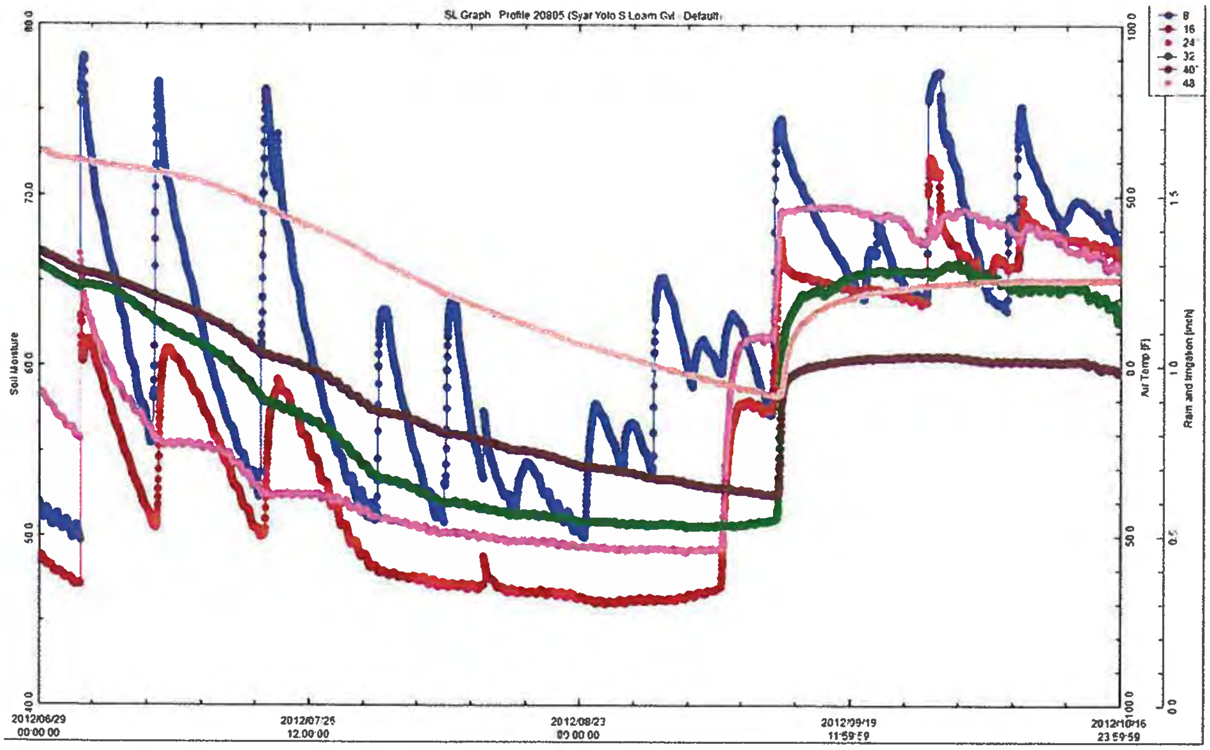
The soil was a sandy loam without any other clear stratification. Nevertheless, moisture was seen to only 16 inches depth during the observation, even though water had ponded at the surface, indicating poor infiltration. Irrigations were not able to raise soil moisture below the 16 inch depth during most of the season. An inadvertently-long irrigation (27.5 hours, 27.5 gallons per vine) was made beginning on September 11. This was accidental. However, it did show that the extra-large volume of irrigation application allowed moisture to reach all levels, apparently to 40 inches and redistributing to 48 inches. While this was an accidental irrigation, it is illustrative of how resistant these soils are to deep percolation using drip irrigation as it took a very high volume of water to reach deep levels (and soil was far from saturated at those levels).

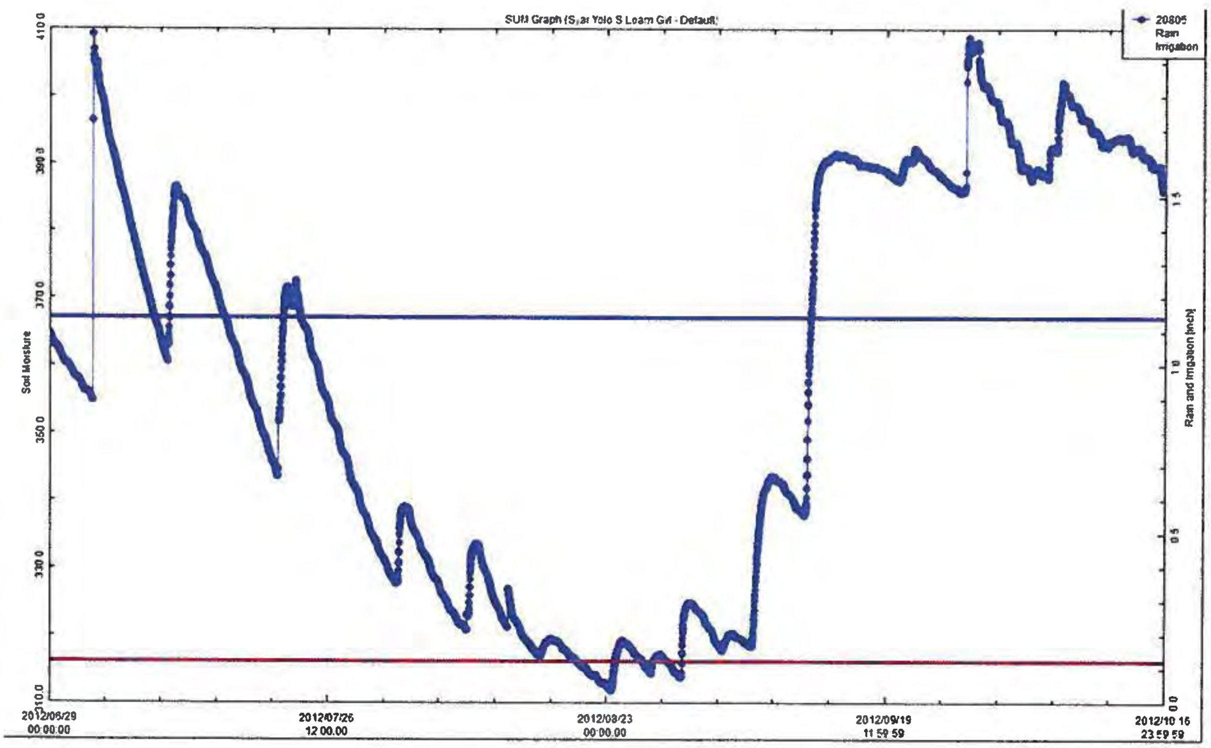
Vines did not reach any level of stress during the season, likely due to the large accidental irrigation. But, early irrigation applications were insufficient to prevent soil moisture deficit and vines may have gotten stressed. However, a more regular pattern of shorter (about 5 hour) irrigations spaced at about 5 day intervals may have resulted in more steady soil moisture without the ponding of water at the surface.

In total, 4.7 inches of water were applied to the block (though over an inch of that was the large irrigation in early September). That quantity equates to 40% of full ETc.

Block at the end of the growing season.

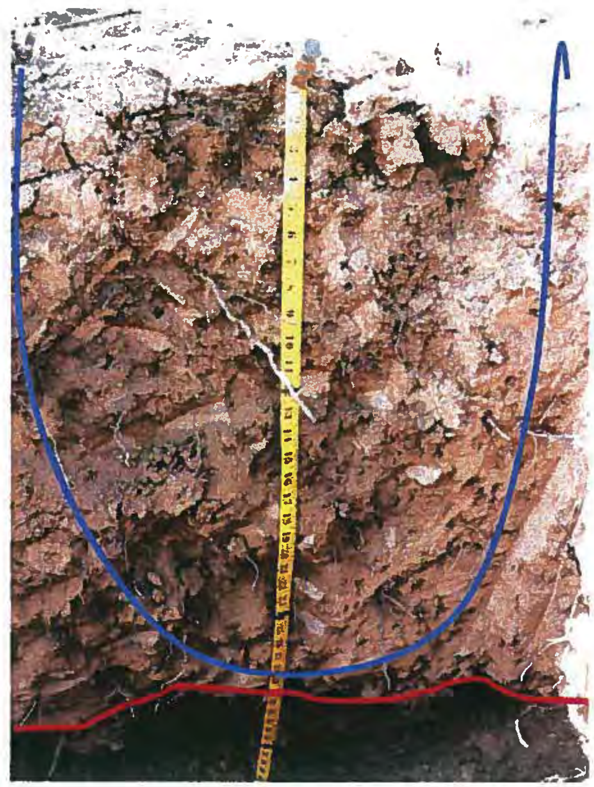
Surface ponding.





Soil moisture information collected during the irrigation season of 2012 at the Yolo Sandy Loam ("gravelly") site. The upper chart shows relative soil moisture content at 6 depths, from 8" to 48" in 8" increments. The lower chart shows a summation of the soil moisture from each level, to indicate the relative water content of the entire profile. The blue line indicates an ideal "full point" and the red an ideal "refill point", as referenced in the text.

Yolo Sandy Loam (non-gravelly)



Extremely uniform silt loam throughout profile. Roots to 36". Wetting from irrigation is widespread to at least 36" deep and 22" away from emitter (radius not diam). Evidence of water channeling along roots and profuse root exudate.

- Chardonnay
- No rocks or gravel at all in the profile
- Vines needed irrigation; single emitter per vine not ideal
- 2.1 inches total irrigation
- 18% of full ETc (June 29 – Oct. 15)
- No visible soil stratification, but percolation to 32" was observed – not to 40".
- Vines experienced moisture stress but did not exhibit stress symptoms. More regular irrigation applications with two emitters per vine would be improvement.

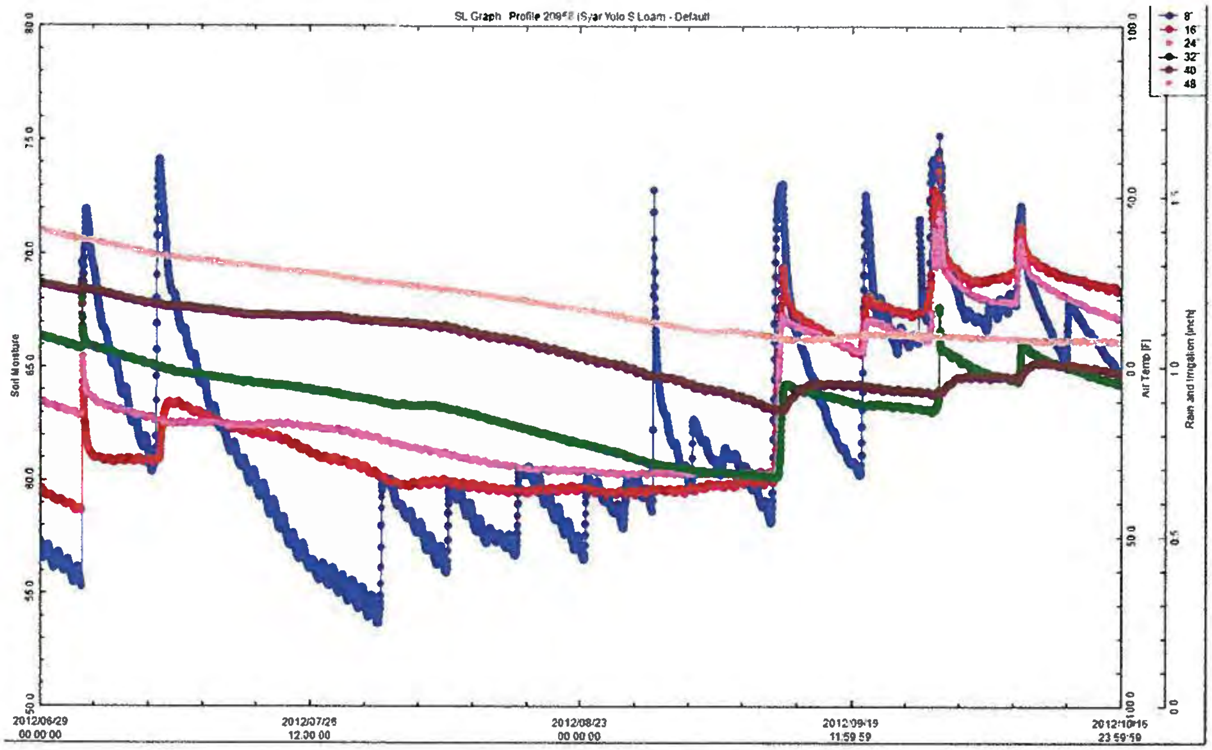
This block was the same blocks at the other Yolo Sandy Loam site, though the soil was considered to be non-gravelly. Indeed, there was little gravel in the profile, except for a transition to unconsolidated gravel at about 32 inches depth. Roots were found to about 36 inches. Like the other Yolo Sandy Loam site, very little uptake occurred at 40 and 48 inches, though there was some root uptake activity apparent at the 40 inch level, beginning in early August. The coarse texture of the soil apparently prevented deep percolation of soil moisture during routine irrigation, as most irrigations were not sensed by the 16 inch sensor. We found, however, that the profile was quite moist throughout the profile, not even having a pronounced wetting pattern. The lack of activity in the soil probe suggests that moisture may have been channeling away from the probe, which can occur with new probe installations. Often, this issue goes away after the probe "settles in" after the first rainy season.

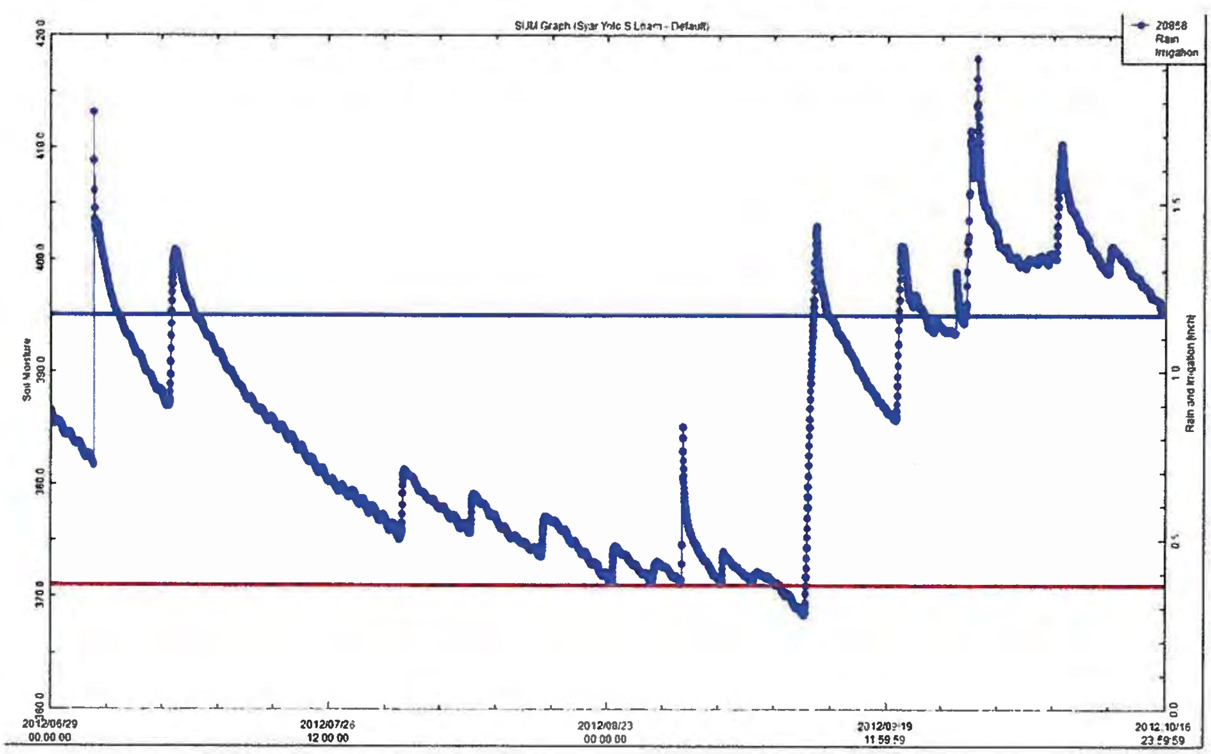
Nevertheless, the accidentally-long irrigation that occurred in the other Yolo Sandy Loam site occurred here as well, as they are the same block. However, this side of the block has only one emitter per vine, so the volume applied was half of that of the other side. The large irrigation was effective at wetting to almost the 32 inch sensor depth, with redistribution occurring to 40 inches.

Like the other side of the block, shorter, more frequent and certainly regular irrigations would have been better than the applications made there this season. However, the vines did not get stressed during the growing season.

Total amount applied to this portion of the block was 2.1 inches, or 18% of full ETc.

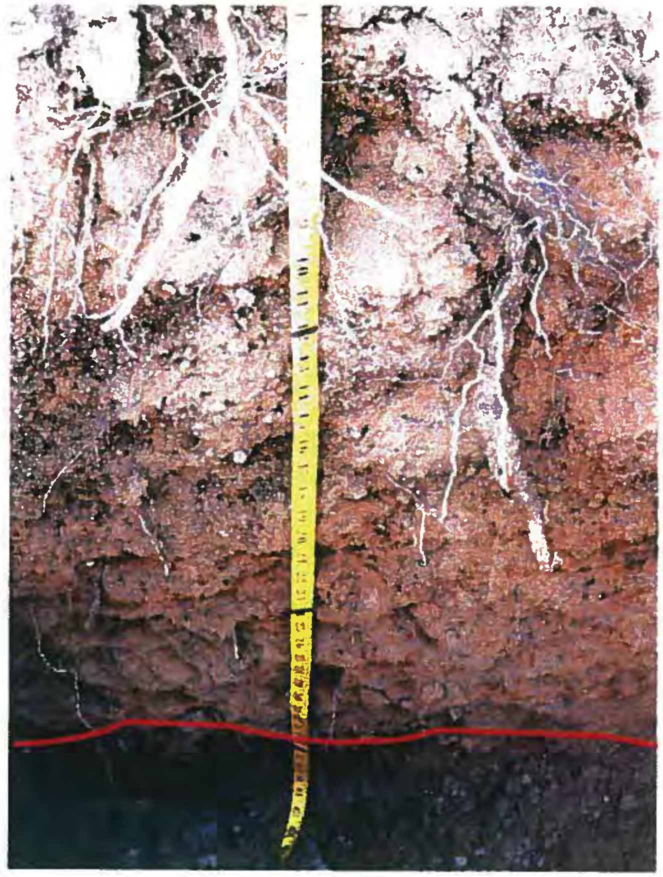
Block at the end of the growing season





Soil moisture information collected during the irrigation season of 2012 at the Yolo Sandy Loam ("non-gravelly") site. The upper chart shows relative soil moisture content at 6 depths, from 8" to 48" in 8" increments. The lower chart shows a summation of the soil moisture from each level, to indicate the relative water content of the entire profile. The blue line indicates an ideal "full point" and the red an ideal "refill point", as referenced in the text.

Arbuckle Gravelly Loam



Loam to 12" then discontinuous layer of gravel to 20" over sandy loam with strong mottles to 37" over gravelly sand that is saturated with water. Roots to 35". Not irrigated yet at time of observation.

- Chardonnay
- Gravel throughout profile. Rust mottles indicative of seasonally-waterlogged soils. Vines did not require irrigation due to moist soil/high water table. Irrigation applied for fertigation only
- 0.8 inches total irrigation
- 7% of full ETc (June 29 – Oct. 15)
- Abrupt stratification at 37" would impede water percolation with drip
- Vines did not experience water stress at all despite lack of irrigation.

This site was known to require very little moisture, but was chosen because it was an Arbuckle soil on flat ground, as opposed to the other site, which was on a slight hillside on a benchland.

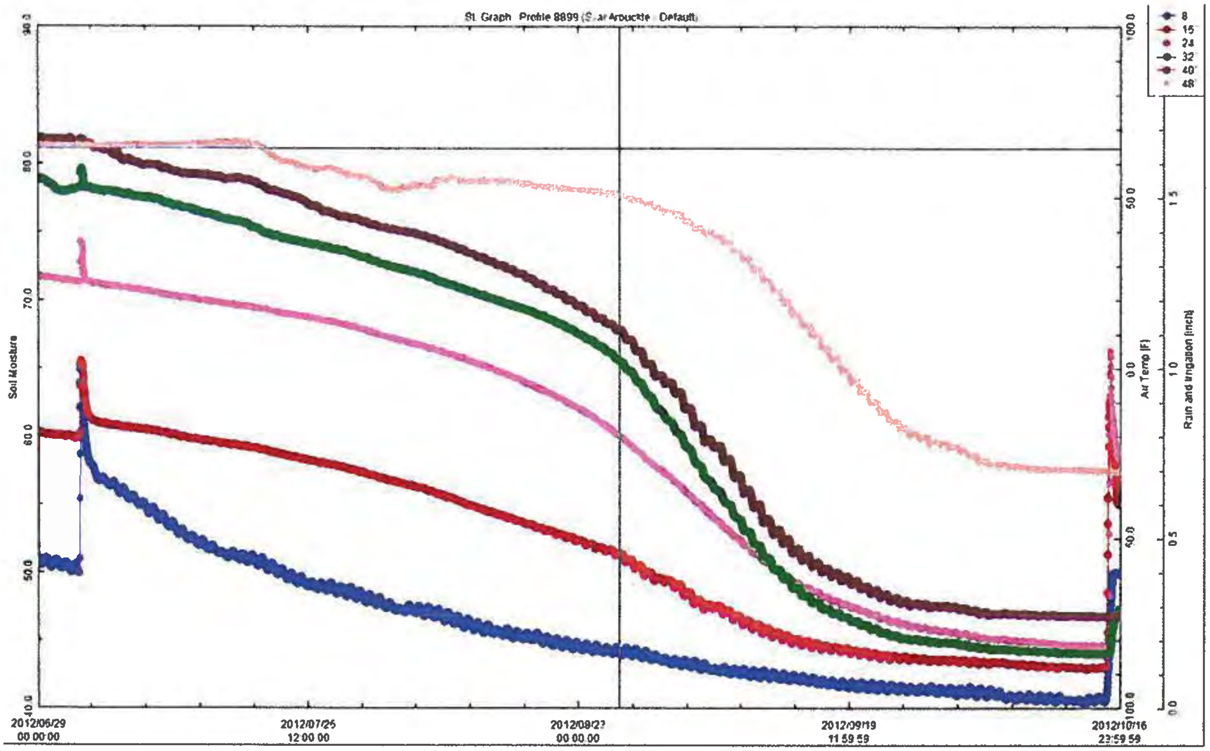
At the time of observation, the soil was waterlogged at about 4 feet depth. There are strong rust mottles, indicative of periodic waterlogging between about 20 inches to the point of soil discontinuity at 37 inches. Below 37 inches, soil transitions to an unconsolidated gravel. Roots were present to only 35 inches, though there are likely deeper roots considering that the "ripples" in the moisture depletion patterns at 48 inches indicates roots in the proximity of the soil moisture sensor.

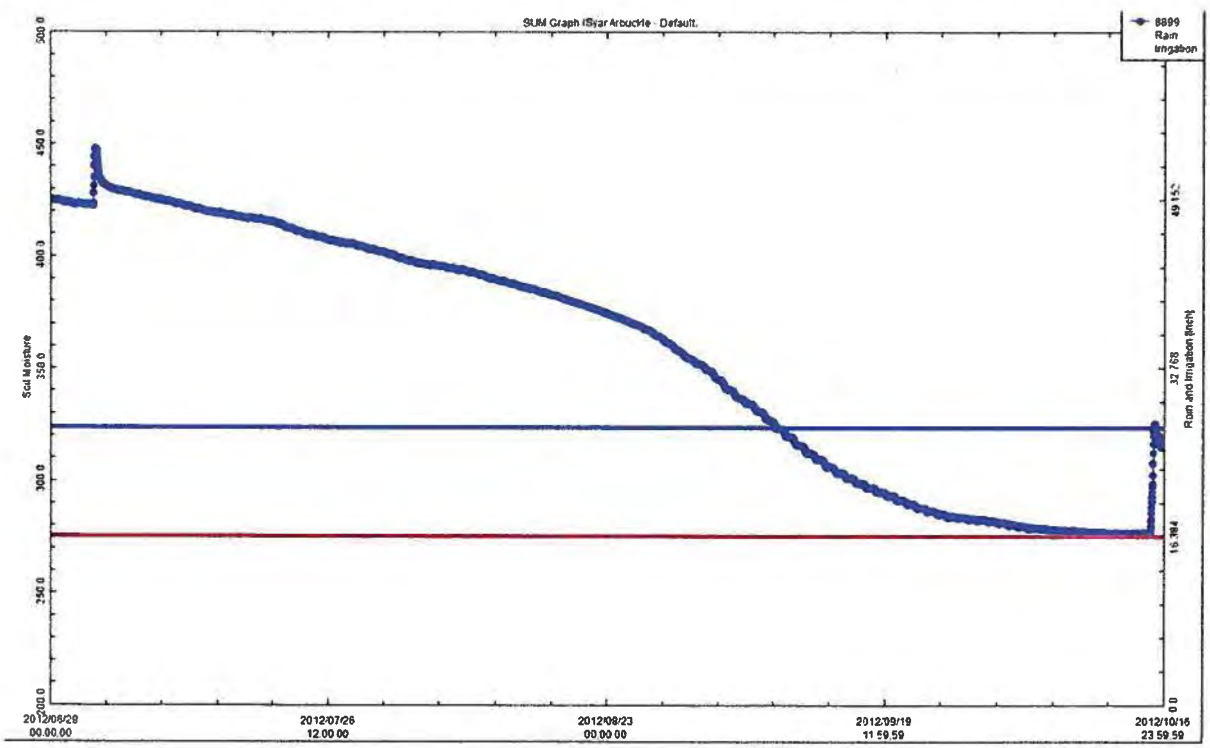
The soil moisture is high in this profile, relieving the vineyard of the need for irrigation. One 8 gallon per vine irrigation was applied on July 3 for the purpose of fertilizer application. No additional irrigation was applied to this site.

Vines did not experience stress at this site, though they became progressively lower in water status as the season progressed due to lack of irrigation. Note that the soil moisture levels "flatten out" towards the end of the season, indicating that vine stress level was increasing. Nevertheless, the vines were not stressed enough to require irrigation.

This site received 0.8 inches of irrigation or 7% of full ETc.

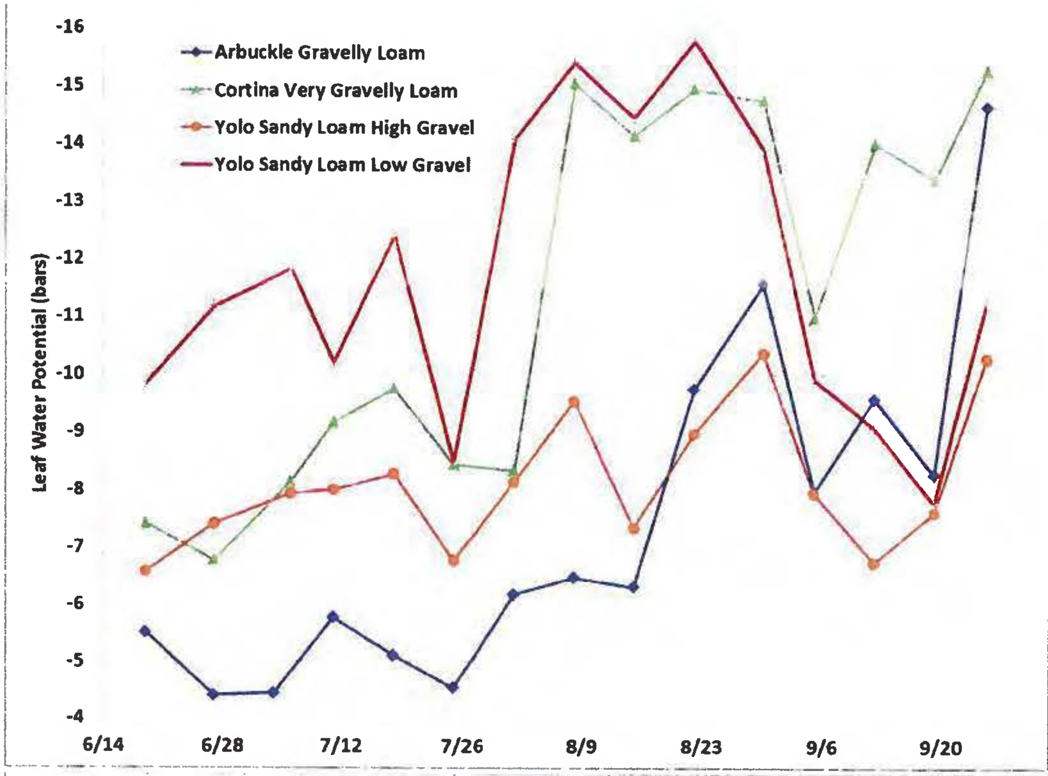
Block close to harvest

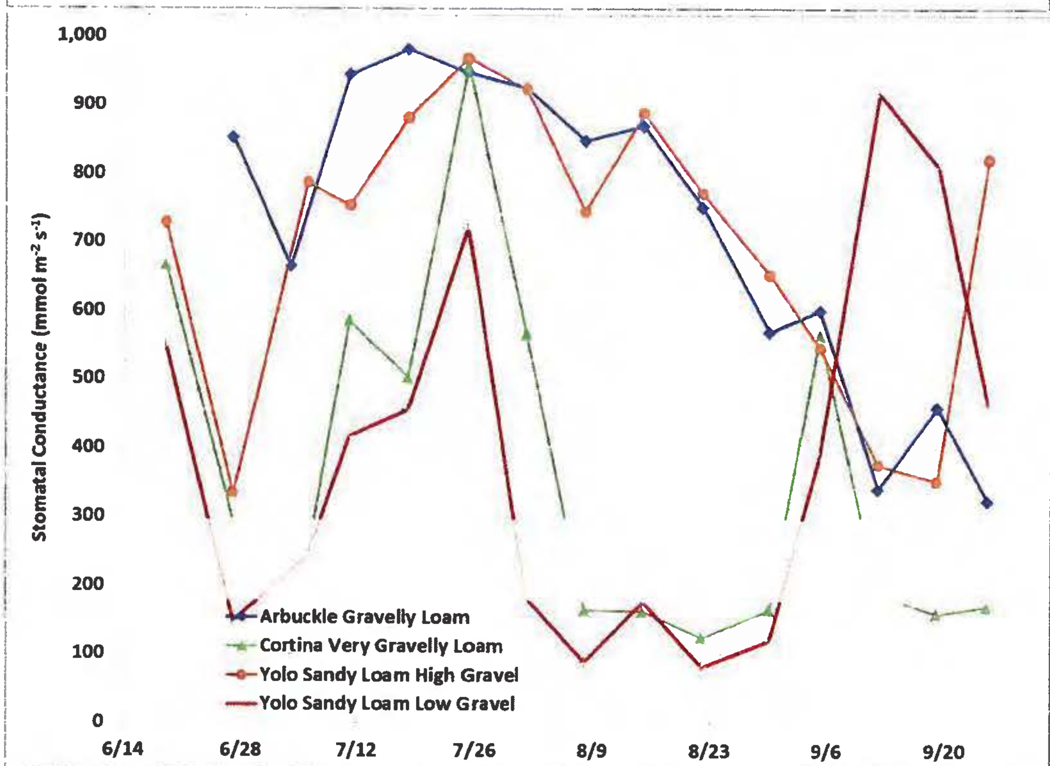




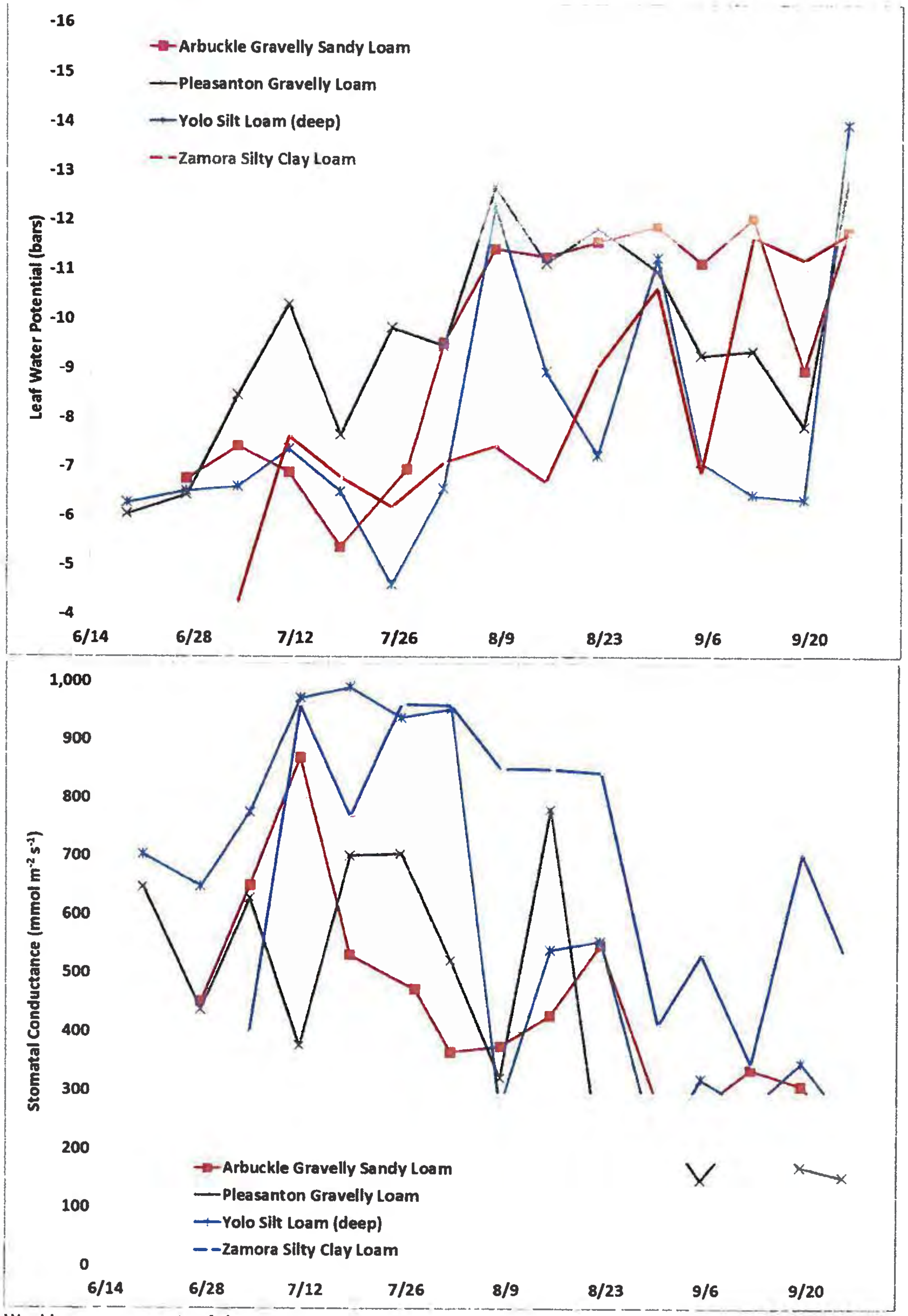
Soil moisture information collected during the irrigation season of 2012 at the Arbuckle Gravelly Loam site. The upper chart shows relative soil moisture content at 6 depths, from 8" to 48" in 8" increments. The lower chart shows a summation of the soil moisture from each level, to indicate the relative water content of the entire profile. The blue line indicates an ideal "full point" and the red an ideal "refill point", as referenced in the text.

Combined Site Information

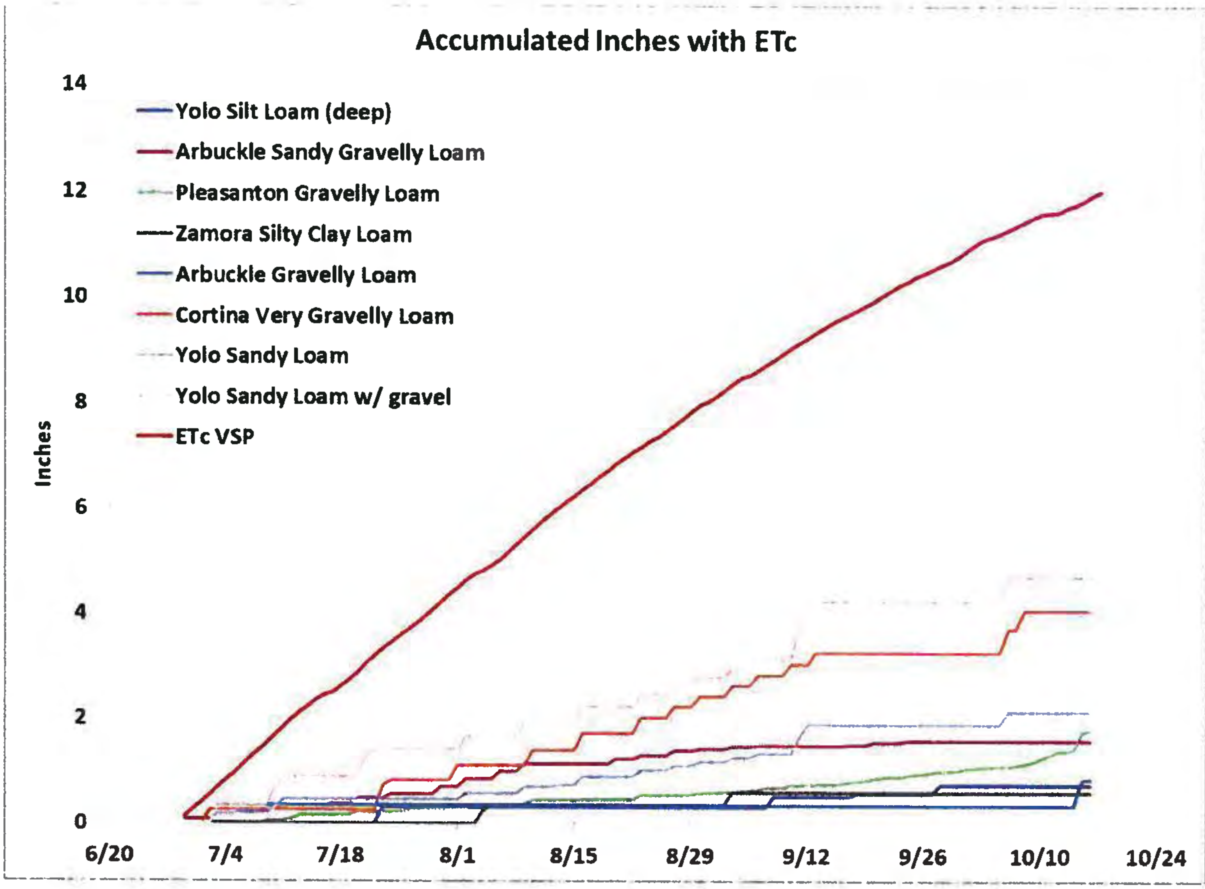




Weekly measurements of vine water status at four of the eight sites. The upper chart shows leaf water potential (pressure chamber measurement) and the lower chart shows stomatal conductance (porometer measurement). Target levels of each measurement are shown by the green shaded areas.



Weekly measurements of vine water status at the remaining four of the eight sites. The upper chart shows leaf water potential (pressure chamber measurement) and the lower chart shows stomatal conductance (porometer measurement). Target levels of each measurement are shown by the green shaded areas.

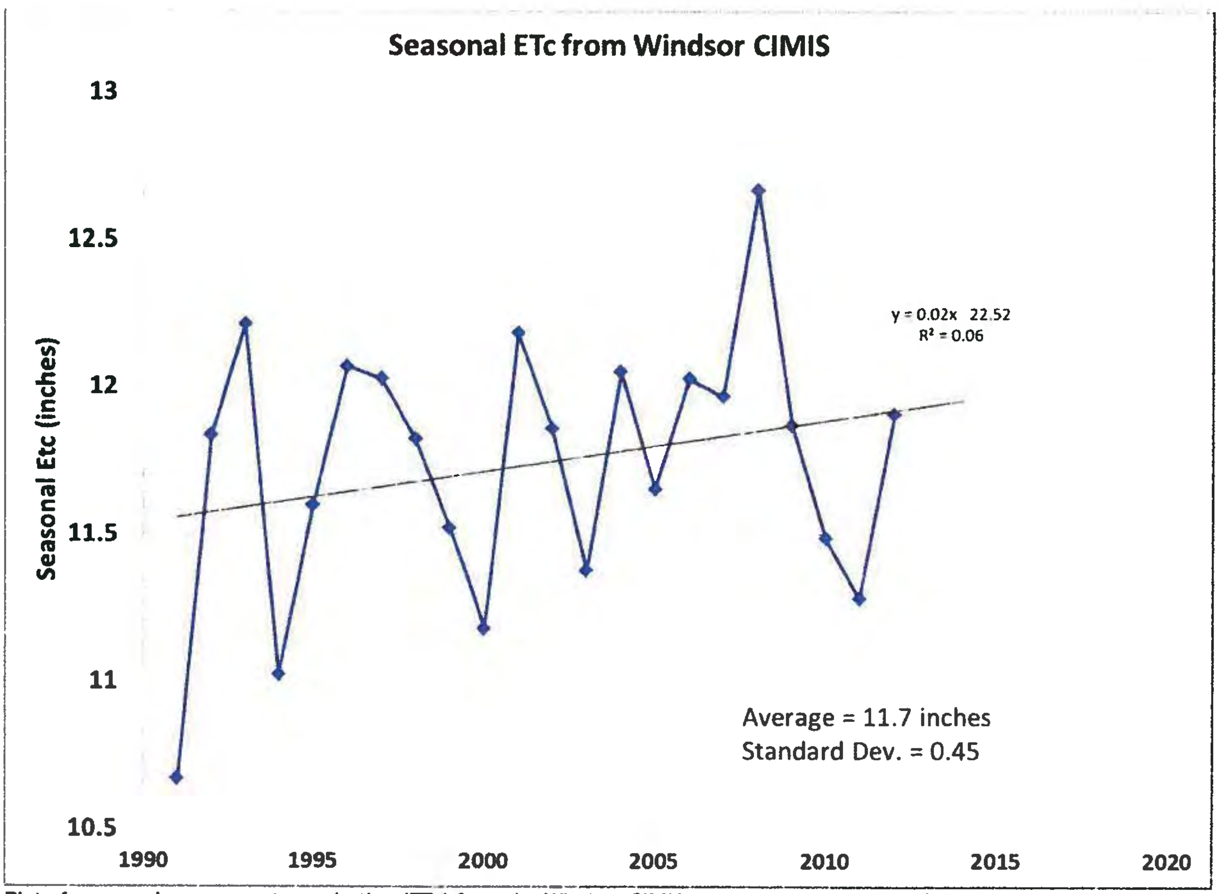


	Yolo Silt Loam (deep)	Arbuckle Gravelly Sandy Loam	Pleasanton Gravelly Loam	Zamora Silty Clay Loam	Arbuckle Gravelly Loam	Cortina Very Gravelly Loam	Yolo Sandy Loam	Yolo Sandy Loam w/ gravel
Gallons/Vine	19	40	44	15	21	101	53	118
Inches	**0.7**	**1.6**	**1.8**	**0.6**	**0.8**	**4.1**	**2.1**	**4.7**
ETc Inches	15.8	11.8	11.8	11.8	11.8	11.8	11.8	11.8
% ETc	**5%**	**13%**	**15%**	**5%**	**7%**	**34%**	**18%**	**40%**

Above: Chart of accumulated irrigation inches at the eight sites along with CIMIS crop evapotranspiration (for VSP trellis). Below: Summary chart of applied irrigation for the season from June 29 through October 15.

The chart and table above summarize the water applications made to all eight sites relative to ETc. This was a relatively cool year, so irrigation requirements in warmer growing seasons may be higher. The chart below shows the history of seasonal crop ET from the Windsor CIMIS station. ETc is indeed variable, with an average of 11.7 inches (very similar to 2012, which had 11.8 inches). Hence, the relatively cool season of 2012 was not unusual with regard to ET, as ET is only somewhat sensitive to temperatures (it also includes wind speed, solar radiation and humidity in its computation). ETc may vary +/- 0.9 inches from the mean (+/- 2*sd), so the maximum expected ETc would be about 12.6 inches, which would be 7% more than 2012's levels. Therefore, the difference in expected irrigation would not be that much higher.

From this study, it appears that about 1.7 to 2 inches can be considered a normal agronomic irrigation need for this region. It is unlikely that 4 inches would ever be needed, despite the sites that did receive that much, but gravelly sites may indeed require 3 to 3.5 inches of irrigation per year.



Plot of seasonal crop evapotranspiration (ETc) from the Windsor CIMIS weather station (June 29 through October 15 of each year). Note that the trendline is not significant, so an upward trend is not necessarily indicated.

More important in determining seasonal irrigation needs would be the amount of spring rainfall that occurs after budbreak. ET does not vary greatly from year to year, but spring rainfall does. Drier springs will require earlier initiation of irrigation while substantial rainfall, which may occur until June in this region, will allow growers to delay irrigation much longer. The use of soil moisture monitoring devices in addition to plant water status measurement equipment (pressure chamber and porometer) eliminates the guesswork of deciding when to initiate irrigation. Estimates of water balance and storage may be made using soil properties coupled with an ET model, but those would be only approximations of the true situation.

Soil Pore Water:

Some measurements of soil pore water were made, both by AGQ and by Advanced Viticulture. We feel that the results from AGQ are not useful, as they did not install their tubes very deeply (the deepest one was at 24 inches). Knowing that the root zones of these vines extends 3 feet or greater at all sites, measuring soil pore water at those shallow depths appears to be meaningless. Additionally, the service provided by AGQ according to their contract fell far short of expectations. These opinions were expressed to the contractor, but they did not agree to relieve us of our payment obligations and we followed through on the payments regardless. Nevertheless, we were disappointed in their contribution to the project.

AGQ samples were taken in early July and again (by us and sent to them) in mid-December, after a substantial rainfall. The grower applied 15 gallons per acre of fertilizer to the vineyard after harvest, but the fertilizer contained only 1% N and the total N applied was approximately 1.5 lb. per acre, which is not high or excessive.

The results do not consistently indicate an accumulation of minerals at deeper depths (see tables to follow). There was a slight accumulation of phosphate at 24 inches at the Cortina site in July, but that was not the case in December. The Yolo site exhibited an elevated nitrate level at 24 inches in December, which had not been seen in July. It is possible that this was due to the post-harvest fertilizer application, as the EC (salinity) was slightly elevated at that same depth.

The Advanced Viticulture installed samplers were sampled in early August and again in mid-December after a substantial rainfall. The soil pore water collected by Advanced Viticulture in August showed elevated nitrate-N levels at 36 inches. Levels were lower at the Yolo site (the other Cortina samples were not extracted because the soil was not moist enough). Nitrate concentration at 36 inches was similar to that at 18 inches at the Yolo Sandy Loam site, though slightly lower.

In December, the soil moisture levels were higher and samples were collected from three samplers at 2 feet depth and from two samplers at 4 feet depth. None of the samples at 2 feet had high levels of nitrate and only one of two samples at 4 feet had elevated levels of nitrate. The variability in the measurements indicates that while these data suggest that nitrate is being leached below the root zone, a more extensive sampling project needs to be done in order to draw any conclusions about leaching of applied fertilizers below the root zone.

The soil pore water sampling method has limitations in that suction can only be provided to about 90 centibars maximum suction. Soil moisture is often at a higher suction (i.e. drier and at lower matric potential), so the pore sampling method is limited during much of the growing season. In fact, we were largely unsuccessful in extracting soil pore water during the growing season, but were successful after the substantial rainfall in December. This points to the need to augment or replace soil pore water sampling with soil sampling, which may be done with a bucket auger and will not be influenced by soil moisture content at the time of sampling.

Note that the results of this study do not suggest that irrigation itself is likely to leach nutrients into the ground water. However, the deep placement of nutrients into the soil, may cause problems with deep leaching due to rainfall events that occur in the fall, winter and spring. Because this region receives high rainfall, it is important that high levels of potentially contaminating, leachable minerals and other toxins are not left to reside in the soil profile after leaf fall in vines because vines will be unable to extract them from the soil profile where they may travel to deeper depths beyond the reach of vines or cover crop roots. This issue requires greater study than this preliminary project covered.

8/6/2012

	EC (dS/m)	Ca (meq/L)	Mg (meq/L)	Na (meq/L)	NO3-N (mg/L)
Yolo No Gravel at 18"	0.67	3.01	1.93	0.6	**23.2**
Yolo with Gravel at 36"					**17.8**
Cortina at 36"	**2.05**	7.52	9.38	1.7	**191.0**

12/13/2012 Cortina	EC (dS/m)	Ca (meq/L)	Mg (meq/L)	Na (meq/L)	NO3-N (mg/L)
2' depth (a)	0.27	0.85	1.16	0.5	0
2' depth (b)	0.19	0.54	0.79	0.3	0.3
2' depth (c)	0.4	1.15	1.62	0.5	0.6
4' depth (a)	0.59	1.8	2.43	0.5	36
4' depth (b)	0.15	0.39	0.71	0.2	0.3
2' depth average	0.29	0.85	1.19	0.43	0.3
4' depth average	0.37	1.10	1.57	0.35	**18.2**

Soil pore water sampling results for various minerals. Measurements were made at two times during the season. Some samples did not collect due to insufficient soil moisture content. The second measurement period occurred during the first heavy rainfall event of the season.

AGQ

ANALYTICAL REPORT FOR NUTRITIONAL ASSESSMENT

Client: ADVANCED VITICULTURE 930 SHILOH RDBUILDING 38. SUITE B 95492 WINDSOR CA	Farm: Control Unit: CORTINA	Jesse Calvillo Laboratory Manager 24-dic-12

Watery Solutions   Sampling Date: 29-ago-2012

Description	pH	E.C. mS/cm 25° C	HCO3- (meq/l)	H2PO4- (mg/l)	Cl- (meq/l)	SO4= (meq/l)	NO3- (meq/l)	NH4+ (meq/l)	Ca++ (meq/l)	Mg++ (meq/l)	Na+ (meq/l)	K+ (meq/	B (mg/l)	Fe (mg/l)	Mn (mg/l)	Cu (mg/l)	Zn (mg/l)
TUBE 20 cm	7,64	0,48	1,27	<0,92	0,41	2,47	1,02	<0,28	1,23	1,86	1,00	0,57	0,14	<0,05	<0,05	0.10	0,36
TUBE 40 cm	7,62	0,70	0,51	<0,92	0,79	5,31	<0.16	<0,28	2,21	3,59	1,42	0,45	0,17	<0,05	<0,05	<0,05	0,20
TUBE 60 cm	7,18	0,34	0,44	2,4	0,34	1,43	0,20	<0,28	0,60	1,12	0,81	0,59	0,10	<0,05	<0,05	<0,05	<0,05

Watery Solutions   Sampling Date: 20-dic-2012

Description	pH	E.C. mS/cm 25° C	HCO3- (meq/l)	H2PO4- (mg/l)	Cl- (meq/l)	SO4= (meq/l)	NO3- (meq/l)	NH4+ (meq/l)	Ca++ (meq/l)	Mg++ (meq/l)	Na+ (meq/l)	K+ (meq/	B (mg/l)	Fe (mg/l)	Mn (mg/l)	Cu (mg/l)	Zn (mg/l)
TUBE 20 cm	6,94	0,38	2,49	<0,92	<0,28	0,78	<0,16	<0,28	0,94	1,52	0,87	0,44	0,06	<0,05	<0,05	<0,05	<0,05
TUBE 40 cm	6,95	0,26	1,63	<0,92	<0,28	0,43	<0,16	<0,28	0,56	1,07	0,62	0,17	<0,05	<0,05	<0,05	<0,05	<0,05
TUBE 60 cm	6,75	0,20	1,53	<0,92	<0,28	<0,21	<0,16	<0,28	0,41	0,79	0,27	0,33	<0,05	<0,05	<0,05	<0,05	<0,05

Laboratory results from AGQ labs for three sampling tubes at the Cortina Very Gravelly Loam Site.

AGQ

ANALYTICAL REPORT FOR NUTRITIONAL ASSESSMENT

Client: ADVANCED VITICULTURE 930 SHILOH RDBUILDING 38, SUITE B 95492 WINDSOR CA	Farm: Control Unit: YOLO SANDY LOAM	Jesse Calvillo Laboratory Manager 24-dic-12

Watery Solutions **Sampling Date:** **31-jul-2012**

Description	pH	E.C. mS/cm 25° C	HCO3- (meq/l)	H2PO4- (mg/l)	Cl- (meq/l)	SO4= (meq/l)	NO3- (meq/l)	NH4+ (meq/l)	Ca++ (meq/l)	Mg++ (meq/l)	Na+ (meq/l)	K+ (meq/	B (mg/l)	Fe (mg/l)	Mn (mg/l)	Cu (mg/l)	Zn (mg/l)
TUBE 20 cm	6,56	0,38	<0,16	<2,92	0,40	1,77	0,20	<0,28	1,41	1,08	1,55	0,34	0,37	15,5	0,28	0,08	0,08
TUBE 40 cm	6,32	0,56	<0,16	<2,92	0,42	4,34	<0,16	<0,28	2,97	1,18	1,48	0,27	0,33	5,07	0,11	<0,05	<0,05
TUBE 60 cm	6,52	0,21	<0,16	3,4	<0,28	0,72	<0,16	<0,28	0,44	2,04	1,04	0,30	0,41	47,2	0,65	0,06	0,07

Watery Solutions **Sampling Date:** **20-dic-2012**

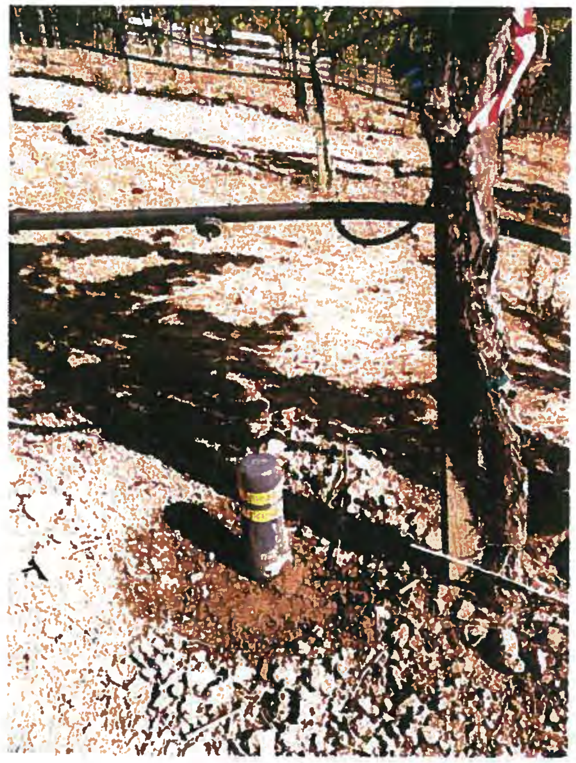
Description	pH	E.C. mS/cm 25° C	HCO3- (meq/l)	H2PO4- (mg/l)	Cl- (meq/l)	SO4= (meq/l)	NO3- (meq/l)	NH4+ (meq/l)	Ca++ (meq/l)	Mg++ (meq/l)	Na+ (meq/l)	K+ (meq/	B (mg/l)	Fe (mg/l)	Mn (mg/l)	Cu (mg/l)	Zn (mg/l)
TUBE 20 cm	6,79	0,29	1,80	<0,92	<0,28	0,60	<0,16	<0,28	1,37	0,77	0,39	0,12	<0,05	<0,05	<0,05	<0,05	0,07
TUBE 40 cm	6,90	0,38	2,64	<0,92	<0,28	0,80	<0,16	<0,28	2,07	0,73	0,86	0,08	<0,05	<0,05	<0,05	<0,05	0,25
TUBE 60 cm	6,86	0,46	2,40	<0,92	<0,28	1,24	0,53	<0,28	1,44	2,23	0,81	<0,05	0,05	<0,05	<0,05	<0,05	0,05

Laboratory results from AGQ labs for three sampling tubes at the Yolo Sandy Loam ("Gravelly") site.

Project Conclusions

- Irrigation amounts varied widely, but some irrigations were not necessary and/or were excessive.
- Nominal irrigation amount was 2.1 inches (51 gal/vine), or 17% of ETc between June 29 and October 15.
- Excluding outliers (accidental irrigations and faulty irrigation systems), average applied irrigation was 1.7 inches (42 gal/vine), or 14% ETc.
- Deep soils and high water tables commonly found in this region allow for late and reduced irrigation relative to ETc in this region.
- Deep percolation of drip irrigation is unlikely in gravelly and especially stratified soils. Deep percolation is more likely in heavier, more uniform soils.
- Rainfall will allow any leachable mineral residue to move deep and potentially below the root zone. It is important that high levels of nitrate, salts or other leachable toxins do not remain in the soil at the end of the growing season.

A



B

C

Equipment used for the project. A) 48" soil moisture probe with internal data logger. B) Soil moisture probe installed near drip emitter. C) Pressure switch installed in an irrigation line, which activates during irrigation applications and events logged in a data logger.

Equipment used for soil pore water sampling. Left, suction lysimeter used to sample at 2 foot and 4 foot depths. Right, suction lysimeter used by AGQ to sample at 20, 40 and 60 centimeters (approx.. 8, 16, and 24 inches).

Gus Yates, Consulting Hydrologist
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315 12th Street, Davis, CA 95616 • Tel/Fax 510-849-4412 • gusyates@comcast.net

September 21, 2010

Mr. Jim Flugum, Deputy Director
Department of Public Works
City of Healdsburg
401 Grove Street
Healdsburg, CA 95448

Subject: Impacts of Recycled Water Irrigation on Groundwater and Surface Water Flow and Quality near Healdsburg: a Generalized Approach

Dear Mr. Flugum:

At your request, I have expanded upon my earlier analysis (Yates, 2010) of potential groundwater and surface water impacts of the Syar Property Recycled Wastewater Agricultural Irrigation Project (Syar vineyard project) to address potential impacts of irrigation at other nearby sites. This report addresses the same types of impacts but converts the previous analysis into a more generalized methodology that could be applied to a variety of recycled water irrigation sites. This approach offers two additional benefits: it explicitly addresses the ranges of uncertainty in the impact evaluations, and those ranges establish limits below which no significant impacts are expected.

Introduction

My recent evaluation of the Syar vineyard project considered only conditions at that site (Yates, 2010). The types of impacts evaluated were the same ones covered in a prior evaluation (Yates, 2009) of the Northern Sonoma County Agricultural Reuse Project (NSCARP), but the conclusions were different for all of the impacts. Recognizing that the conclusions depend on details of the project, the present memorandum identifies key variables that influence the conclusions and identifies ranges of values for those variables that are associated with less-than-significant impacts. Specifically, the potential for adverse impacts depends on numerous factors, including:

- Recycled water quality
- Type of use (irrigation, frost control)
- The ratio of irrigation to deep percolation
- Soil type and slope
- Crop ET, root depth, deficit irrigation
- Groundwater-surface water interactions

- Subsurface dispersion and attenuation

For projects that fall within the specified ranges, this report may be sufficient to conclude that adverse impacts would be less than significant. Otherwise, additional analysis may be needed.

Scope of Analysis

The generalized method addresses five types of potential impacts:

- Surface water and groundwater contamination from irrigation for frost protection
- Excessive nitrogen load on vineyards
- Long-term increases in groundwater salinity
- Reversal of water exchange between surface water and groundwater
- Contamination of groundwater and surface water with metals

All of the impacts are influenced by the quality of the recycled water. Water quality data from the recently upgraded Healdsburg wastewater treatment plant was used in assessing the impacts at the proposed recycled water irrigation areas, but the method is applicable to other sources with different water quality characteristics.

The proposed irrigation sites are shown in **Figure 1**. In this report, the impact evaluation method is applied specifically to the valley floor vineyard areas. Impact conclusions were not drawn for the upland vineyard or the urban turf areas, both of which would likely require more detailed analysis for certain impacts because of differences in soils, slopes, crop types, irrigation rates and irrigation methods.

The remainder of this report explores each of the five types of impacts. For each impact, the method of analysis used in the previous studies is summarized, the key variables affecting the magnitude of the impact are identified, and the ranges of those variables associated with less-than-significant impacts are estimated. Finally, the impact is specifically evaluated for the valley floor vineyard areas.

Impact: Surface Water and Groundwater Contamination from Irrigation for Frost Protection

Method of Analysis

Frost protection is assumed to be by sprinkler during clear, cold nights in spring (no concurrent rainfall). If the sprinkling generates runoff, recycled water can flow directly into creeks and the Russian River. For the Syar vineyard analysis, recycled water was assumed not to be used for frost control, therefore no impact could occur. In contrast, frost control was included as a planned use of recycled water for the NSCARP project. Although

Healdsburg has no near-term plans to use recycled water for frost protection, potential impacts are discussed here in case it comes under consideration at some future date.

Key Variables and Ranges

Frost control consists of a large application of water at a time when soils are typically relatively saturated (at the end of winter) and crop evapotranspiration is small. If the applied water runs off, the nitrogen and metals it contains pose a water quality threat to nearby streams. If it infiltrates, it can raise soil moisture to field capacity and initiate deep percolation, allowing rapid movement of recycled water to the water table. Runoff and deep percolation are therefore key variables in determining the potential for adverse impacts.

Occurrence of Runoff

Uncertainty

Runoff from vineyards is rarely gauged, if ever. The occurrence and amount of runoff depend on the application rate, soil texture, slope, presence of a cover crop and cultivation practices. Anecdotal reports by local residents indicate that runoff occurs on some vineyards for at least some frost control events. Because numerous vineyards will be controlling frost simultaneously, the cumulative volume of runoff into nearby waterways can be substantial. For example, frost control irrigation at a rate of 0.12 in/hr on the 21,000 acres of vineyard proposed for the NSCARP project could have generated 760 cfs of runoff, assuming 30% of the applied water runs off (Yates 2009).

Range that Avoids Impacts

The quality of Healdsburg recycled water is sufficiently high that the existing waste discharge permit for the wastewater treatment plant already allows discharge of recycled water to surface waterways during the frost control season.[1] Therefore, frost protection using Healdsburg recycled water would presumably not have a significant adverse impact on surface water quality. If the recycled water were of lesser quality, the runoff could adversely impact nearby surface water quality unless the grower demonstrates through field data that runoff does not occur or commits to management practices that prevent runoff. Such practices could include tailwater retention ponds constructed at the downslope corner(s) of each irrigation block sized to retain approximately one-half of the maximum anticipated frost control application.

Occurrence and Dilution of Deep Percolation

Uncertainty

[1] Discharge to surface water is prohibited during the low-flow season beginning May 15 each year. Sprinkling for frost protection usually occurs in March and April.

If the root zone were at field capacity at the start of a frost control event, then essentially all of the infiltrated recycled water would become deep percolation. The infiltrated water would pass rapidly through the root zone through relatively large pores, cracks and root tubes in the soil, with little mixing, dilution or attenuation of dissolved constituents. The short-term risk to nearby domestic wells posed by this pulse of recycled water recharge is small primarily because of the high quality of the Healdsburg effluent. Laboratory analyses of 141 constituents in Healdsburg effluent in 2008 (after the treatment plant upgrade) detected no pesticides and only one organic compound, which was two orders of magnitude below the drinking water maximum contaminant level (MCL). The only regulated trace element detected (zinc) was similarly far below the MCL. Major ion concentrations—including total dissolved solids (TDS) and nitrate—were also below their respective MCLs. The only remaining potential concern would be very low concentrations of constituents of emerging concern (for example, pharmaceuticals and personal care products) that are unregulated.

Range that Avoids Impacts

Deep percolation of Healdsburg effluent during frost protection application appears unlikely to impact the potability of groundwater at nearby domestic wells. Under conditions of net annual evaporative concentration of applied recycled water, the total annual load of the constituents could be a concern. This issue is discussed more fully in the section on groundwater salinity, below.

<u>Evaluation of Valley Floor Vineyards</u>

Application of recycled water by sprinkler for irrigation or frost control was explicitly excluded as a proposed use in the project description for the Syar property irrigation project (Jones and Flugum, 2009), and that exclusion is also assumed to apply to the other valley floor vineyards.

If frost protection is requested as a use of recycled water, additional studies and management measures are necessary to prevent runoff and to ensure net annual dilution of recycled water by rainwater when they infiltrate and comingle to become groundwater recharge.

Impact: Excessive Nitrogen Load on Vineyards

The nitrogen contained in recycled water could potentially have two adverse impacts. One is an impact on viticulture (promoting excessive canopy growth on the vines), and the other is an impact on groundwater quality (if the annual nitrogen load exceeds the amount that vines will readily take up).

Method of Analysis

The NSCARP impact evaluation noted that the nitrogen content of recycled water could be excessive for optimal vineyard management in some seasons or on an annual basis. Within the typical range of application rates and recycled water nitrogen concentrations, this constitutes an impact on viticulture, not on groundwater or surface water quality. Up to a point, the vines will take up whatever nitrogen is available and use it to grow additional leaf area. The impact on viticulture is less than significant if the annual nitrogen load from recycled water is well below the normal range of fertilization. Heavier nitrogen loading—beyond the amounts the vines can use—create a risk of leaching from the root zone and contaminating groundwater.

Key Variables and Ranges

Annual Nitrogen Load

The annual nitrogen load equals the nitrogen concentration in the recycled water multiplied by the annual application of recycled water, with appropriate unit conversions to obtain pounds per acre per year. The average nitrogen concentration in treated Healdsburg wastewater is approximately 4 mg/L. The proposed irrigation rate for the Syar vineyards is 4-6 in/yr (depending on vine spacing), which corresponds to 3.8-4.7 lb/ac/yr (Yates 2010).

Uncertainty

The nitrogen concentration in recycled water and the irrigation application rate are both known with considerable accuracy. The range of acceptable nitrogen loading is variable, depending partly on grower preference.

Range that Avoids Impacts

The normal range of annual nitrogen application for table grapes is 22-44 pounds per acre (Peacock, 1998), and a University of California/Napa Sanitation District study found that 14-21 pounds of nitrogen per acre per season is "not exceptionally high, but it may be enough to be of concern to some growers" (University of California Agriculture and Natural Resources, 2006). Allowing for some margin of uncertainty, the nitrogen load from recycled water irrigation of wine grapes would not impact viticulture if it is less than 9 lb/ac/yr (half of the midpoint of the range noted in the U.C./Napa study). This threshold is double the loading that would occur with Healdsburg recycled water at the proposed irrigation rates.

A conservative estimate of the threshold for groundwater quality impacts is the low end of the range of typical table grape fertilization, or 22 lb/ac/yr. Additional analysis should be required for any vineyard irrigation projects with annual loading rates in excess of this threshold, to prevent excessive leaching of nitrogen to the water table. The loading for the proposed Healdsburg projects would be less than one-fourth of this threshold and would create no risk of adverse impact.

Evaluation of Valley Floor Vineyards

Assuming that irrigation rates for other valley floor vineyards are similar to those proposed for the Syar vineyards, the nitrogen load on the vineyards would be well below levels that could cause an adverse impact on vine growth or water quality.

Impact: Long-term Increases in Groundwater Salinity

Many of the constituents in recycled water are not taken up by plant roots and remain in the soil until they are leached out by winter rains. The concentrations of the constituents in this deep percolation—and the corresponding impacts on groundwater quality—depend largely on whether there is net dilution or net concentration of recycled water in the root zone on an annual basis. Use of soil moisture by plants concentrates the dissolved constituents in the soil, whereas infiltration of rainfall dilutes them.

Method of Analysis

The amount of deep percolation beneath a site irrigated with recycled water was calculated for the evaluations of the NSCARP and Syar vineyard projects using a soil-moisture budget approach (Yates 2009, 2010). This mass-balance approach tracks the amount of water stored in the root zone on a daily basis, with inflows from rainfall and irrigation and outflows to evapotranspiration and deep percolation. Deep percolation is difficult to measure directly, and data are not available for vineyards under the horticultural conditions found at the proposed recycled water irrigation sites. Consequently, the soil-moisture-budget (SMB) model of deep percolation is uncalibrated. Numerous variables in the model affect the amount of simulated deep percolation and the determination of whether there is net dilution or concentration of solutes as the recycled water moves through the root zone to become deep percolation. The following analysis addresses this uncertainty.

Key Variables and Ranges

Some of the variables in the SMB model can be estimated relatively accurately. These include rainfall, irrigation rates and reference ET. Root depths and crop coefficients for wine grapes are also reasonably well known. This leaves rainfall runoff as one of the most uncertain terms in the annual water balance. Deep percolation is essentially estimated as the residual of the water balance. Its uncertainty is therefore at least as large as the uncertainty in rainfall runoff. These two key variables are discussed more fully below.

Soil texture also affects deep percolation through its influences on root depth and permeability. Soil texture is relatively easy to measure, so uncertainty is not as big an issue as spatial variability. Floodplain soils commonly include stringers of relatively sandy deposits with lower available water capacity. Vines growing in those areas would not need more water on an annual basis, but could need smaller, more frequent applications of irrigation water. If those areas are irrigated at the same rate as adjacent heavier soils, some of the irrigation water is likely to percolate directly through the root zone to become deep percolation. This rapid pass-through of irrigation water neither concentrates nor dilutes its dissolved constituents. On an annual basis, however, those constituents would have been leached from the root zone by winter rains anyway, so the long-term impact on groundwater quality is essentially the same.

Rainfall Runoff

Uncertainty

Gaging stations operated by the U.S. Geological Survey, California Department of Water Resources and local agencies almost invariably measure runoff from upland watersheds. Runoff data for flat, agricultural areas are available only for research studies, most of which have been in the central United States. It is clear that runoff from valley floor agricultural areas is less than from upland areas because of flatter terrain, different vegetation, cultivation, and typically deeper and loamier soils. The challenge is to quantify the difference.

Some previous studies that included the Healdsburg area estimated average annual runoff from gaging station data and incorrectly implied that those rainfall-runoff relations apply to valley floor areas. For example, a U.S. Geological Survey map of mean annual runoff in the San Francisco Bay region indicated about 20 in/yr of runoff from the valley floor areas along Dry Creek and the middle reach of the Russian River (Rantz, 1974). Similarly, Johnson (2007) plotted rainfall versus runoff for a number of gages in the region, which showed 14-19 in/yr of runoff for watersheds receiving an average of 41 in/yr of rainfall (which is the average for Healdsburg).

In contrast, hydrological studies focused on agricultural areas typically assume or estimate very little runoff. For example, Blaney's benchmark studies in the Oxnard Plain assumed zero runoff from cropland, although annual rainfall in his study area was only 18 inches (Blaney, 1933). A much more recent and comprehensive modeling study of the Central Valley aquifer in California included detailed recharge estimates for 21 subareas (Faunt and others, 2009). The four northernmost subareas (near Redding and Red Bluff) receive almost as much rainfall as Healdsburg, and estimated annual runoff for those subareas was a nearly linear function of annual rainfall (r-squared = 0.97). Projecting that relationship to the amount of rainfall in Healdsburg (41 in/yr) yielded an estimate of 4.8 in/yr of runoff, or about 12% of annual rainfall. The corresponding estimate of deep percolation was 15.9 in/yr.

The uncertainty of runoff estimates is clearly large, given the range of 0-20 in/yr produced by the aforementioned previous studies. Of those, the 5 in/yr estimate from the Central Valley study is probably the most accurate for Healdsburg, given the similarity of rainfall, terrain, soil types and land use, and also the level of effort, data sets and analytical methods used for the study. The uncertainty of that estimate cannot be quantified, but for this investigation a range of 3-10 in/yr is probably reasonable.

Range that Avoids Impacts

Rainfall runoff is only indirectly related to groundwater salinity, through its effect on the estimate of deep percolation. Uncertainty in estimated runoff is included in the discussion of the Range that Avoids Impacts for deep percolation, below.

Deep Percolation

The ratio of annual irrigation to annual deep percolation determines whether solutes in recycled water will be diluted or concentrated by the time they percolate out of the root zone. If annual deep percolation exceeds annual irrigation, concentrations of solutes in the deep percolation will be lower than in the recycled water, and vice versa.

In the SMB model, deep percolation has two components: excess applied irrigation water in summer and excess rainfall infiltration in winter. Excess irrigation can occur due to nonuniformity of application or nonuniformity of soil texture and root depth. Assuming the grower irrigates to provide adequate water to the driest part of a field, other parts receive more than enough water. For most crops, irrigation is managed to bring soil moisture back to field capacity, which means that excess irrigation in the wetter parts of a field causes deep percolation. The situation is different for drip-irrigated vineyards under a regime of regulated deficit irrigation. First, drip emitters have a relatively high uniformity of flow rate (0.92). Second, any slight excess irrigation in a wet part of the field or at an above-average emitter would simply be absorbed by the soil and transpired by the vine. Irrigation efficiency would still be 100 percent for practical purposes, and deep percolation would not occur.

Simulated deep percolation beneath valley floor vineyards near Healdsburg is not sensitive to the assumed irrigation efficiency because rainfall is relatively high and irrigation rates are low to begin with. For example, decreasing the assumed irrigation efficiency from 100% to 92% in the SMB model increased average annual deep percolation by only 0.3 in/yr (1.4%).

The second component of deep percolation occurs in winter, when the seasonal cumulative infiltration of rainfall raises soil moisture in the root zone to field capacity. Additional infiltration passes rapidly through the root zone and becomes deep percolation. The SMB model for the Syar vineyard evaluation estimated that average annual deep percolation was 15 in/yr, or three times larger than the proposed recycled water irrigation rate.

Uncertainty

Uncertainty in the estimate of deep percolation can be assessed by comparing the SMB result with estimates reported in other studies of similar areas, and also by testing the sensitivity of the SMB result to uncertainty in the input variables.

Johnson (2008) evaluated potential impacts of the NSCARP project, for which he used an estimate of 7 in/yr of average annual groundwater recharge. Neither calculations nor a reference were presented to support that number, however. The water balances presented in the Central Valley groundwater study indicated that recharge beneath agricultural land near Healdsburg would be approximately 16 in/yr, which is similar to the SMB model result for the Syar vineyard study.

In the SMB model, uncertainty in the deep percolation estimate derives mostly from uncertainty in the rainfall runoff estimate, because mass balance is preserved for the system as a whole. This relationship is illustrated by the following average-annual mass balance summary of the simulations for the Syar vineyard investigation[2]:

$$\begin{array}{ccccccccccc} \text{Deep percolation} & = & \text{Rainfall} & - & \text{Runoff} & + & \text{Irrigation} & - & \text{Evapotranspiration} \\ 15\ \text{in/yr} & = & 41 & - & 7 & + & 5 & - & 24\ \text{in/yr} \end{array}$$

As discussed earlier, rainfall and irrigation are known relatively accurately. Annual evapotranspiration can be estimated without wading into details of monthly crop coefficients or the effects of water stress on transpiration. During November-March, ET equals reference ET (8.6 inches), because the soil surface has a grass cover crop. During April-October, ET is limited to the amount of applied irrigation water (4.7 inches) plus the amount of soil moisture depletion. A 72-inch root depth with an available water capacity of 0.16 could potentially supply up to 12 inches of soil moisture depletion. These components produce a maximum of 25 in/yr of evapotranspiration. The daily SMB simulations over a 19-year hydrologic period similarly produced an average of 24 in/yr of evapotranspiration, which means the vines used essentially all of the available moisture during the growing season.

Because of the narrow ranges of uncertainty in rainfall, irrigation and evapotranspiration, the range of uncertainty in runoff is the primary source of uncertainty in the estimate of deep percolation. In the previous section, the estimate of average annual runoff was 5 in/yr with a range of uncertainty of 3-10 in/yr. In the SMB model for the Syar vineyards, the runoff parameters were adjusted to obtain a slightly more conservative average of 7 in/yr of runoff and 15 in/yr of deep percolation. Substituting 3 in/yr and 10 in/yr of runoff into the above mass balance equation produces a range of 12-19 in/yr for deep percolation. The other variables contribute additional uncertainty, although it is probably smaller. Allowing for some additional uncertainty, it is unlikely that average annual recharge is less than 9 in/yr. This minimum estimate of recharge is important because it represents the greatest potential for concentrating solutes in recycled water.

[2] This equation does not include frost protection. Frost protection would be equivalent to an additional rainfall event of perhaps 0.7 inches. Given the season for frost protection (March-April) and the typically moist condition in that season, most of the applied water would probably end up as runoff, with slightly smaller amounts becoming deep percolation and additional soil moisture (later lost to ET).

Range that Avoids Impacts

The impact of recycled water irrigation on groundwater salinity is less than significant if the recycled water salinity is acceptable and there is no net annual evaporative concentration of irrigation water by the time it percolates below the root zone. For both potable and irrigation purposes, TDS concentrations less than 500 mg/L are acceptable because they do not impair beneficial uses. The average TDS of Healdsburg recycled water is 330 mg/L, so the key issue is whether there is net dilution or net concentration in the root zone. Rainfall recharge almost certainly averages more than 9 in/yr. Therefore, net dilution would occur for irrigation rates of up to 9 in/yr. If irrigation rates exceed 9 in/yr, additional analysis is warranted to ensure that groundwater salinity is not adversely impacted.

Evaluation of Valley Floor Vineyards

Assuming the irrigation rate for the valley floor vineyards is the same as for the Syar vineyards (4-6 in/yr on a per-acre basis), there would be no adverse impact on groundwater salinity. Vineyard irrigation should not exceed 9 in/yr on any irrigation block, with appropriate metering and monitoring of irrigation operations on a monthly and annual basis to confirm the actual amounts applied.

Impact: Reversal of Water Exchange Between Surface Water and Groundwater

Irrigation with recycled water decreases the amount of groundwater used for irrigation. If recycled water displaces a substantial percentage of existing groundwater pumping, the local water balance of the groundwater system can be fundamentally altered. Along Dry Creek and the Russian River, groundwater is hydraulically coupled to surface water, and changes in pumping are balanced by a change in the amount of seepage to or from the river. A large decrease in pumping can change the prevailing direction of seepage, with consequences for groundwater quality. For example, the NSCARP project could have decreased June-October pumping along Dry Creek by approximately 5,100 AFY (Yates, 2009). Seepage losses along Dry Creek during those months average about 3,000 AF (Johnson, 2008), so the decrease in pumping would have eliminated creek seepage and probably converted the creek from a losing to a gaining stream in summer. The creek water is relatively low in dissolved solids, and eliminating creek seepage would have adversely impacted groundwater quality.

The opposite condition exists along the middle reach of the Russian River, where the river is consistently gaining in all seasons under existing conditions. Irrigating with recycled water instead of groundwater on the adjacent floodplain would increase the rate of groundwater seepage into the river but not reverse the direction of flow (Yates 2010).

Method of Analysis

The evaluations of the NSCARP and Syar vineyard projects considered water levels and water balances in determining whether the projects would substantially alter stream-aquifer interactions. Those key variables are discussed below. In addition, the evaluations included the following assumptions:

- Existing irrigation is by groundwater using local wells
- Surface water has a lower dissolved solids concentration than groundwater
- The stream and aquifer are hydraulically coupled
- Recycled water substitutes 1:1 for groundwater

If any of these assumptions do not apply to a specific situation, additional analysis may be needed.

Key Variables and Ranges

Groundwater and Surface Water Levels

If existing groundwater levels are higher than adjacent surface water levels during the irrigation season, then groundwater seeps into the creek or river. Decreasing groundwater pumping will elevate groundwater levels and increase the rate of groundwater seepage into the surface waterway. Over the course of a year, the increase in seepage will usually balance the change in pumping. This condition would not impact groundwater quality. However, the increased rate of groundwater flow to the surface waterway could potentially affect surface water quality because flow paths from recharge areas to the stream would be on average shallower and faster.

If existing groundwater levels are lower than adjacent surface water levels during the irrigation season, then surface water seeps into the aquifer. A decrease in pumping will raise groundwater levels and decrease the rate of stream percolation. If groundwater levels rise to an elevation higher than the stream surface, the direction of seepage will reverse. A reversal in seepage direction is potentially significant because it would eliminate the water quality benefits of stream recharge, which tends to dilute groundwater salinity.

Uncertainty

Uncertainty in evaluating groundwater-surface water interactions stems primarily from insufficient local data. Stream gages are typically far apart, and monitoring well networks are typically sparse. Spatial interpolation of both data sets can easily incur errors of several feet at any particular location. However, relative elevations between groundwater and surface water at several points along a reach of creek or river often reveal a consistent pattern that can be generalized for the entire reach.

Range that Avoids Impacts

If existing groundwater levels are consistently higher than adjacent surface water levels during April-October, it is reasonable to assume no reversal of seepage direction and no impact on groundwater quality. If existing groundwater levels are consistently lower than adjacent stream levels, then the amount of water level rise associated with recycled water substitution needs to be estimated. This can be done using historical hydrographs and an estimated local water balance.

Local Groundwater Balance

If groundwater levels are consistently lower than the creek or river elevation during the irrigation season, then some of the irrigation pumping probably derives from induced seepage. It may be possible to estimate the magnitude of induced seepage as the difference in surface flow between two stream gauges. This approach was used for an evaluation of Dry Creek, for example (Johnson, 2008; Yates, 2009). Alternatively, induced seepage can be estimated as the difference between pumping and storage depletion using independent estimates of those variables during the summer months.

Uncertainty

Both methods of estimating induced seepage are subject to considerable uncertainty. The amount of uncertainty depends partly on local site conditions that cannot be generalized. It would be prudent to assume an uncertainty of +/- 50%.

Range that Avoids Impacts

The amount of recycled water substitution can be compared with the amount of existing induced seepage to determine the potential impact. If substitution exceeds existing seepage, then it would probably reverse the direction of seepage during all or part of the irrigation season and would probably impact groundwater quality. In this case, additional analysis may be needed. If substitution is less than half of the amount of existing induced seepage, then impacts on groundwater quality are probably less than significant.

Evaluation of Valley Floor Vineyards

The valley floor vineyards proposed for irrigation with recycled water are near the confluence of Dry Creek and the Russian River. The groundwater system is continuous from the Dry Creek valley into the Russian River valley. However, those two waterways have opposite groundwater-surface water relations in summer. Dry Creek is a losing stream during the summer months, whereas the middle reach of the Russian River just below Dry Creek is a gaining stream (Johnson, 2008; Yates, 2010). Two wells in the valley floor vineyard area with long-term water-level records confirm that stream-aquifer relations are transitional and locally variable (Johnson, 2008, Figure 23a). Well 9N/9W-20E2 near the northwest corner of the valley floor vineyard areas shows summer water levels approximately equal to the surface elevation of Dry Creek at that location (within the uncertainty of the estimated surface elevation). Well 9N/9W-28N1,2 near the confluence of Dry Creek and the Russian River has summer water levels 2-3 feet below the estimated surface elevation of Dry Creek, indicating losing streamflow conditions. It appears that Dry Creek is neutral to losing, which indicates that a water balance evaluation is needed.

The groundwater balance near the valley floor vineyards is heavily influenced by municipal pumping at the City's Dry Creek and Fitch well fields. The maximum substitution of recycled water for groundwater pumping on the Syar and valley floor vineyards would be about two-thirds of the recycled water produced during the irrigation season, or approximately 280 AF. The remaining one-third will be used for turf irrigation at parks and schools in Healdsburg. By comparison, production at the Dry Creek and Fitch well fields is approximately 2,100 AFY, most of which is during May-October (Winzler & Kelly Consulting Engineers, 2006). This means that irrigation with recycled water would not decrease local groundwater pumping by more than 25 percent.

Groundwater flow and induced seepage are spatially complex in the valley floor vineyard area. The well fields are located adjacent to Dry Creek and the Russian River on the west and east sides of valley floor vineyard areas, respectively (**Figure 1**). Locally, the capture zones of those well fields probably induce and intercept most of the surface water seepage from the creek and river. Groundwater in the intervening area probably flows south under Dry Creek following the regional down-valley gradient. Raising water levels between the two well fields would probably not alter the average rate or direction of regional flow, but would locally accelerate or retard it. More detailed analysis of groundwater flow and stream-aquifer interaction using a groundwater model would be needed to delineate potential flow impacts in detail.

In this case, the quality of the recycled water is sufficiently high and the proposed application rates sufficiently low that impacts on groundwater quality would not be significant in spite of the localized changes in groundwater flow patterns beneath the valley floor vineyards.

Impact: Contamination of Groundwater and Surface Water with Metals

Previous studies evaluated the potential for six metals regulated under the California Toxics Rule (CTR) to discharge into surface waters at concentrations high enough to impact aquatic life (Yates, 2009; Yates, 2010). The metals were cadmium, chromium, copper, lead, nickel and zinc. For all of the metals except chromium, the CTR limits to protect aquatic life are lower than the corresponding limits for drinking water. The maximum contaminant levels allowed for CTR metals are a function of the hardness of the receiving water.

<u>Method of Analysis</u>

The method of analysis used for evaluating impacts of the Syar vineyard project was to apply a sequence of three dilution steps along the flow path from an irrigation site to a nearby stream via groundwater: dilution during recharge, dilution and attenuation during subsurface transport, and dilution within the receiving water.

Key Variables and Ranges

Dilution Factors

The three dilution factors and maximum allowable concentration in the receiving water are complicated to calculate. However, a simplified approach using conservative assumptions can be used as a screening method to determine whether in-depth analysis is needed. The conservative assumptions are that there is no adsorption or attenuation of metals during recharge or subsurface transport and that there is also no dilution during subsurface transport (equivalent to assuming that seepage into the stream occurs at the same location as the recharge). The simplified approach divides the concentration of each metal by two dilution factors. The first is dilution during recharge, which equals average annual deep percolation divided by average annual irrigation. For the Syar vineyard project, recharge was estimated to be 15 in/yr and irrigation was up to 6 in/yr, for a dilution factor of 2.5 (Yates ,2010). The second dilution factor represents the receiving water and equals the volumetric recharge rate divided by the amount of baseflow in the stream. A recharge rate of 15 in/yr on one acre of vineyard is equivalent to 0.00173 cubic feet per second (cfs). That rate is multiplied by the number of acres of vineyard, and the result is divided into the baseflow in the creek to obtain the dilution factor. For example, recharge from a 100-acre vineyard seeping into a creek with 50 cfs of baseflow would have a dilution factor of 289. Overall dilution is the product of the two factors, or 723 in this case.

After dividing the effluent concentrations by the overall dilution factor, the results are compared with the following maximum concentrations, which are based on average low-flow hardness in the Russian River:

Constituent	Cadmium	Copper	Chromium	Nickel	Lead	Zinc
Constituent Chronic Concentration (μg/L)	3	11	221	65	4	148

Flow in the middle reach of the Russian River is regulated by upstream reservoirs and is subject to minimum flow requirements under State Water Resources Control Board decision D-1610. As a result, minimum baseflow is fairly constant from year to year at 150-200 cfs, although it is sometimes as low as 120 cfs. Baseflow in Dry Creek is similarly regulated and averages about 80 cfs.

If the simplified dilution calculations result in a predicted receiving water concentration greater than 50 percent of the constituent chronic concentration, more complete analysis is needed.

For potential drinking water impacts of chromium, the effluent concentration should be multiplied by the recharge dilution factor only, then compared with the drinking water standard of 50 μg/L.

Uncertainty

Uncertainty in the two dilution factors is compensated for by the conservative assumption that adsorption and the third dilution factor are both zero. Additional insurance against uncertainty is provided by the factor of two margin of safety used when determining whether detailed analysis is necessary.

Range that Avoids Impacts

The concentrations of CTR metals in the receiving stream would not have a significant adverse impact on aquatic life if they are less than their respective CTR constituent chronic concentrations. Impacts of chromium on human health are considered less than significant if the estimated concentration is less than the drinking water standard.

Evaluation of Valley Floor Vineyards

Assuming a recharge rate of 15 in/yr and an irrigation rate of 6 in/yr, the recharge dilution factor for the valley floor vineyards is 2.5. Total recharge flow for the 980 acres of valley floor vineyard averages 1.7 cfs. Conservatively assuming all of the recharge seeps into Dry Creek (which has less baseflow than the Russian River), the stream dilution factor is 47. The overall dilution factor is 118. The concentrations in Healdsburg effluent are all less than the CTR limits to begin with. After dividing the concentrations by 118, they are all less than 1% of the CTR limits for local receiving waters. The average concentration of chromium in Healdsburg recycled water is 48 μg/L. Dividing by the recharge dilution factor (2.5) yields a concentration of 19 μg/L, which is less than half of the drinking water standard. Therefore, potential impacts on aquatic life and drinking water are less than significant.

If a more conservative recharge rate of 9 in/yr is assumed, the recharge dilution factor would be 1.5 and the overall dilution factor would be 71. and the concentrations of CTR metals and chromium would still be below the respective standards for aquatic life and drinking water.

Summary and Conclusions

Previous studies of potential impacts of recycled water irrigation on groundwater and surface water quality near Healdsburg were generalized to apply to similar nearby areas. For each of the potential impacts, a range of values of key variables was identified for which impacts would be less than significant.

Areas proposed for irrigation with recycled water from the Healdsburg WWTP were grouped into four categories: Syar vineyards, other valley floor vineyards, upland vineyards and turf areas at schools and parks. The generalized approach was based primarily on an earlier analysis of the Syar vineyards and could theoretically be applied to all of the areas. However, the focus of the present report is the valley floor vineyard areas. Application of the method to the upland vineyard and urban turf areas could require additional analysis. Major findings for each type of potential impact are as follows:

- If recycled water is used for frost protection, runoff is possible unless retention or other runoff control measures are implemented. With current Healdsburg recycled water quality, impacts of runoff on surface water quality would probably be less than significant.
- If the TDS concentration of recycled water is less than 500 mg/L and there is net dilution of solutes in irrigation water when they are leached downward in deep percolation, the impact on groundwater salinity is less than significant.
- Deep percolation of recycled water applied for frost protection will not significantly impact groundwater salinity if the TDS concentration is less than 500 mg/L and there is net dilution of deep percolation on an annual basis.
- The annual nitrogen load in the irrigation water—which equals the concentration multiplied by the annual irrigation rate—poses a negligible concern for viticulture if it is less than 8 lb/ac and a negligible risk of groundwater quality impacts if it is less than about 25 lb/ac.
- It is impractical to measure deep percolation directly, and the uncertainty in estimating deep percolation beneath vineyards stems primarily from uncertainty in rainfall runoff.
- For rainfall, soil and irrigation practices typical of valley floor vineyards, average annual deep percolation is estimated to be 15 in/yr. The low end of the reasonable range of uncertainty is 9 in/yr.
- For irrigation rates less than 9 in/yr (and possibly as high as 15 in/yr), solutes in recycled water will be diluted by the time they reach the water table. The proposed irrigation rate for the Syar vineyards (4-6 in/yr) is thus in the range of net dilution.
- Irrigation with recycled water decreases groundwater pumping, which elevates groundwater levels. The potential to reverse the direction of stream-aquifer seepage and impact groundwater quality depends on site-specific water levels and groundwater balances. If the adjacent stream reach is gaining under existing conditions, the decrease in pumping would not reverse the direction of seepage. If the reach is losing, the mass balance of the stream and aquifer system must be evaluated to estimate whether a seepage reversal is likely.
- Recycled water contains dissolved metals regulated under the California Toxics Rule. The metals can reach surface waterways via groundwater recharge and subsurface transport. A conservative estimate of potential concentrations in the receiving waterway can be obtained by multiplying the concentrations in recycled water by the dilution factor during recharge and the dilution factor when groundwater seepage mixes into the stream. If those concentrations are less than half of the maximum permissible concentrations, then the impact can be considered less than significant and additional analysis is unnecessary.

- Irrigation of the identified valley floor vineyard areas with recycled water would be less than significant with respect to all of the impacts considered in this report provided the following assumptions are true:
  - o The quality of recycled water remains essentially unchanged
  - o Irrigation does not exceed 9 in/yr on any irrigation block
- It is recommended that the foregoing assumptions be used as thresholds for requiring additional analysis.

I hope that this effort to expand on the Syar vineyard analysis to address potential impacts of the valley floor vineyards and other recycled water use areas facilitates the design and permitting of those projects and others in the future. Please do not hesitate to contact me if you have any questions.

Sincerely,

Gus Yates, PG, CHg

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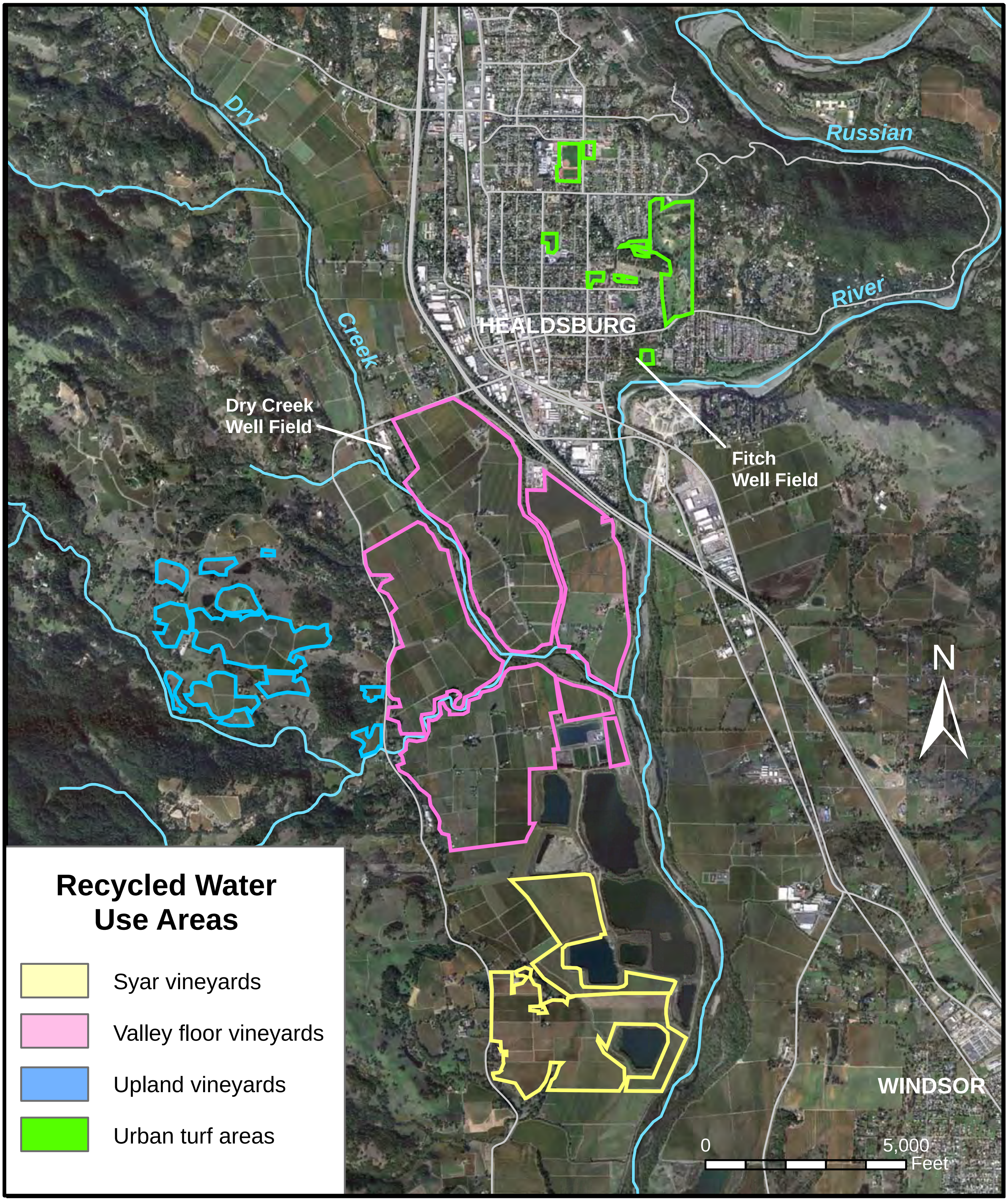

Figure 1. Locations of Proposed Recycled Water Irrigation Areas

City of Healdsburg Wastewater Treatment Plant

Title 22 Engineering Report

August 2010

CITY OF HEALDSBURG
CALIFORNIA SINCE 1867

HDR

City of Healdsburg
Wastewater Treatment Plant

Title 22 Engineering Report

August 2010

REGISTERED PROFESSIONAL ENGINEER
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NO. 64587
EXP. 06/30/2011
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SECTION 1. INTRODUCTION

The current State of California Water Recycling Criteria (adopted in December 2000) requires the submission of an engineering report to the California Regional Water Quality Control Board (RWQCB) and the Department of Public Health (DPH) prior to implementation of a recycled water system. The report must also be amended prior to any modification to existing recycled water projects.

This report supports the use of recycled water from the City of Healdsburg (City) Wastewater Treatment Plant (WWTP). The City provides sewerage service to a population of approximately 13,000, including commercial, industrial, institutional, and residential customers. Wastewater is collected and conveyed by 36 miles of sewer pipeline, nine (9) lift stations, and several miles of force main to the centralized WWTP located to the southwest of the City. A major upgrade of the WWTP, including the installation of advanced wastewater treatment facilities, was completed in August 2008. The advanced treatment facilities, including membrane bioreactors (MBR) and ultraviolet (UV) disinfection, is capable of producing recycled water meeting the California Title 22 non-restricted reuse standards.

The City is currently in the design phase of a recycled water system. The recycled water system is a component of the WWTP Upgrade project for which a Draft Environmental Impact Report (EIR) was issued in February 2005 and a Final EIR was certified in July 2005. Seasonal irrigation was proposed in the EIR because the City's NPDES permit prohibits effluent discharges to the Basalt Pond from May 15 to September 30 each year after 2009. However, the City has requested a 5-year extension to this compliance deadline and expects that this extension will be included, subject to progress on several interim milestones, in an updated NPDES permit expected to be issued by the North Coast Regional Water Quality Control Board (NCRWQCB) in April of 2010.

The first draft of this report was submitted in September 2007. This submittal incorporates changes to the report in response to comments from the DPH, as well as other modifications to the recycled water system plan since that time. These include:

- The addition of approximately 214 acres of vineyard property to the proposed irrigation areas
- Revised plans for the Tayman Park recycled water reservoir, which will now be a newly constructed tank
- Minor changes in the pipeline alignment during detailed design

The purpose of this report is to describe the manner in which the upgraded WWTP is complying with the Water Recycling Criteria, contained in Sections 60301 through 60355, inclusive, of the California Code of Regulations, Title 22. This Engineering Report also is intended to define:

- Recycled water quality and wastewater treatment requirements for the various types of allowed uses

- Use area requirements pertaining to the actual or proposed location(s) of recycled water use
- Reliability features in the wastewater treatment facilities to ensure acceptable performance and adequate water quality

The most applicable Title 22 Criteria to the City's recycled water system under Title 22 include:

- Article 2 – Sources of Recycled Water
- Article 3 – Uses of Recycled Water
- Article 4 – Use Area Requirements
- Article 6 – Sampling and Analysis
- Article 7 – Engineering Report and Operational Requirements
- Article 8 – General Requirements of Design
- Article 10 – Reliability Requirements for Full Treatment

The report is divided into the following sections in accordance with the Guidelines for the Preparation of an Engineering Report for the Production, Distribution and Use of Recycled Water (March 2001):

- Section 1 – Introduction
- Section 2 – Recycled Water Project
- Section 3 – Transmission and Distribution Systems
- Section 4 – Use Areas

Certain types of recycled water uses are not planned by the City at this time, and in such cases, the report subsection is marked Not Applicable.

References used in addressing the various project elements in compliance with Title 22 Criteria include:

- Guidelines for the Preparation of an Engineering Report for the Production, Distribution and Use of Recycled Water (CDPH, 2001)
- State of California Water Recycling Criteria (January 2009)
- California Waterworks Standards
- California Water Code
- Treatment Technology Report for Recycled Water (CDPH, January 2007)
- CDPH Manual of Cross-Connection Control/Procedures and Practices

- Ultraviolet Disinfection Guidelines for Drinking Water and Water Reuse (AWWA/NWRI, May 2003)
- Healdsburg City Council Ordinance No. 976 (Cross-Connection) Control Program)
- Preliminary Design Report, Wastewater Treatment Plant Upgrade Project (HDR, 2005)
- Construction Document, Wastewater Treatment Plant Upgrade Project (the City and HDR, 2008)

SECTION 2. RECYCLED WATER PROJECT

2.1 General

The City is the responsible party for the proposed recycled water system. The City's Public Works Department is managing the planning, design, and construction of the treatment, distribution, and storage facilities. The City's wastewater and water utilities, under the purview of the Public Works Department, will operate and maintain the WWTP and the recycled water system in accordance with applicable law, City ordinances, and the user agreements.

2.2 Rules and Regulations

The City will operate and maintain the upgraded WWTP in such a manner as to comply with its NPDES permit and Title 22 requirements. The Regional Board issued an NPDES permit on October 6, 2004 (Order No. R1-2004-064) and amended the permit with minor modifications on November 29, 2004 (Order No. R1-2004-0111), January 21, 2005 (Order No. R1-2005-084), and January 17, 2008. The Russian River Basin Plan requires Advanced Wastewater Treatment (AWT) for any municipal wastewater discharged to the Russian River or its tributaries, and the City's NPDES permit, as modified, required compliance by May 1, 2008. Final effluent limitations for the City's discharge to the Basalt Pond from the AWT process after May 1, 2008 are summarized in Table 2-1. In addition to the listed constituents, the NPDES permit requires whole effluent toxicity testing, also known as the wet test, that yields no acute toxicity, 70 percent survival for any single assay, and 90 percent survival for any three or consecutive assays.

Table 2-1. Final Effluent Limits (Effective January 1, 2008)

Constituent	Units	Monthly Average	Weekly Average	Any Sample
Biochemical Oxygen Demand (BOD) (20 C, 5-day)	mg/L	10	15	--
	lb/day	117	175	--
Total Suspended Solids	mg/L	10	15	--
	lb/day	117	175	--
pH	std. units	Greater than 6.5 pH and less than 8.5		
Chlorine Residual	mg/L	Non-detect (detection limit = 0.1 mg/L)		
Copper	µg/L	Dependant on future pH and hardness sampling results		
Settable Solids	mg/L	Non-detect		
Total Coliform	MPN/100mL	Seven-day median less than 2.2 No more than one sample in any 30-day period greater than 23 No sample may exceed 240		

In addition to complying with the final effluent limitations (Table 2-1), the City intends to produce disinfected tertiary recycled water as defined by Title 22, Division 4 of the California Code of Regulations, Section 60301, and et seq.

Disinfected tertiary recycled water is defined as filtered and disinfected wastewater with the following criteria:

- The number of total coliform bacteria measured in the disinfected effluent does not exceed 2.2 MPN per 100mL in 7-day median
- The number of total coliform bacteria does not exceed 23 MPN per100 mL in more than one sample in any 30 day period
- No sample measured in the disinfected effluent shall exceed 240 MPN total coliform per 100 mL

Aeration basin effluent will pass through immersed membrane filters, and the membrane filter effluent will pass through an ultraviolet (UV) light disinfection system. The combination of membrane filtration and UV disinfection is anticipated to inactivate and/or remove 99.999 percent of F-specific bacteriophage, MS2 or polio virus (i.e. 5-log credit).

The membrane filtered effluent will meet the requirements of Title 22, Section 60301.320 (b) for turbidity. The filtered effluent will not exceed any of the following:

- 0.2 NTU more than 5 percent of the time within a 24-hour period
- 0.5 NTU at any time

Title 22 does not list specific requirements for UV disinfection, but the CDPH and Regional Board require the UV system design and operation to be in accordance with National Water research Institute (NWRI) guidelines for wastewater reclamation. The following UV disinfection system performance criteria are applicable to the upgraded WWTP:

- A minimum UV dose of 80 mJ/cm^2 under maximum day flow conditions
- Membrane filter effluent UV transmittance of 65 percent or greater at 254 nanometers

Furthermore, Articles 8 and 10 of the California Health Laws related to recycled water list specific requirements for UV disinfection system design criteria including reliability requirements. Provisions of the WWTP Upgrade project addressing these requirements are discussed in Sections 2.6 and 2.9 of this Engineering Report.

In addition, the City's Public Works Department will enforce City Ordinance 763 (Sewer System), City Ordinance No. 976 (Cross-Connection Control Program), and the terms and conditions of the User Agreements.

Note: Currently, the City does not have agreements with planned customers for its disinfected tertiary recycled water. Future recycled water user agreements will be developed to fully reflect the disinfected tertiary recycled water reuse requirements, and including designation of Site Supervisor and Employee Training.

2.3 Producer – Distributor – User

The City's Wastewater and Water Utilities Department will produce and distribute the recycled water supply, under the purview of the Public Works Department.

The recycled water users are described in Section 4 of this report.

2.4 Raw Wastewater

The Guidelines (CDPH 2001) require a characterization of the raw wastewater quality. Raw wastewater quality, including the minimum, maximum, median, and 95th percentile values are shown in Table 2-2. These values are based on data from January 2001 through March 2005.

Table 2-2. Raw Wastewater Quality

Parameter	Minimum	Average	95th Percentile	Maximum
Ammonia (mg/L)	6.6	37	52	75
Biochemical oxygen demand (mg/L)	39	285	560	1,000
Dissolved Oxygen (mg/L)	0	2.4	5.5	11.4
Nitrate (mg/L)	0	0.5	1.0	24
Nitrite (mg/L)	0	0.02	0	1.5
Non-Filterable Residue (mg/L)	6	183	470	930
pH (std. units)	2.4	7.3	7.8	8.9
Suspended Solids (mg/L)	0.9	17	24	40
Temperature (Celsius)	7.2	21	25	27

The wastewater that is received and treated by the City is generated by commercial, industrial, institutional, and residential customers connected to the City's collection system. Residential customers generate about 50 percent of the wastewater by volume. Commercial (i.e. retail store) and institutional (i.e. public school) customers are typical of such customers in other municipal wastewater collection systems. The industrial customers in the City are somewhat unique in that they are largely comprised of viticulture businesses. The single largest discharger to the City's collection system is the Simi Winery, which discharges as much as 20,000 gallons per day.

City Ordinance 763 (Sewer System) includes limitations on and prohibitions of certain waste discharges and requires pretreatment for certain discharges. Furthermore, the City practices a source control program under the terms of Ordinance 763 and the City's NPDES permit. Industrial user programs include:

- Certified Unified Program Agency (CUPA) inspection program, which covers 150 businesses within the City
- Restaurant and food-related business inspection program, geared toward identifying and eliminating oil and grease discharges to the collection system
- Industrial user permitting system with sampling requirements for potential dischargers of high levels of compatible pollutants and pretreatment requirements for one-time groundwater remediation projects

Through these programs, the City exercises some degree of quality control over the wastewater that is collected in the sewerage system.

It is important to note that with completion of the WWTP Upgrade project, the WWTP effluent quality is anticipated to comply with Title 22 standards regardless of the raw wastewater quality, and the proposed supervisory control and data acquisitions (SCADA) system will continuously record the on-line measurements of water quality.

2.5 Treatment Processes

A major upgrade of the WWTP including the installation of advanced wastewater treatment facilities was completed in August 2008. The advanced treatment facilities, including membrane bioreactors (MBR) and ultraviolet (UV) disinfection, is capable of producing recycled water meeting the California Title 22 non-restricted reuse standards.

The WWTP Upgrade project included the following:

- **Influent Equalization:** Two of the existing five (5) treatment ponds were lined with an HDPE liner and will be used for equalization with a total volume of 8.0 million gallons. The plant influent flow in excess of the plant design capacity will temporarily be held in the equalization ponds. The wastewater detained in the equalization pond(s) will be pumped back to the head of the treatment processes when the plant influent flow is below its treatment capacity.
- **Screening and Grit Removal:** Consists of coarse screens (1/4 inch openings) followed by fine screens (1 millimeter openings), and a grit removal system (vortex grit removal, grit washing, and classification).
- **Biological and Aeration Facilities:** Includes two trains of aerobic, anoxic, and pre-anoxic basins to provide biological removal of BOD and nitrogen. Both trains may be operated in parallel. The facility also provides diurnal peak flow equalization to control membrane operation flux.
- **Blower/Electrical Building:** Contains blowers to deliver compressed air to the fine bubble diffusers in the aeration basins and the membrane bioreactor (MBR) process.
- **Return Activated Sludge (RAS) and Waste Activated Sludge (WAS) Pumping:** Non-clog centrifugal RAS pumps return activated sludge from the membrane tank to the aeration basins. Non-clog centrifugal WAS pumps discharge and remove waste excessive biomass from the system.
- **Membrane Bioreactor (MBR):** MBR combines secondary biological treatment and immersed membrane processes. Immersed membranes use a fine filter to separate solids from wastewater.
- **Effluent Disinfection:** Provided by an open channel UV disinfection system equipped with low pressure high intensity (LPHI) UV lamps to ensure effluent complies with Title 22 water quality requirements.
- **Treated Effluent Storage and Pumping:** Provides 24 million gallons of storage for recycled water. An effluent pumping station will be located on the south side of the storage pond.

- **Solids Stabilization:** The Cannibal™ sludge reduction process reduces excess sludge production by continuous removal of non-biodegradable grit and inert solids from activated sludge process.
- **Dewatering Facilities:** A centrifuge provides dewatering in combination with a polymer feed system. A progressing cavity pump will convey digested biosolids to the dewatering centrifuges.
- **Standby Generator:** Provides automatic standby power to the entire WWTP in the event of a power failure.

A site plan of the upgraded WWTP is shown in Figure 2-1 at the end of this section. A process flow schematic is provided in Figure 2-2, and the design criteria are provided in Figure 2-3. The biological and aeration, MBR, UV disinfection, and effluent storage processes are described in greater detail in the following sections.

Biological and Aeration Facilities

The aeration basins provide biological removal of BOD and nitrogen to meet the design effluent goal of ammonia (NH_4-N) less than 1.0 mg/L and total nitrogen (TN) less than 10 mg/L based on a maximum month flow of 3.2 mgd and a maximum month loading conditions. Design criteria for the aeration basins are summarized in Table 2-3.

Two parallel biological treatment trains are provided, as illustrated in Figure 2-4 through Figure 2-9. Each train consists of a pre-anoxic basin, two anoxic basins in series, and an aeration basin. Common to both trains at the influent end of the treatment process are the recycle split box and the influent split box.

Return activated sludge (RAS) from the membrane facility and screened mixed liquor from the Cannibal drum screen are returned to the recycle split box. From the recycle split box, flow is equally divided between the two pre-anoxic trains by overflow weirs. The pre-anoxic basin provides adequate time and space for the RAS dissolved oxygen to be consumed by the biomass before entering the first anoxic basin in the treatment train.

A portion of the RAS and mixed liquor in the recycle split box can be bypassed around both the pre-anoxic basins and anoxic basins and sent directly to the aeration basin. This allows fine-tuning of the flow and detention time in the pre-anoxic basin. A lower flow to the pre-anoxic basin and anoxic basins will result in less denitrification.

Screened and degritted effluent from the headworks is conveyed to the influent split box where it is equally divided between the two treatment trains. Flow splitting is accomplished by overflow weirs. After splitting, influent enters the first anoxic basin into the second anoxic basin and then into the aeration basin. Denitrification occurs under anoxic conditions in the anoxic basins.

The aeration basin is completely mixed and aerated using fine bubble rubber membrane diffusers. The basins provide flow equalization during daily diurnal peak flows to control membrane operating flux. A minimum of 0.20 to 0.25 million gallons are needed to fully equalize diurnal peak flow at the maximum and average day flow rates during the dry season, respectively. The aeration basins were designed to have a side water depth of 16 feet and a total depth of 20 feet with a 4 foot freeboard.

Table 2-3. Aeration Basin Design Criteria

Process Unit	Design Condition	Parameter	Typical Design Criteria	Recommended Operating Conditions
Pre-Anoxic Tank (Remove DO in RAS)	Maximum Month	Hydraulic Retention Time (HRT)	1-2 hrs	1.3 hr
		Percent Anoxic Volume	20-30 percent	16 percent
Anoxic Tank (Denitrification)	Maximum Month	Hydraulic Retention Time (HRT)	1-2 hrs	2 hrs
		Percent Anoxic Volume	20-30 percent	23 percent
Aerobic Tank	Maximum Month	Solids Retention Time (SRT) (aerobic)	12-15 days at 15˚C	12 days at 15˚C
		Mixed Liquor Suspended Solids (MLSS)	8,000 – 10,000 mg/L	9,000 mg/L
	Peak Flow	Oxygen Uptake Rate (OUR)	<80-100 mg/L-hr	77 mg/L-hr

Membrane Bioreactor (MBR)

The Siemens Mempulse MBR system, shown in Figure 2-10 through Figure 2-15, was installed at the WWTP. The membrane system provides an absolute barrier to all micro-organisms and suspended solids greater than 0.1 micron in size. The membrane system consists of four (4) membrane tanks with Siemens 144 B30R modules and one (1) tank with 112 MBR B40N modules. Each membrane cell has one spare slot for an additional rack, bringing the total module capacity in each tank to 160 modules. The MBR system has a capacity of 1.60 mgd average daily flow with peaks up to 4.0 mgd in four (4) tanks with the fifth membrane tank available as standby capacity.

Mixed liquor is continuously pumped into the membrane tanks from the aeration basins, via a common feed manifold supplying the membrane cells. Mixed liquor is fed through a ported manifold that distributes mixed liquor across the width of the tank, and the Siemens Mempulse air-scour system provides the agitation and scouring. Membrane fouling is prevented by creating an airlift at the base of each module. As the two phase jet of air and mixed liquor rise through the module, a turbulent cross flow scours the membrane surface.

After the solid and liquid phases are separated by the membrane process, the concentrated mixed liquor is recirculated back to the biological process.

The MBR system includes microfiltration units comprised of field-installed membrane modules with integral PVC racks and 316L stainless steel headers. Each cell contains butterfly valves and pneumatic actuators with stainless steel discs, filtrate flow meter with controller, pressure transducers and level switches for level control. The filtrate header is equipped with an air educator valve to prime the filtrate pumps.

Each cell contains 16 membrane modules grouped together in manifolded assemblies termed "racks" with integrated 316 stainless steel and PVC pipe work to produce the desired flow. The rack assemblies are manifolded together via a cell filtrate header and an air header. The racks are connected to the filtrate header by flexible hoses and couplings and fixed in place by a series of stainless steel guides. Flow and turbidity are monitored at each individual tank. An additional turbidity meter in the filtrate gallery monitors the combined filtrate.

A total of nine (9) membrane racks are installed in each of tanks 1-4 (fitted with B30R modules), leaving an additional blank slot in each tank for 10 percent spare capacity. Tank 5, which is fitted with B40N modules, contains seven (7) racks because of the higher permeability of the B40 N modules. Each rack is furnished with membrane re-circulation jets, inter-connecting liquid piping, filtrate collection pipe, and lifting lugs.

The MBR design criteria are summarized below.

Table 2-4. MBR Design Criteria

Description	Design Criteria
Peak daily capacity	4.0 mgd (in four tanks, fifth tank used as standby)
Membrane area per module (B30R and B40N)	404 ft^2
Number of membrane trains	5
Number of modules per train	144 (Tanks 1 to 4) / 112 (Tank 5)
Instantaneous flux rate at:	
1.6 mgd (average daily flow)	7.5 GFD (B30R) / 9.6 GFD (B40N)
4.0 mgd (peak daily flow)	19.2 GFD (B30R) / 24.7 GFD (B40N)
4.0 mgd (peak hour flow)	19.2 GFD (B30R) / 24.7 GFD (B40N)
Net flux rate at:	
1.6 mgd (average daily flow)	6.9 GFD (B30R) / 8.9 GFD (B40N)
4.0 mgd (peak daily flow)	17.2 GFD (B30R) / 22.1 GFD (B40N)
4.0 mgd (peak hour flow)	17.2 GFD (B30R) / 22.1 GFD (B40N)
Maximum TMP*	50 kPa
TMP* range	5-50 kPa
MBR influent turbidity	Not monitored
MBR effluent turbidity	Less than 0.2 NTU 95% of the time Not to exceed 0.5 NTU at any time

*TMP = Transmembrane Pressure (kPa)

Regulatory Certification

The January 2007 Treatment Technology Report for Recycled Water has accepted the Siemens/Jet Tech Products/Memjet 0.1 micron PVDF hollow fiber membrane MBR process, as a filtration technology for use in compliance with the California Water Recycling Criteria (Title 22). The CDPH acceptance letters are attached in Appendix A.

Siemens provided a certificate verifying that the membrane installed in the City of Healdsburg WWTP MBR system is identical to the membrane that was recognized by the CDPH as being acceptable for compliance with treatment requirements of the California Recycled Water Criteria. This certificate is attached in Appendix B.

Monitoring and Control

A summary of the MBR monitoring and control equipment is provided in Table 2-5.

Table 2-5. MBR Monitoring and Control Equipment

Description	Qty	Location	Function
Mixed Liquor Feed Flow Meters	5	Mixed liquor feed line into each tank	Monitors the flow of mixed liquor into each tank.
Membrane Tank Level Transmitter and Level Switches	5	Membrane tank	Monitors membrane cell level. Assures membranes are always submerged in water and mixed liquor will not overflow the RAS channel.
Membrane Pressure Transmitter	5	Suction side of each cell filtrate pump	Measures operating pressure in the membrane modules. Pressure reading used for TMP calculation.
Filtrate Flow Meters	5	Discharge side of each filtrate pump	Measure flow through the membranes.
Filtrate Turbidimeter (individual cell)	5	Filtrate lines after each filtrate pump	Monitor filtrate quality from an individual cell.
Filtrate Turbidimeter (combined effluent flow)		Combined filtrate line, 18-inch filtrate manifold	Monitor combined filtrate quality prior to disinfection.
Filtrate Manifold Flow Meter	1	18-inch filtrate manifold	Each of the 5 filtrate pumps discharges to an 18-inch filtrate manifold. The flow meter in this line measures the total filtrate flow to UV disinfection.
Filtrate Manifold Temperature Transmitter	1	18-inch filtrate manifold	Measures temperature of the combined filtrate prior to UV disinfection. Used to calculate the temperature-corrected flux and permeability, which is used to measure performance of the membrane modules and determine when cleaning is required.
Process Air Instruments	1	Blower Building	Process air discharge header is monitored by a pressure indicator, pressure transmitter, and temperature transmitter.
Process Control System	1	Electrical/Blower Building	Consists of a Master Control Panel (MCP), Local Cell Panels, CIP Control Panel, supervisory control and data acquisition (SCADA). The MCP monitors control system operations such as water levels in the MBR system, membrane performance, relaxation, MC and CIP processes, scour air supply, compressed air supply, and chemical addition.

Relaxation

Siemens no longer recommends nor uses a backwash as part of its standard operating procedure for membrane bioreactor systems. A relaxation step in lieu of a backwash provides more than adequate time for the membrane to cleanse via the turbulence caused by the tank aeration.

Relaxation occurs at the completion of 12 minutes filtration, or about 4 times every hour. During relaxation, the filtrate pump is ramped down by the variable frequency drive (VFD) and the filtrate valves are closed to prevent any potential siphon effects. A summary of the relaxation steps is provided in Table 2-6. In periods of high flow or high loading, an extended relaxation of 30 minutes can be initiated to maintain the cleaning interval.

Table 2-6. Relaxation Description

Relaxation Mode	Step	Duration (min)	Flow Through Membranes	Description of Step
Periodic	1. Relaxation	1	0	Filtrate pump VFD frequency is dropped to 0 Hz. Aeration and membrane recirculation pump are still running.
	2. Filtration	12	Filtration flow in forward direction	Filtrate pump is controlled by a VFD to pull filtrate through the membranes, from outside to inside.
Extended	1. Extended Relaxation	30	0	Filtrate pump is stopped. Aeration and membrane recirculation pump are still running.

Integrity Monitoring

A Membrane Integrity Failure Occurrence is defined as a loss of integrity (i.e. partial or complete fiber breaks) that results in any of the following:

- Turbidity exceeding 0.2 NTU for an individual membrane unit more than 5 percent of the time for the last 20 readings (excluding readings taken within 1 hour after membrane unit maintenance clean or clean-in-place (CIP)).
- Turbidity exceeds 0.5 NTU for an individual membrane unit on any single reading at any time (excluding readings taken within 1 hour after membrane unit maintenance clean or CIP).

Filtrate turbidity monitoring is the primary measurement of membrane integrity in a Siemens MBR system. Individual cell turbidimeters are provided in addition to a combined filtrate turbidimeter. The cell filtrate turbidity data is recorded in the plant control system and trend graphs may be viewed as an aid to system integrity maintenance. Based on the requirement to maintain combined effluent below 0.2 NTU, an individual cell turbidity reading consistently (more than 70% of the time for more than 24 hours) above 0.18 NTU will trigger a troubleshooting response. The controller for each tank will automatically stop filtrate flow on a turbidity reading greater than 0.5 NTU, notify the operator immediately and put the tank into recirculation until turbidity falls below this level for 5 seconds or more. If this 0.5 NTU condition persists (in recirculation) for one (1) hour, the tank will shut down and send another notice to the operator. The controller will also notify the operator whenever the turbidity exceeds 0.2 NTU and put tanks into recirculation if turbidity exceeds 0.2 NTU for four (4) hours or more. The controller will return the tank to recirculation filtration only if turbidity falls below 0.2 NTU. If this 0.2 NTU recirculation condition persists for 12 hours, the tank will shutdown and send another notice to the operator.

The leak test is used to localize an integrity loss within a cell. The operator will manually initiate the leak test on the cell and look for a stream of air bubbles to identify the source of the leak. The isolation does not require the cell to be drained or shutdown or the rack to be lifted out of the cell.

The principal steps of the integrity test or pressure decay test (PDT) includes stopping filtration, pressurizing the inside of the module fibers and headers with air at 5 psi, isolating the cell from the air supply and monitoring the pressure decay over a period of time (typically 2-3 minutes). Each cell is tested at intervals determined by the operator.

Effluent Disinfection

Membrane permeate is pumped from the membrane facility to the disinfection basin. UV disinfection is provided by the Trojan UV3000Plus system to disinfect a peak flow of 4.0 mgd. The UV disinfection system, shown in Figure 2-16 and Figure 2-17, consists of one (1) channel with three (3) UV lamp banks (2 duty and 1 redundant) in series. Filtered and UV disinfected wastewater normally flows by gravity to the Effluent Storage Pond or the Basalt Pond discharge.

In case of UV system failure, a motorized and remotely operable slide gate will be shut, in which case the UV channel effluent will overflow and divert all flow to a raw wastewater equalization pond. Any one of the following critical alarms for the UV System will cause the diversion gate to shut:

- Low UV Dose
- Maximum flow exceeded
- UV Transmittance signal fault
- Flow signal fault
- Insufficient number of UV banks in service for current flow
- Low water level shutdown
- High combined filtrate effluent turbidity

These gates may also shut remotely by any operator with access to the SCADA system. All flow retained in the equalization basin(s) will be returned to the treatment processes for full tertiary treatment prior to discharge. The basin has adequate volume for more than 24 hours of emergency storage at ADWF.

The UV system uses horizontal lamps in modular arrangement with parallel modules grouped to form a bank across the open channel. Low pressure, high intensity amalgam lamps are mounted to modules, which hold 8 vertically spaced lamps enclosed in quartz sleeves. The closed end of the quartz sleeve slides into the formed module leg and the open end of the sleeve fastens to a molded lamp holder assembly that is attached to the other module leg. The module legs feature a streamlined design to minimize headloss along the length of the module.

All wiring between the ballast and lamps is contained within the module leg. No wiring is exposed to water. The modules are supported by a module rack, which is anchored to the channel walls. The rack suspends the modules in the channel so that the lowest lamp is located just above the bottom of the channel and the module enclosure sits above the water. The modules are suspended from the rack by the module enclosure. Below the module enclosure is a “light lock” which is used to prevent UV light from escaping above the lamps.

The module enclosure uses an anodized aluminum extrusion. The top of the enclosure is designed with a lip for lifting a single module by hand from the channel. Variable output electronic ballasts and a module control board are housed in the module enclosure. One ballast is provided for every two lamps. The ballasts are mounted on a ballast tray that slides in and out of the enclosure.

The Module Control Board (MCB) is used to monitor the status of the lamps and ballasts. Information is sent between the MCB and the Communications Control Board (CCB) via the Relay Control Board (RCB). One RCB is provided for each module. Both the RCBs and CCB are located in the Power Distribution Center (PDC). The modules are connected to the PDC using a power cable, which extended from one end of the module enclosure. The power cable for each module is plugged into a labeled receptacle on the PDC.

Title 22 standards and NWRI guidelines (Section 2.2) were used to develop the UV disinfection system design criteria, as summarized in Table 2-7.

Table 2-7. UV System Design Criteria

Description	Design Criteria
Peak design flow	4.0 mgd
Average design flow	1.6 mgd
Number of channels	1
Dimensions of the channel	50-ft L x 32-in W x 52-in D
Total number of banks	3 (2 duty, 1 redundant)
Banks in use at peak flow	2
Banks in use at average flow	2
Number of modules per bank	8
Number lamps per module	8
Total number of UV lamps	192
Module material	316 SST Quartz, Teflon
Lamp spacing	4 in

Description	Design Criteria
Lamp arc length	58 in
Sleeve material	Quartz
Sleeve dimensions	1,950 mm x 25 mm x 28 mm
Sleeve nominal wall thickness	1.5 mm
Water level relative to UV lamps	0.45 – 2.45 in
Velocity range	0 – 3 ft/sec
MBR effluent suspended solids	Less than 5 mg/L
MBR effluent average particle size	Maximum 10 Microns
Effluent coliform, 7-day median	Less than 2.2 MPN/100 mL
Effluent coliform	Maximum 23 MPN/100 mL
UV dose (at the end of lamp life time and peak flow)	Minimum 80,000 µW-s/cm^2
Design UV transmittance	65% at 254 nm
UV transmittance reduction factor	80%
Redundancy	Minimum 50%
Minimum and maximum effluent temperature	35/95 °F
Seismic design code	UBC Zone 4

Regulatory Certification

The January 2007 Treatment Technology Report for Recycled Water has accepted the Trojan UV3000Plus, as a disinfection technology for use in compliance with the California Water Recycling Criteria (Title 22). The CDPH acceptance letters are attached in Appendix C.

Trojan provided a certificate verifying that the UV equipment installed is identical to the technology used in the validation testing with respect to lamp spacing, type of lamp, quartz sleeve characteristics, and ballasts. The certificate also verifies that the UV equipment was the same as recognized by the CDPH as being acceptable for compliance with treatment requirements of the California Recycled Water Criteria. This certificate is attached in Appendix D.

Monitoring and Control

A summary of the UV disinfection system monitoring and control equipment is provided in Table 2-8.

Table 2-8. UV Disinfection Monitoring and Control Equipment

Description	Qty	Location	Function
UV Intensity Sensor	3	Positioned between the fifth and sixth lamp from the top	Continuously measures the UV intensity produced in each bank of modules.
On-line UV Transmittance Controller and Sensor	1	UV channel upstream of the first bank of lamps	Sample and measure the percent of UV transmittance (%T) in the effluent. The results are communicated to the SCC from the SC100 Controller and are used to adjust the UV dose in conjunction with flow signals and lamp age.
Photometer	1	Hand held	Measure percent of UV transmittance of unfiltered effluent.

Description	Qty	Location	Function
Level Control Weir	1	End of UV channel	Fixed serpentine weir to maintain the appropriate water level over the lamps at all flows to ensure uniform UV exposure and protect the system.
Water Level Sensor	1	Downstream of the UV system	Provides a digital signal and triggers an alarm when the water level is too low. When the water level is too low, the bank will automatically shutdown.
System Control Center (SCC)	1	UV deck	Monitors and controls all UV system functions including dosage adjustment based on effluent UV transmittance and flow. The PLC controller continuously monitors and controls the system's functions. The controller communicates with the operator interface, PDC, and HSC. Equipped with alarm reporting system for fast and accurate diagnosing of system process and maintenance alarms.
Power Distribution Center (PDC)	1	UV deck next to each bank	Powers each bank of modules. Distributes power from the main electrical service out to the modules in the bank. Contains the communication and control equipment for the bank of lamps. On Bank 1A, the PDC also contains the Hydraulic System Center (HSC).
Communications Control Board (CCB)	3	Within the PDC	Controls and monitors the lamp, ballast, and bank status. The SCC polls each CCB in sequence to continually update the status of modules and ballasts. The messages are decoded by the controller and then checked for error prior to displaying the data on the status screen.
Hydraulic System Center (HSC)	1	UV deck next to each bank	Operates the automatic cleaning system which provides in-channel cleaning of the lamp sleeves while the lamps remain submersed in the channel.

Operations Plan

A copy of the operations and maintenance manual for the UV system is included in Appendix E. The UV system is currently in automatic operating mode pre-set by the manufacturer according to the site conditions. The City has not made any changes to the manufacturer recommended procedures.

Equipment Validation

Trojan Technologies developed the UV3000Plus Validation Report (February 2006) and subsequent revisions (Rev. 1.0 May 2007) submitted to CDPH which describes the results from the performance validation testing of a pilot scale Trojan UV3000Plus system with a lamp spacing of 4 inches. Subsequently, CDPH issued a conditional acceptance letter and a series of extended acceptance letters that provide design conditions and operational settings for the 3000Plus application for California water recycling. The CDPH-approved conditions include the validated flow range being from 6 to 126 gpm per lamp; UVT from 53% and up; and end-of-lamp-life factor of 0.98, etc. The validation is applicable to UV3000Plus systems with banks consisting of 24 to 240 lamps. The banks in the City's UV3000Plus system have 64 lamps; in addition, all design and operation parameters are within the CDPH-approved conditional ranges. Therefore, this validation is applicable to the City's UV system; no full bioassay validation will be performed for this installation; instead a Checkpoint Bioassay will be conducted on the UV system prior to the distribution of the recycled water.

Bioassay Experiments and UV Operational Dose

During the UV system design, sizing of the UV equipment was strictly based on a bioassay testing conducted as part of the pilot testing in the UV3000plus Validation Report. Bioassay testing was conducted during that study by adding concentrated MS-2 coliphage (MS-2), a non-pathogenic indicator virus, to the tertiary filter effluent stream. Samples were collected from the influent and effluent of the UV reactor to determine the inactivation of MS-2 through the disinfection system under different operating conditions.

The UV dose delivered (D_{dose}) by a UV disinfection system is dependant on flow, water quality (measured in terms of ultraviolet transmittance, UVT), and the intensity of the UV output from the lamps (a function of power input). Therefore, bioassay tests were conducted at a range of flows, UVTs, and power settings. A multiple linear regression was performed on the data generated during the bioassay testing to determine the delivered dose per bank as a function of these three (3) variables. The dependant variable for the regression analysis is the log of the delivered dose (mJ/cm2). The independent variables are the log of flow (gpm/lamp), log of UVT (%), and log of power (%). The resulting equation presented below does not include lamp aging and sleeve fouling factors.

$$\text{Log } D_{dose} = -4.63 - (0.70 \times \text{Log Flow}) + (2.91 \times \text{LogUVT}) + (1.09 \times \text{Log Power})$$

(From UV3000plus Validation Report, Rev. 1.0 May 2007)

After the incorporation of appropriate sleeve fouling and lamp aging factors, this equation was used to design and operate the UV3000Plus disinfection system.

Field Commissioning Test

A representative from Trojan was at the plant site to witness the installation and start up of the UV disinfection equipment. A Field Service Report (to the installer/contractor) stating the UV disinfection system and ancillary equipment have been installed correctly and are in satisfactory operating conditions summarizes the following:

- Proper installation of the equipment
- Proper inspection, checking, and adjustment of the equipment
- Start-up and field-testing for electrical components
- Proper operation of controls and alarms
- Proper instrument calibration
- Proper operation under full load conditions
- Proper operation under all control modes

Performance Test

A performance test for the installed UV disinfection system was conducted after system installation. The performance test was conducted during the month of October through December 2008 for a minimum 30 days. Trojan developed a performance test protocol for the UV3000Plus to demonstrate that the installed equipment achieves the design disinfection limits, as indicated in Trojan's Performance Guarantee provided that the peak flow is less than 4.0 mgd, suspended solids do not exceed 5 mg/L and UV transmission is a minimum of 65 percent. A testing matrix was prepared on weekly basis during the performance testing period. A copy of the protocol and a sample testing matrix used for the testing are included in Appendix F.

The performance test was conducted over 30 days in which two sets of samples were collected per day. A set of samples consisted of one microbiological, TSS, and UVT samples collected upstream of the UV system, and one microbiological sample collected downstream of the UV system. The following data was recorded:

- The date and time that the samples were taken.
- The flow through the UV disinfection channel at the time of sampling, as measured from the plant effluent flow meter and displayed on the UV system control screen.
- The hours of operation of each bank, as displayed on the UV system control screen.
- The time of last lamp cleaning.
- The calculated UV intensity measured in mW/cm^2, as displayed on the UV system control screen.
- The total coliform count per 100 mL in the UV disinfection channel influent (membrane permeate) and effluent.
- The percent transmittance at a wavelength of 254 nanometers of the UV disinfection channel influent.
- The total suspended solids (TSS) concentration in the UV disinfection channel influent.
- The performance testing results and the letter from Trojan Technology summarizes the UV system performance are also included in Appendix F.

Effluent Storage and Pumping

Final effluent will flow from the UV disinfection system to either the Basalt Pond or the Effluent Storage Pond for reuse. An 8-foot berm was built up to approximately 8 feet from the existing grade around the Effluent Storage Pond to restrict the view of the treatment pond from the road.

The effluent storage pond will provide 25 million gallons of recycled water storage capacity. The selection of this volume was the result of maximizing storage capacity on the City's property adjacent to the upgraded WWTP while balancing the amount to cut and fill and maintaining the pond bottom well above the groundwater table. An HDPE membrane lines the effluent storage pond to prevent recycled water leakage and infiltration to groundwater.

A pumping station located on the south side of the effluent storage pond will include a set of vertical turbine pumps dedicated to the recycled water system.

Operation and Maintenance Manual

After the construction completion, an operation and maintenance manual for the entire WWTP was developed. The manual is in electronic format and is incorporated into the plant process information and control system (SCADA). The manual is also web-based so that the plant operation personnel can access the manual outside the treatment plant (*http://www.hdreom.com/Eom_Healdsburg/Manual/DisplayPage.aspx?ContentId=4281*). Access can be obtained by contacting the City of Healdsburg Public Works Department.

The manual addresses the details of operation and maintenance of every key WWTP components. The Manual includes the following major chapters:

- Process Overview
- Coarse Screening
- Grit Removal
- Flow Equalization
- Fine Screening
- Biological Treatment
- Membrane Facility
- Effluent Disinfection
- Reclaimed Water Storage
- Cannibal System
- Biosolids Dewatering
- Plant Utilities
- Plant Reliability Features

2.6 Plant Reliability Features

Sections 60333 through 60355 (Articles 8 and 10) of the Water Recycling Criteria define reliability requirements for WWTPs producing recycled water. The upgraded WWTP meets these requirements as follows:

- **Flexibility of Design (Article 8, §60333):** The WWTP has been designed to provide for efficient operation and maintenance and to permit the highest possible degree of treatment under varying circumstances. The capacity and redundancy of critical processes in the upgraded WWTP to achieve adequate treatment under varying flow and loading conditions are highlighted in Figure 2-2 and Figure 2-3.

Process diversion features: The new WWTP includes a number of features that prevent potential overflows resulting from a malfunction within the treatment process:

- Automatic wet-weather flow diversion: The headworks incorporates an automatic downward-acting weir to divert flows to the equalization basin. When the Parshall flume flow-measurement device in the headworks detects flows greater than 4.0 mgd (the WWTP wet-weather capacity), the weir gate, located just downstream of the coarse screening and grit removal in the headworks structure, automatically skims and diverts excess flows to the equalization pond.
- An equalization pumping station located adjacent to the headworks structure pumps equalized inflows back to the head end of the headworks structure. Two 25 HP submersible pumps controlled by variable frequency drives convey flow back from the equalization basin to the headworks for treatment.
- Fail-safe overflow: In addition to the automatic flow diversion to the equalization basin (described below), the new headworks structure also includes a separate "fail-safe" overflow at its head end that will divert all inflows through a 20-inch line to the equalization pond if any malfunction or blockage causes flows to back up in the headworks structure. This overflow is located at the east end of the structure, just upstream of the coarse screens.
- Motorized slide gate diversion: Following construction and start-up of the WWTP, the City added remotely operable motorized gate operators for automatic diversion to equalization storage. The operators were installed on two slide gates just downstream of the "fail-safe" overflow in the headworks. In the event of any malfunction within the WWTP, this now allows the operators to quickly close these gates remotely from the SCADA system screen and divert all influent to the equalization basin via the overflow. In addition, the gates will automatically shut under any of the following conditions:
  - If either of the two aeration basins reach a high level while all filtration tanks are offline, subject to alarms and slight delays to allow an operator to respond.
  - If either of the two aeration basins reaches a high level while all filtration tanks are offline, but aeration basin level levels continue to rise.
  - If the two aeration basins reach a high level.
  - If the discharge channel downstream of the membrane filtration tanks reaches a high level.
- Fine Screen overflow protection: The 1-mm fine screens in the headworks are essential to protect the membrane filters. Because of the small opening size, grease or oil can blind the screens and cause the upstream water level to back up. The City's operation staff has installed a baffle plate above each of the two screens. If any blockage causes the fine screens to blind, water will back up behind the baffle plate (instead of overflowing the screen) and overflow the upstream equalization

weir. This prevents the screens from being bypassed and protects the integrity of the membrane filters.

- Effluent diversion: Effluent diversion: See discussion above for the UV disinfection system.

- **Alarms (Article 8, §60355)**: Alarms are integrated into the local process controls as well as the SCADA system for the upgraded WWTP, including alarm signals for:
  - Interruption of power supply, activation of standby power generator, and return to utility service as indicated by digital outputs from electrical gear
  - Failure of membrane filtration process as indicated by continuous measurement of trans-membrane pressure and effluent turbidity
  - Failure of UV disinfection process as indicated by lamp ballast monitoring and continuous measurement of water level, water temperature, and effluent turbidity
- **Power Supply (Article 8, §60337):** The upgraded WWTP includes a diesel-engine driven generator with an automatic transfer switch, a sound-attenuating weatherproof enclosure, and a diesel storage tank sized to provide 12 hours of operation at normal load. The automatic transfer switch will sense a power failure and start the standby generator, transferring load to the generator and returning the load to utility service when available.
- **Emergency Storage or Disposal (Article 10, §60341):** The 24 million gallon effluent storage pond will provide emergency storage capacity of greater than 24 hours for short-term retention during wet weather flows. The minimum of 20 days of storage capacity for long-term retention is provided during dry weather flows of 1.2 mgd or less.
- **Biological Treatment (Article 10, §60345):** The upgraded WWTP includes two aeration basins, four denitrification basins, and redundant support equipment (Figure 2-2 and Figure 2-3) as well as the process monitoring alarms in Appendix G.
- **Filtration (Article 10, §60351):** The upgraded WWTP includes five membrane filtration basins (Figure 2-2 and Figure 2-3), each equipped with an on-line effluent turbidimeter, as well as the process monitoring alarms in Appendix G. The plant is designed to treat the peak daily capacity in four tanks, in case one membrane tank or one pump or one compressor is out of service (not concurrently).
- **Disinfection (Article 10, §60353):** The upgraded WWTP includes three (3) banks of eight (8) UV disinfection modules with eight (8) UV lamps per module (Figure 2-3), continuous measurement of UV intensity, and the following low and high-priority alarms and set points:
  - High-Priority Alarms
    - Low-Low UV Intensity: This alarm indicates that the UV intensity has fallen below the predetermined set point of 50%.

– Low-Low UV Transmittance: This alarm indicates that the influent UV transmittance has fallen below a predetermined set point of 65 percent.

– Low-Low UV Dose: This alarm indicates that the UV dose has fallen below the alarm limit of 80 mWsec/cm^2. The alarm limit is determined by the dose alarm offset percentage value, which is the percentage of the design dose at which the alarm is triggered.

- Low-Priority Alarms

– Low UV Transmittance: This alarm indicates that the influent water reuse UV transmittance has fallen below a predetermined set point of 67 percent.

– Low Operational UV Dose: This alarm indicates that the operational UV dose has fallen below the predetermined set point of 85 mWsec/cm^2.

The City staffs the WWTP during daytime hours, and the SCADA system provides unattended operations at night. An on-call WWTP operator receives any night-time alarms via an auto-dialer connected to the SCADA system.

2.7 Supplemental Water Supply

The City will produce and deliver disinfected, tertiary recycled water as defined by Title 22, Division 4 of the California Code of Regulations, Section 60301, et. seq. from the WWTP into the recycled water system.

The City intends to install piping so that it has the ability to supplement water in storage at its Tayman Park recycled water tank with fresh water from its Fitch Well Field. The tank connection from the Fitch well field will be through an air-gap fill line to be installed in the new tank (See Section 4 for a full description).

In addition, some of the recycled water customers may retain their existing water supplies and/or develop alternative supplemental water supplies. Precautions for such cases are addressed in Section 4 of this Engineering Report.

2.8 Monitoring and Reporting

Monitoring and reporting for the treatment facility and distribution system will be performed by the City in compliance with Title 22 regulations and Waste Discharge Requirements (WDR). The City will conduct the following monitoring and analyses:

- The effluent will be monitored at least once daily for total coliform bacteria. The samples will be taken from the disinfected effluent and analyzed by an approved laboratory. The upgraded WWTP includes a bacteriological testing laboratory, and the City plans to seek certifications to conduct total coliform testing at the WWTP in the future.

- The City will continuously monitor and record the performance of the membrane filtration system using an on-line turbidimeter for each of the five (5) membrane filtration basins.
- Compliance with the turbidity standard of not exceeding 0.2 NTU more than 5 percent of the time over a 24-hour period shall be determined using the levels of recorded turbidity taken at intervals of no more than 1.2-hours over a 24-hour period (24 x 5% = 1.2).
- Compliance with turbidity limits pursuant to Section 60301.320 (b) (1) shall be determined from the continuous on-line turbidity measurements. In case of turbidimeter failure on an individual cell, the combined filtrate turbidimeter is available to monitor compliance. In the case where no backup is available, the City will collect grab samples at a minimum frequency of 1.2 hours. The City will submit the results of the daily average turbidity monitoring to CDPH and the Regional Board in accordance with monitoring and reporting requirements issued by RWQCB.
- Should the continuous turbidimeter and/or recorder fail, grab sampling at a minimum frequency of 1.2-hours may be submitted for a period of up to 24-hours. (This is for potable water)
- UV intensity, UV transmittance, operational UV dose, and flow rate through the UV disinfection system will be monitored continuously.
- Monitoring of the following UV disinfection system components will be provided:
    - Status of each UV bank (on/off)
    - Status of each UV lamp (Daily check by operator)
    - UV intensity measured by at least one probe per bank
    - Cumulative number of bank on/off cycles
    - Cumulative UV disinfection system power consumption
    - Power set point for the banks (the Trojan 3000Plus system has variable power input to lamps)
    - Liquid level in the UV disinfection banks

Operating records will be maintained at the WWTP including: all required water quality analyses; records of operational problems and equipment breakdowns; diversion to emergency storage or disposal; all corrective or preventative actions. The City will record and maintain a separate file of any process or equipment failures triggering an alarm, the date/time of the alarm, the cause of failure, and corrective action, and will submit a summary of operating records to CDPH and the Regional Board monthly.

At a minimum, the following information will be reported to the Regional Board:

- Results of daily total coliform bacteria monitoring, running 7-day median calculation, maximum daily coliform reading

- Results of minimum daily UV operational dose, minimum daily filter effluent UV transmittance, 95 percentile effluent turbidity (24 hour period), and daily maximum turbidity reading
- Failure of UV disinfection equipment
- Effluent total coliform bacteria MPN greater than 240/100 mL
- Effluent turbidity greater than 0.5 NTU
- UV operational dose lower than 80 mJ/cm^2
- UV transmittance at 254 nm lower than 65%, initiating a plant shut down
- Diversion of inadequately treated water

The City will notify CDPH, the Regional Board, and the Sonoma County Environmental Health Division by telephone in case of an inadvertent delivery of inadequately treated wastewater to a use area within 24 hours.

Monitoring Equipment

The major instruments at the WWTP associated with recycled water production and compliance are shown in Table 2-9 along with sampling frequency and calibration/maintenance frequency.

Table 2-9. Instrumentation List for Recycled Water Production

Instrument	Sampling Frequency	Calibration or Maintenance Frequency
Flow Meters	Continuous	Annually
Turbidimeters	Continuous	Monthly
UV Intensity Sensor	Continuous	Bi-Monthly
On-line UV Transmittance Sensor	Continuous	Weekly
Photometer	Monthly	Monthly

2.9 Contingency Plan

Redundancy of critical processes and other system reliability features are built into the upgraded WWTP (Sections 2.5 and 2.6). Nevertheless, a contingency plan is required by Section 60323(c) of the Water Recycling Criteria to prevent delivery of inadequately treated wastewater to the use areas.

Section 60323 requires a list of specific conditions which would require an immediate diversion to take place. The following conditions would indicate the possibility that the plant is producing inadequately treated effluent. If any of the following conditions occur, the effluent gate valves at the UV structure will close and flow will be diverted to the equalization basin or emergency storage basin in the following circumstances:

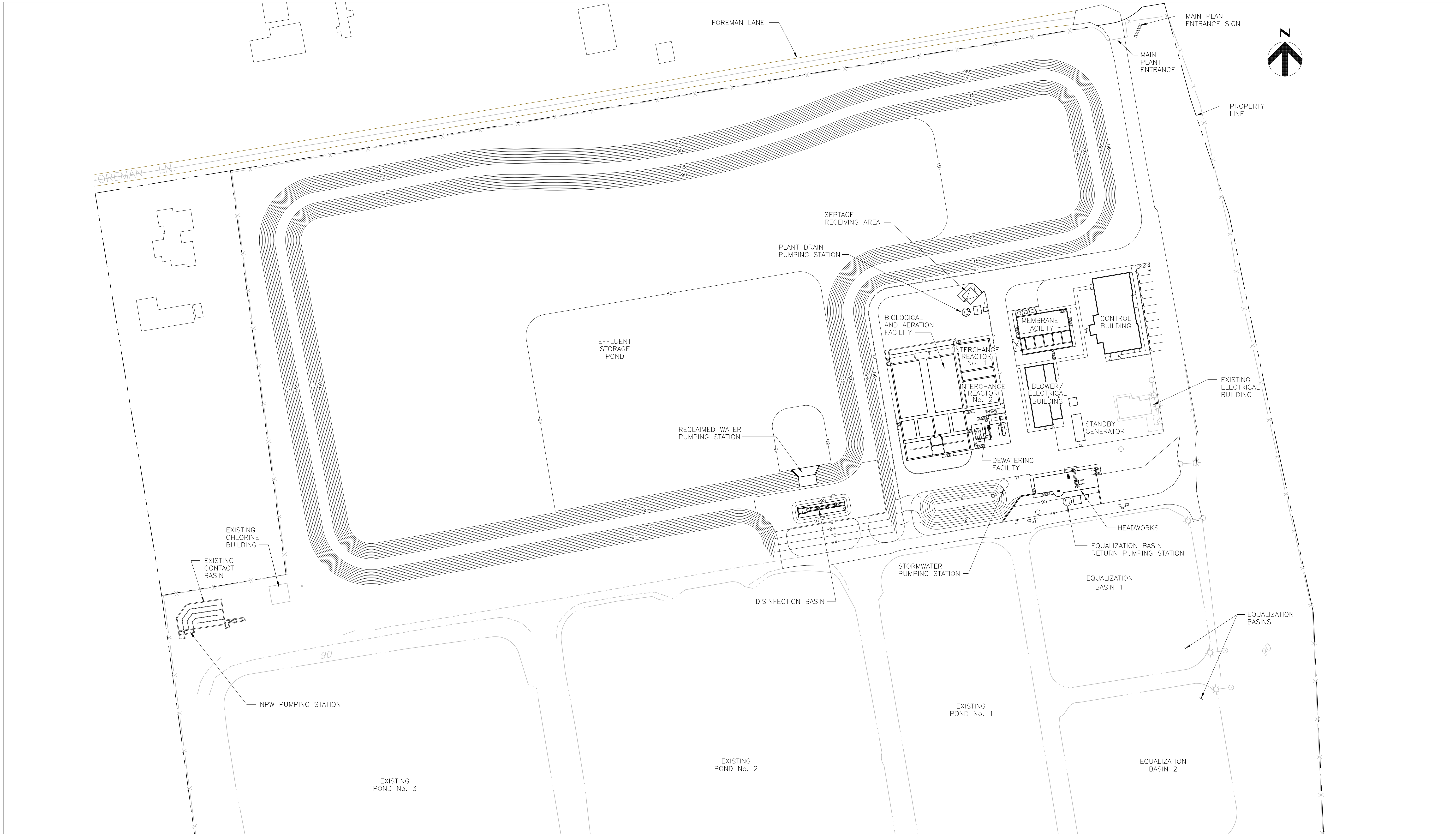
- Failure of upstream treatment processes or the UV disinfection system
- High turbidity in the filtered effluent (see Section 2.6)

- Initiation of any of the following critical alarms:
  - Low UV dose
  - Hydraulic max exceeded
  - UVT signal fault
  - Flow signal fault
  - Not enough healthy banks (for current flow)
  - Low water level shutdown
  - High effluent turbidity (over time)
  - Lamp breakage (mercury release)

Two (2) of the five (5) treatment ponds in the old treatment plant (Ponds A1 and A2) were regarded, lined and converted to influent equalization pond. With a capacity of approximately 5 million gallons, the converted ponds will provide adequate equalization storage capacity for extended wet weather flows. The other three (3) existing treatment ponds (i.e. Ponds P1, P2, and P3) are available for use as emergency storage ponds, providing 15 million gallons of storage capacity. The City will have the ability to divert inadequately treated wastewater from the UV disinfection system to Ponds 1, 2, and 3 and from there to the WWTP headworks and tertiary treatment processes. As described above in Section 2.6, this diversion can be initiated remotely by an operator. The 15 million gallons of capacity in Ponds 1, 2, and 3 will provide more than 24 hours of emergency storage capacity during peak flows.

The City's NPDES permit prohibits effluent discharges to the Basalt Pond from May 15 to September 30 each year after 2009; however the City has requested a 5-year extension to this compliance deadline. The City expects that this extension will be included, subject to progress on several interim milestones, in an updated NPDES permit expected to be issued in April of 2010

In all cases where a shutdown is required, an investigation will be conducted to determine the cause of the incident, and the recycled water will not be redirected for tertiary treatment until the problem has been corrected and the effluent conditions have returned to acceptable levels. Furthermore, in the event of a water quality condition requiring the interruption of recycled water delivery to the use areas, the City would notify CDHS, the Regional Board, and the Sonoma County Environmental Health Division by telephone.

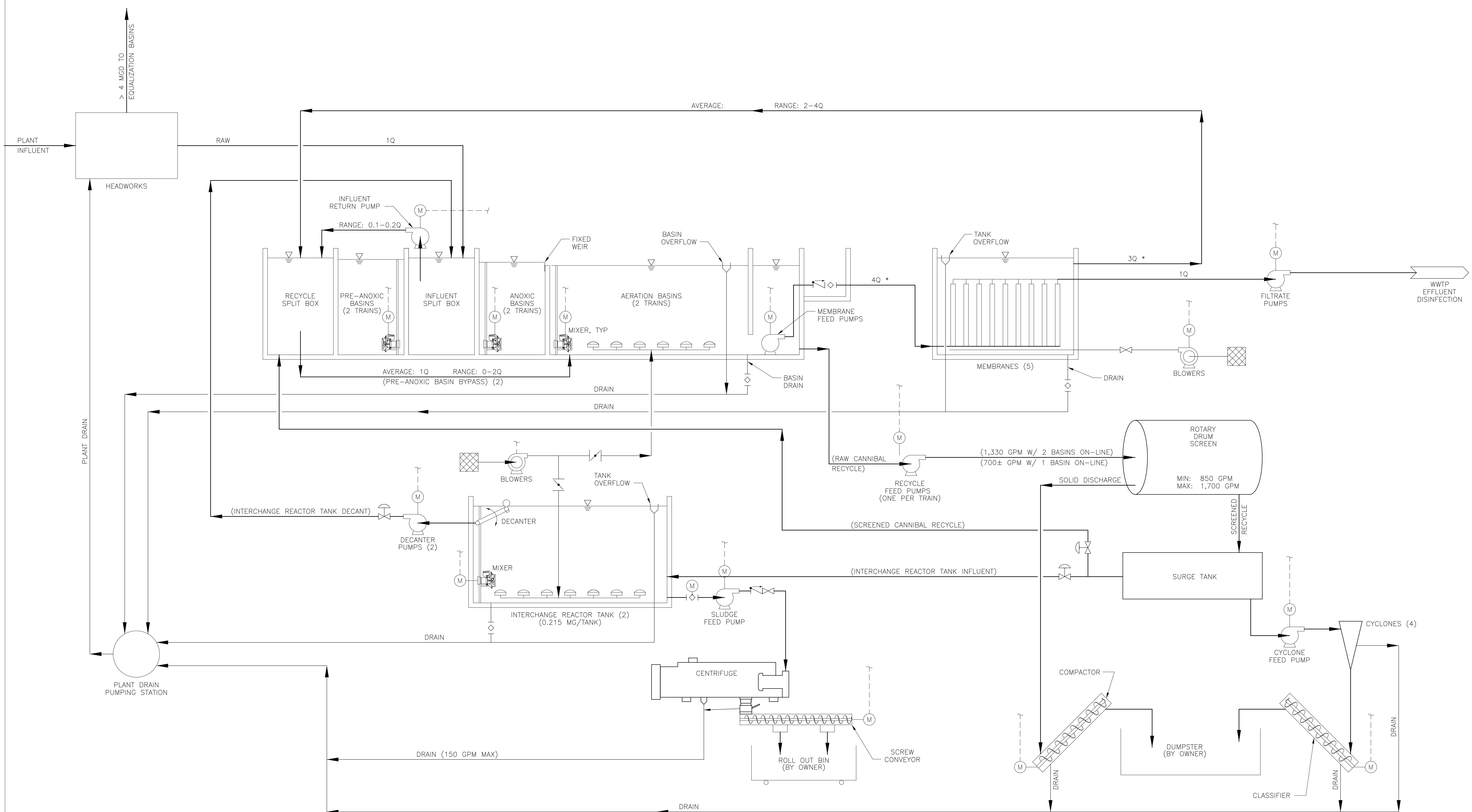


HDR

CITY OF HEALDSBURG, CA
WASTEWATER TREATMENT PLANT
SITE PLAN

DATE
SEPT 2009

FIGURE
FIGURE 1



HDR

CITY OF HEALDSBURG, CA
WASTEWATER TREATMENT PLANT
PROCESS SCHEMATIC

DATE
SEPT 2009

FIGURE
FIGURE 2

PROCESS EQUIPMENT DESIGN CRITERIA

SITE (AREA 200)

EQUALIZATION BASIN RETURN PUMPS (200EBRP101, 200EBRP201)

ITEM	DESIGN
NUMBER	2
TYPE	SUBMERSIBLE NON-CLOG
HORSEPOWER	25
CAPACITY	2400 GPM @ 20 FT
DRIVE	VARIABLE

PLANT DRAIN PUMPS (200PDP110, 200PDP210)

ITEM	DESIGN
NUMBER	2
TYPE	SUBMERSIBLE NON-CLOG
HORSEPOWER (MAX)	9
CAPACITY	700 GPM @ 30 FT
DRIVE	VARIABLE

STORMWATER PUMP (200SWP020)

ITEM	DESIGN
NUMBER	1
TYPE	SUBMERSIBLE NON-CLOG
HORSEPOWER	15
CAPACITY	2800 GPM @ 8 FT
DRIVE	CONSTANT SPEED

HEADWORKS (AREA 202)

COARSE SCREENS (202CSCR101, 202CSCR201)

ITEM	DESIGN
NUMBER	2
TYPE	WEDGE SECTION
CHANNEL WIDTH	48 INCHES
HORSEPOWER	2
CAPACITY	7.5 MGD
OPENING SIZE	.25 INCHES

GRIT BASIN (202GRTV001)

ITEM	DESIGN
NUMBER	1
TYPE	FORCED VORTEX
CAPACITY	10 MGD
DIAMETER	12 FEET
MATERIAL	CONCRETE
GEAR MOTOR HORSEPOWER	1.5

GRIT PUMP (202GRTP002)

ITEM	DESIGN
NUMBER	1
TYPE	VACUUM OR SELF PRIMING
CAPACITY	250 GPM
HORSEPOWER	10
DRIVE	CONSTANT SPEED

GRIT CLASSIFIER (202GRTC008)

ITEM	DESIGN
NUMBER	1
TYPE	FREE VORTEX CENTRIFUGAL SOLIDS SEPARATOR AND CLASSIFIER
CAPACITY	250 GPM

FINE SCREENS (202FSCR110, 202FSCR210)

ITEM	DESIGN
NUMBER	2
TYPE	ULTRA-FINE
CHANNEL WIDTH	48 INCHES
HORSEPOWER	2
CAPACITY	4.0 MGD
OPENING SIZE	1 MM

SCREW CONVEYORS (202SCCV105, 202SCCV205)

ITEM	DESIGN
NUMBER	2
TYPE	SHAFTLESS SCREW
LENGTH (APPROX)	24 FEET
HORSEPOWER	5

PROCESS EQUIPMENT DESIGN CRITERIA

BIOLOGICAL AND AERATION FACILITY (AREA 203)

AERATION BASIN STRUCTURE

ITEM	DESIGN
NUMBER OF TRAINS	2
NUMBER OF BASINS	2
LENGTH	72 FEET
WIDTH	40 FEET
BASIN DEPTH	20 FEET
SIDEWATER DEPTH	16 FEET
CAPACITY	350,000 GALLONS
TOTAL CAPACITY	700,000 GALLONS

DENITRIFICATION

ITEM	DESIGN
NUMBER OF TRAINS	2
NUMBER OF BASINS	4
LENGTH	27.5 FEET
WIDTH	19.25 FEET
BASIN DEPTH	20 FEET
SIDEWATER DEPTH	16 FEET
TOTAL CAPACITY	520,000 GALLONS

MIXERS (203MXR101, 203MXR102, 203MXR103, 203MXR104, 203MXR201, 203MXR202, 203MXR203, 203MXR204)

ITEM	DESIGN
NUMBER	8
TYPE	PROPELLER
HORSEPOWER	3
DRIVE	CONSTANT SPEED

SCUM PUMPS (203SCMP130, 203SCMP230)

ITEM	DESIGN
NUMBER	2
TYPE	SUBMERSIBLE NON-CLOG
HORSEPOWER (MAX)	3.6
CAPACITY	330 GPM @ 14 FT
DRIVE	CONSTANT SPEED

MEMBRANE FEED PUMPS (203MFP100, 203MFP200, 203MFP300, 203MFP400, 203MFP500, 203MFP600)

ITEM	DESIGN
NUMBER	6
TYPE	SUBMERSIBLE NON-CLOG
HORSEPOWER (MAX)	30
CAPACITY	3000 GPM @ 25 FT
DRIVE	CONSTANT SPEED

RECYCLE FEED PUMPS (203RFP120, 203RFP220)

ITEM	DESIGN
NUMBER	2
TYPE	SUBMERSIBLE NON-CLOG
HORSEPOWER (MAX)	7.25
CAPACITY	850 GPM @ 16 FT
DRIVE	VARIABLE

INFLUENT RETURN PUMP (203IRP001)

ITEM	DESIGN
NUMBER	1
TYPE	SUBMERSIBLE NON-CLOG
HORSEPOWER	5
CAPACITY	550 GPM @ 14 FT
DRIVE	VARIABLE

MEMBRANE FACILITY (AREA 204)

RECTANGULAR TANK

ITEM	DESIGN
NUMBER	5
LENGTH	14.5 FEET
WIDTH	10.5 FEET
DEPTH	10.5 FEET
SIDEWATER DEPTH	10 FEET

FILTRATE PUMP (204FP150, 204FP250, 204FP350, 204FP450, 204FP550)

ITEM	DESIGN
NUMBER	5
TYPE	ROTARY LOBE
HORSEPOWER	20
CAPACITY	3000 GPM @ 20 FT
DRIVE	VARIABLE

MEMBRANE CLEANING PUMPS (204MP140, 204MP240)

ITEM	DESIGN
NUMBER	2
TYPE	GEAR
HORSEPOWER	0.5
CAPACITY	60 GPH
DRIVE	CONSTANT SPEED

MEMBRANE CIP PUMPS (204MP041, 204MP030)

ITEM	DESIGN
NUMBER	2
TYPE	GEAR
HORSEPOWER	2
CAPACITY	500 GPH, 1000 GPH
DRIVE	CONSTANT SPEED

PROCESS EQUIPMENT DESIGN CRITERIA

BLOWER BUILDING/ELECTRICAL BUILDING (AREA 205)

MEMBRANE FACILITY AIR SUPPLY

BLOWERS (205BLWR500, 205BLWR600, 205BLWR700)

ITEM	DESIGN
NUMBER	3
TYPE	MULTI-STAGE CENTRIFUGAL
CAPACITY	1,500 SCFM @ 100° F
HORSEPOWER	60
DRIVE	CONSTANT SPEED

AIR COMPRESSORS (205AC160, 205AC260)

ITEM	DESIGN
NUMBER	2
TYPE	ROTARY SCREW
CAPACITY	64 CFM @ 125 PSI
HORSEPOWER	15
DRIVE	CONSTANT SPEED

AERATION BASINS AND INTERCHANGE REACTOR TANKS AIR SUPPLY

BLOWERS (205BLWR100, 205BLWR200, 205BLWR300, 205BLWR400)

ITEM	DESIGN
NUMBER	4
TYPE	MULTI-STAGE CENTRIFUGAL
CAPACITY	2,100 SCFM @ 100° F
HORSEPOWER	150
DRIVE	CONSTANT SPEED

DEWATERING FACILITY (AREA 206)

CENTRIFUGE (206CENT025)

ITEM		DESIGN
NUMBER		1
TYPE		HIGH SOLIDS DEWATERING
HORSEPOWER (MAX)		
MAIN DRIVE		75
BACK DRIVE		20
CAPACITY	AVERAGE	75 GPM
	MAXIMUM	100 GPM
DRIVE		VARIABLE

POLYMER BLENDING UNIT (206PBU035)

ITEM	DESIGN
NUMBER	1
TYPE	MECHANICAL
HORSEPOWER	1.5
CAPACITY (MAXIMUM)	15.2 LBS/HOUR

ROTARY DRUM SCREEN (206RDS001)

ITEM	DESIGN
NUMBER	1
LENGTH (APPROX)	164 INCHES
WIDTH (APPROX)	95 INCHES
HORSEPOWER	1.5
CAPACITY	1825 GPM

WASHER/COMPACTOR (206COMP002)

ITEM	DESIGN
NUMBER	1
TYPE	HORIZONTAL
HORSEPOWER	5
CAPACITY	88 CU FT/HR

CYCLONE FEED PUMP (206CFP005)

ITEM	DESIGN
NUMBER	1
TYPE	PROGRESSIVE CAVITY
HORSEPOWER	5
CAPACITY	64 GPM @ 30 PSI
DRIVE	VARIABLE

CYCLONE MANIFOLD (206M003)

ITEM	DESIGN
NUMBER OF CYCLONES	4
TYPE	RADIAL MANIFOLD SYSTEM
CAPACITY	64 GPM

SURGE TANK

ITEM	DESIGN
NUMBER	1
LENGTH (APPROX)	9.5 FEET
WIDTH (APPROX)	6.5 FEET
HEIGHT (APPROX)	3.0 FEET

GRIT CLASSIFIER (206M004)

ITEM	DESIGN
NUMBER	1
TYPE	GRIT SEPARATOR
CAPACITY	4 GPM
HORSEPOWER	1

SCREW CONVEYOR (206SCCV030)

ITEM	DESIGN
NUMBER	1
TYPE	SHAFTLESS SCREW
LENGTH (APPROX)	20.5 FT
HORSEPOWER (MAX)	7.5
CAPACITY	105 CU FT/HR

PROCESS EQUIPMENT DESIGN CRITERIA

INTERCHANGE REACTOR TANKS (AREA 207)

TANKS

ITEM	DESIGN
NUMBER OF TANKS	2
LENGTH	46 FEET
WIDTH	35 FEET
BASIN DEPTH	20 FEET
SIDEWATER DEPTH	18 FEET
TOTAL CAPACITY	216,800 GALLONS

DECANTER (207DEC103, 207DEC203)

ITEM	DESIGN
NUMBER	2
TYPE	FLOATING
CAPACITY	200-500 GPM

DECANTER PUMPS (207DECP110, 207DECP210)

ITEM	DESIGN
NUMBER	2
TYPE	ROTARY LOBE
HORSEPOWER	7.5
CAPACITY	250 GPM @ 1-10 FT
DRIVE	VARIABLE

MIXERS (207MXR100, 207MXR200)

ITEM	DESIGN
NUMBER	2
TYPE	PROPELLER
HORSEPOWER	10
DRIVE	CONSTANT SPEED

SLUDGE FEED PUMP (207SFP020)

ITEM	DESIGN
NUMBER	1
TYPE	PROGRESSIVE CAVITY
HORSEPOWER (MAX)	20
CAPACITY (MAX)	150 GPM @ 20 PSI
DRIVE	VARIABLE

UV DISINFECTION (AREA 208)

CHANNEL

ITEM	DESIGN
NUMBER	1
LENGTH	50 FEET
WIDTH	32 INCHES
DEPTH	52 INCHES

BANKS

ITEM	DESIGN
NUMBER	3
MODULES PER BANK	8
LAMPS PER MODULE	8
LAMP TYPE	LOW PRESSURE, HIGH INTENSITY
LAMP CONFIGURATION	PARALLEL

RECLAIMED WATER/NPW PUMPING STATION (AREA 209)

NON-POTABLE WATER PUMP (209NPWP101, 209NPWP201)

ITEM	DESIGN
NUMBER	2
TYPE	VERTICAL TURBINE
HORSEPOWER	25
CAPACITY	300 GPM @ 200 FT
DRIVE	CONSTANT SPEED

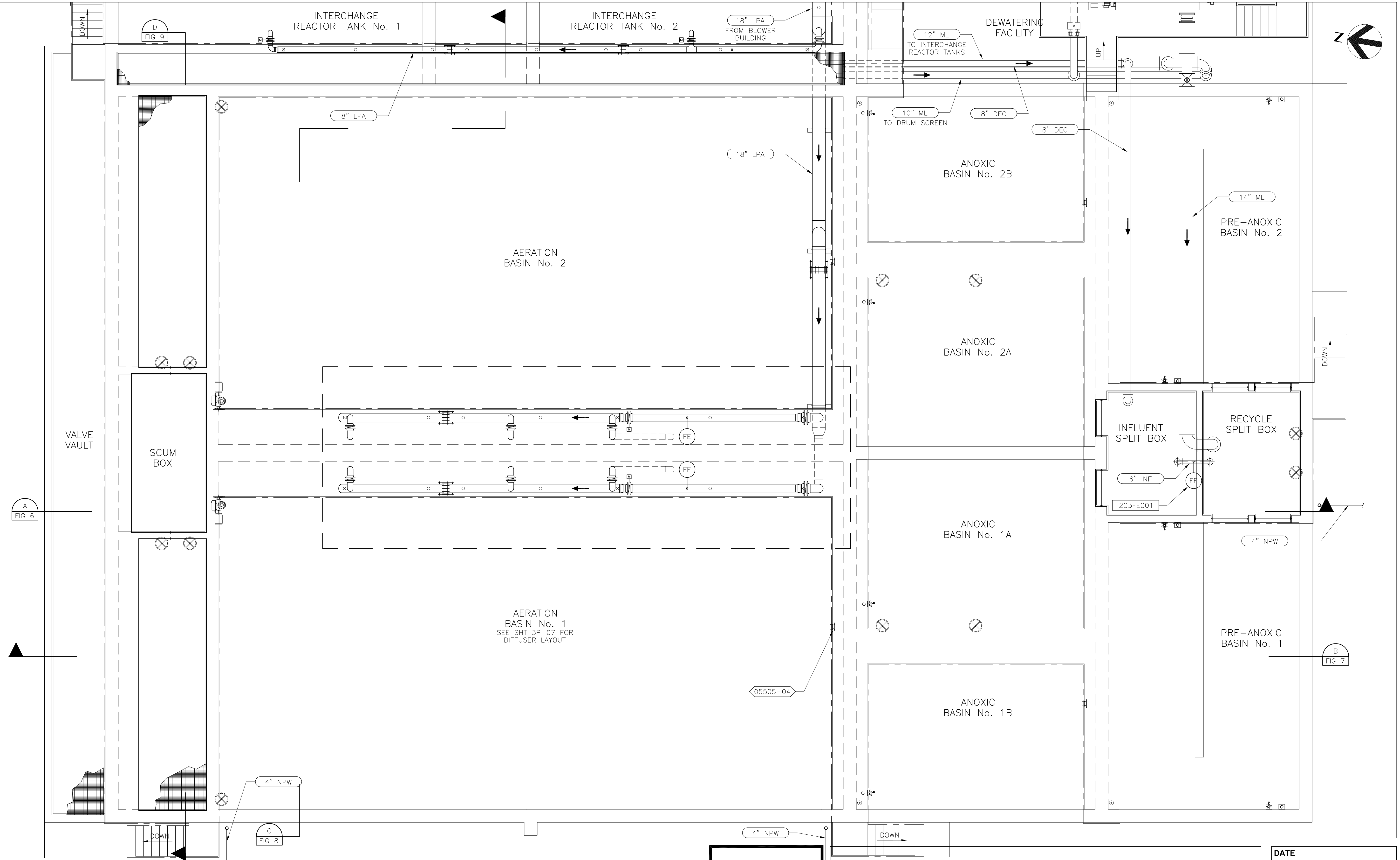
INFLUENT WASTEWATER FLOWS

AVERAGE DAY	1.6 MGD
PEAK HOUR	4.0 MGD

HDR

CITY OF HEALDSBURG, CA
WASTEWATER TREATMENT PLANT
DESIGN CRITERIA

DATE	SEPT 2009
FIGURE	FIGURE 3

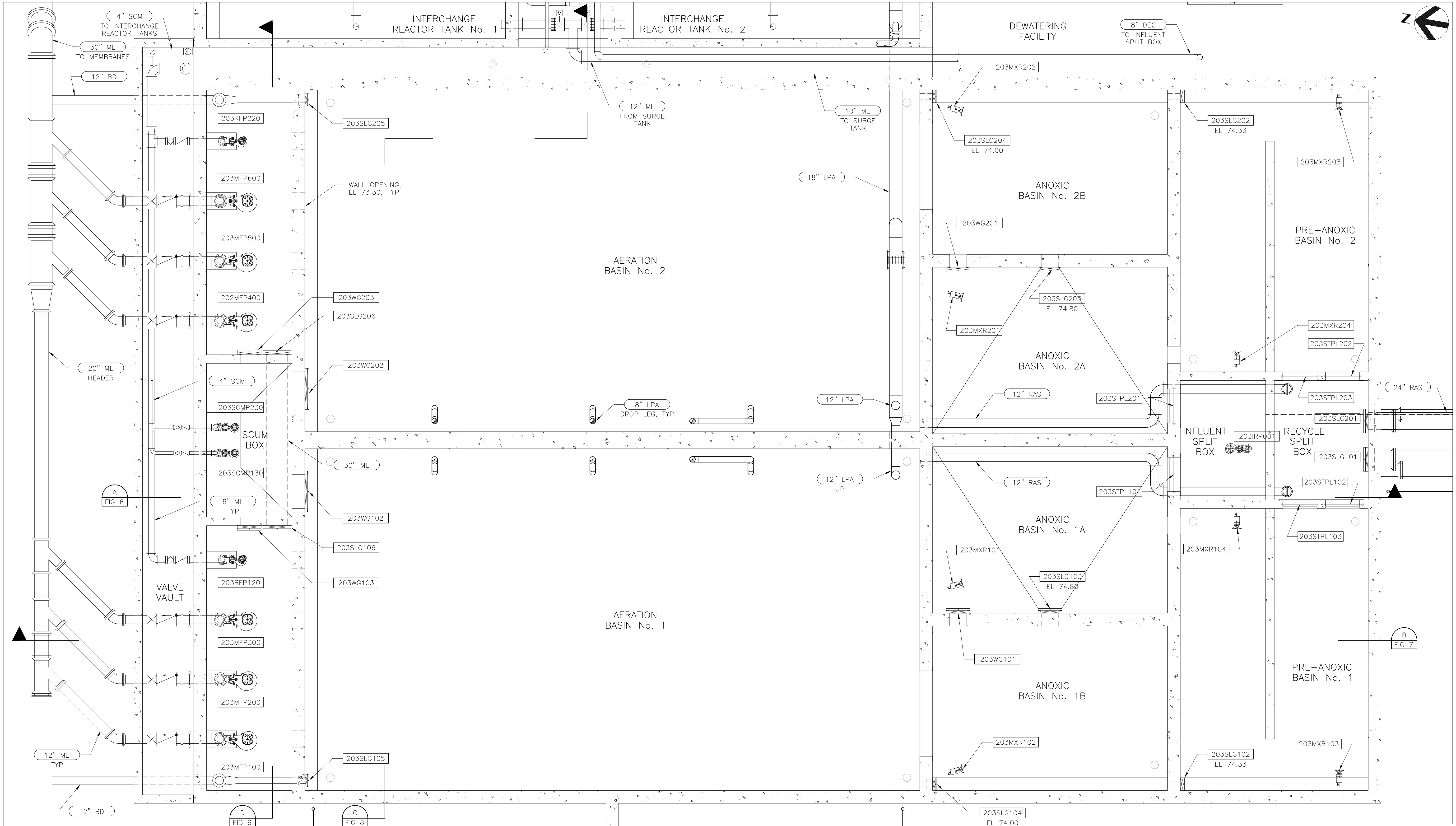


HDR

CITY OF HEALDSBURG, CA
WASTEWATER TREATMENT PLANT
BIOLOGICAL FACILITY DECK PLAN

DATE SEPT 2009

FIGURE FIGURE 4

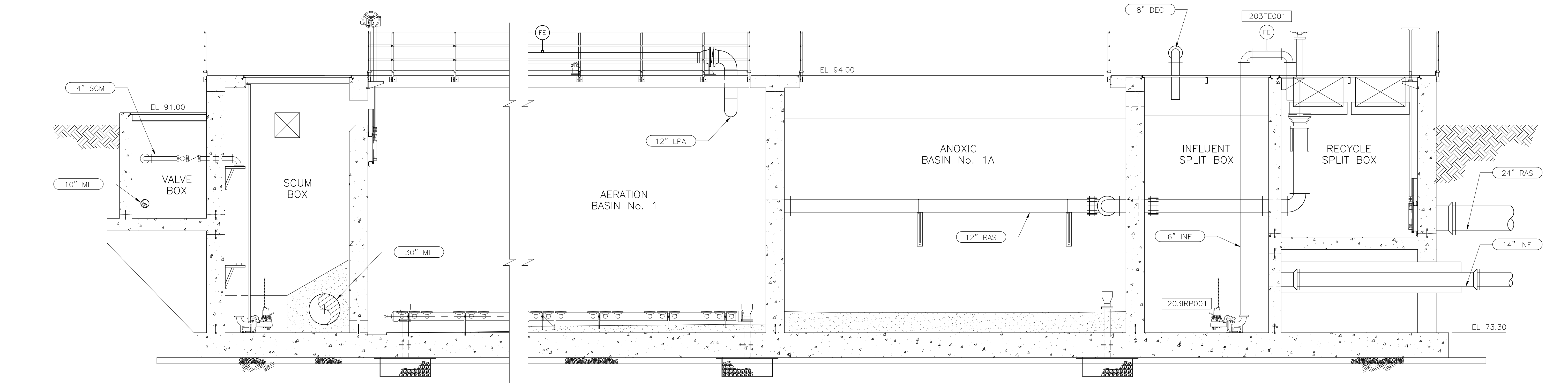


HDR

CITY OF HEALDSBURG, CA
WASTEWATER TREATMENT PLANT
BIOLOGICAL FACILITY LOWER PLAN

DATE
SEPT 2009

FIGURE
FIGURE 5



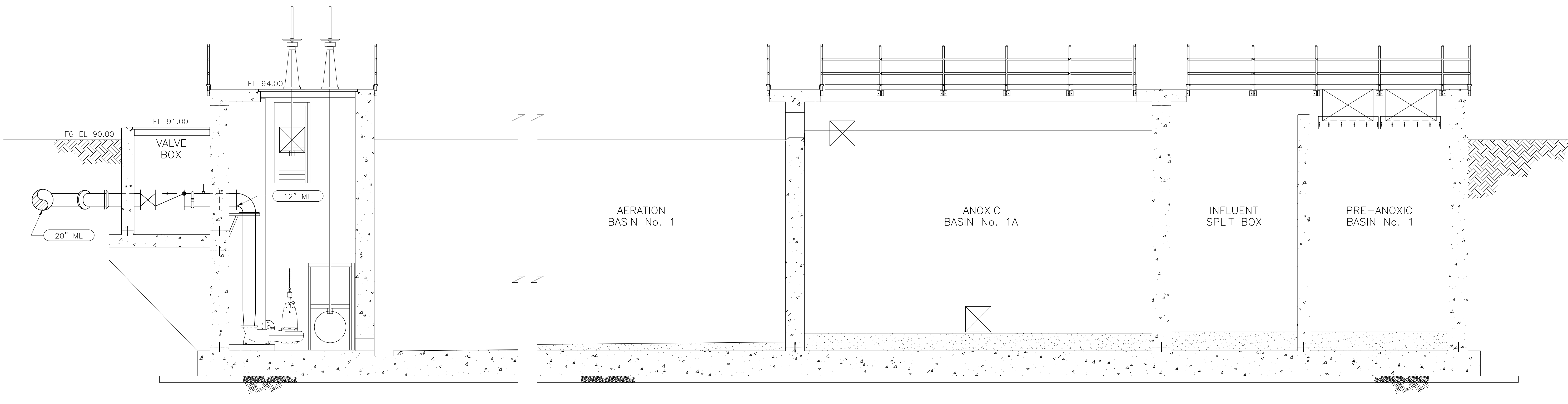
SECTION
1/4" = 1'-0"
A
FIG 5

HDR

CITY OF HEALDSBURG, CA
WASTEWATER TREATMENT PLANT
BIOLOGICAL FACILITY SECTION 1

DATE
SEPT 2009

FIGURE
FIGURE 6

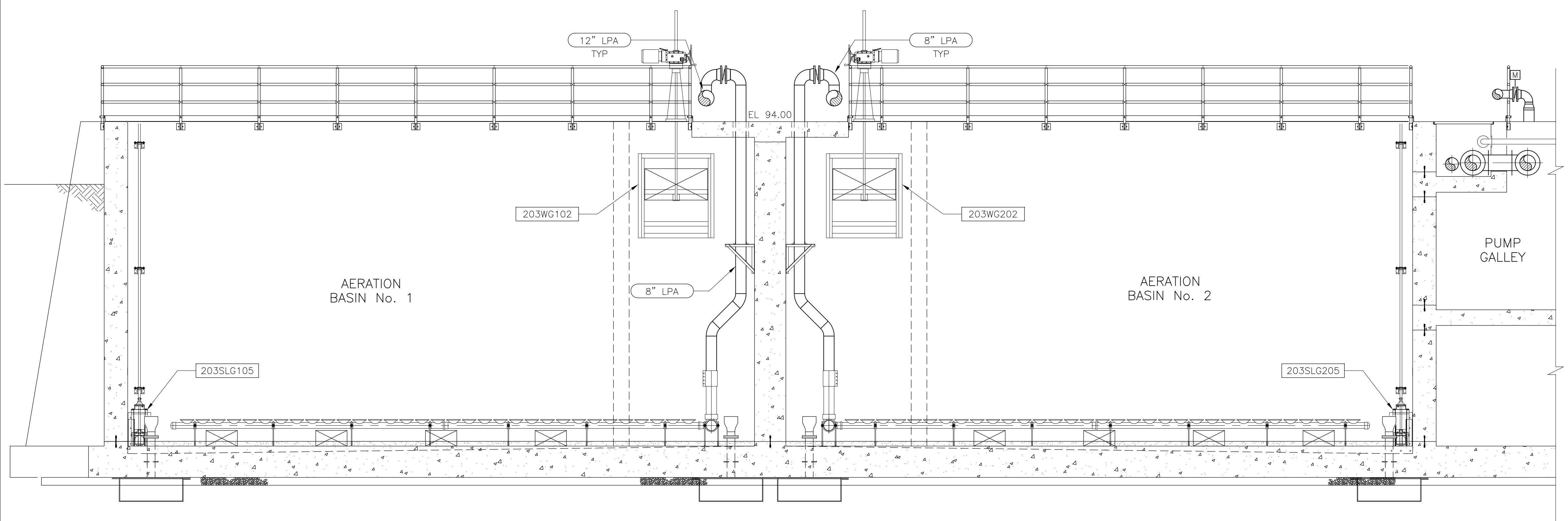


SECTION
1/4" = 1'-0"
B
FIG 5

HDR

CITY OF HEALDSBURG, CA
WASTEWATER TREATMENT PLANT
BIOLOGICAL FACILITY SECTION 2

DATE	SEPT 2009
FIGURE	FIGURE 7

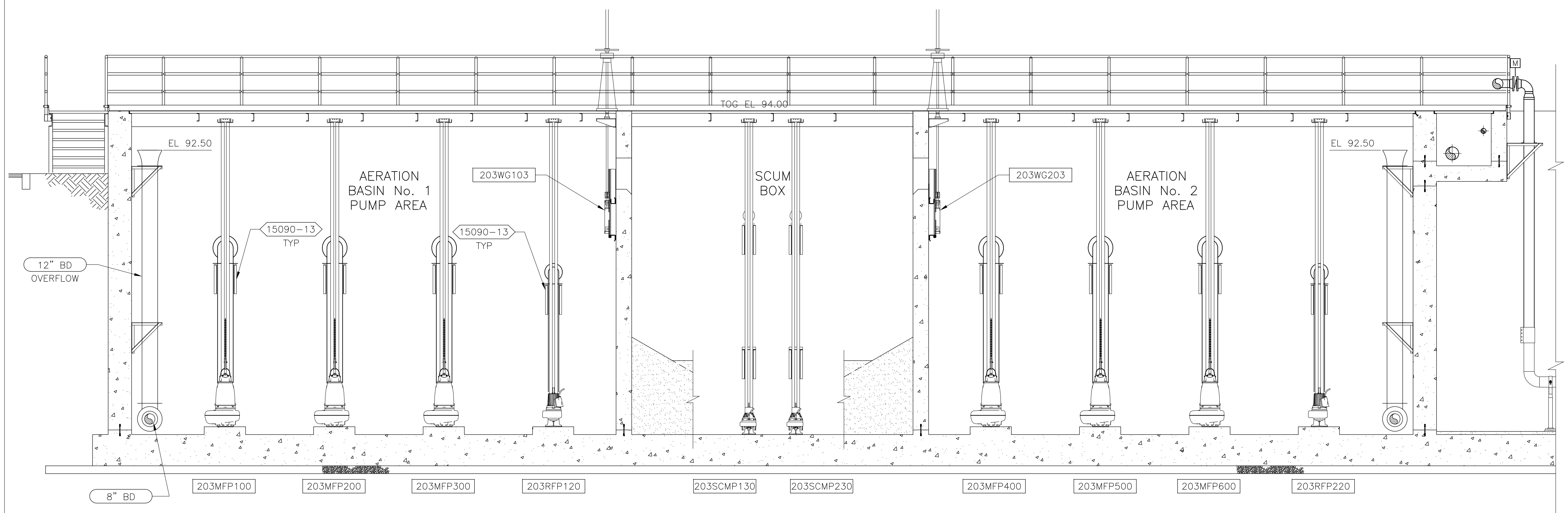


SECTION
1/4" = 1'-0"
C
FIG 5

HDR

CITY OF HEALDSBURG, CA
WASTEWATER TREATMENT PLANT
BIOLOGICAL FACILITY SECTION 3

DATE	SEPT 2009
FIGURE	FIGURE 8



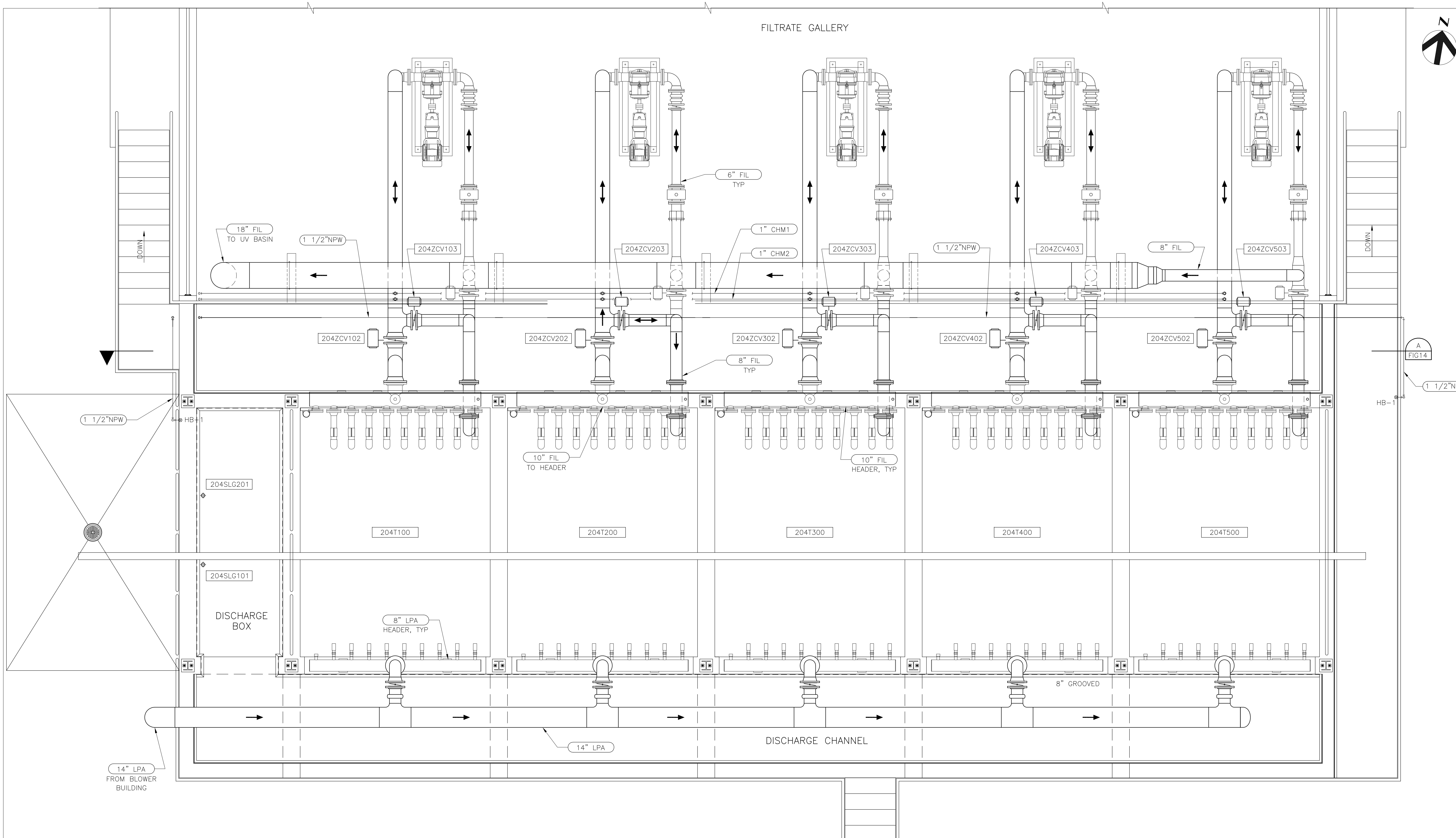
SECTION
1/4" = 1'-0"
D
FIG 5

HDR

CITY OF HEALDSBURG, CA
WASTEWATER TREATMENT PLANT
BIOLOGICAL FACILITY SECTION 4

DATE
SEPT 2009

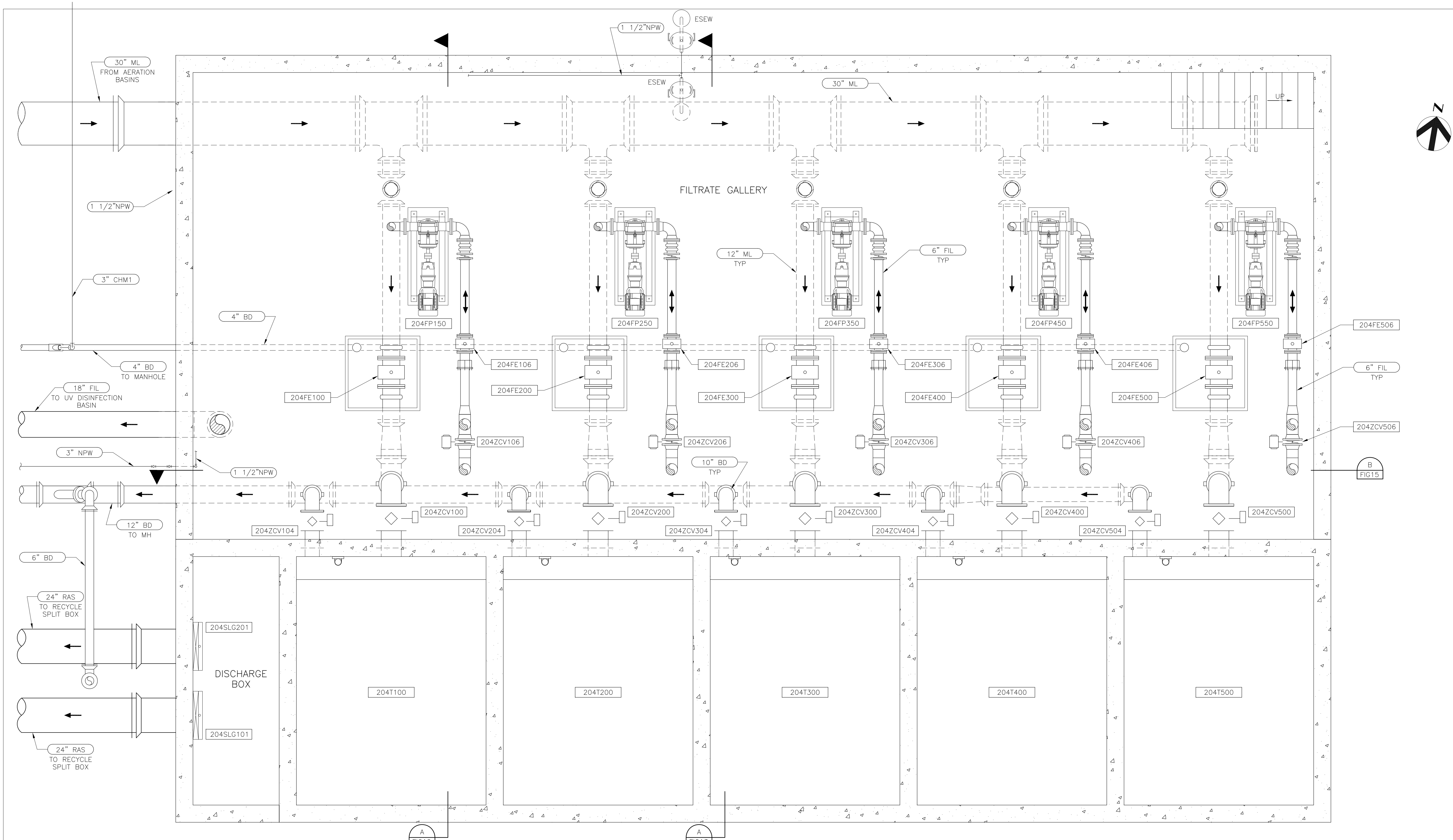
FIGURE
FIGURE 9



CITY OF HEALDSBURG, CA
WASTEWATER TREATMENT PLANT
MEMBRANE FACILITY DECK PLAN

DATE
SEPT 2009

FIGURE
FIGURE 10

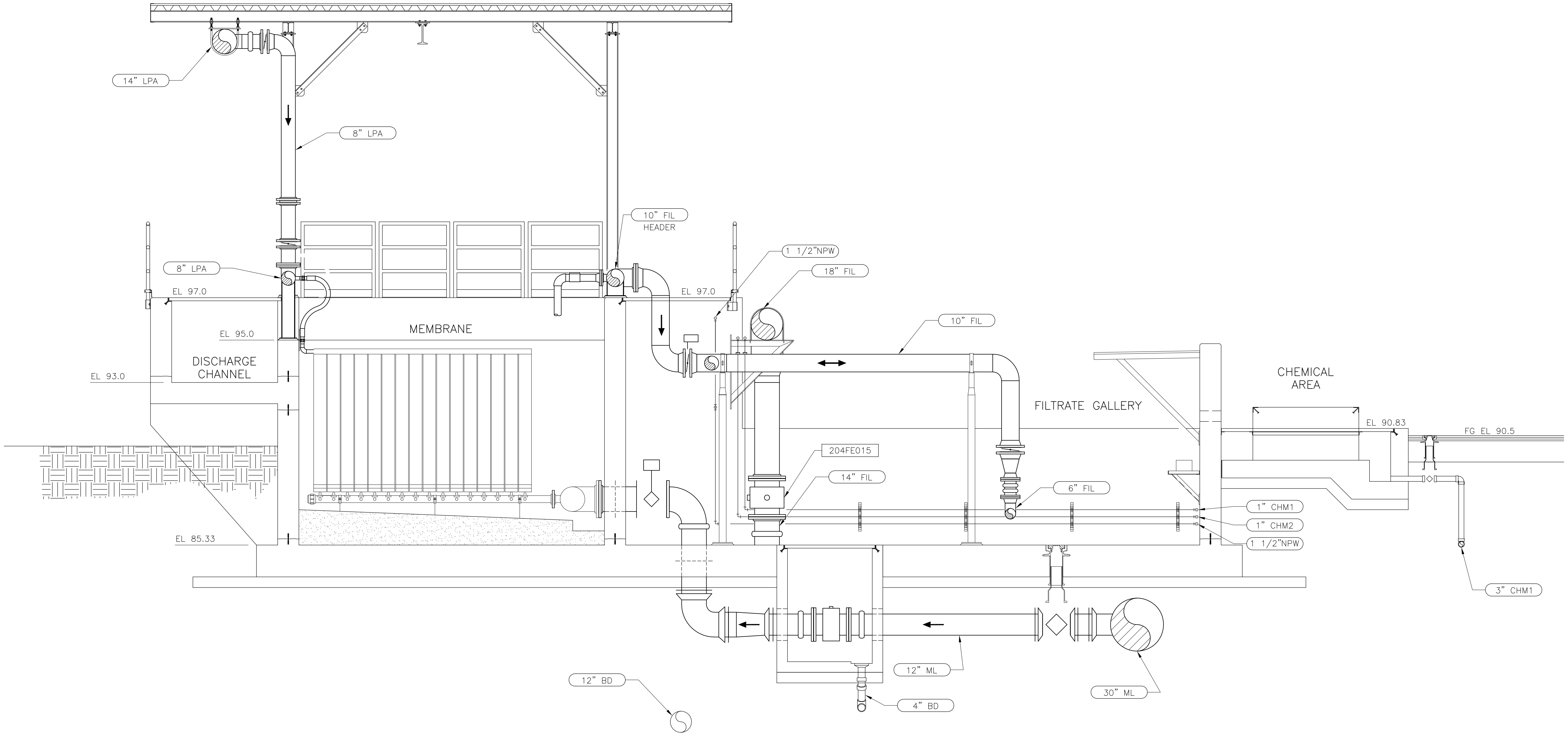


HDR

CITY OF HEALDSBURG, CA
WASTEWATER TREATMENT PLANT
MEMBRANE FACILITY LOWER PLAN

DATE
SEPT 2009

FIGURE
FIGURE 11



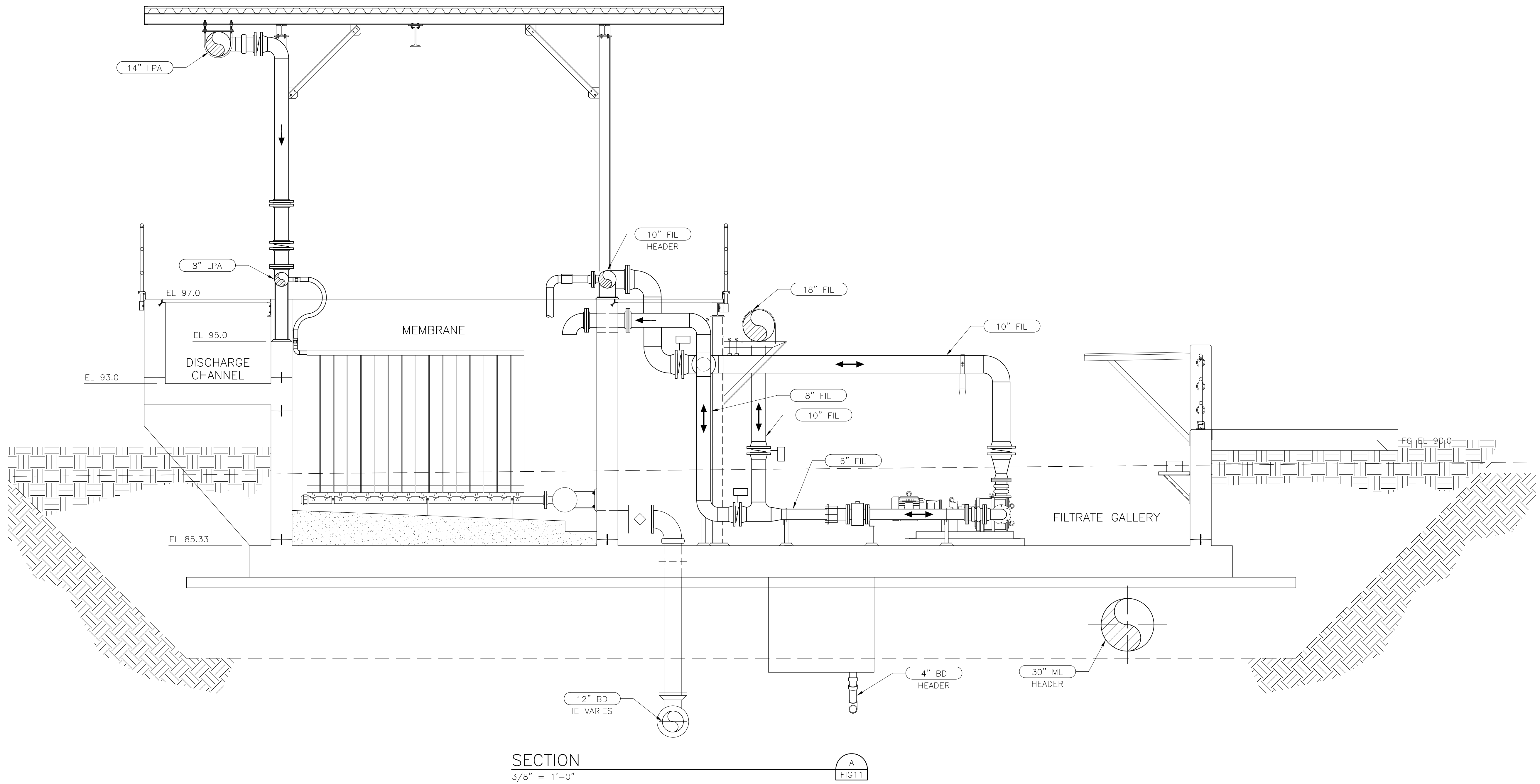
SECTION
3/8" = 1'-0"
A
FIG11

HDR

CITY OF HEALDSBURG, CA
WASTEWATER TREATMENT PLANT
MEMBRANE FACILITY SECTION 1

DATE
SEPT 2009

FIGURE
FIGURE 12

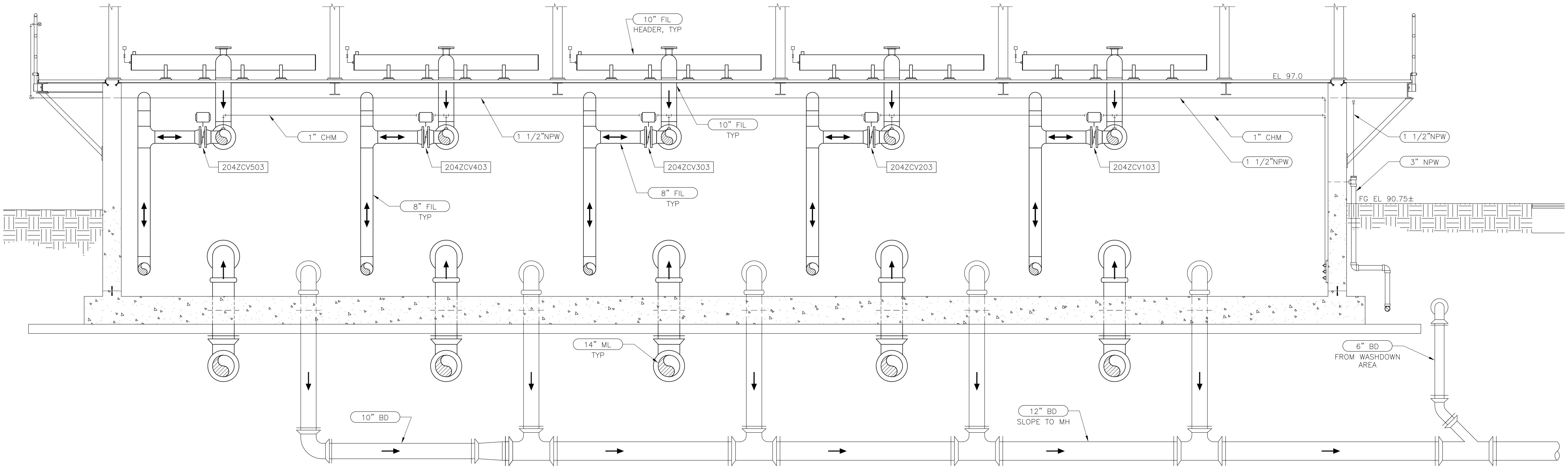


HDR

CITY OF HEALDSBURG, CA
WASTEWATER TREATMENT PLANT
MEMBRANE FACILITY SECTION 2

DATE
SEPT 2009

FIGURE
FIGURE 13



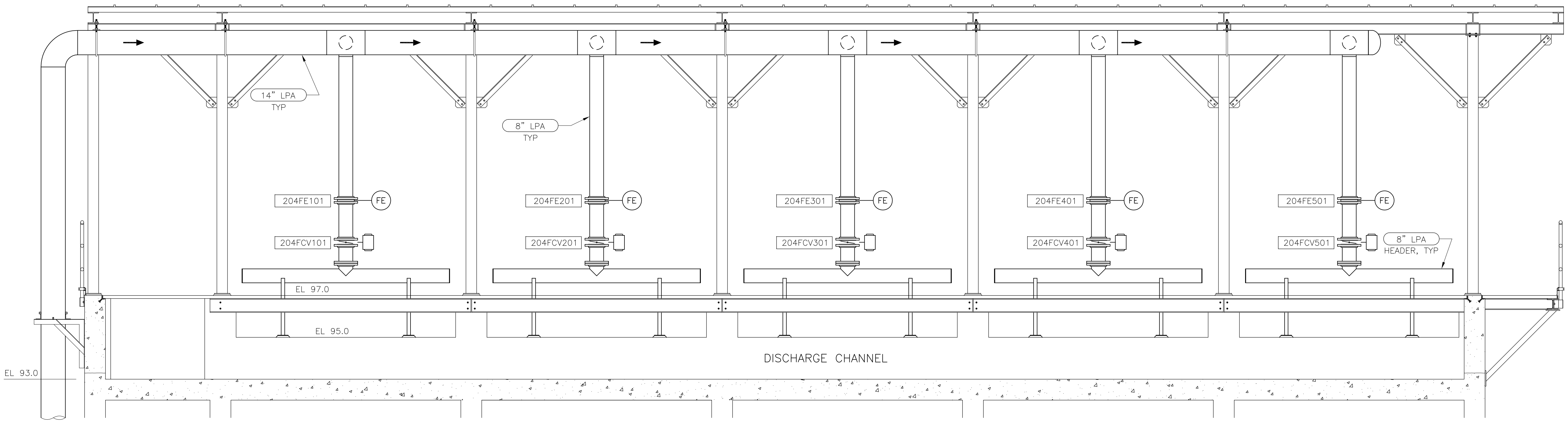
SECTION
3/8" = 1'-0"

A
FIG10

HDR

CITY OF HEALDSBURG, CA
WASTEWATER TREATMENT PLANT
MEMBRANE FACILITY SECTION 3

DATE	SEPT 2009
FIGURE	FIGURE 14

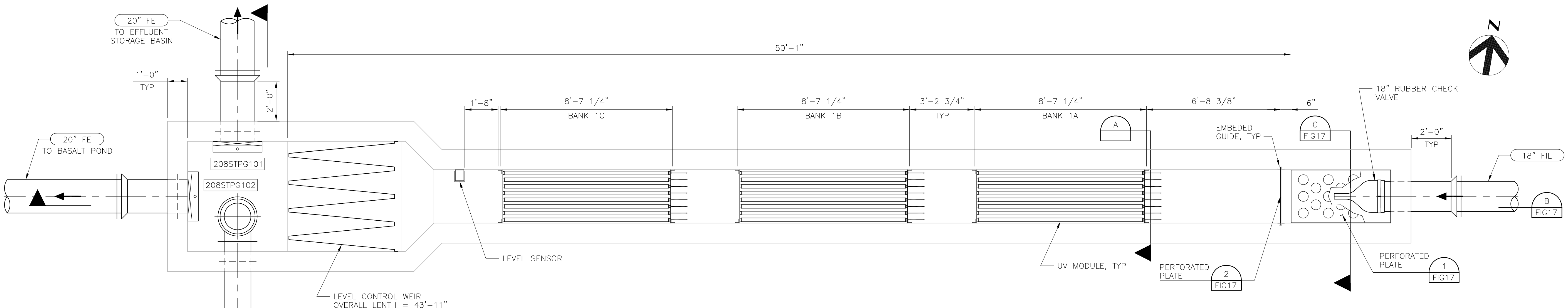


SECTION
3/8" = 1'-0"
B
FIG11

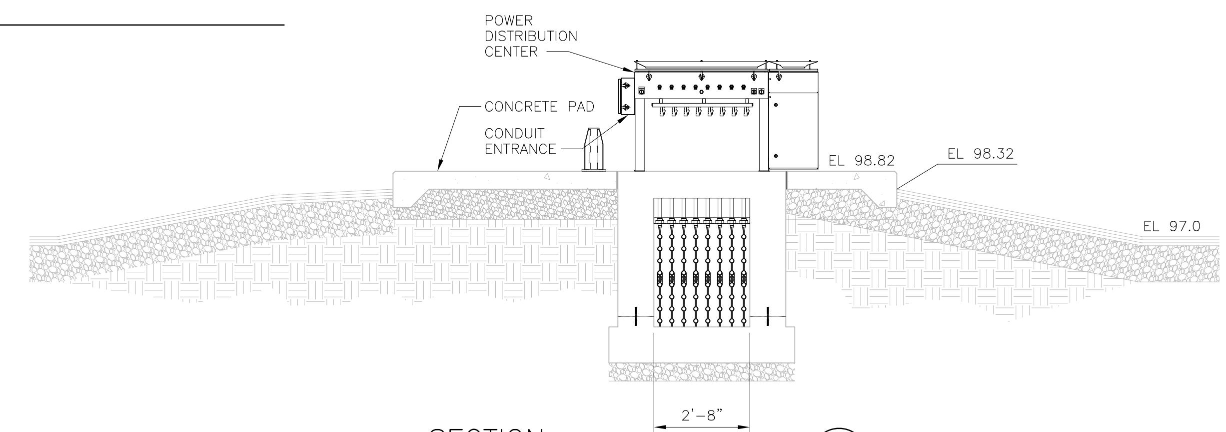
HDR

CITY OF HEALDSBURG, CA
WASTEWATER TREATMENT PLANT
MEMBRANE FACILITY SECTION 4

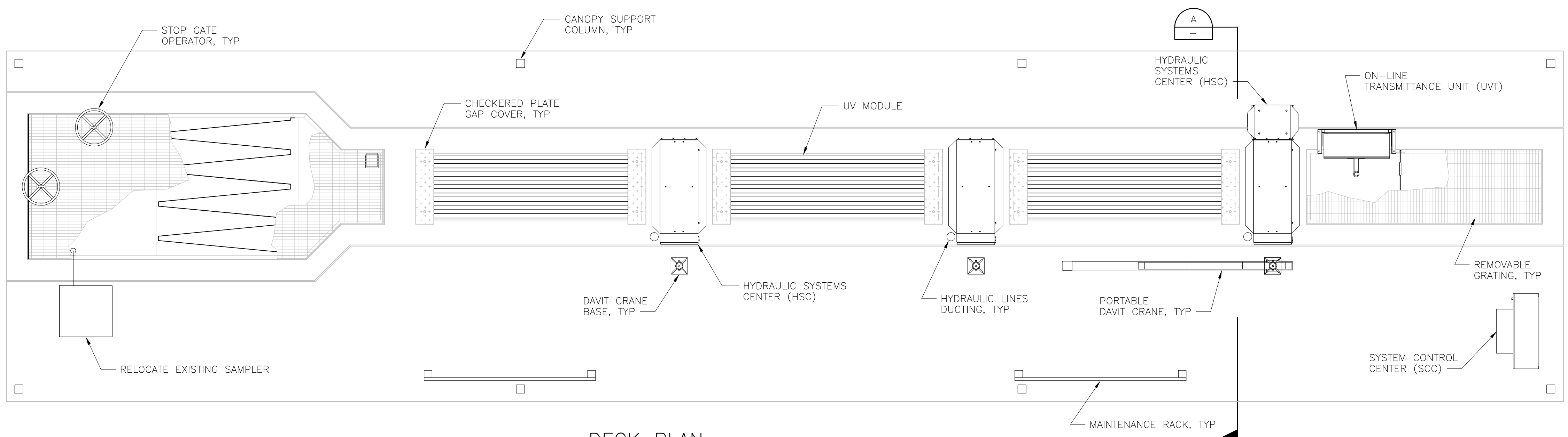
DATE	SEPT 2009
FIGURE	FIGURE 15



SECTIONAL PLAN



SECTION A



DECK PLAN

HDR

CITY OF HEALDSBURG, CA
WASTEWATER TREATMENT PLANT
DISINFECTION BASIN
PLANS AND SECTION

DATE	SEPT 2009
FIGURE	FIGURE 16

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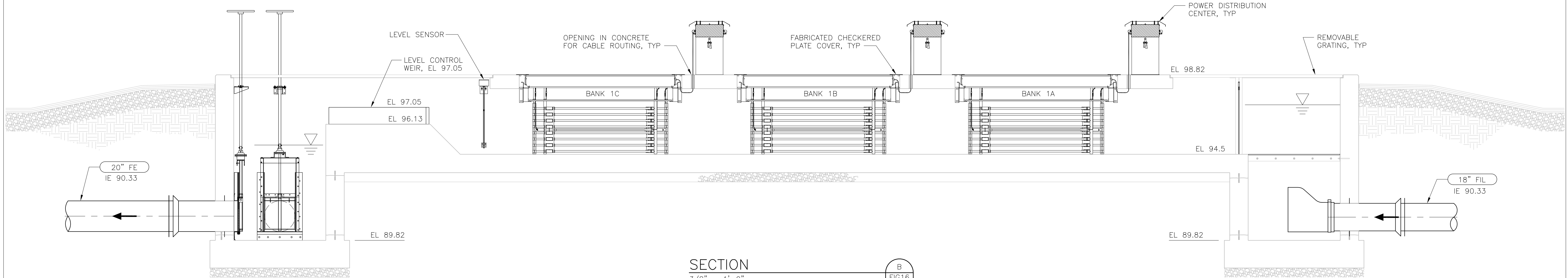
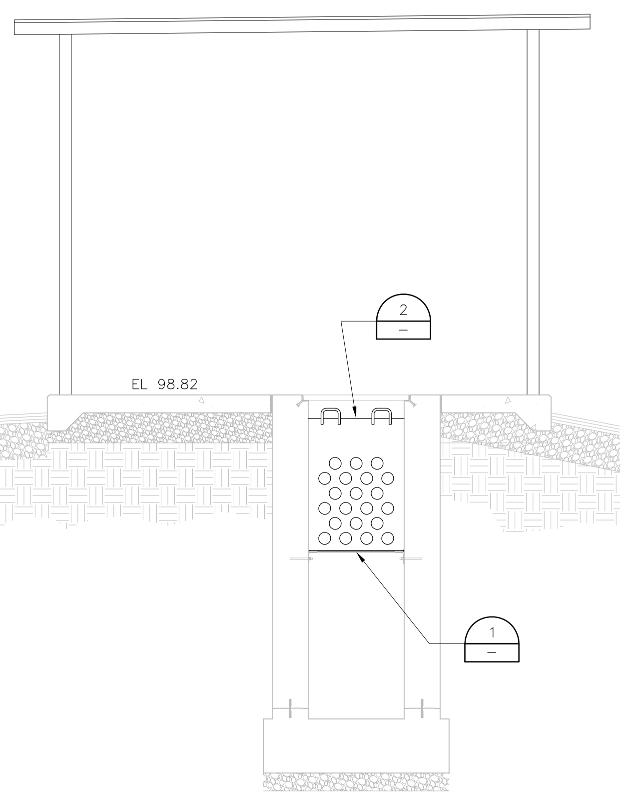
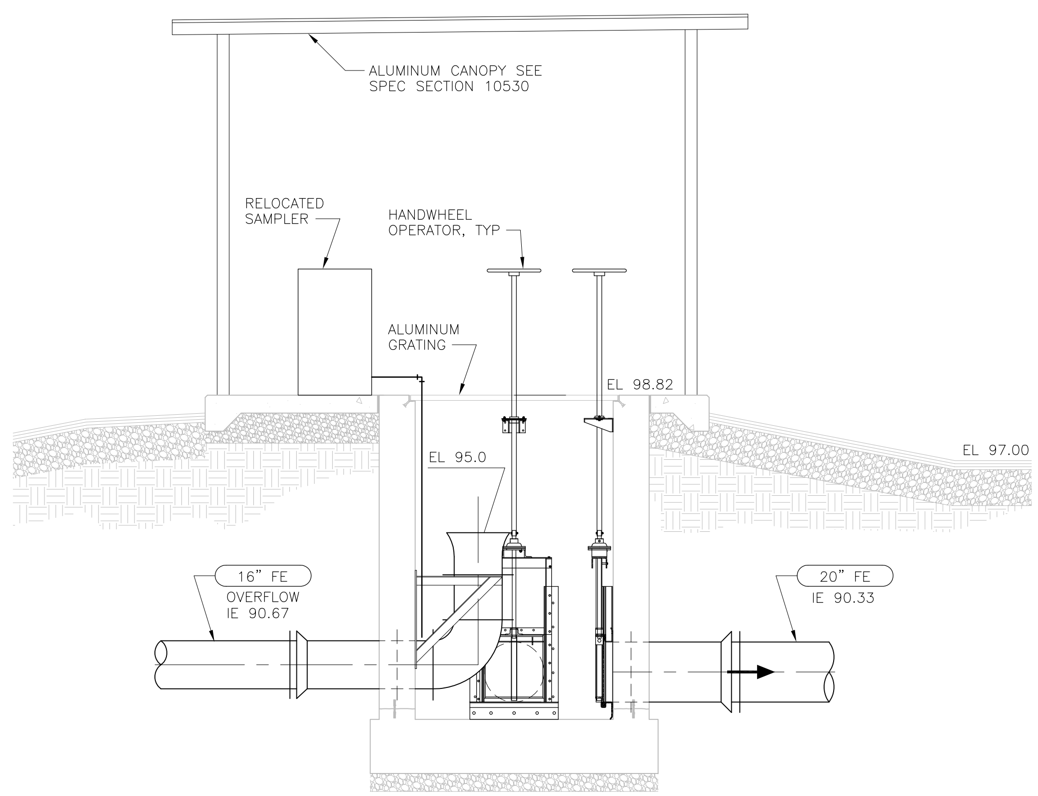


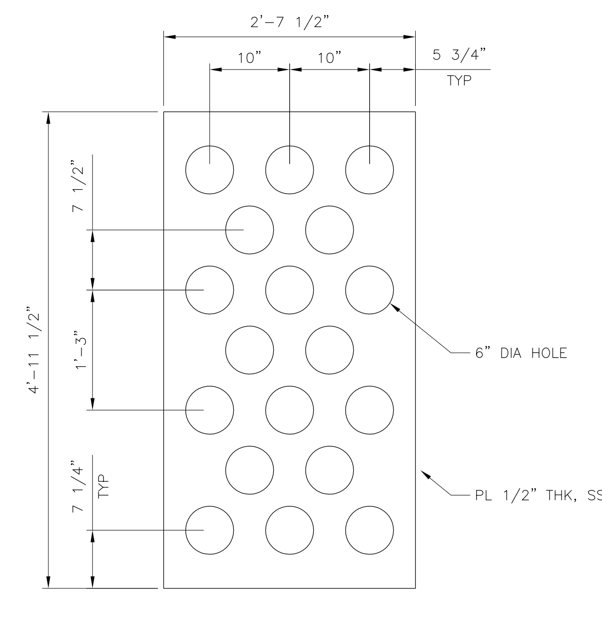
SECTION B FIG16
3/8" = 1'-0"



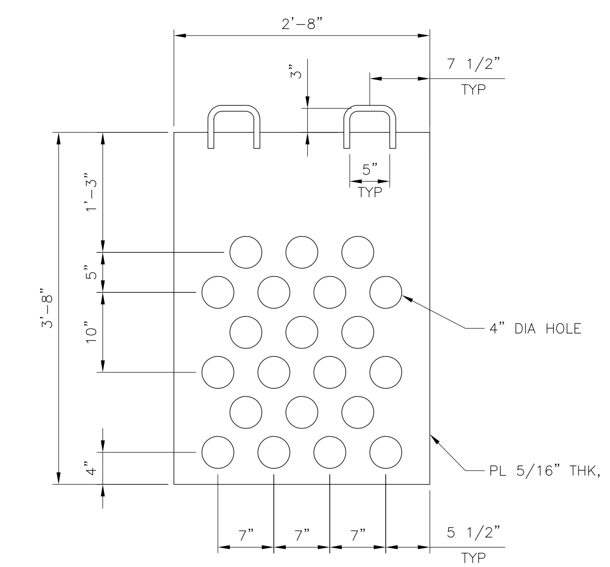
SECTION C FIG16
3/8" = 1-0"



SECTION D FIG16
3/8" = 1'-0"



SECTION 1 FIG16
1" = 1'-0"



SECTION 2 FIG16
1" = 1'-0"

HDR

CITY OF HEALDSBURG, CA
WASTEWATER TREATMENT PLANT
DISINFECTION BASIN
SECTIONS AND DETAILS

DATE	SEPT 2009
FIGURE	FIGURE 17

SECTION 3. TRANSMISSION AND DISTRIBUTION SYSTEMS

The computer model software EPANET was used in the preliminary design of the Recycled Water transmission and distribution systems. EPANET is a Windows based program that performs steady state and extended period simulation of hydraulic and water-quality behavior within pressurized pipe networks. The water distribution system is represented in the model as a network of nodes and node-connecting elements. Junction nodes represent specific points in the water distribution system such as pipe intersections, pipe ends, and turnouts. Boundary nodes represent points in the water system that define specific hydraulic grades, such as storage tanks. Node-connecting elements or links represent various system components that affect the flow rates and energy losses throughout the system. Examples of links are pipes.

EPANET was developed by the Water Supply and Water Resources Division (formerly the Drinking Water Research Division) of the U.S. Environmental Protection Agency's National Risk Management Research Laboratory. It is public domain software that may be freely copied and distributed among users.

3.1 Hydraulic Model Element Naming Scheme

Models are built with specific element names representing key hydraulic facilities because this naming convention allows the modeler to easily locate specific elements. As each facility is created in the model, pipes, nodes, pumps, tanks, and valves must be named logically and sequentially. Table 3-1 summarizes the hydraulic element functions.

Table 3-1. Hydraulic Network Elements

TYPE	DESCRIPTION	PREFIX
Junction	Removes (demand) or adds (inflow) water from/to the system	J
Node	Represents transition in pipeline characteristic or point where pressure or water quality is monitored	N
Tank	Represents storage capacity	T
Reservoir	Represents an infinite external source	R
Pump	Raises the hydraulic grade to overcome elevation differences and friction losses	PMP
Control Valve	Controls flow or pressure in the system based on specified criteria	PRV/FCV
Pipeline	Conveys water from one node to another	P

Table 3-2 shows the naming scheme used in the hydraulic model. This scheme is based on the hydraulic element prefix and the pressure zone.

Table 3-2. Naming Scheme for Hydraulic Network Elements

MODEL ELEMENT	NAMING SCHEME
Pipelines	"1" = Sequential Number P-1-1 "1" = Pressure Zone 1 "P" = Pipeline
Junctions	"115" = Sequential Number J-1-115 "1" = Pressure Zone 1 "J" = Junction
Nodes	"115" = Sequential Number N-1-115 "1" = Pressure Zone 1 "N" = Node
Tanks	"T1" = Tank ID at Site T-1-T1 "1" = Pressure Zone 1 "T" = Tank
Booster Pumps	"A" = Booster Pump ID PMP-1-A "1" = Pressure Zone 1 "PMP" = Pump
Control Valves	"1" = Sequential Number PRV-1-1 "1" = Pressure Zone 1 "PRV" = Pressure Reducing Valve

3.2 Modeling Assumptions and Criteria

Establishing computer modeling assumptions and criteria is critical for creating, calibrating, verifying, and running the model, and interpreting the results of the simulations. The assumptions and criteria used for the City's Recycled Water distribution system hydraulic model include:

- Allowable pipe sizes were limited to 8, 12, and 16 inches in diameter. By limiting the number of distribution system pipe sizes, the City can stock a limited number of sizes.
- Agricultural areas irrigate over an 8-hour period from 6:00 a.m. to 2:00 p.m. and urban areas irrigate over an 8-hour period from 10:00 p.m. to 6:00 a.m.
- Information on pipe length was determined by importing a scaled image of Exhibit 2-8 from the Draft EIR and tracing pipeline alignments in EPANET. Pipe length accuracy was assumed to be ±25 feet.
- Pipe diameters and pressures were based on desirable pipe velocity and junction pressure; and available pipe sizes (8, 12, or 16-inch).
- PVC was the assumed pipe material, and a C-factor of 130 was used in the model.
- Ground surface elevations outside the City limits were estimated using the United States Geological Survey quadrangle map with an estimated accuracy of five feet. Surface elevations inside the City limits were estimated using available digital topographic maps provided by the City with an estimated accuracy of one foot.
- The water demands in the model were expressed in gallons per minute (gpm).

The following distribution system evaluation criteria were used to select pipe diameters under the maximum day demand and peak hour demand conditions. These criteria define the desired level of service and were used to aid in the design of the system.

Maximum pipe velocities were limited to be about five feet per second (fps) or less; making allowances for any unanticipated factors. Greater pipe velocities are acceptable but should not exceed ten fps because of undesirable friction losses and pumping costs. Pipe velocities below four fps can allow any potential sediment to collect on the pipeline bottom; however, because the supply for the Recycled Water system is tertiary treated water, sediment should not be a problem and pipe velocities below four fps are acceptable. Lower initial velocities and friction losses also allow for future expansion.

Typically, most water pressure is lost as water is conveyed through small diameter pipes, water meters, etc. from the distribution system to the final point of use. Since the recommended pressure requirements for irrigation systems typically range from 30-60 psi (depending on irrigation method), pressures will likely need to be increased at some of the use areas. Individual sites should be evaluated to determine pumping requirements as a function of site topography and other factors.

3.3 Water Demands

The distribution system pipe sizes are based on the projected Recycled Water demands. Recycled Water demands were calculated by multiplying the acreage of the use area by the appropriate crop type unit water demand. Land use areas were obtained from the Wastewater Treatment Plant Upgrade Project Draft EIR. It is estimated that ultimately 89 acres of turf and 1,261 acres of vineyard will be irrigated by the City. The historical crop water demand or evapotranspiration (ET) was determined from the decommissioned California Irrigation Management Information System (CIMIS) station located northeast of the City. The Healdsburg CIMIS station was in operation from August 1986 through March 1994 and used grass as the ET reference crop. Water consumed by irrigated turf in the City should be similar to the reference ET at the Healdsburg CIMIS station.

Turf

The ET for various Sonoma County CIMIS stations is shown in Table 3-3. The ET varies by microclimate and the Healdsburg CIMIS ET is slightly higher than ETs at other stations in Sonoma County. Turf would consume about 51 inches or 4.2 acre-feet (af) supplied from precipitation and irrigation. Since turf irrigation generally occurs from May through October, the amount of water applied by an irrigation system is about 36 inches per acre (ac) or 3 af/ac for the year based on summation of the data in Table 3-3.

Table 3-3. Average Monthly Evapotranspiration, inches

NAME	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
Healdsburg	1.27	1.85	3.26	4.70	5.94	6.99	7.77	6.80	5.21	3.53	1.97	1.22	50.51
Santa Rosa	0.82	1.44	2.87	4.31	5.26	6.14	6.30	5.76	4.25	3.10	1.38	0.86	42.49
Windsor	0.88	1.55	2.99	4.53	5.46	6.47	6.53	5.87	4.36	3.24	1.37	0.96	44.21
Petaluma East	0.98	1.65	2.81	4.25	5.61	6.26	6.47	5.86	4.49	3.05	1.54	0.98	43.95
Bennett Valley	0.82	1.44	2.87	4.31	5.26	6.14	6.30	5.76	4.25	3.10	1.38	0.86	42.49
Valley of the Moon	0.97	1.59	3.02	4.52	5.62	6.60	7.06	6.31	4.69	3.28	1.49	0.98	46.13

The maximum month ET occurs in July at 7.77 inches or 0.65 acre feet per acre. Assuming this volume is spread over the entire month, the maximum day application rate is 4.75 gpm/ac. Assuming most turf areas are irrigated over an 8-hour period from 10:00 p.m. to 6:00 a.m., a peak hour factor of 3 would be applied to the maximum day demand. The peak hour demand for the turf areas as a whole is 14.2 gpm/ac. Table 3-4 summarizes the turf and vineyard unit water demands.

Landscape irrigation water meter records from schools and parks were used to verify the turf ET assumptions. Meter records indicate the maximum month demand generally occurs in July or August. Maximum month application rates for turf were between 0.37 af/ac to 0.87 af/ac with an average of 0.59 af/ac. Therefore, the 0.65 af/ac maximum month demand based on ET appears reasonable and is used in the turf demand calculations.

Vineyards

Vineyards consume significantly less water than turf due to the plant type as well as managerial practices. According to local grape growers, the annual volume of water applied to vineyards is between 90 and 120 gallons per vine per year or 2.7 and 3.5 inches per acre per year at a vine density of 800 vines per acre. The start of the irrigation season depends on weather but is generally between April and June and ends in September. For planning purposes, the vineyard irrigation season is assumed to be from May through September. Irrigation scheduling is discussed in greater detail in Section 4 of this report.

Table 3-4. Unit Water Demand Summary

	TURF	VINEYARD
Average Annual Applied Water af/ac	3.02	0.33
Maximum Month (July), af/ac	0.65	0.10
Maximum Day Demand, gpm/ac	4.73	0.72
Peak Hour Factor	3	3
Peak Hour Demand, gpm/ac	14.2	2.2

The monthly demand curve for vineyards would be similar to turf with the peak demand occurring in July. Based on previous discussions with agricultural experts regarding vineyard demand patterns and rounding up the annual demand to 4.0 inches per acre (about 0.33 af/ac), it is anticipated that vineyard managers will apply about 1.2 inches of water in July or 0.10 af/ac. The maximum day demand would be about 0.72 gpm/ac. To ensure the pipeline is adequately sized, it is assumed the growers would apply this volume over an 8-hour period between 6:00 a.m. to 2:00 p.m. resulting in a peak hour factor of 3.0. The peak hour demand for vineyards would be about 2.2 gpm/ac.

The 2007 Title 22 Report calculated all of the total water demands by multiplying the unit water demand in Table 3-4 by the irrigated area of each land use type in the proposed service area. During final design of the system, selected demands for several turf areas were revised when better information became available for specific sites. These included demands for Tayman Park Golf Course, Badger Park, and school turf areas. In addition, 214 acres of vineyard property owned by Syar Industries (area 8a on Table 3-6) was added. These were properties that had been acquired or newly planted by Syar since preparation of the 2007 Title 22 Report.

Other irrigation water demands were revised based on discussions with the City, Tayman Park Golf Course (TPGC) management staff, and meter records for the well that supplies the TPGC. The TPGC obtains irrigation water from Well No. 1 in Badger Park, and had estimated their maximum day water usage during the peak irrigation period at approximately 600,000 to 800,000 gpd. Water is pumped from the well to a storage tank at the golf course where it boosted by an on-site pump station to the various irrigation zones throughout the golf course.

To confirm this demand, the City correlated the pump power meter and flow meter data for the service that supplies the TPGC. A simple linear regression correlated the daily pump power usage with daily pumped irrigation water. This relationship, which proved to be a reliable indicator of metered water use, was then used to estimate the TPGC historical water usage based the extensive power usage history.

Table 3-5 summarizes the estimated historical water usage at the TPGC for the period of record (2003 – 2008) based on the linear regression analysis and power record for the Badger Park Well No. 1 pump. During this period, the TPGC averaged approximately 220,000 gallons per day (gpd) during the peak irrigation month, which is generally in July or August. This estimated daily demand is significantly less than the daily demand estimated by the TPGC management staff.

Table 3-5. *Tayman Park Golf Course Estimated Historical Water Usage*

YEAR	ANNUAL AVERAGE	MONTHLY AVERAGE	MAXIMUM MONTH	MAXIMUM MONTH	AVERAGE DAY MAX MONTH	PEAKING FACTOR	ESTIMATED PEAK HOUR DEMAND
	(MG)	(MG)	(MG)		(GPD)		(GPM)
2008	33.302	2.775	6.638	July	214,133	3.0	13,829
2007	27.188	2.266	5.521	August	178,089	3.0	11,502
2006	25.308	2.109	8.753	July	282,350	3.0	18,235
2005	22.160	1.847	4.790	August	154,506	3.0	9,978
2004	36.214	3.018	7.356	June	237,294	3.0	15,325
2003	33.305	2.775	7.892	July	254,572	3.0	16,441
Period of Record	29.580	2.465	8.753	July	282,350	3.0	18,235

Metered water use records from the City for 2007 and 2008 were used to confirm the estimated irrigation water demands from the 2007 Title 22 Report. These water records include both potable water (water not billed as irrigation) and water billed as irrigation. Facilities included Fitch Mountain School (FMS), Healdsburg High School (HHS), Healdsburg Junior High School (HJH), Healdsburg Elementary School (HES), Recreation Park and Badger Park. The daily peaking factor of 3.0 was then applied to estimate the peak irrigation demand flow rates.

There were several disparities and inconsistencies in the metered use records for HJH, HES, Badger Park and Recreation Park, which do not correlate well with the 2007 Title 22 Report estimates. However, based on the water use records, the total irrigation water demand among all these facilities was similar to the demands in the 2007 Title 22 Report. Therefore, the estimate of the peak daily demand is between 1.9 MGD and 2.0 MGD.

Table 3-6 presents a revised overall demand estimate using the water use records for 2007/2008 where available, and compares the estimated water demands from the 2007 Title 22 Report. Overall water demands are similar. The large decrease in the estimate for Tayman Park Golf Course is largely offset by the increase from the addition of the Syar vineyard acreage.

Table 3-6. Revised Irrigation Demand

SITE ID	OWNER	CROP TYPE	AREA, AC	2007 Title 22 Report Estimated Demands			Revised Demands		
				ANNUAL AVERAGE DEMAND, MG	PEAK DAILY DEMAND, GPD	PEAK IRRIGATION DEMAND, GPM	ANNUAL AVERAGE DEMAND, MG	PEAK DAILY DEMAND, GPD	PEAK IRRIGATION DEMAND, GPM
1	Foreman Lane Area	Vineyard	262.2	28.3	272,160	567.0	28.3	272,160	567.0
2	Tayman Park[1]	Turf	57.7	56.7	392,400	817.5	*29.6*	*314,160*	*655.0*
3	Badger Park[3]	Turf	2.4	2.3	16,128	33.6	*0.07*	*839*	*1.7*
4	Recreation Park[5]	Turf	2.4	2.3	16,272	33.9	*1.76*	*16,072*	*33.5*
5	East of Foss Creek	Vineyard	171.6	18.6	178,128	371.1	18.6	178,128	371.1
6	West of Foss Creek	Vineyard	307.8	33.6	319,536	665.7	33.6	319,536	665.7
7	North of Foreman Lane	Vineyard	21.5	2.3	22,320	46.5	2.3	22,320	46.5
8	Syar	Vineyard	95.7	10.4	99,360	207.0	10.4	99,360	207.0
8a	Syar	Vineyard	214	N/A	N/A	N/A	*23.0*	*221,875*	*462.2*
9	Syar	Vineyard	9.9	1.0	10,224	21.3	1.0	10,224	21.3
10	Abbe	Vineyard	4.9	0.7	5,040	10.5	0.7	5,040	10.5
11	Abbe	Vineyard	25.7	2.9	26,640	55.5	2.9	26,640	55.5
12	Abbe	Vineyard	4.9	0.7	5,040	10.5	0.7	5,040	10.5
13	Abbe	Vineyard	11.5	1.3	11,952	24.9	1.3	11,952	24.9
14	Abbe	Vineyard	3.3	0.3	3,456	7.2	0.3	3,456	7.2
15	Passalacqua	Vineyard	7.0	0.7	7,344	15.3	0.7	73,44	15.3
16	Passalacqua	Vineyard	13.3	1.3	13,824	28.8	1.3	13,824	28.8
17	Passalacqua	Vineyard	76.1	8.1	78,912	164.4	8.1	78,912	164.4
18	Passalacqua	Vineyard	15.5	1.6	16,128	33.6	1.6	16,128	33.6
19	Passalacqua	Vineyard	6.5	0.7	6,768	14.1	0.7	6,768	14.1
20	Passalacqua	Vineyard	1.0	0.0	1,008	2.1	0.0	1,008	2.1
21	Passalacqua	Vineyard	9.3	1.0	9,648	20.1	1.0	9,648	20.1
22	Westside Road – Foreman Lane	Vineyard	213.3	23.1	221,328	461.1	23.1	221,328	461.1
23-27	Oak Mound Cemetery	Turf	4.8	4.9	32,694	68.2	4.7	32,694	68.2
28	HJH Field[2]	Turf	3.3	3.3	22,608	47.1	*6.12*	*46,755*	*97.4*
29	HHS Field	Turf	11.8	11.7	80,064	166.8	*9.13*	*93,655*	*195.1*
30	FMS Field	Turf	2.9	2.9	19,440	40.5	*3.71*	*26,601*	*55.4*
31	HES Field[4]	Turf	3.6	3.6	24,624	51.3	*0.17*	*2,684*	*5.6*
Total			1563	224	1,913,046	-	214.8	2,064,150	-
Turf Subtotal			88.9	87.5	604,230	1,259	55.3	533,459	1,111
Vineyard Subtotal			1475	136.5	1,308,816	2,727	159.5	1,530,691	3,189

Note: Oak Mound Cemetery is not included in demand calculation

[1]Tayman Park CG demand was revised using power and water use records for 2003 – 2008

[2]HJH actual water usage is taken from Meter 0096630189 indicated as "Not billed as irrigation"

[3]Badger Park records appear to be incomplete or missing water

[4]HES records appear to be incomplete or missing water

[5]Recreation Park records have large disparity between 2007 and 2008 metered use

The daily average WWTP effluent flow from 2001 to 2005 was 930 gpm (1.34 mgd). The dry weather effluent flow during the summer months (June, July, and August) is approximately 790 gpm (1.14 mgd). At the current level of inflows, the City could not provide enough recycled water to irrigate all of the areas identified, even with 24 MG in storage at the start of the season. However, the City will be serving recycled water on a voluntary basis, and users will connect gradually. The system includes more potential demand than the City can supply because it is unlikely that every user will choose to connect. As more users connect and demand gradually increases, the City will need to manage deliveries, and may eventually refuse new users when it reaches the demand that it can reliably supply. However, dry weather flows will also increase at some point in the future. The sizing of facilities in this report is therefore based on meeting all projected demands in the potential service area.

3.4 Model Inputs

EPANET requires data inputs to accurately model the distribution system. Data typically consist of pipeline alignment, pipe size, pipe elevation, pipe material, reservoir size, and demands. The following section briefly summarizes model input data.

Distribution System Layout

The distribution pipeline alignment from the Draft EIR was imported and scaled into EPANET. Model junctions were then added along the pipeline alignment to represent the location of irrigation demands. Junctions were also placed where a pipe branched or changed in size. Large vineyard areas were modeled with multiple junctions with each junction supplying an area of about 100 acres.

Pipes were added between junctions along the proposed alignment. Pipe lengths were calculated by EPANET. Initial pipe diameters were assigned to each pipe based on the Draft EIR recommendations. Final pipeline diameters were determined in model runs as discussed in subsequent sections of this report.

The distribution system is shown in Figure 3-1. The distribution system is divided into three branches: 1) Tayman Park branch (Foreman Lane north to Fitch Mountain School); 2) Mill Creek branch (Foreman Lane east to Mill Creek Road); and 3) Syar branch (Foreman Lane south to Syar ponds). Phased construction of the distribution system is likely.

Model Elevations

Ground surface elevations were estimated from United States Geological Survey (USGS) and digital topographic maps. Ground surface elevations ranged from 70 feet mean sea level (MSL) at junction J-2-4 to 225 feet MSL at the Tayman Park reservoir. The ground surface is generally flat south of Highway 101 and undulates north of Highway 101.

Reservoirs

The Draft EIR recommended two storage facilities in addition to the 24 MG effluent pond storage; two existing reservoirs located at Tayman Park Golf Course, and a proposed new tank to be located on the Passalacqua property (site ID # 17). The proposed tank on the Passalacqua property is referred to as the Mill Creek reservoir in this report. This tank was later eliminated from the design when the hydraulic modeling determined that it was not necessary.

The Tayman Park reservoir consists of two side-by-side concrete tanks that were disconnected from the potable water system in April 2001 when they were replaced by two new reservoirs at a new location for the potable water supply. The decommissioned reservoirs were proposed to be used for the Recycled Water system. The two reservoirs were nonetheless modeled as one reservoir for simplicity. Due to cost and environmental considerations, the City later decided to demolish the old reservoirs and instead construct a single new reservoir at the same location with the same capacity, 0.75 MG. The bottom elevation of the reservoir will be 239 feet MSL, with a maximum water depth of 27 feet, resulting in a maximum water surface elevation of 266 feet MSL.

The Mill Creek reservoir was modeled at the same elevation and operational height, about 15 feet, as the Tayman Park reservoir. The Mill Creek reservoir would have a diameter of 65 feet and a height allowing 15 feet of usable storage, equivalent to about 0.37 MG of storage capacity.

The water supply into the Recycled Water system was modeled as an infinite source, and therefore, the 24 MG effluent storage pond on the suction side of the Recycled Water pump station was not included in the model. The limited seasonal storage capacity of the effluent storage pond is discussed in Section 3.3 of this report.

Demands

Model demands are summarized in Table 3-4.

3.5 Model Results

The results described below utilized the 2007 Title 22 Report demands and use of the old Tayman Reservoirs described above. However, subsequent model runs during final design, which did incorporate these changes, indicated that the changes did not significantly affect these results.

An extended period simulation was run for a period of 30 days using July demands to determine operational parameters such as pipeline velocity, system pressure, pumping rate and head, and reservoir levels. During the extended period analysis, turf demands occurred from 10:00 p.m. to 6:00 a.m., and vineyard demands occurred from 6:00 a.m. to 2:00 p.m. There were no demands from 2:00 p.m. to 10:00 p.m., which allowed the refilling of the storage reservoirs.

Pipe Diameters and Lengths

Desirable velocities and junction pressures previously discussed in the modeling assumptions and criteria section of this report were used to aid in pipe sizing. Selected pipe diameters were 8 and 12 inches based on velocities and pressures in various model runs. Twelve-inch diameter pipes ran from the WWTP pump station to the Tayman Park Reservoir (node J-1-1 to node T-1-Tayman) and the first 9,410 feet of the Mill Creek branch (junctions J-1-2 to J-2-6) as shown in Figure 3-1. The remaining pipe diameters were 8-inch.

Total pipeline length is approximately 46,617 feet with 22,201 feet of 8-inch diameter pipe and 24,416 feet of 12-inch diameter pipe. Approximately 4,310 feet of the 12-inch diameter pipe (4,310 feet) is already in place from Magnolia pump station to Kinley Drive.

Depending on the point of connection location for some agricultural irrigation systems, about 3,560 feet of 8-inch diameter pipe (pipes P-1-7 and P-3-3) may not be necessary because two model junctions (J-1-8 and J-3-3) did not have assigned demands. These junctions can be used in future model scenarios when the point of connection between the irrigation system and the distribution system is known.

Pipe Velocity

Pipe velocities are shown in Figure 3-2 and Figure 3-3 for turf areas and vineyard areas, respectively. The pipe velocities and distribution system pressures differ when irrigating turf and vineyard areas as a result of differing crop water demands. When irrigating turf areas, velocities range from 0.13 to 3.71 fps under peak hour demands as shown in Figure 3-2. Most of the lower velocities are in the 8-inch diameter pipes delivering water to individual sites such as Badger Park and Healdsburg Junior High. The higher velocities are in the transmission line from the WWTP pump station to the Oak Mound Cemetery.

When irrigating vineyard areas, pipe velocities increase and range from 0.71 to 5.5 fps as shown in Figure 3-3. The lowest pipeline velocity occurs in pipe P-1-3 because water is supplied from both Tayman Park reservoir and the WWTP pump station. The maximum velocity of 5.5 fps occurs in the pipeline from the WWTP to the first junction (P-1-1). The velocity is between 5.0 and 5.5 fps in pipes P-1-4 and P-2-1 which are 8-inch diameter and 12-inch diameter, respectively.

It is anticipated that the actual velocities shown under the vineyard irrigation scenario will be lower than modeled because the peak hour factors used for vineyards are conservatively estimated. Vineyard irrigation will likely occur over a twelve hour period rather than an eight hour period, thereby reducing the pipe velocity. Although in some cases the velocities appear to be lower than desirable, the use of a 6-inch diameter pipe would have increased some velocities to unacceptable levels. The designated diameters balance system needs with the possibility of future expansion.

Distribution System Pressure

Distribution system pressures for turf and vineyard irrigation are included in Figure 3-2 and Figure 3-3, respectively. When irrigating turf areas, pressures at various sites will range from 32 to 63 psi under peak hour demands as shown in Figure 3-2. Distribution system pressures will range from 32 to 45 psi in the vicinity of the Tayman Park reservoir because the sites are relatively close in elevation to the Tayman Park reservoir.

When the Recycled Water distribution system pressures are less than 45 psi, it may be necessary for the user to operate booster pumps to meet minimum sprinkler pressure requirements. Each individual site will need to be evaluated to determine if booster pumps are necessary as determined by the irrigation system type, ground surface elevation, and the pipeline size from the distribution system turnout to the irrigation system.

Based on ground surface elevations and an assumed pressure requirement of at least 60 psi, booster pumping may be required on the following turf locations:

- Tayman Park (Model Junction J-1-14, site ID 2)
- Oak Mound Cemetery (Model Junction J-1-15, site ID 23-27)
- Healdsburg High School (Model Junction J-1-20, site ID 20)
- Fitch Mountain School (Model Junction J-1-21, site ID 30)

Distribution system pressures for vineyard areas under peak hour demands range from 39 to 59 psi based on Tayman Park reservoir as the only storage facility (see next subsection). The majority of vineyards are provided with adequate pressure as shown in Figure 3-3. However, some vineyards on undulating topography may need booster pump stations. Based on ground surface elevations and an assumed minimum pressure requirement of at least 30 psi, the following vineyard sites may require booster pump stations:

- Passalacqua (Model Junction J-2-6, site IDs 16-21)
- Abbe (Model Junction J-2-5, site IDs 10-13)

Storage Reservoirs

The Draft EIR recommended water storage facilities at Tayman Park and on the Passalacqua property (Mill Creek reservoir). Initially, the Recycled Water distribution system was modeled with both reservoir sites. However, the extended period analysis revealed that only the Tayman Park reservoir is necessary. When modeling both the Tayman Park reservoir and Mill Creek reservoir, the water surface elevation in the Tayman Park reservoir fluctuated about one foot while the 65-foot diameter Mill Creek reservoir fluctuated about 13 feet over a 24 hour period. Therefore, the City has the opportunity to defer or eliminate construction of the Mill Creek reservoir or other supplemental storage facility.

The Mill Creek reservoir was removed from the model, and the Tayman Park reservoir remained full during the turf irrigation period because the pump station will have sufficient capacity to meet the peak hour demands for turf areas. When irrigating vineyards, about half of the Tayman Park storage is depleted and the water surface elevation decreases by about eight feet from 240 to 232 feet MSL. It takes about five hours for the pump station to refill the reservoir after the vineyard irrigation period, and then the pump station is idle for about three hours.

Pump Station

To conservatively meet maximum day demands for the entire service area, the 2007 Title 22 Report found that the pump station would need to have a reliable capacity of 1,360 gpm (Table 3-6) with a total dynamic head (TDH) of 210 feet. The pump curve used in EPANET was created by entering a single point head-flow combination operating point of 1,360 gpm at a TDH of 210 feet. EPANET then created the pump curve by assuming a shutoff head at zero flow equal to 133 percent of the design head and a maximum flow at zero head equal to twice the design flow.

The 2007 Title 22 Report recommended two duty pumps and one standby pump at the WWTP, with each pump capable of producing a minimum of 680 gpm at a TDH of 210 feet.

The pump selection during final design was based on the capability of meeting the majority of the demands with one duty pump and one stand-by pump for redundancy, and all demands with two duty pumps and one stand-by pump.

The system curve, which represents the head loss in the transmission system between the 24 million gallon (MG) storage reservoir and Tayman Reservoirs, is shown in Figure 3-4, and is based on the final piping system design. Figure 3-4 shows the pump and efficiency curves for a single pump operated on a variable frequency drive (VFD), and two pumps in parallel. The pump shown is a 100 horsepower Floway model 12JKM vertical turbine pump (Pump Curve "A", 1,770 RPM). A total of 4 stages (bowls) will achieve the required discharge head. The impeller diameter is 8.5 – 9.0 inches. The VFD analysis shows the pump curves and efficiencies as motor speed is reduced from 100% to 70% of full speed.

This pump would operate on a VFD at approximately 85 – 90% of peak speed, which will produce a discharge of about 890 gpm at 205 feet of total dynamic head. On a daily basis there is flexibility in the City's system operation. Operating the pump at full speed will provide additional capacity and operational flexibility. For example, the City could choose operate the pump near full speed to meet the full turf irrigation demand, without drawing water from the Tayman Reservoirs.

This pump selection generally agrees with the approach recommended in the 2007 Title 22 Report, which utilizes two duty pumps and one stand-by pump to meet the peak day demands for the entire system. The existing wet well has space for up to four pumps. With only three pumps required in this case, the space for a fourth pump is redundant, and could be used for an additional pump in the future if the WWTP was expanded beyond its current 1.6 million gallons per day (MGD) capacity.

The standby power generator for the WWTP will also serve the Recycled Water pump station.

3.6 Distribution System Mapping

Figure 3-5 through Figure 3-12 show the proposed Recycled Water pipeline alignment from the WWTP to the turf areas along with existing potable, sewer and storm drain pipelines. The existing pipeline alignments were obtained from the City of Healdsburg's Geographical Information System (GIS) and located approximately. Each type of pipeline is designated by a separate color indicating the function as shown in the figure legend. Similar mapping of the Recycled Water pipeline alignment in the vineyard areas is not included in this report because vineyard irrigation with Recycled Water is anticipated as a second phase of the project and no other City utilities are in the service area.

The Recycled Water pipeline will be installed in accordance with Title 22 California Code of Regulations, California Safe Drinking Water Act and Related Laws and Regulations to meet the separation requirements from the potable, sewer and storm drain pipelines. The separation requirements are as follows:

- Recycled Water mains shall be installed below the frost line or shall be otherwise protected to prevent freezing.
- Recycled Water mains shall not have less than 30 inches of cover over the top of the pipe except where necessary to avoid underground obstructions or rocky conditions.
- Recycled Water mains shall be installed at least:
  - Four feet horizontally from and one foot lower than a water main.
  - One foot higher than a sanitary sewer crossing the Recycled Water main.
  - Twenty-five feet horizontally from sewage leach fields, cesspools, seepage pits and septic tanks.
- If the above requirements cannot be met due to topography, inadequate right-of-way or easements or conflicts with other provisions of the regulations, lesser separation is permissible if:
  - The water main and Recycled Water pipes are located as far apart as feasible within the conditions listed above.
  - The water main is appropriately constructed to prevent contamination of the potable water supply by Recycled Water leakage.

Figure 3-13 shows the conceptual pipeline separation along South University Avenue at Healdsburg Avenue. The Recycled Water pipeline will maintain the appropriate separation distances from other utilities to the greatest extent possible.

The 2007 Title 22 Report described a Highway 101 under-crossing for the Recycled Water pipeline just south of the intersection of Kinley Drive and West Slough, starting on the west side of Highway 101. During final design the crossing location was shifted approximately 500 feet to the east to shorten the crossing length. The utilities will be installed under the highway by means of trenchless construction, and terminate near the southwestern corner of Kennedy Lane at Healdsburg Avenue. The preferred alternative is the installation of a 36-inch steel casing by means of bore and jack. The casing would contain the reclaimed water pipeline and an encased potable water pipeline.

A utility survey including potholing and condition assessment of the existing pipeline from the Magnolia Lift Station to Foreman Lane should occur prior to bidding the Recycled Water system project. This will confirm pipeline elevations and locations, and the adequacy of and connection requirements for the existing pipeline from the Magnolia lift station to Foreman Lane.

3.7 Summary

A summary of the Recycled Water distribution system is presented in Table 3-7. The Tayman Park reservoir is capable of providing sufficient storage capacity, making the Mill Creek reservoir unnecessary. About half of the Tayman Park reservoir volume will be used during vineyard irrigation, and negligible volume is used during turf irrigation. Some irrigation sites may require booster pumping to meet sprinkler pressure requirements.

Table 3-7. Distribution System Summary[(a)]

Total Irrigated Area, ac	1564
Total Irrigation Demand, MG	224
Length of 4-inch diameter pipe, ft	660
Length of 8-inch diameter pipe, ft	213,171
Length of 12-inch diameter pipe[(b)], ft	21,552
Length of 16-inch diameter pipe, ft	44
Total pipe length, ft	35,427
Pipeline Velocity (turf area), fps	0.13 – 3.71
Available Distribution System Pressure (turf area), psi	32 – 63
Pipeline Velocity (vineyard area), fps	0.71 - 5.5
Available Distribution System Pressure (vineyard area), psi	39 – 59
Pump Capacity, gpm	1,700 @ 310" TDH (2 pumps)

(a) Total potential, not all of which will ultimately be served
(b) Includes 4,310 feet of existing pipe.

Two active duty and one standby Recycled Water pumps will be installed at the WWTP. Each pump will be capable of producing approximately 890 gpm at a TDH of 205 feet. A variable frequency drive will provide more efficient and flexible operation because of the potential range in operating TDH.

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Site ID	Model Junction	Owner	Crop Type	Area, ac
1	J-2-1, J-2-2, J-2-3	Foreman Lane Area	Vineyard	262.2
2	J-1-14	Tayman Park	Turf	57.7
3	J-1-13	Badger Park	Turf	2.4
4	J-1-17	Recreation Park	Turf	2.4
5	J-1-9, J-1-10	East of Foss Creek	Vineyard	171.6
6	J-1-5, J-1-6, J-1-7	West of Foss Creek	Vineyard	307.8
7	J-1-3	North of Foreman Lane	Vineyard	21.5
8	J-3-2	Syar	Vineyard	95.7
8a		Syar	Vineyard	214.0
9	J-3-1	Syar	Vineyard	9.9
10	J-2-5	Abbe	Vineyard	4.9
11	J-2-5	Abbe	Vineyard	25.7
12	J-2-5	Abbe	Vineyard	4.9
13	J-2-5	Abbe	Vineyard	11.5
14	J-2-5	Abbe	Vineyard	3.3
15	J-2-4	Passalacqua	Vineyard	7.0
16	J-2-6	Passalacqua	Vineyard	13.3
17	J-2-6	Passalacqua	Vineyard	76.1
18	J-2-6	Passalacqua	Vineyard	15.5
19	J-2-6	Passalacqua	Vineyard	6.5
20	J-2-6	Passalacqua	Vineyard	1.0
21	J-2-6	Passalacqua	Vineyard	9.3
22	J-2-7, J-2-5	Westside Road/Foreman Lane	Vineyard	213.3
23	J-1-15	Oak Mound Cemetery	Turf	0.2
24	J-1-15	Oak Mound Cemetery	Turf	1.8
25	J-1-15	Oak Mound Cemetery	Turf	1.1
26	J-1-15	Oak Mound Cemetery	Turf	0.7
27	J-1-15	Oak Mound Cemetery	Turf	1.0
28	J-1-19	HJH Field	Turf	3.3
29	J-1-20	HHS Field	Turf	11.8
30	J-1-21	FMS Field	Turf	2.9
31	J-1-16	HES Field	Turf	3.6
Total				**1,563.8**

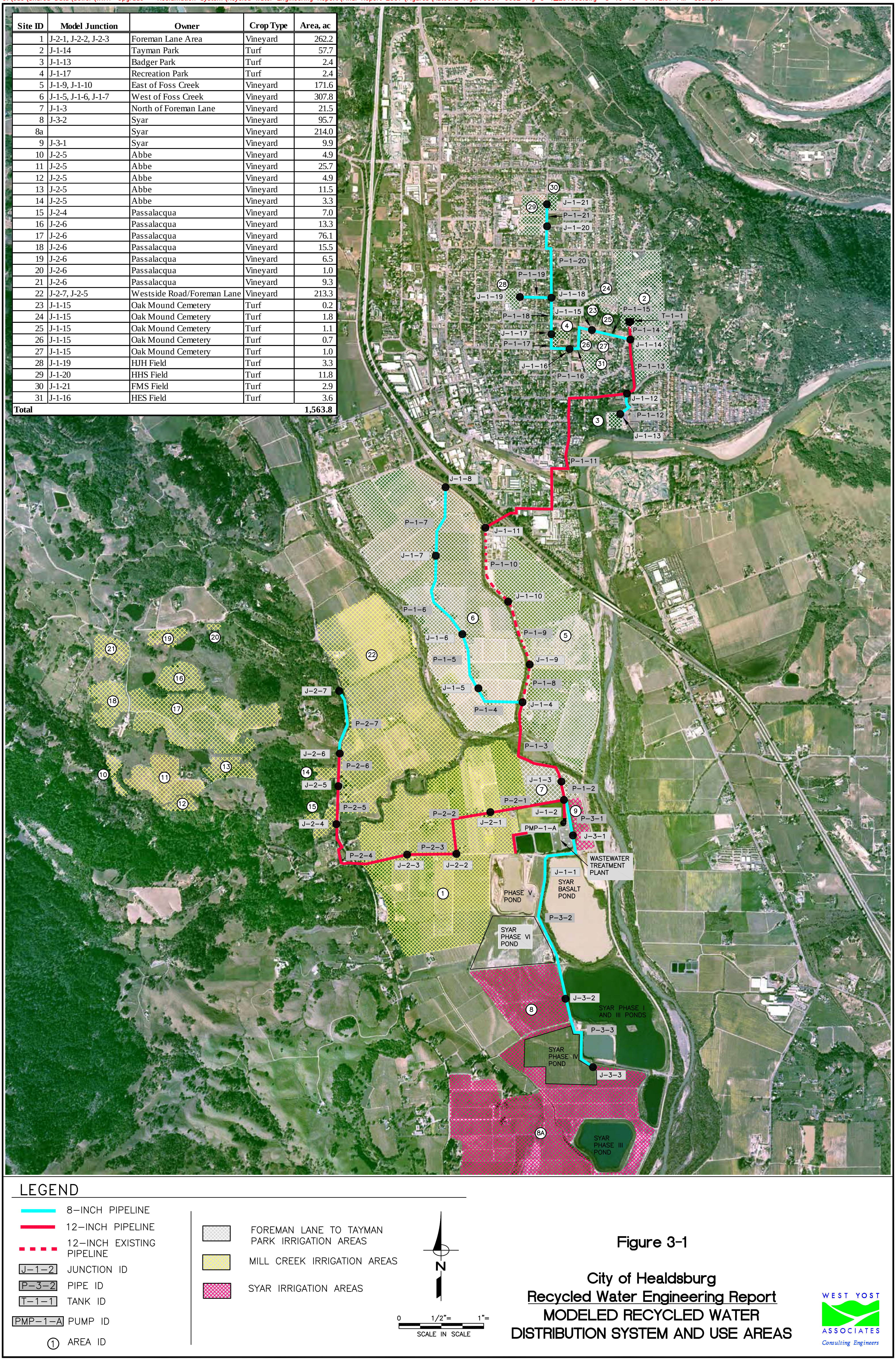

Figure 3-1

City of Healdsburg
Recycled Water Engineering Report
MODELED RECYCLED WATER DISTRIBUTION SYSTEM AND USE AREAS

WEST YOST ASSOCIATES
Consulting Engineers

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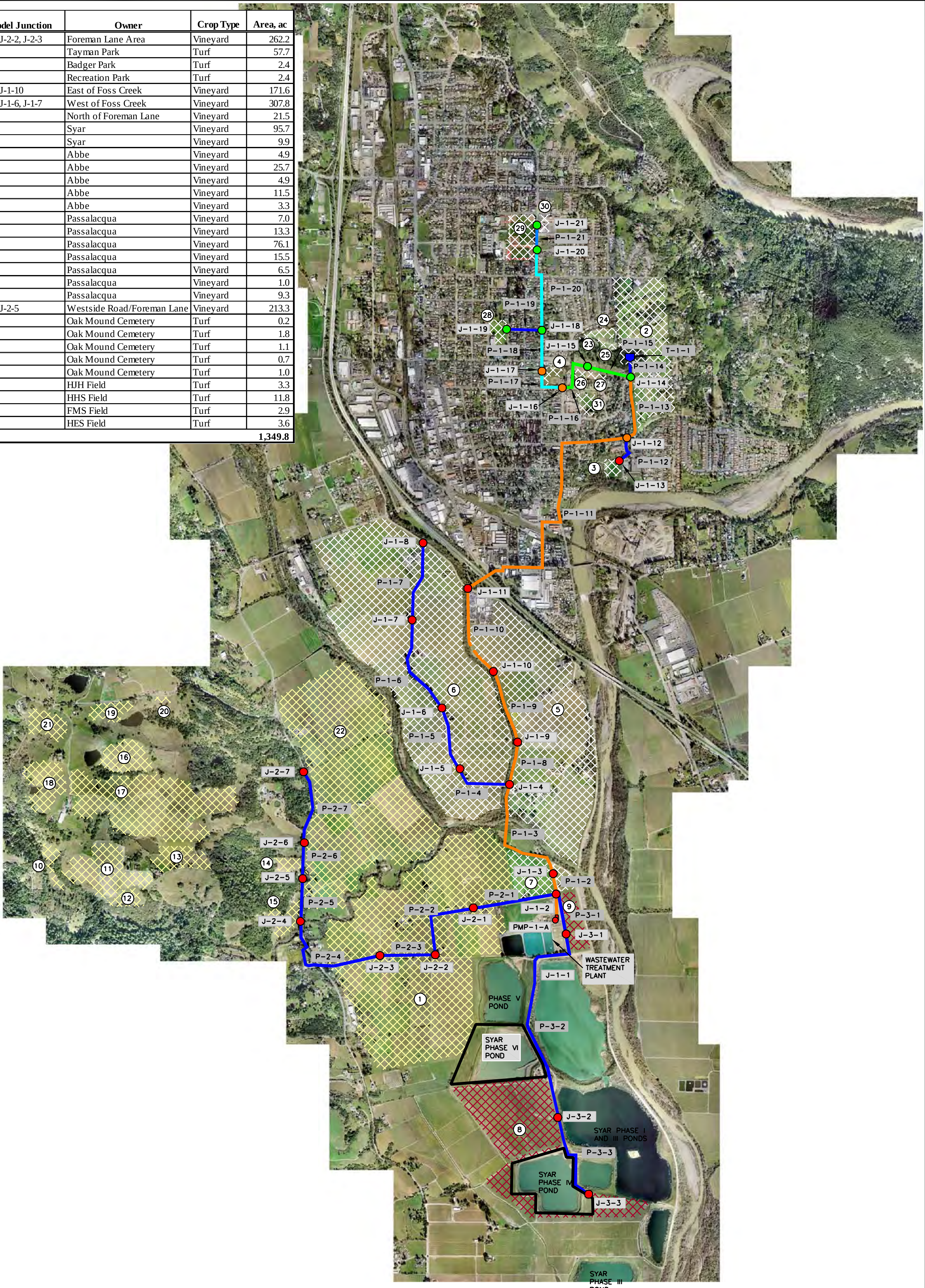
Site ID	Model Junction	Owner	Crop Type	Area, ac
1	J-2-1, J-2-2, J-2-3	Foreman Lane Area	Vineyard	262.2
2	J-1-14	Tayman Park	Turf	57.7
3	J-1-13	Badger Park	Turf	2.4
4	J-1-17	Recreation Park	Turf	2.4
5	J-1-9, J-1-10	East of Foss Creek	Vineyard	171.6
6	J-1-5, J-1-6, J-1-7	West of Foss Creek	Vineyard	307.8
7	J-1-3	North of Foreman Lane	Vineyard	21.5
8	J-3-2	Syar	Vineyard	95.7
9	J-3-1	Syar	Vineyard	9.9
10	J-2-5	Abbe	Vineyard	4.9
11	J-2-5	Abbe	Vineyard	25.7
12	J-2-5	Abbe	Vineyard	4.9
13	J-2-5	Abbe	Vineyard	11.5
14	J-2-5	Abbe	Vineyard	3.3
15	J-2-4	Passalacqua	Vineyard	7.0
16	J-2-6	Passalacqua	Vineyard	13.3
17	J-2-6	Passalacqua	Vineyard	76.1
18	J-2-6	Passalacqua	Vineyard	15.5
19	J-2-6	Passalacqua	Vineyard	6.5
20	J-2-6	Passalacqua	Vineyard	1.0
21	J-2-6	Passalacqua	Vineyard	9.3
22	J-2-7, J-2-5	Westside Road/Foreman Lane	Vineyard	213.3
23	J-1-15	Oak Mound Cemetery	Turf	0.2
24	J-1-15	Oak Mound Cemetery	Turf	1.8
25	J-1-15	Oak Mound Cemetery	Turf	1.1
26	J-1-15	Oak Mound Cemetery	Turf	0.7
27	J-1-15	Oak Mound Cemetery	Turf	1.0
28	J-1-19	HJH Field	Turf	3.3
29	J-1-20	HHS Field	Turf	11.8
30	J-1-21	FMS Field	Turf	2.9
31	J-1-16	HES Field	Turf	3.6
Total				1,349.8



LEGEND

NODE PRESSURE, psi	PIPELINE VELOCITY, fps
0.0	0.0
15.0	1.0
30.0	2.0
45.0	3.0
60.0	4.0
100	5.5

FOREMAN LANE TO TAYMAN PARK IRRIGATION AREAS

MILL CREEK IRRIGATION AREAS

SYAR IRRIGATION AREAS

① AREA ID

N

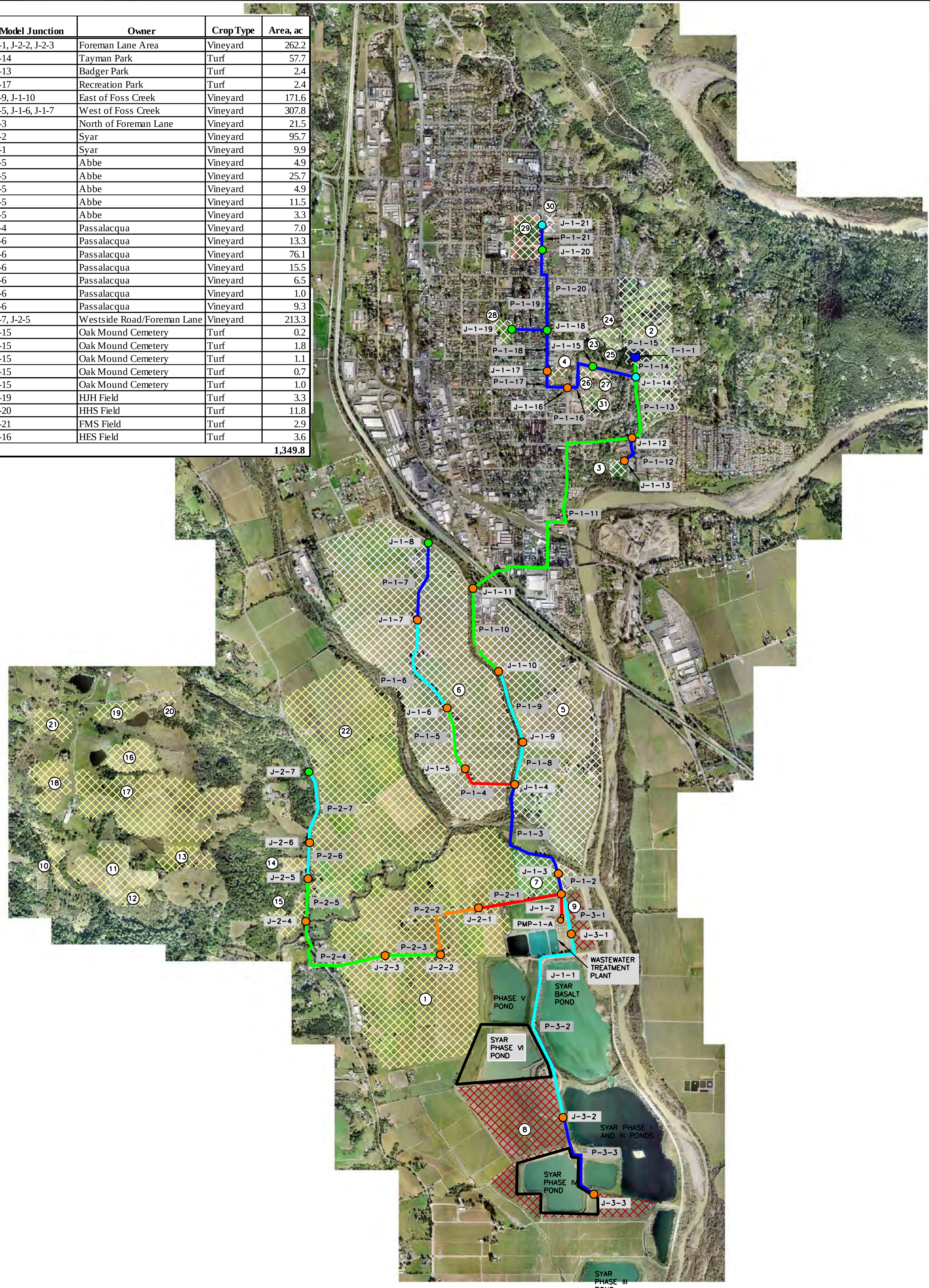
0 1000 2000
SCALE IN FEET

Figure 3-2
City of Healdsburg
Recycled Water Engineering Report
DISTRIBUTION SYSTEM MAP KEY

WEST YOST ASSOCIATES
Consulting Engineers

C:\pwworking\sac\d0145001\70004-0602-Fig-3-3.dwg 8-19-10 10:45:40 AM ablomqui

Site ID	Model Junction	Owner	Crop Type	Area, ac
1	J-2-1, J-2-2, J-2-3	Foreman Lane Area	Vineyard	262.2
2	J-1-14	Tayman Park	Turf	57.7
3	J-1-13	Badger Park	Turf	2.4
4	J-1-17	Recreation Park	Turf	2.4
5	J-1-9, J-1-10	East of Foss Creek	Vineyard	171.6
6	J-1-5, J-1-6, J-1-7	West of Foss Creek	Vineyard	307.8
7	J-1-3	North of Foreman Lane	Vineyard	21.5
8	J-3-2	Syar	Vineyard	95.7
9	J-3-1	Syar	Vineyard	9.9
10	J-2-5	Abbe	Vineyard	4.9
11	J-2-5	Abbe	Vineyard	25.7
12	J-2-5	Abbe	Vineyard	4.9
13	J-2-5	Abbe	Vineyard	11.5
14	J-2-5	Abbe	Vineyard	3.3
15	J-2-4	Passalacqua	Vineyard	7.0
16	J-2-6	Passalacqua	Vineyard	13.3
17	J-2-6	Passalacqua	Vineyard	76.1
18	J-2-6	Passalacqua	Vineyard	15.5
19	J-2-6	Passalacqua	Vineyard	6.5
20	J-2-6	Passalacqua	Vineyard	1.0
21	J-2-6	Passalacqua	Vineyard	9.3
22	J-2-7, J-2-5	Westside Road/Foreman Lane	Vineyard	213.3
23	J-1-15	Oak Mound Cemetery	Turf	0.2
24	J-1-15	Oak Mound Cemetery	Turf	1.8
25	J-1-15	Oak Mound Cemetery	Turf	1.1
26	J-1-15	Oak Mound Cemetery	Turf	0.7
27	J-1-15	Oak Mound Cemetery	Turf	1.0
28	J-1-19	HJH Field	Turf	3.3
29	J-1-20	HHS Field	Turf	11.8
30	J-1-21	FMS Field	Turf	2.9
31	J-1-16	HES Field	Turf	3.6
Total				1,349.8



LEGEND

NODE PRESSURE, psi	PIPELINE VELOCITY, fps
0.0	0.0
15.0	1.0
30.0	2.0
45.0	3.0
60.0	4.0
100	5.5

FOREMAN LANE TO TAYMAN PARK IRRIGATION AREAS

MILL CREEK IRRIGATION AREAS

SYAR IRRIGATION AREAS

① AREA ID

N

0 1000 2000
SCALE IN FEET

Figure 3-3
City of Healdsburg
Recycled Water Engineering Report
DISTRIBUTION SYSTEM MAP KEY

WEST YOST ASSOCIATES
Consulting Engineers

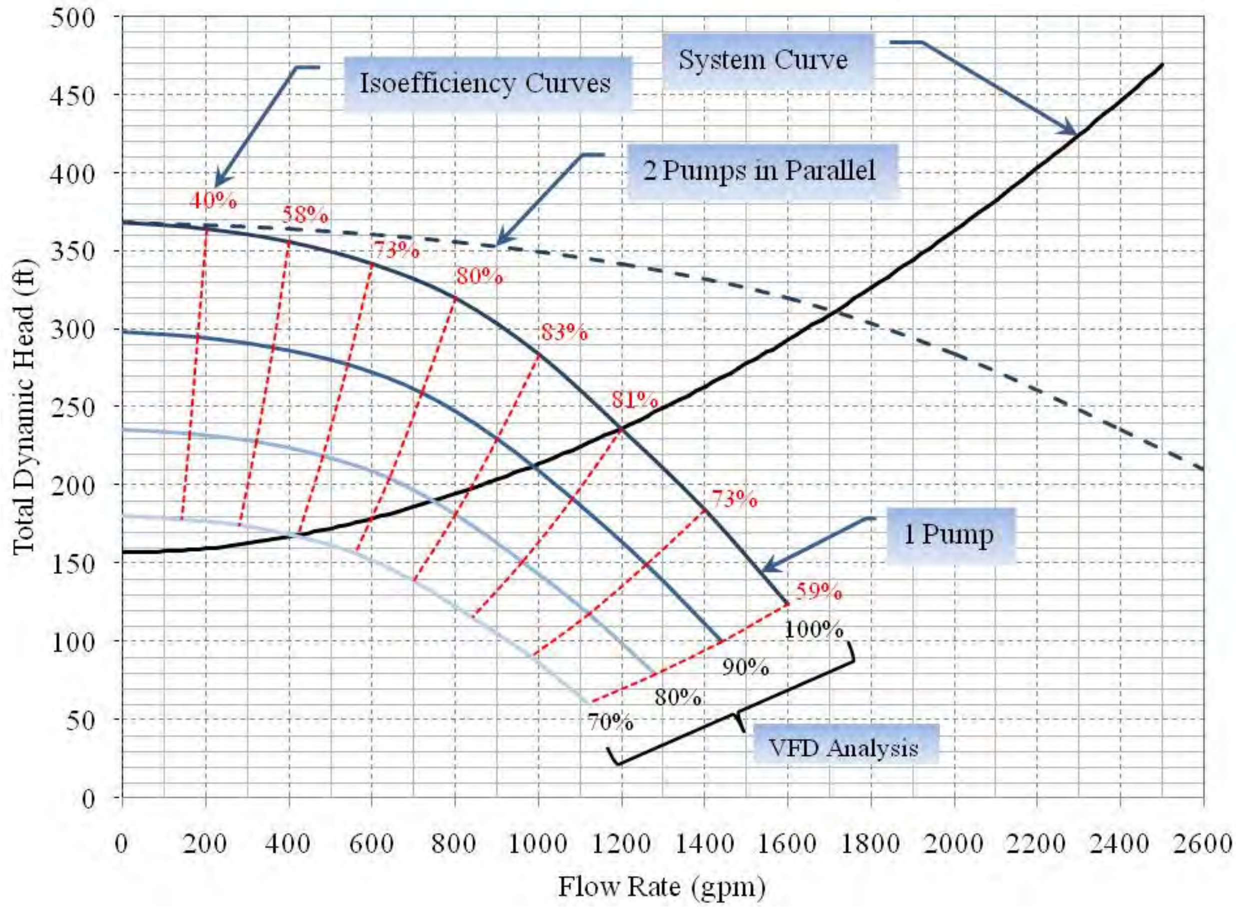
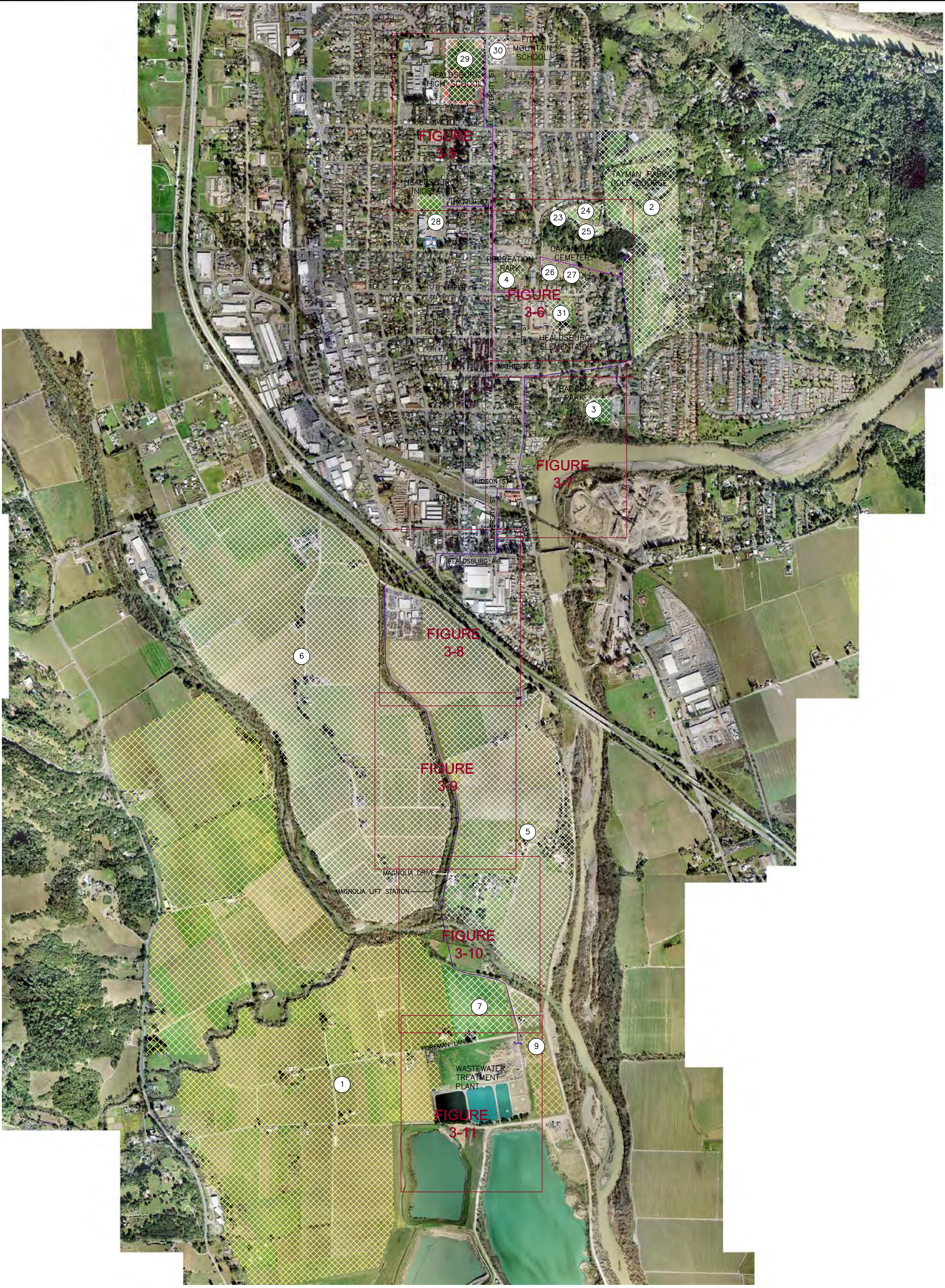


Figure 3-4

City of Healdsburg
<u>Recycled Water Engineering Report</u>
RECYCLED WATER PUMP AND EFFICIENCY CURVES



LEGEND

FOREMAN LANE TO TAYMAN PARK IRRIGATION AREA

MILL CREEK IRRIGATION AREA

PROPOSED 8-INCH DIAMETER RECYCLED WATER PIPELINE

PROPOSED 12-INCH DIAMETER RECYCLED WATER PIPELINE

① AREA ID

N

SCALE: N.T.S.

Figure 3-5
City of Healdsburg
Recycled Water Engineering Report
DISTRIBUTION SYSTEM MAP KEY

WEST YOST ASSOCIATES
Consulting Engineers

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LEGEND

DOMESTIC WATER
SANITARY SEWER
STORM DRAIN
PROPOSED RECYCLED WATER
RECYCLED WATER USE AREA
① AREA ID

Source: City of Healdsburg. Note: Pipelines are approximately located. Precise locations of all utilities are required prior to construction.

Recycled water main installation

(a) Recycled water mains shall be installed below the frost line or shall be otherwise protected to prevent freezing

(b) Recycled water mains shall not have less than 30 inches of cover over the top of the pipe except where necessary to avoid underground obstructions or rocky conditions

(c) Recycled water mains shall be installed at least:
(1) 10 feet horizontally from and 1 foot lower than water main
(2) One foot higher than the sanitary sewer crossing the recycled water main
(3) Ten feet horizontally from sewage leach fields, cesspools, seepage pits and septic tanks.

(d) If the above requirements cannot be met due to topography, inadequate right-of-way or easements or conflicts with other provisions of these regulations, lesser separation is permissible if:
(1) The water main and recycled water line are located as far apart as feasible within the conditions listed above.
(2) The water main is appropriately constructed to prevent contamination of the water main by recycled water leakage.

N

0 100 200
SCALE IN FEET

PRELIMINARY - NOT FOR CONSTRUCTION

DRAFT

Figure 3-6

City of Healdsburg
Recycled Water Engineering Report
DISTRIBUTION SYSTEM

WEST YOST ASSOCIATES
Consulting Engineers

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LEGEND

DOMESTIC WATER	STORM DRAIN
SANITARY SEWER	PROPOSED RECYCLED WATER
RECYCLED WATER USE AREA	① AREA ID

Source: City of Healdsburg. Note: Pipelines are approximately located. Precise locations of all utilities are required prior to construction.

PRELIMINARY - NOT FOR CONSTRUCTION

DRAFT

Recycled water main installation

(a) Recycled water mains shall be installed below the frost line or shall be otherwise protected to prevent freezing

(b) Recycled water mains shall not have less than 30 inches of cover over the top of the pipe except where necessary to avoid underground obstructions or rocky conditions

(c) Recycled water mains shall be installed at least:
  (1) 10 feet horizontally from and one foot lower than water main.
  (2) One foot higher than the sanitary sewer crossing the recycled water main
  (3) Ten feet horizontally from sewage leach fields, cesspools, seepage pits and septic tanks.

(d) If the above requirements cannot be met due to topography, inadequate right-of-way or easements or conflicts with other provisions of these regulations, lesser separation is permissible if:
  (1) The water main and recycled water line are located as far apart as feasible within the conditions listed above.
  (2) The water main is appropriately constructed to prevent contamination of the water main by recycled water leakage.

N

0 100 200
SCALE IN FEET

Figure 3-7

City of Healdsburg
Recycled Water Engineering Report
DISTRIBUTION SYSTEM

WEST YOST ASSOCIATES
Consulting Engineers

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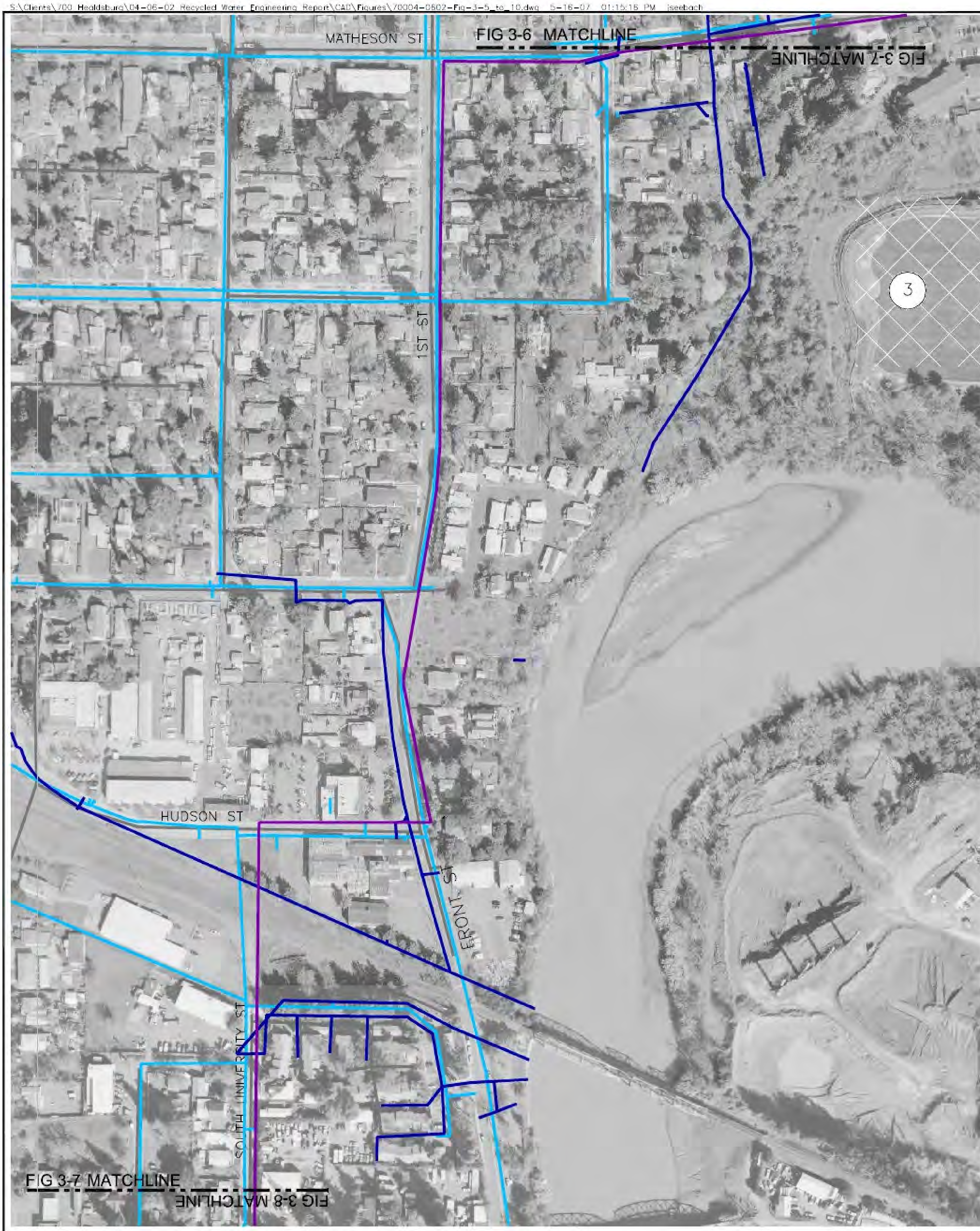

LEGEND

DOMESTIC WATER
SANITARY SEWER
STORM DRAIN
PROPOSED RECYCLED WATER
RECYCLED WATER USE AREA
① AREA ID

Source: City of Healdsburg. Note: Pipelines are approximately located. Precise locations of all utilities are required prior to construction.

Recycled water main installation

(a) Recycled water mains shall be installed below the frost line or shall be otherwise protected to prevent freezing

(b) Recycled water mains shall not have less than 30 inches of cover over the top of the pipe except where necessary to avoid underground obstructions or rocky conditions

(c) Recycled water mains shall be installed at least:
(1) 10 feet horizontally from and one foot lower than water main.
(2) One foot higher than the sanitary sewer crossing the recycled water main
(3) Ten feet horizontally from sewage leach fields, cesspools, seepage pits and septic tanks.

(d) If the above requirements cannot be met due to topography, inadequate right-of-way or easements or conflicts with other provisions of these regulations, lesser separation is permissible if:
(1) The water main and recycled water line are located as far apart as feasible within the conditions listed above.
(2) The water main is appropriately constructed to prevent contamination of the water main by recycled water leakage.

N

0 100 200
SCALE IN FEET

PRELIMINARY - NOT FOR CONSTRUCTION

DRAFT

Figure 3-8

City of Healdsburg
Recycled Water Engineering Report
DISTRIBUTION SYSTEM

WEST YOST ASSOCIATES Consulting Engineers

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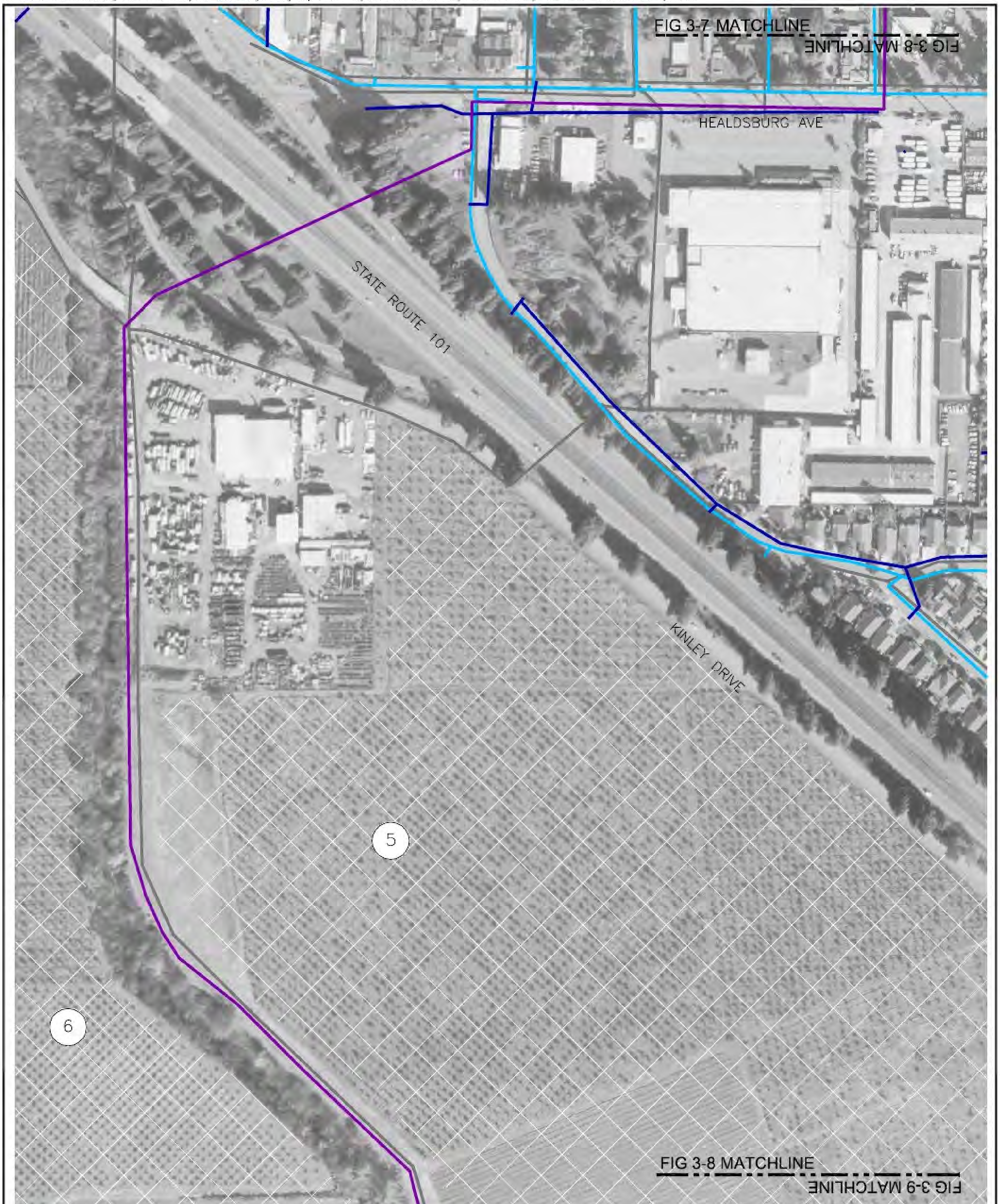

LEGEND

DOMESTIC WATER
SANITARY SEWER
STORM DRAIN
PROPOSED RECYCLED WATER
RECYCLED WATER USE AREA
① AREA ID

Source: City of Healdsburg. Note: Pipelines are approximately located. Precise locations of all utilities are required prior to construction.

Recycled water main installation

(a) Recycled water mains shall be installed below the frost line or shall be otherwise protected to prevent freezing

(b) Recycled water mains shall not have less than 30 inches of cover over the top of the pipe except where necessary to avoid underground obstructions or rocky conditions

(c) Recycled water mains shall be installed at least:
(1) 10 feet horizontally from and one foot lower than water main.
(2) One foot higher than the sanitary sewer crossing the recycled water main.
(3) Ten feet horizontally from sewage leach fields, cesspools, seepage pits and septic tanks.

(d) If the above requirements cannot be met due to topography, inadequate right-of-way or easements or conflicts with other provisions of these regulations, lesser separation is permissible if:
(1) The water main and recycled water line are located as far apart as feasible within the conditions listed above.
(2) The water main is appropriately constructed to prevent contamination of the water main by recycled water leakage.

N

0 100 200
SCALE IN FEET

PRELIMINARY - NOT FOR CONSTRUCTION

DRAFT

Figure 3-9

City of Healdsburg
Recycled Water Engineering Report
DISTRIBUTION SYSTEM

WEST YOST ASSOCIATES
Consulting Engineers

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LEGEND

DOMESTIC WATER
SANITARY SEWER
STORM DRAIN
PROPOSED RECYCLED WATER
RECYCLED WATER USE AREA
① AREA ID

Source: City of Healdsburg. Note: Pipelines are approximately located. Precise locations of all utilities are required prior to construction.

Recycled water main installation

(a) Recycled water mains shall be installed below the frost line or shall be otherwise protected to prevent freezing

(b) Recycled water mains shall not have less than 30 inches of cover over the top of the pipe except where necessary to avoid underground obstructions or rocky conditions

(c) Recycled water mains shall be installed at least:
(1) 10 feet horizontally from and one foot lower than water main.
(2) One foot higher than the sanitary sewer crossing the recycled water main.
(3) Ten feet horizontally from sewage leach fields, cesspools, seepage pits and septic tanks.

(d) If the above requirements cannot be met due to topography, inadequate right-of-way or easements or conflicts with other provisions of these regulations, lesser separation is permissible if:
(1) The water main and recycled water line are located as far apart as feasible within the conditions listed above.
(2) The water main is appropriately constructed to prevent contamination of the water main by recycled water leakage.

N

0 100 200
SCALE IN FEET

PRELIMINARY - NOT FOR CONSTRUCTION

DRAFT

Figure 3-10

City of Healdsburg
Recycled Water Engineering Report
DISTRIBUTION SYSTEM

WEST YOST ASSOCIATES
Consulting Engineers

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LEGEND

DOMESTIC WATER
SANITARY SEWER
STORM DRAIN
PROPOSED RECYCLED WATER
RECYCLED WATER USE AREA
① AREA ID

Source: City of Healdsburg. Note: Pipelines are approximately located. Precise locations of all utilities are required prior to construction.

Recycled water main installation

(a) Recycled water mains shall be installed below the frost line or shall be otherwise protected to prevent freezing

(b) Recycled water mains shall not have less than 30 inches of cover over the top of the pipe except where necessary to avoid underground obstructions or rocky conditions

(c) Recycled water mains shall be installed at least:
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(2) One foot higher than the sanitary sewer crossing the recycled water main.
(3) Ten feet horizontally from sewage leach fields, cesspools, seepage pits and septic tanks.

(d) If the above requirements cannot be met due to topography, inadequate right-of-way or easements or conflicts with other provisions of these regulations, lesser separation is permissible if:
(1) The water main and recycled water line are located as far apart as feasible within the conditions listed above.
(2) The water main is appropriately constructed to prevent contamination of the water main by recycled water leakage.

N

0 100 200
SCALE IN FEET

PRELIMINARY - NOT FOR CONSTRUCTION

DRAFT

Figure 3-11

City of Healdsburg
Recycled Water Engineering Report
DISTRIBUTION SYSTEM

WEST YOST ASSOCIATES
Consulting Engineers

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LEGEND

DOMESTIC WATER
SANITARY SEWER
STORM DRAIN
PROPOSED RECYCLED WATER
RECYCLED WATER USE AREA
① AREA ID

Source: City of Healdsburg. Note: Pipelines are approximately located. Precise locations of all utilities are required prior to construction.

PRELIMINARY - NOT FOR CONSTRUCTION

DRAFT

Recycled water main installation

(a) Recycled water mains shall be installed below the frost line or shall be otherwise protected to prevent freezing

(b) Recycled water mains shall not have less than 30 inches of cover over the top of the pipe except where necessary to avoid underground obstructions or rocky conditions

(c) Recycled water mains shall be installed at least:
(1) 10 feet horizontally from and one foot lower than water main.
(2) One foot higher than the sanitary sewer crossing the recycled water main
(3) Ten feet horizontally from sewage leach fields, cesspools, seepage pits and septic tanks.

(d) If the above requirements cannot be met due to topography, inadequate right-of-way or easements or conflicts with other provisions of these regulations, lesser separation is permissible if:
(1) The water main and recycled water line are located as far apart as feasible within the conditions listed above.
(2) The water main is appropriately constructed to prevent contamination of the water main by recycled water leakage.

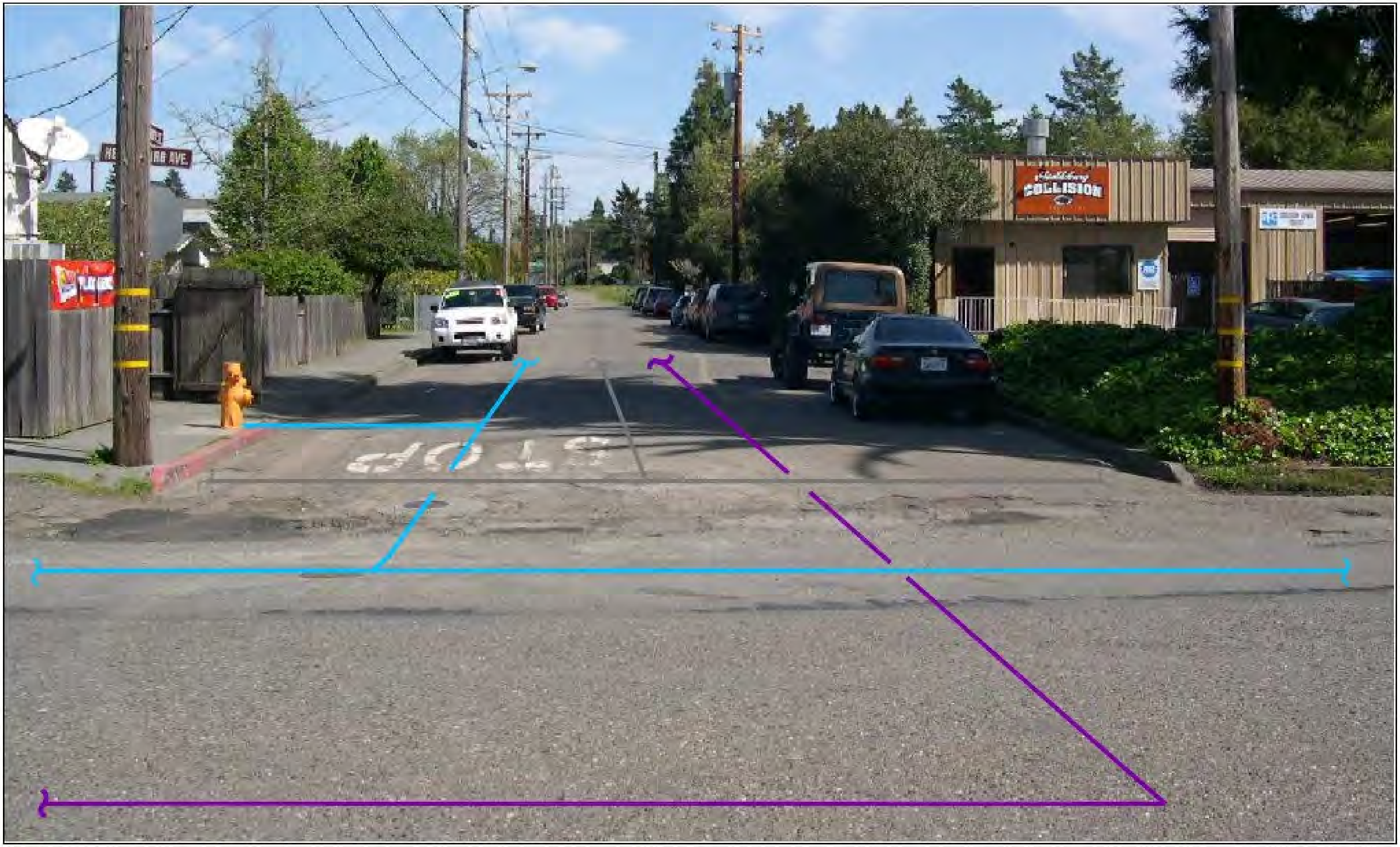
N

0 100 200
SCALE IN FEET

Figure 3-12

City of Healdsburg
Recycled Water Engineering Report
DISTRIBUTION SYSTEM

WEST YOST ASSOCIATES
Consulting Engineers



LEGEND

DOMESTIC WATER

SANITARY SEWER

PROPOSED RECYCLED WATER

DRAFT

Figure 3-13

City of Healdsburg

Recycled Water Engineering Report

CONCEPTUAL PIPELINE SEPARATION

WEST YOST ASSOCIATES Consulting Engineers

SECTION 4. USE AREAS

The ultimate Recycled Water use areas consist of approximately 1,350 acres and include 89 acres of turf and 1,261 acres of vineyards as discussed in Section 3.3. Turf areas inside the City limits consist of one cemetery, one golf course, two parks and four schools. The use areas within the City limits are currently irrigated using potable water from the City with the exception of Tayman Park Golf Course and Badger Park. Use areas outside the City limits are privately owned vineyards supplied with surface water captured in on-site reservoirs or groundwater supplied from irrigation wells.

The proposed use areas would be supplied by disinfected tertiary Recycled Water from the WWTP, as discussed in Section 2, from May 15 through September 30 in accordance with the City's NPDES permit and Title 22 requirements. The City will be responsible for delivering Recycled Water to the use areas while the landowner and/or user will be responsible for all on-site improvements necessary for Recycled Water use, monitoring, and reporting to the City. The City is planning to establish a Recycled Water User Agreement with each landowner and/or user prior to delivering Recycled Water.

The Recycled Water system may be constructed in phases. This first phase would consist of the pump station, the transmission and distribution system to deliver Recycled Water to the turf areas, and connection of the Recycled Water distribution system to the abandoned Tayman Park Reservoir. Vineyard areas could be connected in subsequent phases based on customer interest.

4.1 Irrigated Areas

Ultimate recycled water use areas inside the City limits consist of about 89 acres of irrigated turf varying in size from 2.4 to 58 acres each as shown in Table 4-1. Ultimate Recycled Water use areas outside of the City limits total 1,475 acres consisting of vineyards with individual areas ranging in size from 22 to 308 acres. Some of the identified vineyard areas may consist of multiple owners along Foreman Lane and Foss Creek resulting in multiple connections to the Recycled Water system.

Irrigation System Types and Mapping

Use areas inside the City limits are primarily irrigated by sprinkler systems as summarized in Table 4-1. Available irrigation maps in Figure 4-1 through Figure 4-9 show irrigated areas and underground piping at each site. The quality of the mapping is dependent on the information that was obtained from the proposed users. Most of the school sites have relatively new irrigation systems that are operated by an irrigation controller and automatically adjusted based on weather and turf conditions. The school sites are irrigated the same night at each site about four times per week from May through October.

Oak Mound Cemetery has various irrigation zones with one timer. However, most of the zones are manually irrigated during daylight hours. Each zone is irrigated every other day during the dry season for about one hour. There are two metered potable water connections. One metered connection is for irrigation and hose bibbs near the entrance, while the other connection is for irrigation, hose bibbs and two small buildings with toilets. Separating the potable and Recycled Water systems will entail consultation with Oak Mound Cemetery representatives to determine the potable water needs and points of use. Unless isolated from the Recycled Water system, the hose bibbs would need to be replaced with quick coupler devices, appropriately labeled as "Recycled Water do not drink" in both English and Spanish.

Table 4-1. Anticipated Recycled Water Use Area Summary

SITE ID	OWNER	LAND USE TYPE	CROP TYPE	IRRIGATION METHOD	AREA, AC	RECYCLED WATER IRRIGATION SCHEDULE[A]	IRRIGATION MAP FIGURE NUMBER
1	Foreman Lane Area	Agricultural	Vineyard	Drip	262.2	6:00 a.m. to 6:00 p.m.	N/A
2	Tayman Park	Golf Course	Turf	Sprinkler	57.7	10:00 p.m. to 6:00 a.m.	4-1
3	Badger Park	Park	Turf	Sprinkler	2.4	10:00 p.m. to 6:00 a.m.	4-2
4	Recreation Park	Park	Turf	Sprinkler	2.4	10:00 p.m. to 6:00 a.m.	4-3
5	East of Foss Creek	Agricultural	Vineyard	Drip	171.6	6:00 a.m. to 6:00 p.m.	N/A
6	West of Foss Creek	Agricultural	Vineyard	Drip	307.8	6:00 a.m. to 6:00 p.m.	N/A
7	North of Foreman Lane	Agricultural	Vineyard	Drip	21.5	6:00 a.m. to 6:00 p.m.	N/A
8, 8a,9	Syar	Agricultural	Vineyard	Drip	320	6:00 a.m. to 6:00 p.m.	N/A
10-14	Abbe	Agricultural	Vineyard	Drip	50.2	6:00 a.m. to 6:00 p.m.	N/A
15-21	Passalacqua	Agricultural	Vineyard	Drip	128.7	6:00 a.m. to 6:00 p.m.	N/A
22	Multiple[b]	Agricultural	Vineyard	Drip	213.3	6:00 a.m. to 6:00 p.m.	N/A
23-27	Oak Mound Cemetery	Cemetery	Turf	Sprinkler	4.9	10:00 p.m. to 6:00 a.m.	4-4
28	HJH Field[c]	School	Turf	Sprinkler	3.3	10:00 p.m. to 6:00 a.m.	4-5
29	HHS Field[d]	School	Turf	Sprinkler	11.8	10:00 p.m. to 6:00 a.m.	4-6 & 4-7
30	FMS Field[e]	School	Turf	Sprinkler	2.9	10:00 p.m. to 6:00 a.m.	4-8
31	HES Field[f]	School	Turf	Sprinkler	3.6	10:00 p.m. to 6:00 a.m.	4-9

(a) Assuming eight hours of irrigation within these time spans
(b) Multiple owners (yet to determine) near Westside Road and Foreman Lane
(c) HJH = Healdsburg Junior High School
(d) HHS = Healdsburg High School
(e) FMS = Fitch Mountain School
(f) HES = Healdsburg Elementary School

The irrigation system and booster pumps at Recreation Park were installed in 1999. The Park is irrigated from midnight to 7:00 a.m. Irrigation water for Badger Park and Tayman Park Golf Course is supplied from a groundwater well at Badger Park. Irrigation scheduling information was unavailable for Badger Park and Tayman Park. Individual use area deviations from the hydraulic modeling assumptions about irrigation schedules (Section 3) are not anticipated to alter the overall conclusions.

Use areas outside the City limits are primarily vineyards with drip irrigation systems. Depending on the type of drip irrigation system, each vine could have between one and four drip emitters with each emitter flowrate between 0.5 and 2.0 gallons per hour. Vineyard blocks are irrigated once or twice per week. Depending of the grower's management practices, each vine probably receives between 6 and 16 gallons of water per week.

The drip irrigation systems are primarily supplied by groundwater wells. Some vineyards use surface water that is collected and stored under an appropriative right for irrigation purposes. Some vineyard areas have overhead sprinkler systems that are used for frost protection during the early spring months when Recycled Water discharge to the Basalt Pond is permissible. It is anticipated that Recycled Water for frost protection use will be limited and constrained to whatever the system designed for drip irrigation can provide.

In most cases, use areas inside the City limits will be irrigated at night between the hours of 10:00 p.m. to 6:00 a.m., helping to minimize public contact with Recycled Water. It is anticipated the use areas outside the City limits will be irrigated for eight hours during the daylight hours of 6:00 a.m. to 6:00 p.m. as shown in Table 4-1. Offsetting the two demand periods will spread the Recycled Water demand over the course of the day.

Surrounding Land Uses

Land use types within the City were identified from the City's General Plan. The Recycled Water use areas inside the City limits are commercial and institutional turf areas surrounded by residential areas as shown in Figure 4-10. The one exception is Badger park (site ID #3), which is bordered to the south by the Russian River.

Land use types outside the City limits were obtained from the Department of Water Resources 1999 Land Use Survey, although it is recognized that some land uses have changed since 1999 (e.g. Mill Creek area is now primarily vineyard). Recycled Water use areas outside the City limits are primarily vineyards surrounded by other vineyards, native vegetation, rural residential housing, and perennial creeks as shown in Figure 4-10. The Draft EIR also identified the potential for redwood tree irrigation in portions of the Syar property, however this was not included in final design of the system.

Access Control

Access control varies from site to site. Some use areas have perimeter fencing and locked gates while other sites have unrestricted pedestrian access. Because the City is using disinfected tertiary Recycled Water, perimeter fencing is not necessary at each site; however, signage will need to be installed at pedestrian access locations at each site in accordance with Section 60310 of the Water Recycling Criteria (Criteria). Except at the Oak Mound Cemetery, turf irrigation will normally occur at night (10:00 p.m. to 6:00 a.m.), limiting the risk of public contact with Recycled Water.

Turf areas are generally accessible during daylight hours while public access is restricted at night. Current site access control is summarized in Table 4-2. Pedestrian access at Badger Park is unrestricted at this time. There are entrance gates to restrict vehicular access but no perimeter fencing to restrict pedestrian access. Tayman Park Golf Course has perimeter fencing to prevent pedestrians from walking onto the site and the locked gate at the vehicle entrance would prevent vehicular access at night. Pedestrians could walk around the vehicle gate, follow the access road to the club house, and gain access to the use areas. Recreation Park has perimeter fencing and locked perimeter gates limiting public access to designated use periods.

Table 4-2. Recycled Water Use Area Access Summary

SITE ID	OWNER	LAND USE TYPE	RESPONSIBLE PARTY	POTENTIAL ACCESS	TYPE OF ACCESS CONTROL	DEGREE OF ACCESS CONTROL
1	Foreman Lane Area	Agricultural	Owner	Employees	None	Low
2	Tayman Park (including reservoir site)	Golf Course	City	Public	Perimeter fencing	Medium
3	Badger Park	Park	City	Public	None	Low
4	Recreation Park	Park	City	Public	Perimeter fencing, locked gates	High
5	East of Foss Creek	Agricultural	Owner	Employees	None	Low
6	West of Foss Creek	Agricultural	Owner	Employees	None	Low
7	North of Foreman Lane	Agricultural	Owner	Employees	None	Low
8-9	Syar	Agricultural	Owner	Employees	None	Low
10-14	Abbe	Agricultural	Owner	Employees	None	Low
15-21	Passalacqua	Agricultural	Owner	Employees	None	Low
22	Multiple[(a)]	Agricultural	Owner	Employees	None	Low
23-27	Oak Mound Cemetery	Cemetery	Owner	Public	Perimeter fencing, locked gates	High
28	HJH Field[(b)]	School	City	Public	Perimeter fencing, gates	Medium
29	HHS Field[(c)]	School	City	Public	Perimeter fencing, traffic bollards	Low
30	FMS Field[(d)]	School	City	Public	Partial perimeter fencing, lockable gates	Low
31	HES Field[(e)]	School	City	Public	Partial perimeter fencing, lockable gates	Low

(a) Multiple owners (yet to determine) near Westside road and Foreman Lane
(b) HJH = Healdsburg Junior High School
(c) HHS = Healdsburg High School
(d) FMS = Fitch Mountain School
(e) HES = Healdsburg Elementary School

Oak Mound Cemetery has perimeter fencing around the site and a locked gate to restrict both vehicular and pedestrian access. The gate is closed and locked at night. Healdsburg Junior High has perimeter fencing and lockable perimeter gates. Healdsburg High School has perimeter fencing with breaks to allow pedestrian access. Traffic bollards are installed at the fence breaks to restrict vehicular access. Fitch Mountain School has perimeter fencing with lockable gates on the south side of the use area. There is no perimeter fencing on the east side. Healdsburg Elementary School has incomplete perimeter fencing with gaps allowing unrestricted pedestrian access.

Vineyard areas are privately owned and public access is not allowed on these sites. Employees will be notified that Recycled Water will be used on-site. Education and training programs to better understand the precautions of using Recycled Water will be offered by the City to each contracted user.

Signage

Signs will need to be placed in access areas where Recycled Water is used in accordance with the Criteria and printed in Spanish and in English.

As stated in Section 60310 of the Criteria, Recycled Water warning signs should meet the following criteria:

- Be no less than 4 inches high by 8 inches wide
- Include the wording “Recycled Water- Do Not Drink”
- Display the international symbol for “Do Not Drink”

The Criteria state that CDHS may accept alternative signage and wording (or an educational program) provided that an equivalent degree of protection is provided by the alternative.

User Agreements

User Agreements will establish user responsibilities for the application of Recycled Water in accordance with applicable laws, statutes, rules, regulations, and guidelines including those promulgated by CDHS and the Regional Board. These requirements include the following:

- The use of Recycled Water shall be for irrigation only within designated areas.
- Irrigation runoff shall be minimized or controlled. Required actions to control runoff include, but are not limited to:
  - Maintenance of check dams and containment berms by keeping them clear of silt, sediment and vegetation, and free of gaps, breaks, holes, and other conditions that could compromise the integrity of the dam/berm
  - Minimizing the accumulation of water behind check dams by reapplying such water to irrigation land in a timely manner
  - Emptying the check dams of any captured runoff flows at the end of the irrigation season
  - Controlling all stormwater runoff in this manner for at least 30 days past the last day of irrigation with Recycled Water
  - Ensuring runoff does not enter storm drain facilities

- Spray shall be controlled. Required actions to control spray runoff include, but are not limited to:
  - Ensuring spray and/or mist does not enter dwellings, designated outdoor eating areas, or storm drain facilities
  - Ensuring any drinking water fountains are protected from spray and/or mist
- Public areas where Recycled Water is used should be restricted and/or clearly marked with appropriate signage.
- Piping, controllers, valves, etc. should be clearly marked and secured to ensure operation only by the user.
- Hose bibbs shall be replaced with appropriately labeled quick coupler devices.
- New construction should ensure at least a four foot horizontal and a one foot vertical separation between all pipelines transporting Recycled Water and those transporting potable water, with the potable water line above the Recycled Water line.
- There shall be no connection between the potable water system and the Recycled Water piping.
- Air-gap separation or appropriate backflow prevention devices shall be provided at all potable water service connections to the Recycled Water use area. State policy also requires that supplementing the Recycled Water supply by connection with irrigation or industrial wells requires an air-gap separation device.
- No irrigation or impoundment of Recycled Water shall occur within 50 feet of any domestic water supply well (unless specific requirements are met to protect the well).
- Inspection, supervision, and employee training shall be provided.
- Maintenance will be provided for access roads, including grading and debris removal. Additionally, the tenant should be responsible for repair of all fencing and gates, repair and maintenance of all drainage ditches and culverts to ensure movement of return flows and to minimize standing water in fields, repair of flood irrigation valves (excluding City-owned valves), removal of noxious weeds, and field maintenance and monitoring.
- Cooperate with vector control officials.
- Operation of the Recycled Water irrigation and return flow pumping and distribution facilities, such that the irrigation demands are reliably met.

It is sometimes appropriate for the User Agreement to include restrictions on the timing of Recycled Water irrigation to minimize potential for public exposure (depending on the degree of public access to the site or adjacent areas). As User Agreements are executed by the City and users, the Agreements will be incorporated into Appendix H of this report.

Water Wells

The City owns and operates the public water system within the City limits. City well fields are located in the northern, western, and southern portions of the City and are known as the Gauntlett, Dry Creek, and Fitch Mountain well fields, respectively. Groundwater from the municipal wells is chlorinated and fluoridated prior to entering the distribution system. The Gauntlett well field, located at the northern portion of the City, has four permitted wells. The supply from these wells has been designated by CDHS as groundwater under the influence of surface water. In September 2005, the City began operation of a 2.6 mgd membrane filtration plant to treat the water supply from the Gauntlett well field. These wells are permitted for use 12 months out of the year.

The Dry Creek well field has five permitted wells that have been designated as groundwater wells by CDHS. The Fitch Mountain well field has four permitted wells. The supply from these wells has been designated by CDHS as groundwater under the influence of surface water. Because of surface water influence, CDHS permits use only after water quality verification and limited to May through October. It is anticipated by 2012, raw water from the Fitch Mountain well field will be piped to and treated at an expanded membrane filtration plant near the Gauntlett well field.

There are very few domestic wells within the City limits and none of the known domestic wells are within 50 feet of Recycled Water use areas inside the City limits. Outside the City limits, individual homes are supplied by domestic wells, and some use areas could be within 50 feet of the wells. Under these circumstances, certain conditions must be met when using Recycled Water near domestic water supply wells.

Separation Distance to Supply Wells

According to Section 60310 of the Criteria, irrigation with tertiary treated Recycled Water shall not take place within 50 feet of any domestic water supply well unless the following five conditions have been met:

1. A geological investigation demonstrates that an aquitard exists at the well between the uppermost aquifer being drawn from and the ground surface.

2. The well contains an annular seal that extends from the ground surface into the aquitard.

3. The well is housed to prevent Recycled Water spray from coming into contact with the wellhead facilities.

4. The ground surface immediately around the wellhead is contoured to allow surface water to drain away from the well.

5. The well owner waives the buffer zone requirement.

Satisfying these criteria will entail case by case consultations with the applicable Recycle Water users. In some locations, this will require minor modifications to the irrigation plumbing to isolate a small number of vines within 50 feet of the domestic wells. Prior to beginning irrigation with recycled water, City staff would inspect the site of each domestic well with user staff to insure that the necessary 50 foot buffer has been created.

Well Construction Information

To locate groundwater wells within the use areas, well completion reports, also known as well driller logs, were obtained from the California Department of Water Resources (DWR). Well logs are confidential, and publishing of site specific information is prohibited by DWR. Therefore, only general well construction information is contained in this section.

Approximately 275 well logs were obtained from DWR. The well logs include agricultural, domestic, industrial, monitoring and test wells. The years of construction ranged from the early 1920s to the mid-2000s. About 64 of the wells are domestic wells within 1,000 feet of the use areas, and these wells are the focus of this report.

According to the well logs, domestic well construction is generally completed to a depth of 50 to 300 feet, but some domestic wells are as deep as 500 feet. The well casings are generally 5 to 10 inches in diameter. Sanitary seals range from 0 to 30 feet deep with most wells sealed to a depth of 20 feet.

The well locations shown in Figure 4-11 are based on the well log street address. Associating the street address with the specific well location is difficult because the street address does not necessarily align with structures identified in the aerial photographs. Therefore, the location of each well in Figure 4-11 is approximate and will need to be field verified in consultation with the Recycled Water users.

Groundwater wells are identified in Figure 4-11 by the well log number followed by the year the well was drilled. For example, the designation 122323-1977 corresponds to well log number 122323 for a well that was drilled in 1977. Not every building identified in aerial photographs has an associated well log. Therefore, buildings that appear to be homes without associated well logs have been identified in Figure 4-11 as homes with potential wells.

Prior to delivering Recycled Water to the use area, the site will need to be evaluated to determine the proximity between the domestic well and the use area. If the application of Recycled Water is within 50 feet of a domestic well, the previously mentioned conditions will need to be met.

Supplemental Water Supply

The proposed Recycled Water use areas are currently irrigated with either potable water supplied by the City, privately owned surface water facilities or groundwater wells. Supplying Recycled Water to these use areas could reduce or eliminate dependency on the current water supply source. The Recycled Water users will most likely maintain their current water source as a back-up to minimize impacts due to interruption in the delivery of Recycled Water or to preserve water rights.

Where required by Title 22 regulations, appropriate cross-connection control measures must be installed at sites that maintain a back-up water supply, and the User Agreement will need to identify the responsible party for each back-up supply to ensure that cross-connection controls are implemented properly.

The proposed use areas within City limits will have City-approved backflow prevention devices installed at any potable water supply connections. Before irrigation systems are connected to the Recycled Water distribution system, measures will need to be taken to ensure the backflow prevention device is properly functioning to prevent cross connections with the potable water system. Quick coupler devices will be installed in place of hose bibbs and clearly labeled as Recycled Water, encouraging disconnection when not in use to prevent inadvertent use of Recycled Water.

The vineyard areas served by this project have historically used on-site wells as the water supply source. These systems are typically configured so that the irrigation system and potable household supplies are each supplied from separate dedicated wells. For dedicated irrigation systems, cross-connection or air-gap control is not required. However, if the cross-connection survey finds any cross-connection between the potable and irrigation water supplies, the Criteria would require that the potable supply be protected by air gap separation.

The Tayman Park reservoir will have a supplemental potable water supply from the City's Fitch Well Field near Badger Park. The supply will be connected to the existing 16-inch water line that extends from the Fitch Well Field to the twp 1.65 MG potable water tanks at the Tayman Park Golf Course. This supply will be fed from a separate 8-inch water line which will be mounted to the exterior of the tank and extend over the top of the tank wall. This will provide at least the required minimum of 16" (2 diameters) in air-gap separation between the potable water fill inlet and the top of the tank overflow weir. The fill will be controlled by an 8-inch motorized valve on the fill line. Figure 4-12 shows a cross section of the fill lines and overflow within the tank.

Cross-Connection Control

The purpose of a cross-connection control program is to protect the public water system from contamination by isolating potential contaminants and providing continual maintenance of backflow prevention assemblies. City Ordinance No. 976 establishes a cross-connection control program for the City and has been adopted in accordance with the California Code of Regulations, Title 17. This ordinance includes the following requirements:

- Allowable backflow prevention devices
- Backflow prevention assembly location
- Required testing and maintenance frequency for backflow devices
- City's right to enter private property
- Cross-Connection Control Program enforcement
- Monthly service fees
- City's right to terminate a customer's water service

In general, the City's cross-connection ordinance requirements are adequate for the protection of public water supplies. However the following issues should be considered when Recycled Water is to be supplied to users within the City:

- Each Recycled Water user will need to designate a reclamation supervisor who would serve as the direct contact with the City on any Recycled Water issue, including adherence to the City's cross-connection control program. Items that should be considered in the User Agreement with respect to a cross-connection control program include:
  - The user must comply with all orders, instructions, regulations, and notices from the local health officer with respect to the installation, testing, and maintenance of backflow prevention devices.
  - The user may be required to pay fees to the local health officer to offset the costs of the cross-connection control program.

The user will be ultimately responsible for ensuring that violations to the cross-connection control program do not occur. The City will require that the initial cross-connection control survey and shutdown test be conducted at all future recycled water use sites to ensure that no cross-connections exist. The results of each initial cross-connection inspection and shutdown test will be documented with a summary of findings in a written report, which will be maintained on file. Each report will be submitted to the Department within two weeks of activation of any new recycled water use site.

In the event that violations do occur, the user will be held responsible.

- All pipes installed on or after June 1, 1993 for the purpose of conveying Recycled Water should be colored purple or distinctively wrapped with purple tape (including backflow prevention devices). Note that purple pipe is not required for municipal and industrial facilities that have established an alternative labeling or marking system on their premises that clearly distinguishes Recycled Water from potable water. Furthermore, distinctive purple pipe is not required in agricultural use areas.
- The types of backflow protection required at premises where Recycled Water is supplied are as follows:
  - An air-gap backflow prevention device is required on premises where City water is used to supplement the Recycled Water supply.
  - A reduced pressure principle backflow prevention device is required on premises where Recycled Water is used to supplement an existing irrigation water supply, and there is no interconnection with the potable water system.
  - A double check valve assembly backflow prevention device is required if residences using Recycled Water for landscape irrigation are part of an approved dual plumbed use area with an alternative backflow protection plan. An alternative backflow protection plan would need to include an annual inspection and annual shutdown test of the Recycled Water and potable water systems.

4.2 Impoundments

The City will store Recycled Water in one pond on City owned property at the WWTP. Public access is restricted by a perimeter chain link fence at this site. Recycled Water storage in the distribution system will be limited to the new Tayman Park reservoir (Section 3).

The Tayman Park reservoir will be located adjacent to the Tayman Park Golf Course. The reservoir site is on a hilltop well screened by trees above the Oak Mound Cemetery. The tank will be bolted glass-fused-to-steel construction, and will have a diameter of 67 feet, with 28.5-foot high side walls. Critical areas of the tank will be protected with fencing and locked man-gates, including area around the tank ladder access and where fill lines are exposed outside the tank. Fencing will be 6' chain-link with an angled 3-strand barbed wire security fence at the top.

As depicted in Figure 3-4, the overflow line from the new Tayman Park reservoir will be directed to a drain line that discharges to the north slope of the hilltop site. Drainage from this location flows down the north slope to a small drainage tributary running east to west across the golf course. Levels in the reservoirs will be monitored by an existing Supervisory Control and Data Acquisition System (SCADA) owned and operated by the City. The recycled water irrigation pumps at the treatment plant, as well as the motor-operated valve on the potable water fill line, will be controlled by programmable logic controllers (PLC's) which monitor the water level transducer in the tank. With proper operation, the tank overflow will never be used. The City operates eight tanks in its existing water distribution system using identical controls, and has never experienced an overflow with this control system.

4.3 Cooling

Cooling water is not an element of the City's Recycled Water program.

4.4 Groundwater Recharge

Groundwater recharge is not an element of the City's Recycled Water program.

4.5 Dual Plumbed Use Areas

The WWTP will use Recycled Water as the water supply for the fire suppression. In addition to the fire suppression system, Recycled Water will be used for in-plant process flows for screen washing, wash-down, and scum control. Because Title 22 excludes fire suppression systems from the definition of dual plumbed use areas and the Recycled Water requirements do not apply to the use of onsite Recycled Water at a WWTP with public access restricted, dual plumbed use is not an element of the City's Recycled Water program.

4.6 Other Industrial Uses

Industrial use is not an element of the City's Recycled Water program.

4.7 Use Area Design

Designs for areas Badger Park and Recreation Park (Site ID's 3 and 4) have been included in Appendix I. Other use area designs will be added to Appendix I of this report as they are completed during the final design process. All designs will adhere to the requirements discussed in Section 4 of this report.

4.8 Use Area Inspections and Monitoring

Runoff

Use areas within the City limits have sprinkler systems for turf irrigation. Sprinkler systems have a higher runoff probability due to typical application rates and potential overspray onto sidewalks. Sprinklers need to be adjusted to prevent overspray onto sidewalks, which can cause runoff. The sprinkler application rate must be lower than the soil's infiltration rate. If application rates are greater than the soil's ability to infiltrate the water, runoff or ponding will occur. Individual sites will need to be inspected to verify that sprinkler heads do not overspray sidewalks, drinking fountains, picnic areas, or any other areas where runoff could occur.

The turf areas inside the City limits are generally irrigated every couple of days in the summer depending on temperatures. Some school sites include smart, weather based, irrigation controllers to prevent over watering. These controllers use local weather and soil moisture information to automatically adjust irrigation schedules. These controllers, properly installed and adjusted, should minimize runoff and ponding.

The direction of on-site drainage varies from site to site as summarized in Table 4-3. Some sites such as Tayman Park and Oak Mound Cemetery are characterized by undulating hillside topography, and runoff could occur in several directions. Other sites such as Recreation Park are generally flat. The irrigation area at Healdsburg Junior High is located in a depression, which would prevent off-site runoff.

The direction of drainage outside the City limits also varies between sites as summarized in Table 4-3. A significant number of the vineyard areas are flat. However, vineyard sites numbered 10 through 21 are characterized by undulating topography. Even on the very steep slopes, however, vineyard irrigation runoff should be nonexistent as a result of the drip irrigation system used and management practices. Drip irrigation systems are low volume irrigation systems, with drip emitter flow rates typically in the range of one-half to two gallons per hour, and operate between four to eight hours at a time. Grower's often under-irrigate vineyards to stress the grapes, so the runoff risk is very low during the irrigation season.

Inspection and Maintenance

As part of any User Agreement, the City will designate a Recycled Water supervisor (Site Supervisor) who will serve as the direct contact with the City on any recycled water issues. The Site Supervisor would be responsible for ensuring that all aspects of the User Agreement are met, including cross-connection avoidance. The City will train the designated Site Supervisors to ensure adherence to all aspects of the user agreement, the City's reclamation permit. The training will include prevention of cross-connections during the installation, operation and maintenance of the user's pipelines and equipment; day-to-day operations; compliance with CDHS and Regional Board regulations; and monitoring and coordination with the City and with regulatory agencies, as necessary. The City will be provided with telephone and/or pager numbers to allow for 24-hour communications with the Recycled Water supervisor.

In addition, the City's user agreements will include language requiring Site Supervisors to communicate at least quarterly to inform the City of any system modifications, system irregularities, verify employee training. The language will also require that Site Supervisors promptly report any unusual occurrences that may result in a violation of the agreement.

Table 4-3. Direction of Drainage

SITE ID	LOCATION	LAND USE TYPE	CROP TYPE	IRRIGATION METHOD	DIRECTION OF DRAINAGE
1	Foreman Lane Area	Agricultural	Vineyard	Drip	Generally Flat
2	Tayman Park	Golf Course	Turf	Sprinkler	Varies
3	Badger Park	Park	Turf	Sprinkler	West
4	Recreation Park	Park	Turf	Sprinkler	Generally Flat
5	East of Foss Creek	Agricultural	Vineyard	Drip	Generally Flat
6	West of Foss Creek	Agricultural	Vineyard	Drip	Generally Flat
7	North of Foreman Lane	Agricultural	Vineyard	Drip	Generally Flat
8-9	Syar	Agricultural	Vineyard	Drip	Generally Flat
10-14	Abbe	Agricultural	Vineyard	Drip	Varies
15-21	Passalacqua	Agricultural	Vineyard	Drip	Varies
22	Multiple[(a)]	Agricultural	Vineyard	Drip	Generally Flat
23-27	Oak Mound Cemetery	Cemetery	Turf	Sprinkler	Varies
28	HJH Field[(b)]	School	Turf	Sprinkler	Generally Flat
29	HHS Field[(c)]	School	Turf	Sprinkler	Generally Flat to Northwest
30	FMS Field[(d)]	School	Turf	Sprinkler	Generally Flat
31	HES Field[(e)]	School	Turf	Sprinkler	Generally Flat

(a) Multiple owners (yet to determine) near Westside Road and Foreman Lane.
(b) HJH = Healdsburg Junior High School
(c) HHS = Healdsburg High School
(d) FMS = Fitch Mountain School
(e) HES = Healdsburg Elementary School

Additionally, the User Agreements should include a clause specifying that the City, CDHS, Regional Board, and County health and vector control officials can access the site to: observe the Recycled Water facilities to ensure they are in compliance with the state and local regulations; maintain any City-owned facilities; read Recycled Water flow meters; and verify that the user is operating the facilities in accordance with the User Agreement. Finally, if the City has a User Agreement with a landowner, and the landowner were to lease the property to another party, that party must be responsible for all aspects of the User Agreement, unless alternative arrangements are made.

For irrigation areas covered by User Agreements, controls and other requirements will be necessary to ensure that Recycled Water is applied in accordance with applicable laws, statutes, rules, regulations, and guidelines. Therefore, the City's User Agreements should clearly establish which party is responsible for each part of the agreement. Possible controls include the following:

- Recycled Water flow meters to monitor delivery volumes for reporting to CDHS and the Regional Board on an annual basis and for City monitoring purposes, and fittings to connect the City's Recycled Water pipeline to the user's irrigation system (easements may be needed by City to establish such connections).
- Replacement of any hose bibbs with quick coupler devices.
- Either provision of unirrigated buffer zones with a minimum 50-foot radius around domestic wells, relocation of domestic wells to a minimum of 50 feet horizontally from the closest Recycled Water use area, or protection of any domestic well within 50 feet of the use area to prevent intrusion of Recycled Water into the wellhead.
- Provision of unirrigated buffer zones or relocation or protection of any drinking fountains and outdoor eating areas to prevent contamination from spray drift.
- Air-gap separation or backflow prevention devices for on-site potable water systems.
- Fencing and appropriate signage.
- Marking of all piping, valves, valve boxes, controllers, and any other irrigation components to differentiate from potable water facilities.
- Dams and embankments to prevent runoff from leaving the user's property during irrigation and pumping equipment to re-apply collected drainage to the use area.

The existing sprinklers at Oak Mound Cemetery could spray Recycled Water onto the perimeter access roads. This condition, coupled with undulating topography, increases the probability of runoff at the site. Therefore, the irrigation system at Oak Mound Cemetery should be improved and/or closely monitored for runoff control.

Two other sites that may need to be monitored are the City's Fitch Mountain and Dry Creek well fields. The nearest well in the Fitch well field is located approximately 500 feet east of the Badger Park use area. Title 22 treated recycled water cannot be used within 50 feet of a groundwater well without meeting certain conditions for well construction. The City wells are relatively shallow; the deepest is completed to a depth of 85 feet. The two oldest wells, constructed in 1973, have a 20-foot sanitary seal with the top of the well screen beginning at 20 feet below ground surface. As previously discussed, the City recently constructed a membrane filtration plant to treat the water supply from the Gauntlett well, and it is anticipated that raw water from the Fitch Mountain well field will eventually be piped and treated at an expanded membrane filtration plant.

The Dry Creek well field is located west of the City at the corporation yard along Westside Road and Dry Creek. There are five municipal wells located at the site but only one well log was available. The well log indicated the well is completed to a depth of 53 feet below ground surface with a sanitary seal to a depth of 20 feet and the top of the well screen starting at 34 feet below ground surface. The Dry Creek wells are not within 50 feet of the nearest use areas and no additional wellhead precautions are necessary.

Recycled Water irrigation at Badger Park and use areas near the Dry Creek well field should be closely monitored by the City to prevent over-irrigation and potential contamination of the water supply.

4.9 Education Programs/Employee Training

City employees responsible for operating and overseeing the Recycled Water system will need regular training with regards to monitoring and reporting requirements. Training sessions should include a discussion of the safety procedures that should be used when operating the Recycled Water facilities. The safety training should include, but is not limited to, the following guidelines involving the use of Recycled Water:

1. Direct contact with Recycled Water is to be avoided, and Recycled Water should never be used as drinking water.

2. Irrigation using Recycled Water is only allowed on the designated use areas.

3. Irrigation drainage water must be captured and returned to the use area when using Recycled Water for irrigation.

4. Recycled Water is not to leave the use area or to be used for any purpose other than irrigation of the designated use area.

Farmers applying Recycled Water for irrigation purposes are required to adhere to the restrictions identified in the User Agreement. A typical user agreement is provided in Appendix H. This example user agreement could be used as a template and modified to meet City requirements. Training materials will be made available by the City to the Recycled Water users.

SCALE: NTS

Note: Image obtained from others

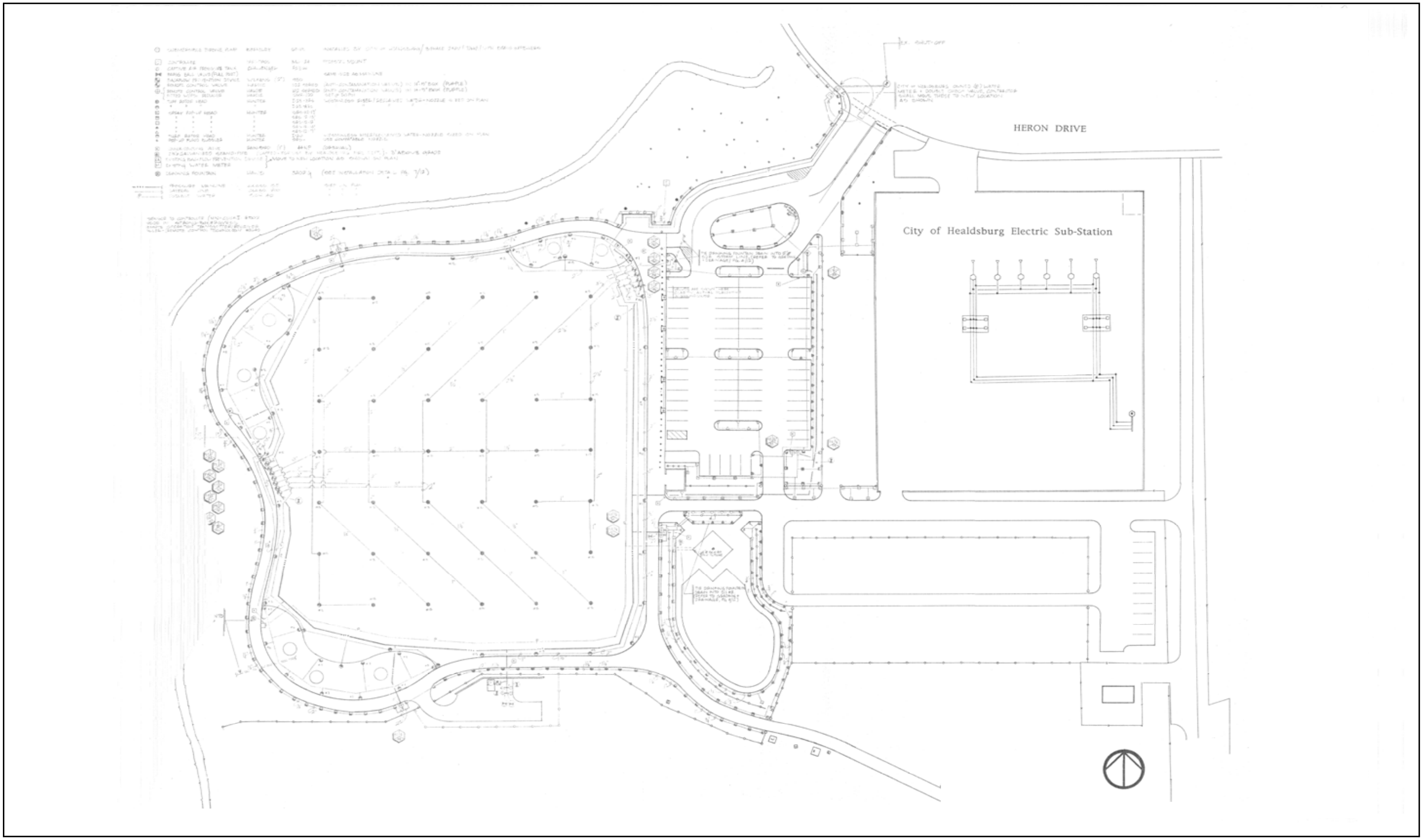
Figure 4-1

DRAFT

City of Healdsburg
Recycled Water Engineering Report
TAYMAN PARK IRRIGATION LAYOUT

WEST YOST ASSOCIATES
Consulting Engineers

S:\Clients\700 Healdsburg\04-06-02 Recycled Water Engineering Report\CAD\Figures\Tayman park irrigation map.dwg 5-07-07 10:02:39 AM jwestra



Note: Image obtained from others

Figure 4-2

City of Healdsburg
Recycled Water Engineering Report

BADGER PARK IRRIGATION LAYOUT

WEST YOST ASSOCIATES
Consulting Engineers

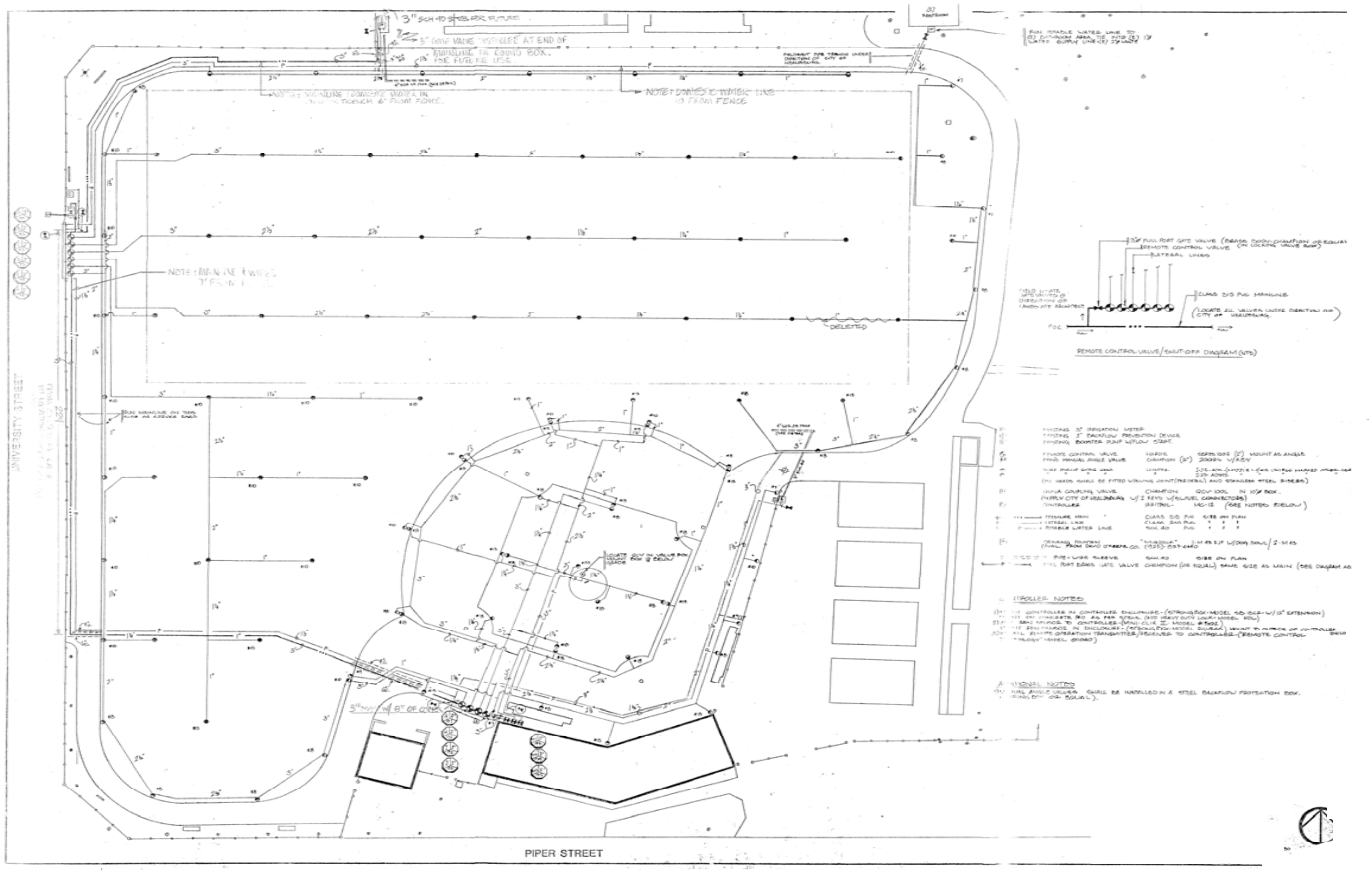


Figure 4-3

City of Healdsburg
Recycled Water Engineering Report
RECREATION PARK IRRIGATION LAYOUT

Note: Image obtained from others

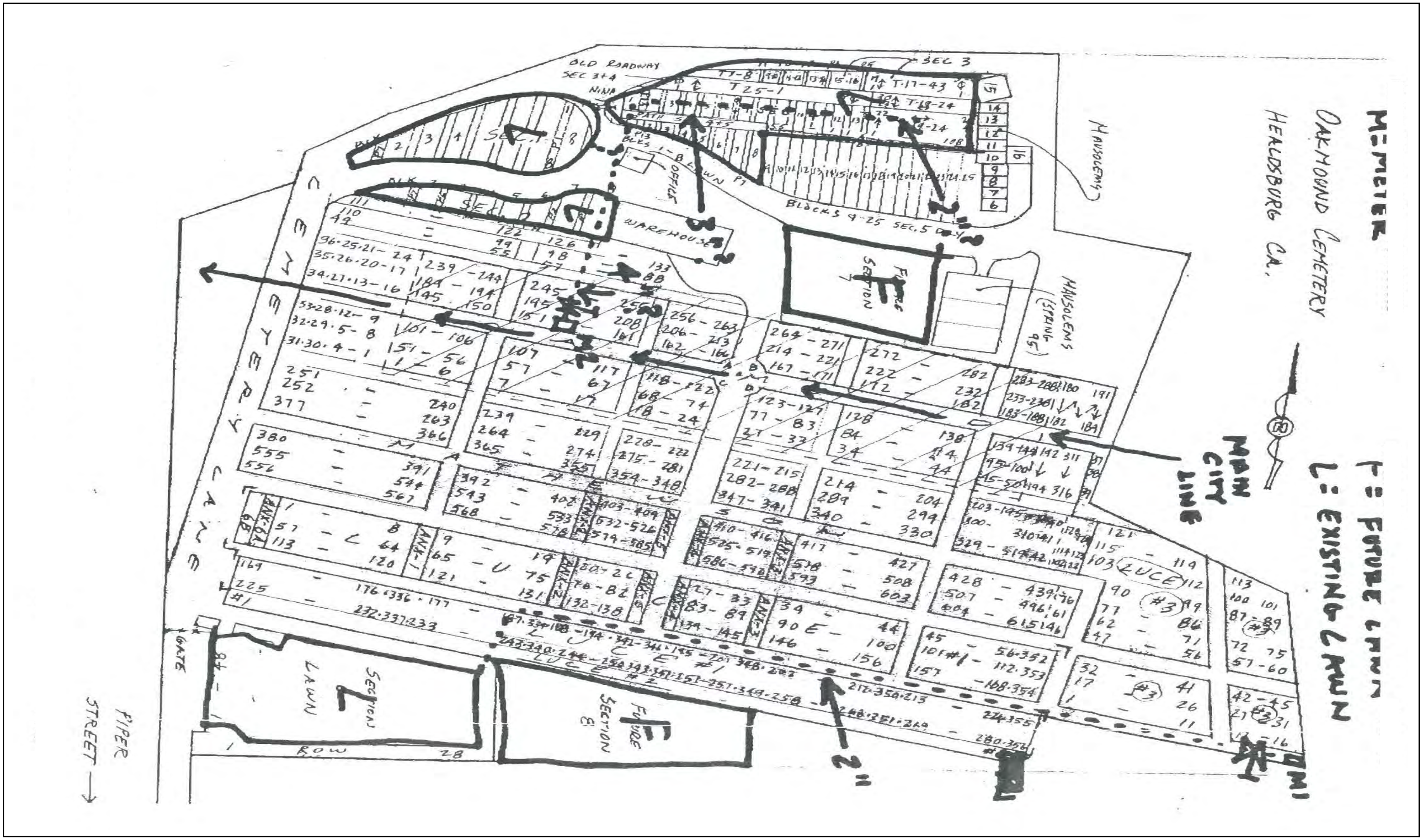


Figure 4-4

City of Healdsburg
Recycled Water Engineering Report
OAK MOUND CEMETERY IRRIGATION LAYOUT

Note: Image obtained from others

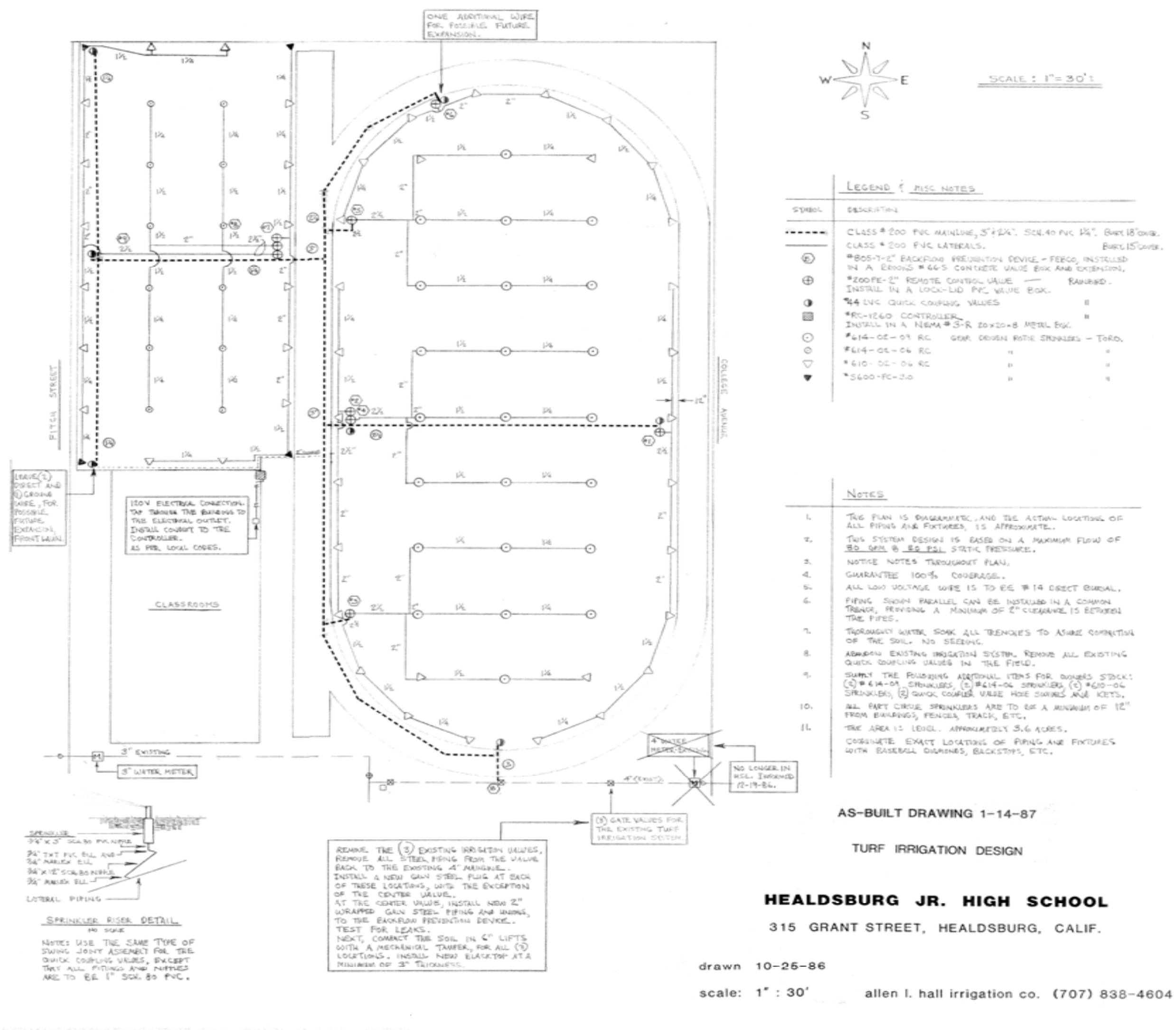


Figure 4-5

City of Healdsburg
Recycled Water Engineering Report

HEALDSBURG JR. HIGH SCHOOL IRRIGATION LAYOUT

Note: Image obtained from others

WEST YOST ASSOCIATES
Consulting Engineers

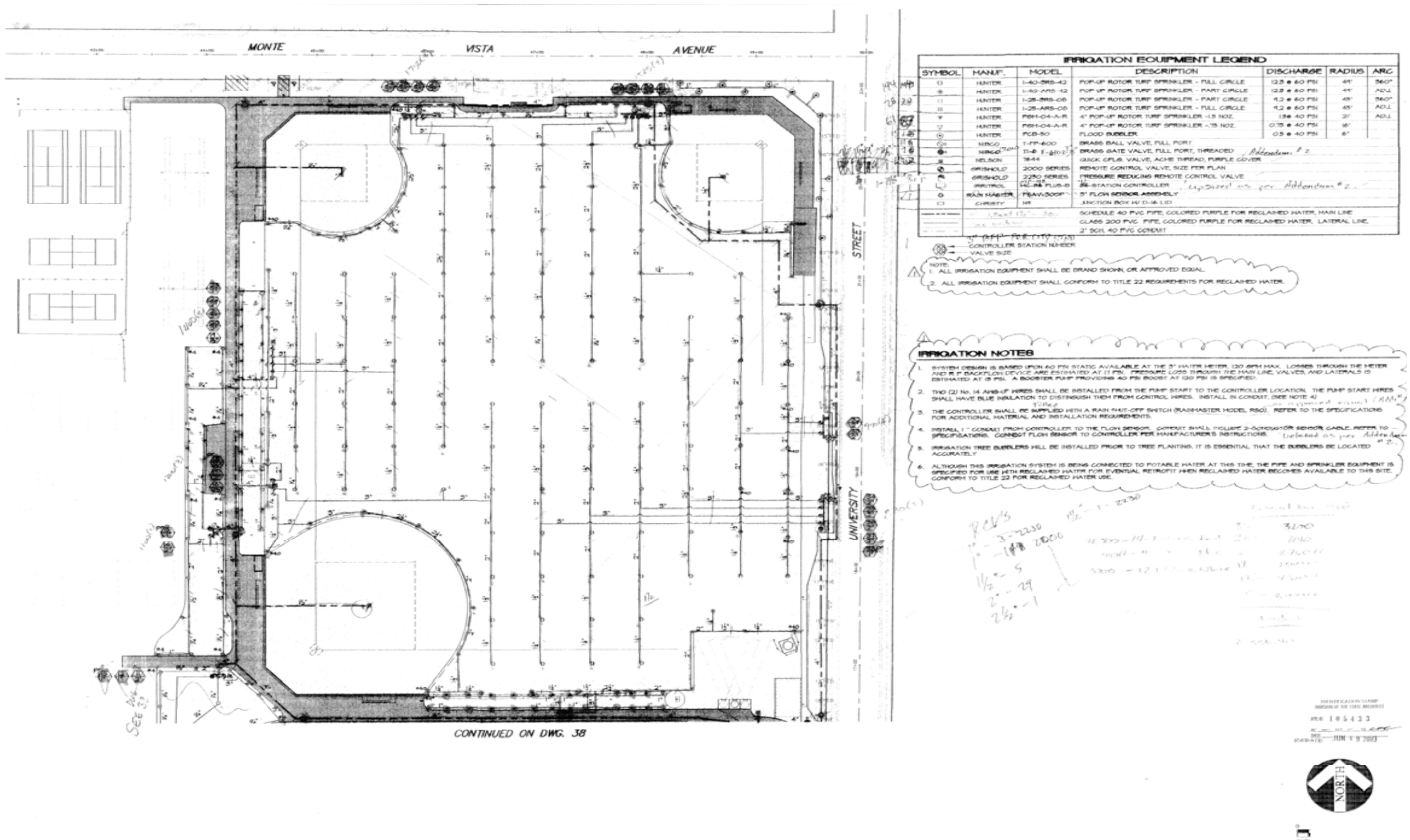


Figure 4-6

City of Healdsburg

Recycled Water Engineering Report

HEALDSBURG HIGH SCHOOL IRRIGATION LAYOUT - NORTH PORTION

Note: Image obtained from others

WEST YOST ASSOCIATES
Consulting Engineers

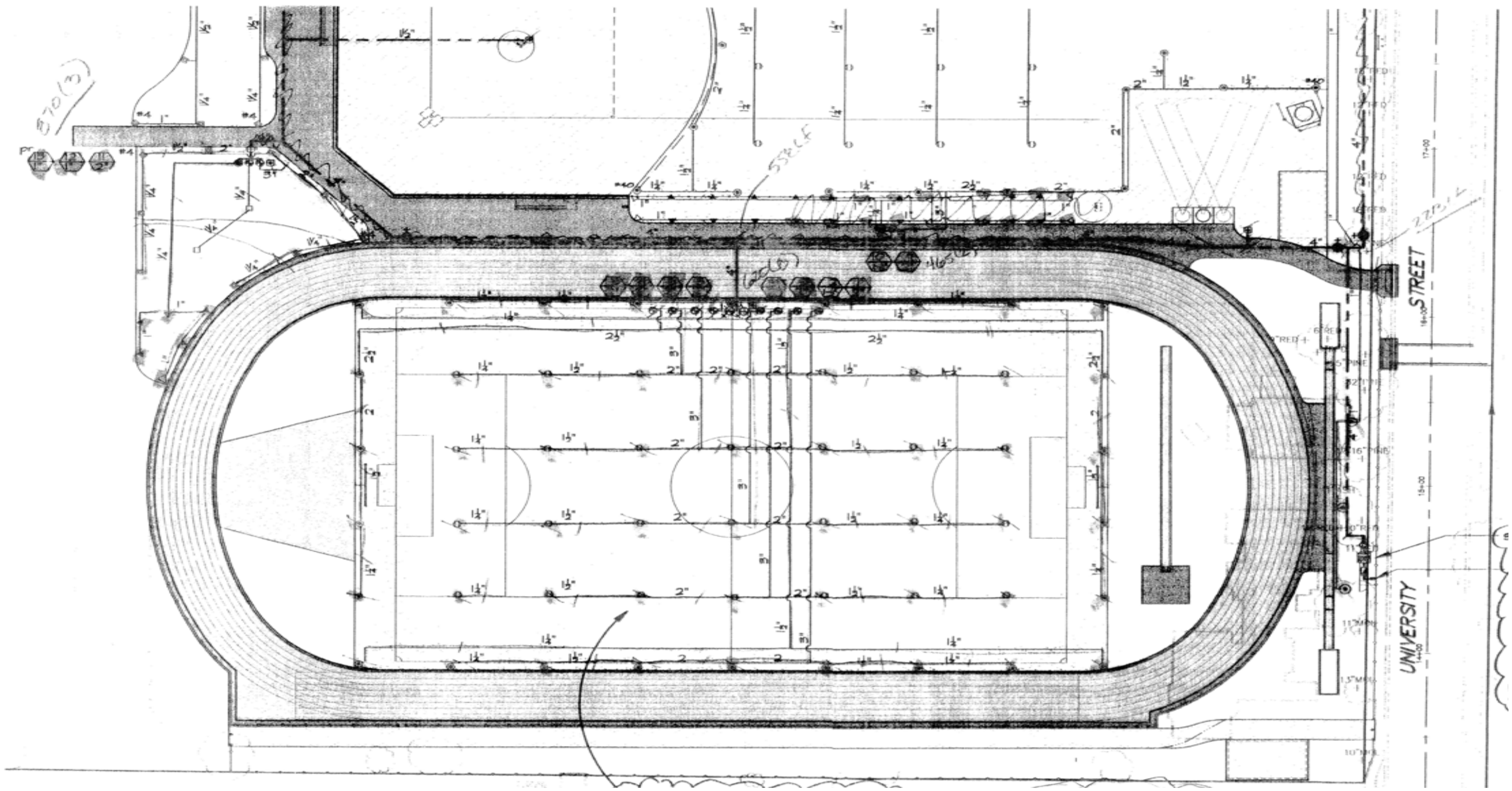


Figure 4-7

City of Healdsburg
Recycled Water Engineering Report
HEALDSBURG HIGH SCHOOL IRRIGATION LAYOUT - SOUTH PORTION

Note: Image obtained from others

WEST YOST ASSOCIATES
Consulting Engineers

Note: Image obtained from others

Figure 4-8

City of Healdsburg
Recycled Water Engineering Report

FITCH MOUNTAIN SCHOOL IRRIGATION LAYOUT

WEST YOST ASSOCIATES *Consulting Engineers*

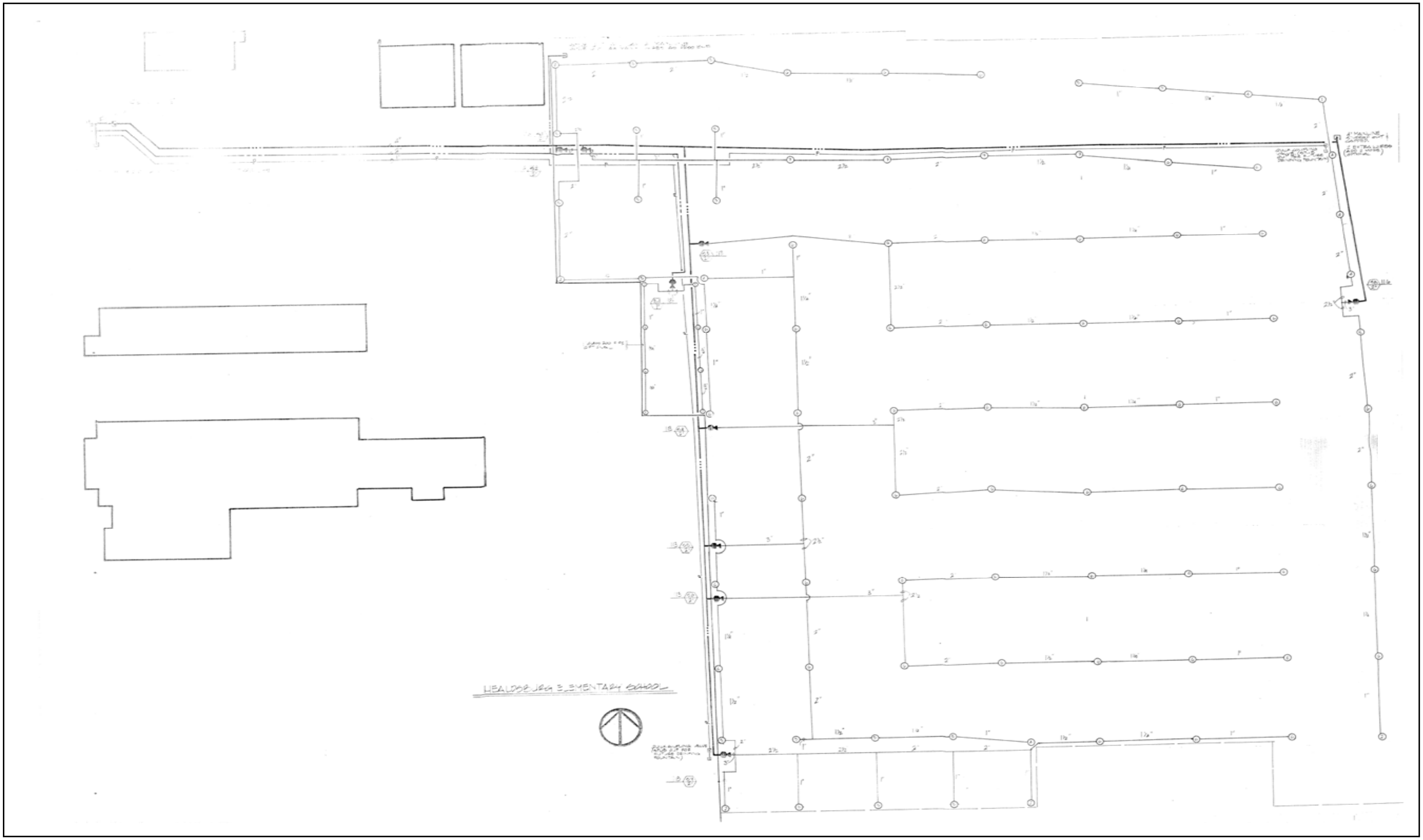
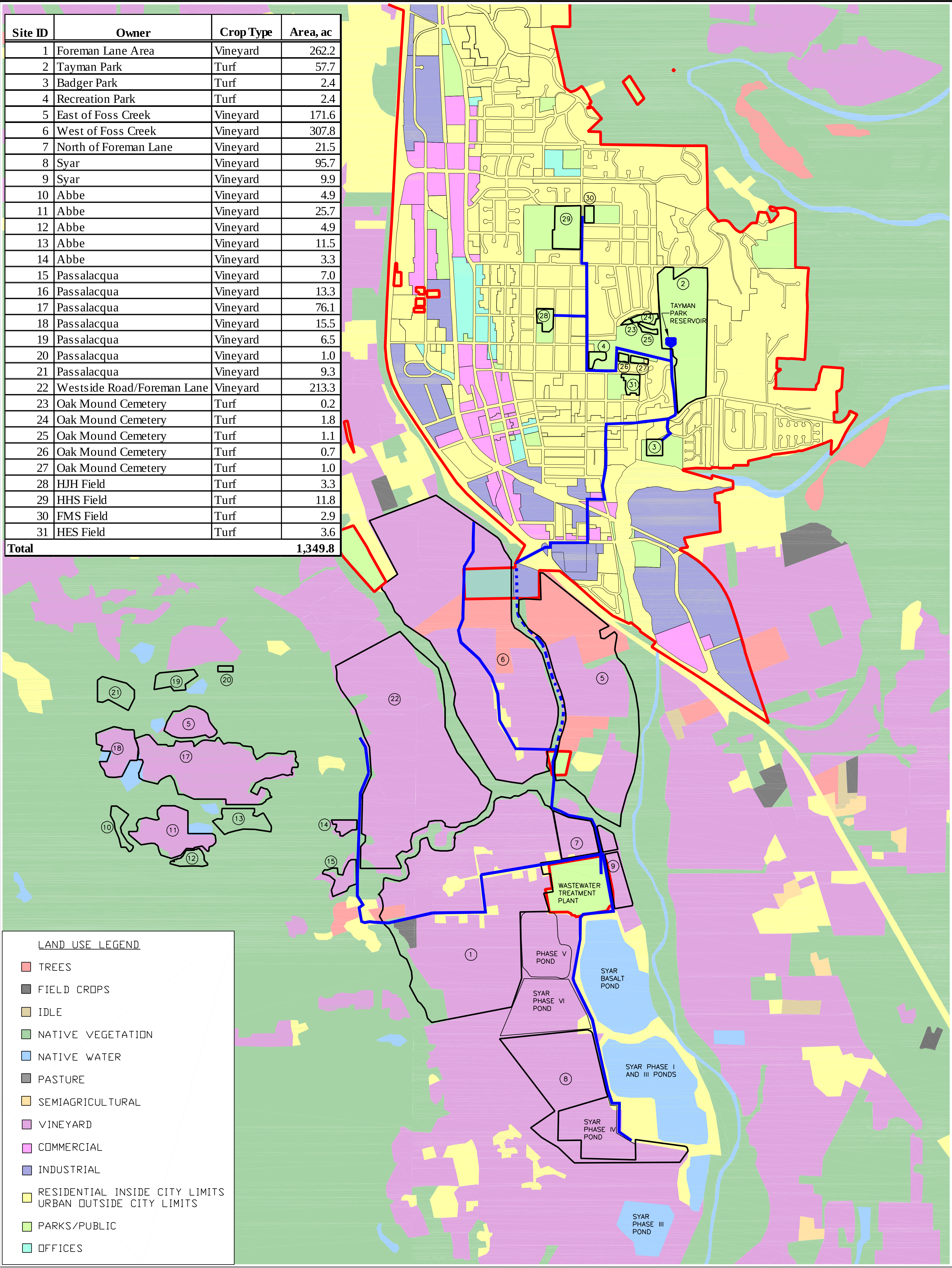


Figure 4-9

City of Healdsburg
Recycled Water Engineering Report
HEALDSBURG ELEMENTARY SCHOOL IRRIGATION LAYOUT

Note: Image obtained from others

Site ID	Owner	Crop Type	Area, ac
1	Foreman Lane Area	Vineyard	262.2
2	Tayman Park	Turf	57.7
3	Badger Park	Turf	2.4
4	Recreation Park	Turf	2.4
5	East of Foss Creek	Vineyard	171.6
6	West of Foss Creek	Vineyard	307.8
7	North of Foreman Lane	Vineyard	21.5
8	Syar	Vineyard	95.7
9	Syar	Vineyard	9.9
10	Abbe	Vineyard	4.9
11	Abbe	Vineyard	25.7
12	Abbe	Vineyard	4.9
13	Abbe	Vineyard	11.5
14	Abbe	Vineyard	3.3
15	Passalacqua	Vineyard	7.0
16	Passalacqua	Vineyard	13.3
17	Passalacqua	Vineyard	76.1
18	Passalacqua	Vineyard	15.5
19	Passalacqua	Vineyard	6.5
20	Passalacqua	Vineyard	1.0
21	Passalacqua	Vineyard	9.3
22	Westside Road/Foreman Lane	Vineyard	213.3
23	Oak Mound Cemetery	Turf	0.2
24	Oak Mound Cemetery	Turf	1.8
25	Oak Mound Cemetery	Turf	1.1
26	Oak Mound Cemetery	Turf	0.7
27	Oak Mound Cemetery	Turf	1.0
28	HJH Field	Turf	3.3
29	HHS Field	Turf	11.8
30	FMS Field	Turf	2.9
31	HES Field	Turf	3.6
Total			1,349.8



LEGEND

PROPOSED RECYCLED WATER PIPELINE

EXISTING PIPE

CITY LIMITS

USE AREA

1 AREA ID

N

0 1000 2000
SCALE IN SCALE

Land Use Source:
Outside city limts: 1999 DWR land use survey.
Inside city limits: city of Healdsburg zoning maps ammended 2/21/06
Land uses may have changed in intervening years.

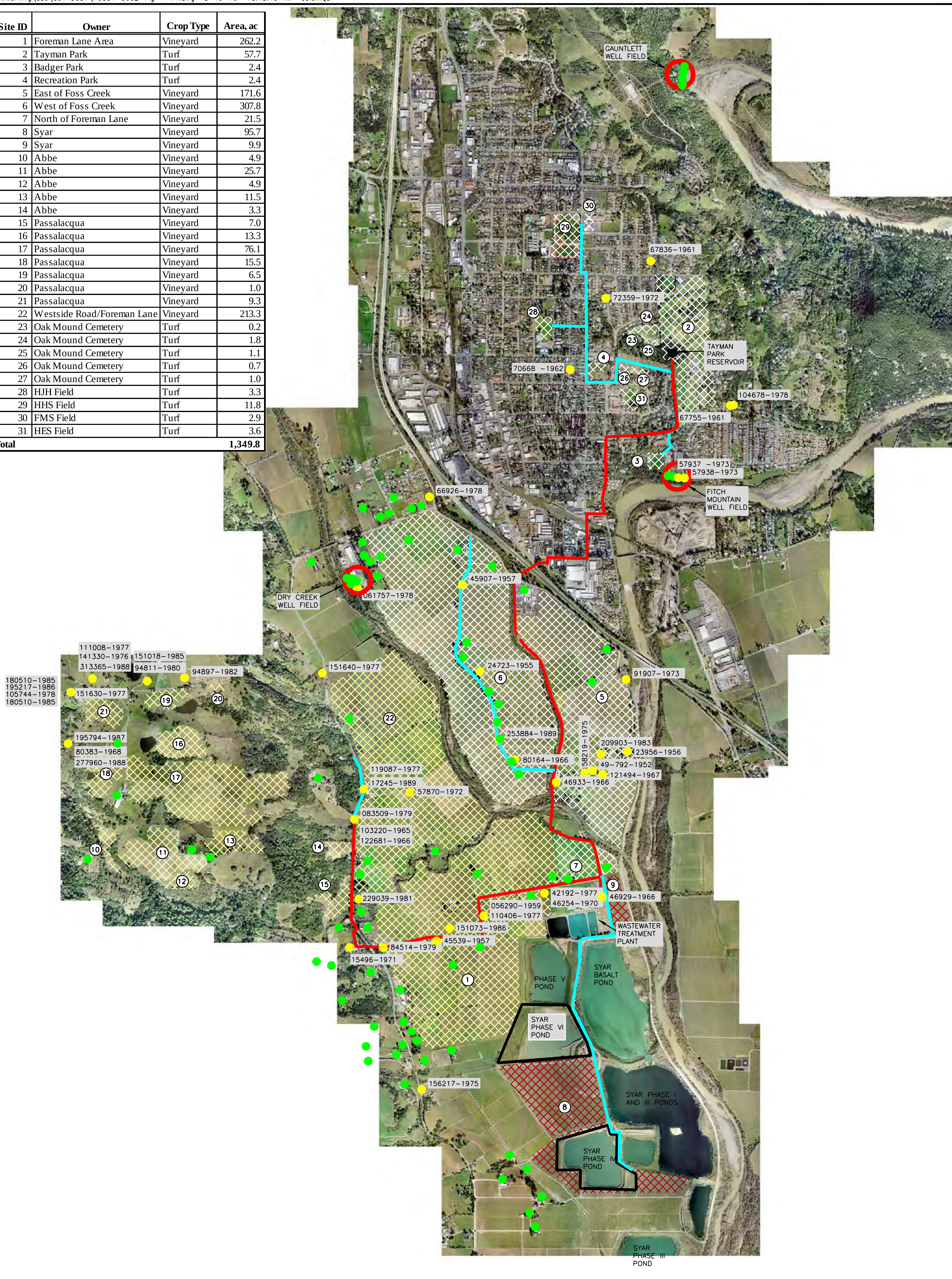
DRAFT

Figure 4-10

City of Healdsburg
Recycled Water Engineering Report
LAND USE

WEST YOST ASSOCIATES
Consulting Engineers

Site ID	Owner	Crop Type	Area, ac
1	Foreman Lane Area	Vineyard	262.2
2	Tayman Park	Turf	57.7
3	Badger Park	Turf	2.4
4	Recreation Park	Turf	2.4
5	East of Foss Creek	Vineyard	171.6
6	West of Foss Creek	Vineyard	307.8
7	North of Foreman Lane	Vineyard	21.5
8	Syar	Vineyard	95.7
9	Syar	Vineyard	9.9
10	Abbe	Vineyard	4.9
11	Abbe	Vineyard	25.7
12	Abbe	Vineyard	4.9
13	Abbe	Vineyard	11.5
14	Abbe	Vineyard	3.3
15	Passalacqua	Vineyard	7.0
16	Passalacqua	Vineyard	13.3
17	Passalacqua	Vineyard	76.1
18	Passalacqua	Vineyard	15.5
19	Passalacqua	Vineyard	6.5
20	Passalacqua	Vineyard	1.0
21	Passalacqua	Vineyard	9.3
22	Westside Road/Foreman Lane	Vineyard	213.3
23	Oak Mound Cemetery	Turf	0.2
24	Oak Mound Cemetery	Turf	1.8
25	Oak Mound Cemetery	Turf	1.1
26	Oak Mound Cemetery	Turf	0.7
27	Oak Mound Cemetery	Turf	1.0
28	HJH Field	Turf	3.3
29	HHS Field	Turf	11.8
30	FMS Field	Turf	2.9
31	HES Field	Turf	3.6
Total			1,349.8



LEGEND

- 8-INCH PIPELINE
- 12-INCH PIPELINE
- 12-INCH EXISTING PIPELINE
- ① AREA ID
- PROBABLE WELL, LOCATION BASED ON AERIAL PHOTOGRAPH
- KNOWN WELL LOG
- 15496-1971 (LOG NUMBER – YEAR DRILLED)
- FOREMAN LANE TO TAYMAN PARK IRRIGATION AREAS
- MILL CREEK IRRIGATION AREAS
- SYAR IRRIGATION AREAS

NOTE: WELLS ARE APPROXIMATELY LOCATED

N

0 1000 2000
SCALE IN FEET

Figure 4-11
City of Healdsburg
Recycled Water Engineering Report
DISTRIBUTION SYSTEM MAP KEY

WEST YOST ASSOCIATES
Consulting Engineers

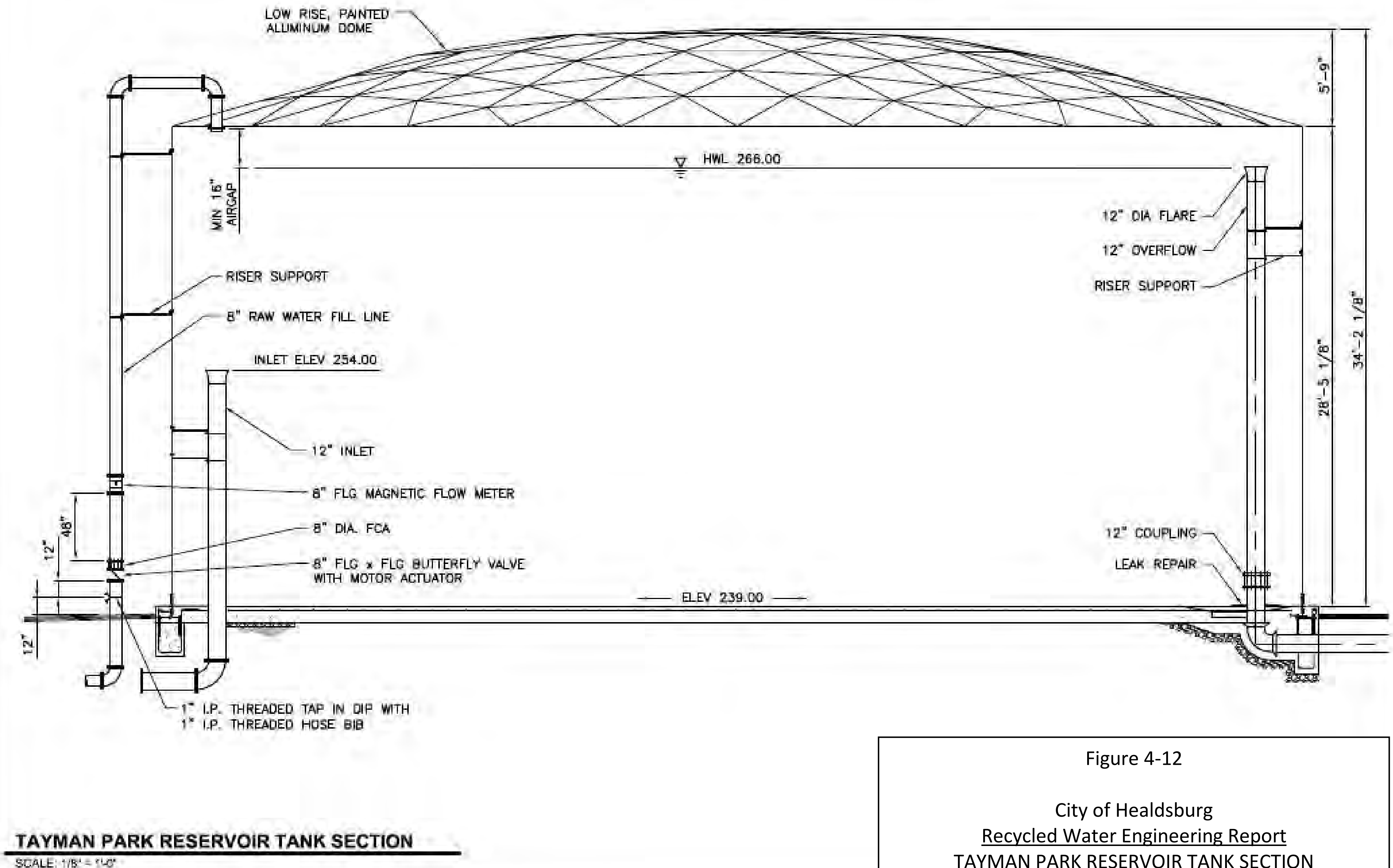


Figure 4-12

City of Healdsburg
Recycled Water Engineering Report
TAYMAN PARK RESERVOIR TANK SECTION

APPENDIX A

CDPH Acceptance Letters for MBR Equipment

State of California—Health and Human Services Agency
Department of Health Services

California Department of Health Services

DIANA M. BONTÁ, R.N., Dr. P.H.
Director

GRAY DAVIS
Governor

RECEIVED
OCT 10 2002

October 7, 2002

Mr. Matt Kuzma
Product Manager - Membrane Bioreactor
US Filter
1051 Blake
Edwardsville, KS 66111

Subject: Use of US Filter/Jet Tech Products Memjet™ membrane bioreactor (MBR) technology to comply with California Water Recycling Criteria

Dear Mr. Kuzma:

By letter dated August 12, 2002, US Filter/Jet Tech Products requested Departmental acceptance of the US Filter/Jet Tech Products Memjet™ membrane bioreactor (MBR) technology using the polyvinylidene fluoride (PVDF) 0.1 micron membrane as an acceptable filtration technology for compliance with the California Water Recycling Criteria (Title 22). This filtration system utilizes the same 0.1 micron PVDF hollow fiber membrane that was demonstrated and approved as a compliant filtration technology under the California Surface Water Treatment Rule. The Memjet™ MBR operates under vacuum, submerged in a bioreactor tank.

The Water Recycling Criteria recognize membrane filtration as an acceptable filtration technology provided prescribed performance (i.e. turbidity) requirements are reliably met. The turbidity performance criteria require that the filtered wastewater not exceed any of the following;

Division of Drinking Water and Environmental Management, Recycled Water Unit
1180 Eugenia Place, Suite 200, Carpinteria, California 93013
(805) 566-9767; (805) 745-8196 fax
Internet Address: www.dhs.ca.gov/ps/ddwem/

1. 0.2 NTU more than 5 percent of the time within a 24-hour period; and

2. 0.5 NTU at any time.

Demonstration studies have been conducted using the US Filter/Jet Tech Products Memjet™ 0.1 micron PVDF hollow fiber membrane which have sufficiently demonstrated the membranes ability to comply with the above stated turbidity performance requirements. Therefore, the Department of Health Services accepts the use of this membrane treatment process, identified as the US Filter/Jet Tech Products/Memjet™ 0.1 micron PVDF hollow fiber membrane MBR process, as a filtration technology for use in compliance with the Water Recycling Criteria. Based on performance data, the membrane filtration units will be limited to a maximum loading rate of 25 gfd and a maximum TMP of 7.2 psi.

It is noted that the Department considers a properly filtered and disinfected recycled water meeting the turbidity performance and coliform requirements outlined in the criteria to be essentially pathogen free. Treatment requirements determined necessary to meet the disinfected tertiary - 2.2 criteria include membrane filtration to reduce turbidity to less than a daily average of 0.2 NTU and disinfection to ensure a minimum CT of 450 milligram-minutes per liter at all times. This treatment scheme is intended to remove solids (including some pathogens) and properly prepare the water for effective disinfection in order to achieve an approximately five-log reduction of virus.

However, the current turbidity performance standards are based on achievable turbidity performance in membrane filters and do not necessarily assure any specific minimum level of pathogen removal. This is a recognized issue in the regulations that we feel needs to be addressed by the Department and the water recycling industry.

It is recognized that biological treatment introduces additional variables into the picture, as the type of biological treatment can impact the particle size distribution and downstream filter and disinfection performance. However, the integration of these processes, into a process train, are not fully understood at this time and must be addressed by industry and regulators. Nevertheless, it remains the intent of the Department that an essentially pathogen free effluent be produced by maintaining a 5-log virus removal/inactivation barrier through filtration and disinfection.

This acceptance letter is specific to the MemjetTM MBR process described in your August 12, 2002 submittal utilizing the 0.1 micron polyvinylidene fluoride hollow fiber membrane. Any proposed changes made in the physical attributes or character of the MBR treatment unit or this membrane shall be reviewed in advance by the Department to determine whether the modifications will require additional testing.

The Department will continue to review all proposed projects on a case-by-case basis to determine full compliance with all applicable treatment and reliability features required by the Water Recycling Criteria. This will include the collective review of all treatment unit processes, operational controls (e.g. loading rates, TMP, frequency of integrity tests), 'O&M' procedures, etc.

If you have any questions concerning this letter, please contact the undersigned at (805) 566-9767.

Sincerely,

Jeffrey L. Stone, Chief
Recycled Water Unit
Division of Drinking Water
and Environmental Management

cc: Recycled Water Committee

Techlistingdisk4/USFJetTechappr1tr.doc

State of California—Health and Human Services Agency

Department of Health Services

California Department of Health Services

SANDRA SHEWRY
Director

ARNOLD SCHWARZENEGGER
Governor

January 12, 2005

Warren Johnson
Project Manager – Product Development
MEMCOR AUSTRALIA PTY LTD
(ABN 86 003 581 566)
15 Blackman Crescent
South Windsor NSW 2756
Locked Mailbag No. 1
Windsor NSW 2756
AUSTRALIA

Dear Mr. Johnson:

RESPONSE TO 8 DECEMBER 2004 LETTER RE CDHS CONDITIONAL ACCEPTANCE OF USFILTER MEMCOR S10V MEMBRANE AS AN ALTERNATIVE FILTRATION TECHNOLOGY

On review of your supplementary information, the California Department of Health Services' Water Treatment Committee (WTC) has accepted your arguments for revising the *Giardia* and *Cryptosporidium*log removal credits for your S10V membrane. The revised the log removal credits for your alternative filtration technology are 4-log *Giardia* and 4-*Cryptosporidium*. The virus removal credit remains unchanged at 1.5-log. No other conditions outlined in the previous letter of conditional acceptance have changed.

The WTC has also agreed to remove the restriction on percent recycle, but our field offices reserve the right to increase the removal and inactivation requirements based on source water quality. For example, in sources with marginal microbiological water quality, concentrating the solids under crossflow operation might increase indicator concentrations above the limits for which the minimum surface water treatment rule requirements (3-log *Giardia* and 4-log virus removal and inactivation) apply. Should this occur, it would be reasonable to assume that our field offices would increase the removal and inactivation requirements to compensate for the increased microbial loading in the reactor.

Recommendation:

When particle counts are only sufficient to demonstrate a limited degree of removal, coliform detection in filtered water complicates acceptance of the MIT argument. Although we see no evidence of this problem in your studies, we offer the following recommendations to change the testing protocol to minimize the impacts of regrowth and potential contamination problems arising from the disassembly, shipping, and reassembly of equipment. We suspect that some of these recommendations have already been incorporated into testing and apologize for repeating them here. The Department recommends:

1. increasing bacteriological sampling frequency in source and finished water.

2. locating the particle counters as close to the product water as possible to minimize post filter contamination (bacterial regrowth and sloughing) from confounding your results, and

3. cleaning and disinfecting the system before beginning testing.

Based on problems with having low particle concentrations in source waters you may also want to consider expanding the discussion of results to include the supplementary MIT justification for increasing the log *Giardia* and *Cryptosporidium* into the report as needed. This would improve your presentation in cases where the argument for 4 log *Giardia* and *Cryptosporidium* removal credit cannot be supported because of the inability to achieve a 4-log virus removal 95% of the time.

Should you have any questions regarding the content of this letter, please feel free to contact me at (510) 849-5050.

Very truly yours,

Original signed by

Richard H. Sakaji, PhD, PE
Senior Sanitary Engineer

cc: WT Committee
chron

Dr. Samer Adham
MWH
300 North Lake, Suite 1200
Pasadena, CA 91101

November 18, 2005

Mr. Ed Jordan
VP Global Membrane Products Manager
US Filter
1051 Blake
Edwardsville, KS 66111

Subject: Use of US Filter/Jet Tech Products Memjet™ membrane bioreactor (MBR) technology using the B30R Module to comply with California Water Recycling Criteria

Dear Mr. Jordan:

By letter dated October 27, 2005, US Filter/Jet Tech Products requested Departmental acceptance of the US Filter/Jet Tech Products Memjet™ membrane bioreactor (MBR) technology using the B30R membrane module. As indicated in your letter, this is the same membrane technology as that previously accepted by the Department using the polyvinylidene fluoride (PVDF) 0.1 micron hollow fiber membrane. The primary difference is the physical configuration of the modules, going from a cylindrical (B10R) to a square or rectangular (B30R) configuration. The Departments Recycled Water Committee has reviewed your submittal and has determined that the B30R module configuration is an acceptable filtration technology for compliance with the California Water Recycling Criteria (Title 22).

This acceptance letter is specific to the MemjetTM MBR process using the B30R modules described in your October 27, 2005 submittal utilizing the 0.1 micron polyvinylidene fluoride hollow fiber membrane. Any proposed changes made in the physical attributes or character of the MBR treatment unit or this membrane shall be reviewed in advance by the Department to determine whether the modifications will require additional testing.

The Department will continue to review all proposed projects on a case-by-case basis to determine full compliance with all applicable treatment and reliability features required by the Water Recycling Criteria. This will include the collective review of all treatment unit processes, operational controls (e.g. loading rates, TMP, frequency of integrity tests), 'O&M' procedures, etc.

If you have any questions concerning this letter, please contact the undersigned at (805) 566-9767.

Sincerely,

Jeffrey L. Stone

Jeffrey L. Stone, Chief
Recycled Water Unit
Division of Drinking Water
and Environmental Management

cc: Recycled Water Committee

C:\mydocuments\treatmnenttechnolgies\USFILTERB30RAPPLTR.doc

State of California—Health and Human Services Agency
California Department of Public Health

MARK B HORTON, MD, MSPH
Director

ARNOLD SCHWARZENEGGER
Governor

October 29, 2008

Aaron Balczewski
Director of Process Technology, Memcor Products
Siemens Water Technologies
725 Wooten Road
Colorado Springs, CO 80915

Subject: Use of Siemens/Memcor B40N PVDF membrane to comply with California Water Recycling Criteria

Dear Mr. Balczewski:

By letter dated September 24, 2008, Siemens Water Technologies Corp. requested Departmental acceptance of the Siemens Memcor B40N polyvinylidene fluoride (PVDF) membrane filtration treatment units an acceptable filtration technology for compliance with the California water Recycling Criteria (Title 22). Included with your letter of request was a validation report confirming the performance of this membrane and demonstrating equivalency to the previously accepted B30R membrane module.

The Siemens/Memcor B40N PVDF membrane filtration treatment units utilize the same fiber chemistry as the PVDF hollow fiber membrane that was demonstrated and accepted as a compliant filtration technology for the B30R modules (see acceptance letter dated November 18, 2005). The PVDF membranes used in the B40N modules have a specified nominal and absolute pore size of 0.04 micron and 0.1 micron respectively.

The Department has reviewed your submittal and has determined that the B40N module configurations are acceptable treatment technologies for compliance with the California Water Recycling Criteria (Title 22).

The acceptance of your technology is specific to the 0.04 micron PVDF hollow fiber membrane. Any proposed changes made in the physical attributes or character of this membrane module shall be reviewed in advance by the Department to determine whether the modifications will require additional testing.

The Department will continue to review all proposed projects on a case-by-case basis to determine full compliance with all applicable treatment and reliability features required by the Water Recycling Criteria. This will include the collective review of all treatment unit processes, operational controls (e.g. loading rates, TMP, frequency of integrity tests), 'O&M' procedures, etc.

If you have any questions concerning this letter, please contact the undersigned at (805) 566-9767.

Sincerely,

Jeffrey L. Stone, Chief
Recycled water Unit
Division of Drinking Water
And Environmental Management

Cc: Recycled Water Committee

C:\Treatment/Siemens/B40NAcceptLtr

APPENDIX B

Siemens Installation Certificate

SIEMENS

October 30, 2009

Mr Jim Flugum
Senior Civil Engineer
City of Healdsburg, CA
340 Foreman Ln
Healdsburg, CA95448

Re: City of Healdsburg, CA WWTP
MBR Modules Installation Certification

Dear Jim,

This letter is to confirm that the MBR system installed at the City of Healdsburg WWTP was installed using the B30R modules and the B40N modules which have been certified by the State of CA Department of Health Services as compliant with the California Water Recycling Criteria (Title 22). The B30R modules were certified via letter of 11/18/05 and the B40N modules were certified via letter of 10/29/08 from Jeffrey Stone of the Department of Health Services

Sincerely,

Robert G. Spuhler
Project Manager
Siemens Water Technologies

cc: Jeff Picirillo – Siemens Water Technologies Corp.
Brian Diamantini – City of Healdsburg
Gerin James – Siemens Water Technologies Corp.

APPENDIX C

CDPH Acceptance Letter for UV Disinfection Equipment

State of California—Health and Human Services Agency

Department of Health Services

California Department of Health Services

DIANA M. BONTÁ, R.N., Dr. P.H.
Director

GRAY DAVIS
Governor

June 11, 2003

Mr. Andrew Salveson
Carollo Engineers
2700 Ygnacio Valley Road, Suite 300
Walnut Creek, CA 94598

Dear Mr. Salveson:

CONDITIONAL ACCEPTANCE FOR A REVISED TROJAN 3000+ QUARTZ SLEEVE FOULING FACTOR

Based on the performance of the Trojan LPHO lamps tested and reported in "Trojan Technologies UV3000Plus Interim Sleeve Cleaning Report," by Carollo Engineers (Walnut Creek, CA; April 2003), the Department accepts Trojan's proposal to modify the 3000+ quartz sleeve fouling factor to 0.95 from the general default of 0.80 recommended in the NWRI/AWWARF UV Disinfection Guidelines. Site specific testing must be conducted to establish the proper maintenance requirements, such as cleaning frequency, to ensure the lamp fouling factor is never less than 0.95 (The Department recommends the protocol given in the previously referenced report be followed. Such testing should also set site specific testing to determine quartz sleeve replacement intervals is also needed.

Summary

The following comments have been prepared following a review of Trojan 3000+ Quartz Sleeve Fouling test reports by the Department's Water Recycling Committee.

It is recommended that based on the results of the study, the Department accept the use of a 0.95 fouling factor for the Trojan 3000+ LPHO lamps provided short-term site-specific studies are conducted to validate and establish appropriate operation and maintenance practices to ensure operation at or above the minimum 0.95 fouling factor can be sustained. In future tests, the study protocol should be modified to collect more measurements in the early stages of lamp fouling to better quantify the sleeve cleaning frequency needed to maintain the 0.95 fouling factor.

From the data plotted Figure 3.3 the trend of the data would appear to show some irreversible quartz sleeve fouling. Could the continual irreversible decline be rectified by

Drinking Water Technical Programs Branch, 2151 Berkeley Way, Room 458, Berkeley, CA 94704-1011
(510) 540-2158 FAX (510) 540-2152
DHS Internet Address: www.dhs.ca.gov Program Internet Address: www.dhs.ca.gov/ps/ddwem

replacement of the cleaning sleeve at the end of six months or are stronger measures needed?

The conditional acceptance of the modified fouling factor is specific to the Trojan LPHO lamps tested and reported previously. Trojan lists these part numbers for the UV equipment tested in the referenced report:

UV 3000Plus Lamp 302509

UV 3000Plus Sleeve 316136.

Trojan is asked to inform the Department should they make any changes to the physical characteristics (e.g., composition or character) of the previously listed quartz sleeves or lamps. Because changes to the design or manufacturing of the lamp or sleeve can affect performance, Trojan is asked to please submit a letter to the Department illustrating the impact of the change on disinfection performance so that the department can determine whether the modification will require additional testing.

We appreciate the time, effort, and resources your clients have invested in testing their equipment. The information provided over the years has proven invaluable to the Department for the development of scientifically sound public policy regarding UV disinfection.

Should you have any questions regarding the content of this letter, please free to contact me at (510) 849-5050.

Very truly yours,

Original signed by

Richard H. Sakaji, PhD, PE
Senior Sanitary Engineer

cc: Water Recycling Committee
chron