May 27, 2014

Chair Felicia Marcus and Board Members
c/o Jeanine Townsend, Clerk to the Board
State Water Resources Control Board
1001 I Street, 24th Floor
Sacramento, CA 95814
Sent via electronic mail to: commentletters@waterboards.ca.gov

RE: Comment Letter – General Order WDRs for Recycled Water Use

Dear Chair Marcus and Board Members:

On behalf of California Coastkeeper Alliance and Heal the Bay (CCKA and HTB), we submit the following comments on the *Draft General Waste Discharge Requirements for Recycled Use* ("Draft Order") dated April 29, 2014. Our organizations strongly support the goal of expanding recycled water use in the state of California and meeting the Recycled Water Policy's near-term goal of an additional one million acre-feet of recycled water used per year – *consistent with* state and federal water quality law and policy. We were active members of the drafting group for the Recycled Water Policy and have long-advocated for prudent water recycling projects throughout California.

We commend the State Water Resources Control Board (Board) and the Administration on California's drought response efforts. Since the Drought State of Emergency declared in January, we have seen many positive actions to help expand local water sources. For instance, in the Los Angeles Region two permits that help reduce the need for imported water have recently been approved: Water Recycling Requirements for the Alamitos Barrier Recycled Water Project and Water Reclamation Requirements and Waste Discharge Requirements for Groundwater Recharge for the Rio Hondo and San Gabriel River Spreading Ground. These permits both allow for the use of 100 percent recycled water for groundwater recharge projects. Increased water recycling is a large component of water sustainability in California. As recognized in the Draft Order, an estimated 0.9 million to 1.4 million acre-feet of "new water" could be realized by 2030 through recycling of municipal wastewater that would otherwise be discharged into the ocean or saline bays. This volume of water represents a large opportunity for additional water supply in California.

However, we are concerned that the Draft Order delegates responsibility to permittees to ensure beneficial uses are protected. Further, we are not convinced that the Draft Order will help drought relief efforts or expedite recycled water for irrigated lands more expeditiously in California. Alternatively, the Draft Order may interfere with efforts to better manage our groundwater basins and promote local water.

As described in detail below, we recommend the State Board make the following revisions to the Draft Order:

- Remove provisions allowing permittees to self-enforce through the unenforceable standards in Provision 28, and clearly define when a Permittee is out of compliance;
- Add precise language from the Recycled Water Policy addressing salt and nutrient management;

- Incorporate a sunset provision stating the Order will no longer be in effect once the Drought State of Emergency has been terminated;
- Identify what constitutes a sufficient water and nutrient balance analysis;
- Require project proponents to conduct site specific soil studies to assess agronomic rates when special circumstances exist that may impact sensitive beneficial uses;
- Add the most sensitive beneficial uses to Table 2 and allow public review for projects that may impact those sensitive beneficial uses;
- Add an explicit statement that existing WDRs are not preempted by this Order and that Executive Officers should not approve NOIs for parties with existing WDRs;
- Include a public petition process regarding the Executive Officer's determination of whether special site considerations exist that necessitate an individual WDR;
- Add frost control as an unauthorized activity under Provision 10 of the Order;
- Include minimum priority pollutant monitoring requirements;
- Use both *E. coli* and enterococci as monitoring surrogates for pathogens; and
- Include an adequate monitoring program sufficient to determine compliance with the Anti-Degradation Policy.

A. THE GENERAL ORDER IMPROPERLY DELEGATES RESPONSIBILITY TO PERMITTEES TO ENSURE PROTECTION OF WATER QUALITY STANDARDS.

1. The State Board's delegation of responsibility to permittees is inappropriate.

The authority to set and enforce water quality objectives rests with the State Board, a principle established though the Porter-Cologne Act, the Clean Water Act, and case law. The Draft Order, however, makes it clear that the State Board seeks to shed key regulatory responsibilities when permitting the administration and use of recycled water. As stated in the Draft Order:

> The intent of this order is to streamline the permitting process and *delegate the responsibility* of administrating water recycling programs to recycled water Producers and/or Distributors to the fullest extent possible.[1]

Specifically, key sections of the Draft Order delegate the responsibility to protect water quality and beneficial uses to permittees (Administrators). Finding 33, for example, states that the Administrator of recycled water is charged with ensuring the Users abide by any water quality objectives established to protect beneficial uses. Section C.6 of the Draft Order is more explicit in its devolution of authority from the State Board to Administrators when it states:

> The Administrator shall ensure recycled water meets the quality standards of this General Order and shall be responsible for the operation and maintenance of major transport facilities and associated appurtenances. The Administrator shall require Users to apply and/or use recycled water in accordance with all applicable CDPH water recycling criteria and to comply with this General Order, including requirements to apply only at agronomic rates and not cause unauthorized degradation, pollution, or nuisance.

Placing the onus to protect public and environmental heath upon regulated parties reduces Regional Boards' oversight, establishes clear conflicts of interest, and broadly weakens the testing and monitoring protocols designed to safeguard water quality and beneficial uses. Section C.7 further devolves State Board responsibility to regulated parties when it states:

[1] Draft Order, 12.

> The Administrator shall conduct periodic inspections of the User's facilities and operations to determine compliance with conditions of the Administrator requirements and this General Order.

Together, Finding 33 and sections C.6 and C.7 set up a system of self-policing and permittee driven oversight that will fail to fully protect human and ecosystem health from constituents of emerging concern, nutrient overexposure, and the impacts of high salinity.

2. *The Draft Order disregards the State Board's responsibility to issue WDRs that are protective of beneficial uses not just public health.*

The Draft Order offers no explicit protection to safeguard or monitor environmental impacts. Rather, the Order relies solely on Title 22 of the California Code of Regulations to establish standards and protections. Title 22 is only concerned with public health. Thus relying on this provision provides incomplete and inconsistent safeguards against the unintended consequences of non-potable recycled water. As the Draft Order states:

> Title 22 imposes limitations on the uses of recycled water, based on the level of treatment and the specific use in order *to protect human health*. By restricting the use of recycled water to Title 22 requirements, this order ensures that recycled water is used safely.[2]

Title 22 cannot ensure that recycled water is used in a manner that adequately protects the environment, in addition to public health, when no monitoring is required to ensure groundwater is not being impacted and salt and nutrient plans are not established. The Draft Order claims the requirement for the use of agronomic irrigation rates justifies limiting protection to Title 22. The Order states:

> Application of recycled water is limited to agronomic rates, which *limits* the potential for significant amounts of recycled water to impact groundwater quality and allows crops to take up wastewater constituents such as nitrogen compounds.

This statement runs contrary to scientific studies which show the agronomic application of recycled water does have the potential to increase salinity and nitrates beyond crop root zones.[3] [4] Well-established scientific literature finds that the improper introduction of CECs, salts, and nutrients found concentrated in recycled water have wide-ranging and significant impacts on ecosystem health.[5] [6] These impacts have the potential to be particularly pronounced in watersheds with low salinity, such as many Region One waterways that depend on low salinity levels in order to support endangered salmon.

Further, the Draft Order allows for uses beyond irrigation of agriculture. How will the appropriate application or storage rates be determined for these other uses? Also, how does the Draft Order address storage facilities used for future irrigation?

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[2] Draft Order, 9.

[3] Segal, E., Dag, A., Ben-Gal, A., Zipori, I., Erel, R., Suryano, S., & Yermiyahu, U. (2011). Olive orchard irrigation with reclaimed wastewater: Agronomic and environmental considerations. Agriculture, ecosystems & environment, 140(3), 454-461.

[4] Qian, Y. L., & Mecham, B. (2005). Long-term effects of recycled wastewater irrigation on soil chemical properties on golf course fairways. Agronomy Journal, 97(3), 717-721.

[5] Toze, S. (2006). Reuse of effluent water—benefits and risks. Agricultural water management, 80(1), 147-159.

[6] Kim, S., & Aga, D. S. (2007). Potential ecological and human health impacts of antibiotics and antibiotic-resistant bacteria from wastewater treatment plants. Journal of Toxicology and Environmental Health, Part B, 10(8), 559-573.

3. *The General Order may encourage long-term perpetuation of water intensive practices.*

As Finding 2 of the Draft Order articulates, drought conditions are a common and reoccurring phenomenon in the state, and California's current demand for water even outpaces what conditions can supply during years of above normal precipitation. As the current drought has illustrated, there is a serious and immediate need to reform how California allocates, delivers, and governs the state's overstressed water resources. Providing recycled water to certain questionable or unreasonable uses may delay the initiative for meaningful water reform, ultimately postponing conspicuous issues until the economic and environmental systems dependent on water face a full and complete collapse.

The proven, cost effective way to create more water for all beneficial uses is through measures that promote lasting conservation and responsible use. During drought conditions the state should prioritize long-term conservation programs. These measures can be pursued in agricultural as well as in urban landscapes, exemplified by rebates incentivizing lawn removal. In the City of Las Vegas alone, required removal programs have led to annual savings of around 26,000 acre-feet, or about the storage capacity of a medium sized reservoir[7]. In the agricultural sphere, the adoption of irrigation and conservation best management practices, typified by the California Sustainable Winegrowing Program[8], provides a template of water creating strategies the state could incentivize with minimal investment. Furthermore, the adoption of agricultural metering and groundwater monitoring should be encouraged. Conservation measures create more water for agricultural and industrial uses than non-potable recycled water, at a fraction of the cost

4. *The Draft Order sets vague enforcement standards and places a heavy resource burden on Regional Boards to determine when self-policing Administrators are out of compliance.*

In instances of non-compliance, the General Order provides vague and unenforceable guidelines for when enforcement actions should take place. The Draft Order states "[r]ecycled water use shall not create unacceptable groundwater and/or surface water degradation."

The General Order fails to define what constitutes an "unacceptable" degradation of surface or groundwater. Further, the Order neither stipulates who nor by what evaluation protocol a designation of "unacceptable" degradation will be reached. To fully protect water quality and beneficial uses, the Draft Order must stipulate clearly what will be considered an "unacceptable" degradation of water quality, by what protocols such a designation will be made, and who will be given the authority to reach such a decision.

The safe use of recycled water for irrigation will require monitoring and enforcement to ensure groundwater resources, ecosystems, and beneficial uses are protected. The delegation of responsibility to Administrators to ensure compliance with the Draft Order will only place a further burden on Regional Boards to ensure regulatory compliance. The lack of Regional Board resources to fully monitor the application of recycled water will create opportunities for abuse and unintended consequences, endangering water quality, ecosystems, and beneficial uses.

Therefore, we request the State Board <u>remove provisions allowing permittees to self-enforce; and remove the unenforceable standards in Provision 28 by clearly defining when a project is out of compliance</u>.

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[7] Green, E., (2009) DWP offers cash incentives to water lawns. The Los Angeles Times. Available at http://articles.latimes.com/2009/jun/13/home/hm-grass13.

[8] Gleick, P. H., Ross, N., Allen, L., Cohen, M. J., Schulte, P., & Smith, C. (2010). California farm water success stories. Oakland, CA: Pacific Institute.

B. THE GENERAL ORDER SHOULD BE CONSISTENT WITH THE RECYCLED WATER POLICY.

HTB and CCKA were very involved in the development of the Recycled Water Policy. This was a widely supported Policy but also took significant negotiation to reach agreement. The Draft Order, while well intended, may undermine some of the important aspects of the Recycled Water Policy. As stated in the Recycled Water Policy, "[i]t is the intent of the State Water Board that the general permit for landscape irrigation projects be consistent with the terms of this Policy."[9] Thus, the State Board should modify the Draft Order to ensure consistency with the Policy.

1. *The General Order disincentivizes salt and nutrient management planning in direct conflict with the Recycled Water Policy.*

As acknowledged in the Recycled Water Policy, "landscape irrigation with recycled water…may, regardless of its source, collectively affect groundwater quality over time".[10] The Policy contends that "the appropriate way to address salt and nutrient issues is through the development of regional or subregional salt and nutrient management plans …."[11] The Policy incentivizes Permittees to undertake salt and nutrient management planning by creating a mechanism for flexibility with Basin Plan requirements and effluent limits if the salt and nutrient management plan demonstrates that the project uses less than 10 percent of the assimilative capacity.[12]

While the Draft Order "reasserts the need for comprehensive salt and nutrient management planning and directs that salinity and nutrient increases should be management in a manner consistent with the Recycled Water Policy," it provides no incentive for Permittees to move forward with the development of these plans.[13] Instead, the Order seems to downplay potential salt impacts. Simply encouraging Permittees to develop a salt and nutrient plan will likely not lead to the development of the resource-intensive plans. Thus, the Draft Order is inconsistent with the Recycled Water Policy.

While there may be areas of the state where imported water increases salt levels far more than recycled water discharges (such as in Region 2 where the template order was taken), that is not the case in all regions. Without salt and nutrient management plans, we will miss the opportunity to help inform policy and basin management decisions in the short-term and long-term. Further, this may actually impede efforts to prepare for drought and maximize local water resources. If a Permittee does not undertake a salt and nutrient management planning, we have less monitoring of the groundwater basins to understand water quality concerns. Also the plans are supposed to outline "water recycling and stormwater recharge/use goals and objectives."[14] Without the plans, we could in advertently see less focus on developing and implementing water recycling and stormwater goals.

As suggested below, we believe salt and nutrient plans can be incentivized by requiring Administrators to either conduct site specific monitoring, or instead, be allowed to actively participate in the adoption of a salt and nutrient management plan.

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[9] Recycled Water Policy, 10.
[10] *Id* at 14.
[11] *Id* at 5.
[12] *Id* at 14.
[13] Draft Order, 4.
[14] Policy, 8.

2. *The Draft Order should address how Permittees will manage salt and nutrients in the absence of salt and nutrient plans.*

Although the Draft Order requires project applicants to be consistent with an applicable salt and nutrient management plan for a groundwater basin/sub-basin, it is unclear what conditions are required when salt and nutrient management programs have not yet been developed or completed for individual basins or sub-basins. For example, in Region 4, there are no plans that have been approved to-date. Salt and nutrient management plans will not be completed before the Draft Order is adopted or by the time NOIs for recycled water projects are approved for coverage under this Order. The Draft Order should address how project proponents will manage salt and nutrients in the absence of basin or sub-basin salt and nutrient management plans.

To be consistent with the adopted State's Recycled Water Policy and safeguard against groundwater impairments, we suggest the following be included in the Order to address this shortcoming:

> In the event that a project is being proposed in a basin where a salt/nutrient management plan is being prepared, the Administrator must either perform site specific monitoring, or actively participate in the development and implementation of a salt/nutrient management plan, including basin/sub-basin monitoring.

This language comes directly out of the Recycled Water Policy provisions for streamlined permitting (Section 7.b.4.). While this section only applies to "landscape irrigation" we believe it should be applied to both landscape and agriculture irrigation under the Draft Order, given the Recycled Water Policy never intended for agricultural irrigation to be streamlined.

C. THE GENERAL ORDER DOES NOT CLEARLY HELP IMPROVE DROUGHT CONDITIONS AND SHOULD INCLUDE A SUNSET PROVISION TO PUT PERMITTEES ON NOTICE THAT IT IS TEMPORARY.

1. *The General Order does not explain how it will improve California's drought conditions.*

The Draft Order's findings describe the need for streamlined permitting in order to respond to the current Drought State of Emergency. Although increased recycled water use is an important aspect of water sustainability, it is unclear how the Draft Order will, in practice, do anything to help drought-relief efforts.

For instance, there are currently dozens of water recycling permits in effect in Region 4, including some that were adopted in the 1980's and others adopted in recent years. Heal the Bay has attended nearly every Los Angeles Regional Water Quality Control Board hearing for the last 20 years and has worked closely with stakeholders in the region and has never heard the arguments that the permit process or monitoring requirements have delayed non-potable recycled water projects. Also, we have sat on the City of Los Angeles Recycled Water Advisory Group for the last 6 years and have not heard of any permitting concerns.

To the contrary, a municipal recycled water survey conducted by the State Board in 2009 identified an increase in the use of recycled water in California, and Region 4, despite the fact that the Los Angeles Region's recycled water permits have had for over a decade of monitoring of numeric limits to protect water quality.[15] Does the State Board have specific examples where this is the case for urban irrigated landscape permits? If not, we are concerned that the Draft Order weakens standards rather than streamlining projects.

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[15] State Water Board, Website: Grant Loans for Recycled Water, last visited March 27, 2014, available at http://www.waterboards.ca.gov/water_issues/programs/grants_loans/water_recycling/docs/munirecsrvy/fig_1.pdf.

We whole-heartedly agree that we have much un-realized potential for recycled water in California and much more needs to be done. However, instead of permitting being the barrier, we believe that the main barriers are infrastructure costs and the lack of indirect and direct potable standards.

2. *The Draft Order should no longer be in effect once the Drought State of Emergency is terminated.*

On April 25, 2014, the Governor issued an Executive Order declaring a continued state of emergency due to severe drought conditions. Directive Number 10 of the Executive Order directed the State Board to adopt statewide general waste discharge requirements to facilitate the use of treated wastewater. To allow the State Board to adopt this statewide order as quickly as possible, the Governor also suspended the environmental review required by the California Environmental Quality Act (CEQA). In declaring this Executive Order, the Governor cited his authority under Government Code section 8567.

Government Code section 8567 provides the Governor authority "to may make, amend, and rescind orders and regulations necessary" to address the state of emergency.[16] However, Government Code section 8567 goes on to explicitly state that "[w]henever the state of war emergency or state of emergency has been terminated, *the orders and regulations shall be of no further force or effect*."[17]

The State Board's Fact Sheet makes clear that this "draft General Order was developed in response to the Governor's Jan. 17, proclamation of a Drought State of Emergency."[18] The State Board also acknowledges that this "General Order is intended to satisfy the directive No. 10 requirements."[19] The State Board further explains that Directive Number 19 of the Executive Order suspended the California Environmental Quality Act (CEQA) requirements to conduct an environmental review "to allow the State Water Board to adopt this General Order as quickly as possible."[20] The Draft Order was developed and will be adopted in response to the Governor's Executive Order executed under his state of emergency authority – specifically Government Code section 8567. Therefore, this General Order must only be temporary until the State of Emergency is terminated.

The State Board makes no statement on the record that this General Order is intended to be temporary. The State Board likely rests upon its authority to adopt a general WDR for recycled water regardless of the State of Emergency, and likely considers Section 8567 to only apply to the CEQA suspension. We agree that a WDR could be adopted by the State Board without the Governor's Declaration. We also stipulate that the Governor has suspended CEQA. However, we maintain that the Governor ordered this Draft Order be adopted without a CEQA review under his state of emergency authority. The combination of Directive 10 and Directive 19 creates a situation where the State Board is not simply using its authority. Rather, the State Board is using authority given to it under a state of emergency to adopt this Draft Order. Therefore, we conclude that the Draft Order cannot be permanent because it was adopted in response to a state of emergency declaration, and was done without a proper CEQA analysis.

We request the State Board make an explicit statement – through a sunset provision – that the General Order will no longer be in effect once the Drought State of Emergency has been terminated. Moreover, the State Board should put permittees on notice that once the state of emergency is over, any water recycling project covered by this temporary General Order will need to obtain an individual WDR permit.

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[16] Gov. Code 8567(a).
[17] Gov. Code 8567(b) [*Emphasis added*].
[18] Fact Sheet, 1.
[19] State Water Board, Website: Land Disposal Program, last visited March 27, 2014, available at http://www.waterboards.ca.gov/water_issues/programs/land_disposal/waste_discharge_requirements.shtml.
[20] *Id*.

D. THE GENERAL ORDER MUST TAKE REGIONAL VARIATIONS INTO CONSIDERATION TO PROTECT GROUNDWATER.

1. *Water recycling criteria should be regionally based on beneficial uses, groundwater characteristics, and soil types that affect water quality.*

Regional variations of beneficial uses, local groundwater quality, and soil type demand regional standards should take precedent over statewide criteria. Detailed recycled water project descriptions are essential to understand whether recycled water use may impact surface water or groundwater quality. Although Attachment A-Notice of Intent (General Instructions) outlines project information needed for permit approval by Regional Boards, the description of estimated amounts of recycled water applied at use area(s) of each user needs to be expanded. California's landscapes are not uniform; site specific conditions such as soils, slope, precipitation, and water table elevation all influence the volume of recycled water that can be applied to use.

The Draft Order ignores site specific requirements existing in individual permits. Individual permits contain additional requirements to help protect beneficial uses. For example, the City of Ventura Water Recycling Requirements contains specific limits. Additionally, some Region 4 water recycling permits contain additional use area requirements as well as more frequent monitoring of recycled water usage when compared to the Draft Order.[21]

It is essential that water balance and nutrient balance analysis accurately illustrate agronomic rate application and impacts from uses without an associated agronomic rate in specific use areas. For example, a Region Two water recycling permit should not be applied to Region One where sensitive salmonid habitat is particularly sensitive to increased salinity from recycled water. Over the past seven years, the Russian River Valley has seen a large increase in proposals to transport recycled water to vineyards. This has led to increased concerns from local citizens regarding protecting endangered salmon and preserving high quality groundwater that provides well water via private and small community systems to 25 percent of residents in the Russian River watershed. In particular the soils in the major alluvial Valley—where most grapes are produced—are highly porous and lie over shallow groundwater tables that allow rapid movement of water both vertically and laterally. Any over-irrigation beyond plant requirements could move towards streams and affect prey for Endangered Species Act (ESA) listed Salmon and Steelhead or could percolate downward to increase the concentration of solids to the point of violating drinking water standards.[22]

We are unsure what signifies acceptable water balance and nutrient balance analysis; does the Administrator estimate water and nutrient balance? Third-Parties? Regional Board Staff? The Draft Order should address this shortcoming and <u>explicitly identify what constitutes sufficient water and nutrient balance analyses and determination of agronomic rates</u>.

2. *The Draft Order's use of evapotranspiration-based agronomic rates will lead to over-irrigation of recycled water.*

The Order's reliance on using evapotranspiration (ET) values for crops calculated from the local CIMIS weather stations will lead to over-irrigation rates that could imperil groundwater or cause recycled water to reach streams during gaining periods. Mark Greenspan PhD, a U.C. Davis vineyard irrigation expert,

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[21] Waste Discharge Requirements and Title 22 Water Recycling Requirements issued to Camarillo Sanitary District and City of Camarillo (Order No. R4-2013-0140); Water Recycling Requirements and Waste Discharge Requirements for City of Oxnard Groundwater Recovery, Enhancement, and Treatment Program-Nonpotable Reuse Phase I (R4-2011-0079).
[22] Yates, 2009.

performed a study in 2012 to investigate the volumes of vineyard irrigation and the potential for irrigation water to percolate towards groundwater. The study was commissioned by Westside Association to Save Agriculture and funded by legal settlement with a local gravel company to understand possible implications of future use of recycled water in vineyards.[23] The study, 2012 Middle Reach Russian River Vineyard Irrigation Demonstration Project, is incorporated by reference in Attachment One. The conclusions from Dr. Greenspan's study include:

- Irrigation amounts varied widely, but some irrigations were not necessary and/or were excessive;
- Nominal irrigation amount was 2.1 inches or just 17% of ETc, excluding outliers and faulty systems average applied was 1.7" or 14% of ETc (ETc calculations would be 12.35");
- Deep soils and high water tables commonly found in the [Russian River watershed] allow for late and reduced irrigation relative to ETc in this region;
- Deep percolation of drip irrigation is unlikely (at study rates not ETc rates) in gravelly and 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 root zone. It is important that high levels of nitrate, salt or other leachable toxins do not remain in the soil at the end of the growing season.

Moreover, the study reveals that even using the study's irrigations rates, a fraction of the ETc rates, recycled water was still detected below the root zone at several sites.[24] If irrigators were using ETc based irrigation volumes rates, the study concludes that the rate would be six times higher than the study's rate and would have led to recycled water leaching below the root zone in several soil types.[25] The study revealed that using ET based irrigation volumes would have led to much earlier onset of irrigation when soils might still be saturated leading to higher risk of leaching.[26] The study also showed that the same irrigation volume used over different soil types moved water to different depths depending on soils types showing that soil type is a critical factor to determine agronomic rates that would prevent movement below root zones.

Finally, we note that any over-irrigation with recycled water would also lead to over-application of nitrates if factoring in nitrogen content of recycled water. A recent University of Calgary study showed that legacy applications of nitrogen fertilizers remain in soil for decades and a significant fraction slowly leaches to groundwater.[27] The agronomic rate as set forth CIMIS even acknowledge this significant source of nitrogen in agricultural regions where nitrogen fertilizers have been applied for over a hundred years to a variety of crop types.

3. *The Draft Order will lead to unenforceable Basin Plan violations due to over-irrigation of recycled water.*

In the Russian River the majority of vineyard irrigation along the river and major tributaries such as Dry Creek are from wells that pump underflow or the alluvial aquifer adjacent to the Russian River. Attachment Two is a comment letter we incorporate by reference regarding the proposed North Sonoma County Agricultural Reuse Project, which discusses how the project increases salinity using irrigation rates similar to the ET derived rates that would be used in this Draft Order. The comments show that the project would violate the total dissolved solids (TDS) drinking water standard of 500mg/L within a few

[23] Greenspan, 2013.
[24] Greenspan, 2009.
[25] *Id*.
[26] *Id*.
[27] Sebilo, 2013.

years.[28] The already high groundwater concentration of TDS 200mg/L, loss of river percolation into groundwater from reduced pumping, and application of 11.5 inches of recycled water per year that contains 432mg/L TDS would lead to an estimated concentration of 680mg/L and more than double existing concentrations and violate drinking water standards. The 11.5 inches is equivalent to ET based rates and explains why using ET to determine agronomic rates could lead to basin plan violations. The comment letter also explains what site specific studies should be employed to ensure protection of beneficial uses. This is a critical issue in the Russian River since almost 25 percent of residents rely on individual or small community groundwater well systems for drinking water. Sonoma County has one of the highest per capita well use, it cannot afford to put its groundwater at risk since it is currently a quarter of the total supply.[29]

Although the Order seeks to further extend our states water portfolio by increasing use of recycled water, if it pollutes existing well water supplies, it will actually decrease our net state water portfolio and not meet the main intent of this Order.

Therefore, we suggest that the Draft Order <u>require project proponents to conduct site specific soil studies to determine appropriate irrigation rates, or nitrate applications, if any of the following are present:</u>

- <u>Sensitive beneficial uses;</u>
- <u>High quality groundwater;</u>
- <u>High groundwater tables; or</u>
- <u>The potential for salts to leach into groundwater and degrade water quality beyond potable standards.</u>

4. *The Draft Order's Evapotranspiration Derived Agronomic Rates Pose Risks to Listed Salmonids.*

In Region 1, Coho and Steelhead juveniles are present during the entire summer along the length of Dry Creek.[30] In the Russian River Biological Opinion, NOAA Fisheries directed Sonoma County Water Agency and the Army Corps to perform extensive restorations actions that will total almost $45,000,000 to restore habitat.[31] This is one of the largest outlays of public funding for salmon restoration in one stream in the state's history and seeks to utilize the clean, cold flows from Lake Sonoma in Dry Creek to re-establish our almost extinct population of Coho Salmon.

A U.C. Davis Aquatic Toxicologist, Dr. Teh, was hired to investigate the potential impacts to ESA-listed salmonids from use of recycled water in the Dry Creek watershed. The Dry Creek watershed is a prime viticulture area and presently has no irrigation or discharge or recycled water or treated wastewater since it is distant from area POTWs. Dr. Teh's comments, incorporated by reference in Attachment Three, on the North Sonoma County Agricultural Reuse Project discuss how the "cumulative impacts of contaminants to key organisms and to food web species in the environment or through contaminant-induced changes in nutrient and oxygen dynamics will significantly alter the ecosystem function" and further states that, "indirect effects of contaminants across trophic levels in the Russian River-Dry Creek watershed may have profound implications."[32]

In hydrologist Gus Yates' comment letter (Attachment Two) on the same Project – which could have obtained coverage under this Order as drafted – states that, "constant seepage from groundwater into streams—without the seasonal reversal that occurs under existing conditions—creates a new pathway for

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[28] Yates, 2009.
[29] Sonoma County, 2010.
[30] NOAA, 2008.
[31] NOAA RRBO, 2008.
[32] Teh, 2009.

chronic contamination of surface waterways by pollutants contained in recycled water".[33] The seasonal reversal is going from a gaining stream to a losing stream when vineyard pumps start up for irrigation season, introduction of recycled water for irrigation would reduce pumping and add new water and reverse the current summer losing stream regime to a gaining stream as recycled water for irrigation would percolate back into Dry Creek.

Moreover, Region 1 has a summer discharge prohibition on all effluent discharge to protect sensitive beneficial uses such as REC1 and RARE from May 1 to October 1st. This prohibition is intended to protect uses when flows can be very low after rains season and any recycled water from over-irrigation that might flow over the surface for Frost Protection or subsurface from lateral movement from drip irrigation at ET based rates could harm beneficial uses.

It is critical that agronomic rates be regional specific. Therefore, we suggest that <u>where sensitive beneficial uses exist, the Draft Order should provide public review of an Executive Officer's determination regarding whether an individual WDR is warranted</u>.

5. *The Draft Order should ensure all Beneficial Uses are listed in Section 32.*

Draft Order, Section 32, Table 2, provides a summary of the identified beneficial uses by region. However, it seems that only beneficial uses for human use are listed, ignoring many of the sensitive beneficial uses that should be protected under this Order. For example, under Region One it lists: MUN, AGR, IND, PROC, FRESH, CUL, which are some of the least sensitive beneficial uses in Region 1.

In setting criteria to protect beneficial uses, U.S. EPA regulations require states to "protect [not 'reasonably' protect or 'balance'] the designated use." The regulations add that "for waters with multiple use designations, the criteria shall support the most sensitive use"; balancing that does not protect the most sensitive use is inconsistent with the Clean Water Act.[34]

We suggest the State Board <u>add the most sensitive beneficial uses to Table 2, including COLD, RARE and SPWN, to ensure protection of sensitive ecosystems</u>.

E. THE EXECUTIVE OFFICER SHOULD NOT BE GIVEN UNILATERAL AUTHORITY TO DETERMINE WHETHER SPECIAL CIRCUMSTANCES WARRANT A SITE-SPECIFIC PERMIT.

1. *Existing individual WDRs should not be preempted by this General Order.*

The Draft Order authorizes an Executive Officer to deny an existing Permittee coverage under the Order only when unacceptable water quality degradation exists. Provision 28 of the Draft Order states:

> If the use of recycled water as allowed by this General Order could result in unacceptable water quality degradation as described below, the Regional Water Board's Executive Officer may elect to continue coverage under an existing order for the discharge or propose a new site-specific order for consideration by the Regional Water Board.[35]

The phrase "may elect to continue coverage under an existing order" implies that this Order will preempt all existing WDRs. It is inappropriate for this Order to preempt any existing WDRs. This Draft Order is intended to help streamline recycled water permits to help ease drought conditions. If an existing permit

[33] Yates, 2009.
[34] 40 CFR § 131.11(emphasis added); see also 40 CFR § 131.6.
[35] Draft Order, 11.

already exists then there is no need to streamline. Furthermore, existing permits already have site specific considerations; and therefore, it would be inappropriate for an Executive Officer to unilaterally weaken those requirements under the Draft Order. New water supplies will not be created by preempting existing WDRs—only the weakening of standards will occur.

Of note, enforcement records in Region 4 indicate numerous violations of individual water recycling requirements, including violations of effluent limits. There appears to be a misconception behind this Draft Order that water recycling permits are less important because of the regulations and permits covering the initial treatment process. This is not an appropriate conclusion. For instance there are some water recyclers that do additional treatment to the already treated water they receive. In addition, there are many smaller Permittees such as mobile home parks who have small treatment plans and may not have the expertise on-site equivalent to that of a large POTW. Thus there are many instances when an individual permit is necessary for proper oversight and specific requirements.

We request the Draft Order <u>be explicit that existing WDRs are not preempted by this Order and that Executive Officers should not approve NOIs for parties with existing WDRs.</u>

2. *An Executive Officer should be required to cover a project under an individual WDR when it is determined that water quality will be degraded.*

Provision 28 provides Executive Officers with the discretion to require coverage under an individual WDR when water quality degradation may occur. There should be no permissive authority here. If a project is likely to degrade water quality, the Executive Officer must require an individual WDR.

We request Provision 28 be revised to read "…the Regional Water Board's Executive Officer ~~may~~ <u>shall</u> ~~elect to continue coverage under an existing order for the discharge or~~ propose a new site-specific order for consideration by the Regional Water Board."

3. *An Executive Officer should not be given the unilateral authority to determine whether special site specific circumstances warrant an individual WDR without public review.*

The Draft Order allows the Executive Officer to determine whether coverage under the Order is appropriate without any public review. Provision 28 runs contrary to case law that eliminating meaningful agency review and public oversight violates fundamental provisions of the Clean Water Act, and has been expressly invalidated by the Ninth Circuit. In *Environmental Defense Center, Inc. v. U.S. E.P.A*, the Court held:

> Management programs that are designed by regulated parties must, in every instance, be subject to meaningful review by an appropriate regulating entity to ensure that each such program reduces the discharge of pollutants to the maximum extent practicable.[36]

The Ninth Circuit further reasoned that "Congress identified public participation rights as a critical means of advancing the goals of the Clean Water Act in its primary statement of the Act's approach and philosophy."[37] Thus the public must be given the opportunity to participate in the permitting and compliance process.

Finding 28 of the General Order circumvents the public review and comment requirements of the Clean Water Act by allowing a Regional Water Boards' Executive Officer alone to determine whether special

[36] 344 F.3d 832, 854-56 (9th Cir. 2003).
[37] *Id*. at 856-57.

circumstances warrants a Permittee to have site-specific requirements. As such, this section violates the Clean Water Act and is contrary to the Ninth Circuit's ruling in *Environmental Defense Center*.

We request the Draft Order include a public petition process regarding the Executive Officer's determination of whether special site considerations exist. Petitions for a public hearing shall be granted for any NOI within a region where sensitive beneficial uses –such as SPAWN or RARE – exist. Petitions for public hearing shall also be granted where existing studies find the potential for groundwater contamination exists due to evapotranspiration derived irrigation rates.

F. FROST PROTECTION SHOULD BE PROHIBITED IN THE ORDER.

Water is one of the most effective means of frost protection for emergent grape vines. Water is applied through high-volume overhead Rainbird type sprinklers that run for several hours prior to freezing to coat the vulnerable buds in a coating of ice. This normally occurs during spring months when the ground is saturated which leads to ponding and run-off.

The Draft Order does not expressly prohibit the use of recycled water for frost protection. Frost protection by definition has no linkage to agronomic rate, since it is not an irrigation use of water. This Draft Order relies on agronomic rate as mitigation to protect against groundwater or surface water pollution. Additionally, Section 25 of the Draft Order states that agronomic rates are Best Practical Treatment Control (BPTC) to avoid degradation. Since frost protection is by definition not an agronomic rate, it should be prohibited. The use of recycled water for frost protection should be prohibited in the Order.

Hydrologist Gus Yates's Attachment Two comment letter discusses how using recycled water for frost protection will lead to ponding and run-off, leading to well water impacts. Any frost water that infiltrates into soil will simply pass through root zones and percolate to the water table along with salts, nitrate, metals and organic carbon it contains. These conditions will also produce surface runoff – including all of the salts, nitrate, dissolved organic carbon, metals and other pollutants flows without dilution to local creeks.[38] Any surface runoff from frost protection will directly harm salmonids and the food web that support juvenile salmonid growth and development.[39]

One other problematic use of recycled water in Region 1 is to establish cover crops before fall rains, this is accomplished by using overhead sprinklers to thoroughly soak ground in late fall and almost always results in ponding and some run-off due to non-agronomic rates of sprinklers compared to drip irrigation. Due to the potential for ponding and runoff and potential to load soil with leachable materials prior to fall rains that will drive it to groundwater this could result in basin plan violations and should be prohibited.

We request the State Board add "frost control" and "overhead sprinklers to establish cover crops" as an unauthorized activity under Provision 10 of the Draft Order.

[38] Yates, 2009.
[39] Teh, 2009.

G. THE GENERAL ORDER NEEDS ADEQUATE MONITORING TO ENSURE PERMITTEES ARE NOT DEGRADING WATER QUALITY.

1. *It is inappropriate for Permittees to self-select their priority pollutants to be monitored without adequate public review.*

We are concerned with the Draft Order's proposal for monitoring Potentially Present Priority Pollutants (P4s). As outlined, the Draft Order requires that the applicant "determine the Potentially Present Priority Pollutants List (P4 List) and submit that with the Notice of Intent."[40] This is very subjective. Instead, P4 monitoring decisions should be made by the regional boards and CDPH.

We suggest the Draft Order include minimum priority pollutant monitoring requirements for the four categories of recycled water projects contained in the Draft Order.

2. *Single indicator bacteria monitoring is not adequate to protect all beneficial uses.*

Pathogens are a constituent of concern identified by the State Water Board to possibly degrade groundwater quality. We are concerned that solely using coliform bacteria as a surrogate for pathogens may not adequately protect all beneficial uses. What is the reasoning for using only coliform bacteria as a pathogen surrogate? Does "coliform bacteria" in the Draft Order refer to fecal, total, both? Coliform bacteria is too broad of a category to use as a surrogate for pathogens. The U.S. EPA epidemiological studies state that *E. coli* and enterococci exhibit the strongest correlation to pathogen in fresh water, and thus, are the most protective of beneficial uses. [41]

We recommend the Draft Order use both *E. coli* and enterococci as monitoring surrogates for pathogens.

H. THE STATE BOARD NEEDS TO PERFORM A PROPER ANTI-DEGRADATION ANALYSIS TO ENSURE THE DRAFT ORDER DOES NOT RESULT IN LONG-TERM GROUNDWATER DEGRADATION.

1. *The General Order's antidegredation analysis conflicts with the Recycled Water Policy.*

The Antidegredation Policy applies to the disposal of waste to high-quality surface water and groundwater. The Policy requires that the quality of existing high-quality water be maintained unless the State finds that any change will be consistent with maximum benefit to the people of the State, will not unreasonably affect present and anticipated beneficial use of such water, and will not result in water quality less than that prescribed in policies as of the date on which such policies became effective. The Policy also requires best practicable treatment or control of discharges to high-quality waters to assure that pollution or nuisance will not occur, and that the highest water quality consistent with maximum benefit to the people of the state will be maintained.

The State Board's Recycled Water Policy explains how the Antidegredation Policy will be applied in instances where a streamlined irrigation with recycled water permit is being developed. First, if a project "meets the criteria for a streamlined irrigation permit and is within a basin where a salt/nutrient management plan satisfying the provisions of paragraph 6(b) is in place may be approved without further anti-degradation analysis".[42] Second, if a project is within a basin where a salt and nutrient management plan is being prepared for approval, then the project proponent must demonstrate "through a salt/nutrient

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[40] Draft Order, 4.
[41] Ambient Water Quality Criteria for Bacteria--1986, January, 1986, EPA 440/5-84-002; Health Effects Criteria for Fresh Recreational Waters, August, 1984, EPA 600/1-84-004; Health Effects Criteria for Marine Recreational Waters, August, 1983, EPA 600/1-80-031.
[42] Recycled Water Policy, 14.

mass balance or similar analysis that the project uses less than 10 percent of the available assimilative capacity as estimated by the project proponent in a basin/sub-basin (or multiple projects using less than 20 percent of the available assimilative capacity as estimated by the project proponent in a basin/sub-basin)."[43] And finally, if a project is not within a basin with a salt and nutrient management plan, then the State Board finds that "the use of water for irrigation may, regardless of its source, collectively affect groundwater quality over time."[44] The Draft Order's antidegredation analysis ignores its Antidegredation Policy and conflicts with the Recycled Water Policy.

To be consistent with the Recycled Water Policy's antidegredation provisions, we suggest the following be included in the Order:

> <u>In the event that a project is being proposed in a basin where a salt/nutrient management plan is being prepared, the administrator must show through a salt/nutrient mass balance or similar analysis that the project uses less than 10 percent of the available assimilative capacity as estimated by the project proponent in a basin/sub-basin (or multiple projects using less than 20 percent of the available assimilative capacity as estimated by the project proponent in a basin/sub-basin)</u>.

This language comes directly out of the Recycled Water Policy provisions regarding antidegredation (Section 9.d.2.). Again, we understand this section applies to "landscape irrigation" but believe it should be applied to both landscape and agriculture irrigation given the Recycled Water Policy never intended for agricultural irrigation to be streamlined.

2. *The Order's analysis of whether recycled water will degrade high quality waters is insufficient and conflicts with recent case law.*

The Order finds that it "requires compliance with water quality objectives, prohibits pollution or nuisance, and allows adoption of site-specific requirements where necessary to prevent significant degradation." However, in a recent decision, *Association De Gente Unida Por El Agua v. Central Valley Regional Water Board* (*Agua*)[45], the Court of Appeal held that Antidegredation Policy "applies whenever there is: (a) existing high quality water, and (b) an activity which produces or may produce waste or an increased volume or concentration of waste that will discharge into such high quality water."[46]

Similar to the analysis the State Board performed here in the Draft Order, the court in *Aqua* was not convinced by the Board's contention that no analysis under Antidegredation Policy was necessary because the order prohibits further degradation of groundwater.[47] First, the court found that an actual showing of degradation is not required; instead the policy applies when there "is a determination that the receiving water is high quality water and that an activity will discharge waste into the receiving water." The policy presumes from these two facts that the quality of the receiving water will be degraded by the discharge of waste.[48] Second, the Court found the monitoring system upon which the order relies to support its contention that no further degradation will occur was insufficient for the task.[49]

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[43] *Id*.
[44] *Id*.
[45] Associacion De Gente Unida Por El *Agua* v Central Valley Regional Water Board (2012) 210 Cal.App.4th 1255, 1258.
[46] *Id* at 1268.
[47] *Id* at 1280.
[48] *Id* at 1272.
[49] *Id* at 1273, 1274-1275, 1280.

Similar to the Draft Order, *Agua's* monitoring program was determined by the court to be incapable of "alert[ing] the Regional Board if a dairy is degrading the groundwater."[50] For instance, the monitoring program was limited to existing supply wells, which were not located in the proper areas to detect degradation and would not show pollution until several years after its release.[51] The order also did not contain a timetable for monitor well installation, an enforcement mechanism for violations, nor did it test for all constituents of concern.[52]

Overall, "monitoring conducted from supply wells alone does not provide either an accurate or a timely indication of groundwater degradation."[53] Therefore the Court found that the Anti-Degradation Policy applied to the Regional Board's Order because of evidence in the record that at least some of the groundwater affected is high quality groundwater and the Order allows the discharge of waste to groundwater.[54]

Similarly, evidence in the record exists that groundwater will be affected by this Draft Order. And just as in *Agua*, there is no monitoring in place to accurately quantify the amount of groundwater degradation.

We suggest the Draft Order contain an adequate monitoring program sufficient to determine compliance with the Anti-Degradation Policy and water quality objectives. We suggest the Draft Order <u>require Permittees to:</u>

1. <u>Monitor in locations adequate to detect degradation;</u>
2. <u>Include a timetable for monitoring installation;</u>
3. <u>Include an enforcement mechanism for violations of monitoring program;</u>
4. <u>Ensure monitoring test for each constituent of concern;</u>
5. <u>Include remediation measures in the event the monitoring detects degradation.</u>

3. The State Board needs to provide a proper antidegredation analysis.

The Order states that to "the extent a discharge covered under this General Order may be to high quality waters, this General Order is consistent with the Anti-degradation Policy as described in the findings below. Salt and Nutrient Management Plans will require analysis on an ongoing basis to evaluate inputs to the basin, the salt and nutrient mass balance, and the available assimilative capacity."[55] This type of circular statement is precisely what *Agua* determined to be not sufficient as a proper antidegredation analysis.

The State Board must adhere to the follow analysis to determine whether the antidegredation analysis of Resolution 68-16 applies.

1. Establish the baseline water quality, which is the best level of water quality that has existed since 1968.
2. Compare the baseline water quality to the water quality objectives.
3. If the baseline water quality is equal to or less than the objectives, the objectives set forth the water quality that must be maintained or achieved.
4. If the baseline water quality is better than the water quality objectives, the policy applies and the baseline water quality must be maintained in the absence of findings required by the Anti-degradation policy.

[50] *Id* at 1274.
[51] *Id* at 1274-1275.
[52] *Id* at 1275.
[53] *Id* at 1275.
[54] *Id* at 1286.
[55] Draft Order, 7.

5. Existing high quality waters are waters with existing background quality unaffected by the discharge of waste and of better quality than that necessary to protect beneficial use
6. Where the waters contain levels of water quality constituents or characteristics that are better than the established water quality objectives, such waters are considered high quality waters.

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Reuse and recycling of our limited water resources will be essential to meet the ever-growing demand for water in California, including water needs for a healthy environment. As we have articulated repeatedly, the laudable goal of encouraging wastewater reuse and recycling can and should be pursued without diminishing the commitment to protect and enhance water quality fully in the process. We look forward to working with you to ensure clean, abundant water for California.

Sincerely,

Sean Bothwell
Staff Attorney
California Coastkeeper Alliance

Kirsten James
Science and Policy Director, Water Quality
Heal the Bay

ATTACHMENT ONE

2012 Middle Reach Russian River Vineyard Irrigation Demonstration Project

Mark Greenspan, Ph.D., CPAg, CCA

Advanced Viticulture, Inc.

Windsor, CA

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.

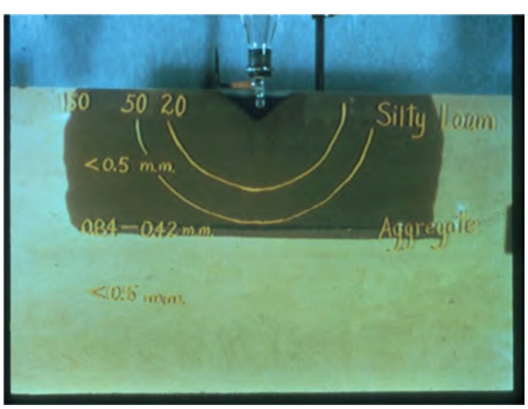
The vine water status measurements are shown in groups of four sites each after the discussions of the individual sites. Note that the green shaded areas represent the ideal target levels of those measurements.

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.

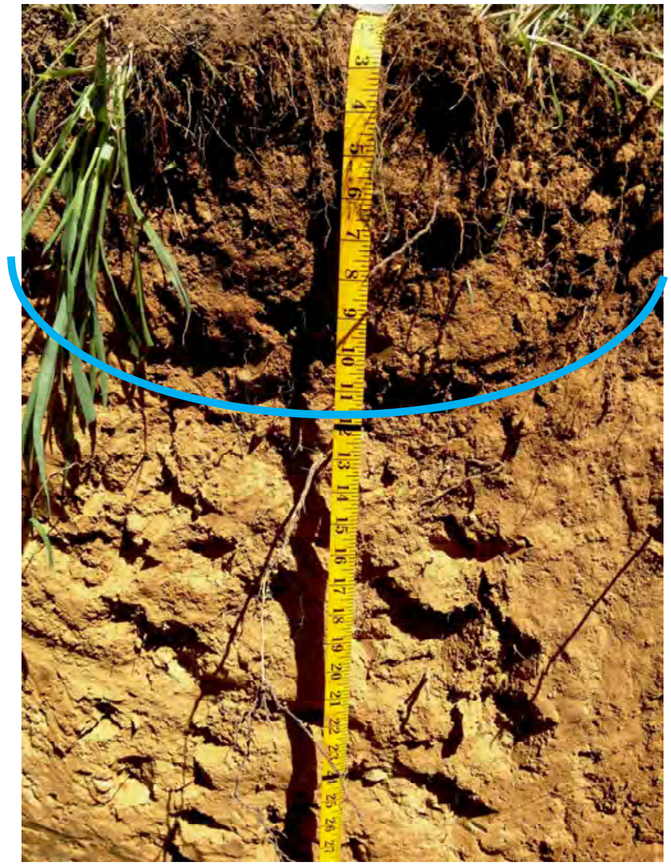
What are the consequences of these findings and theory? It was feared that excessive irrigation could cause deep percolation of moisture below the root zone, potentially below the depth at which roots could extract moisture. This could cause contamination of the groundwater by leaching of contaminants 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.

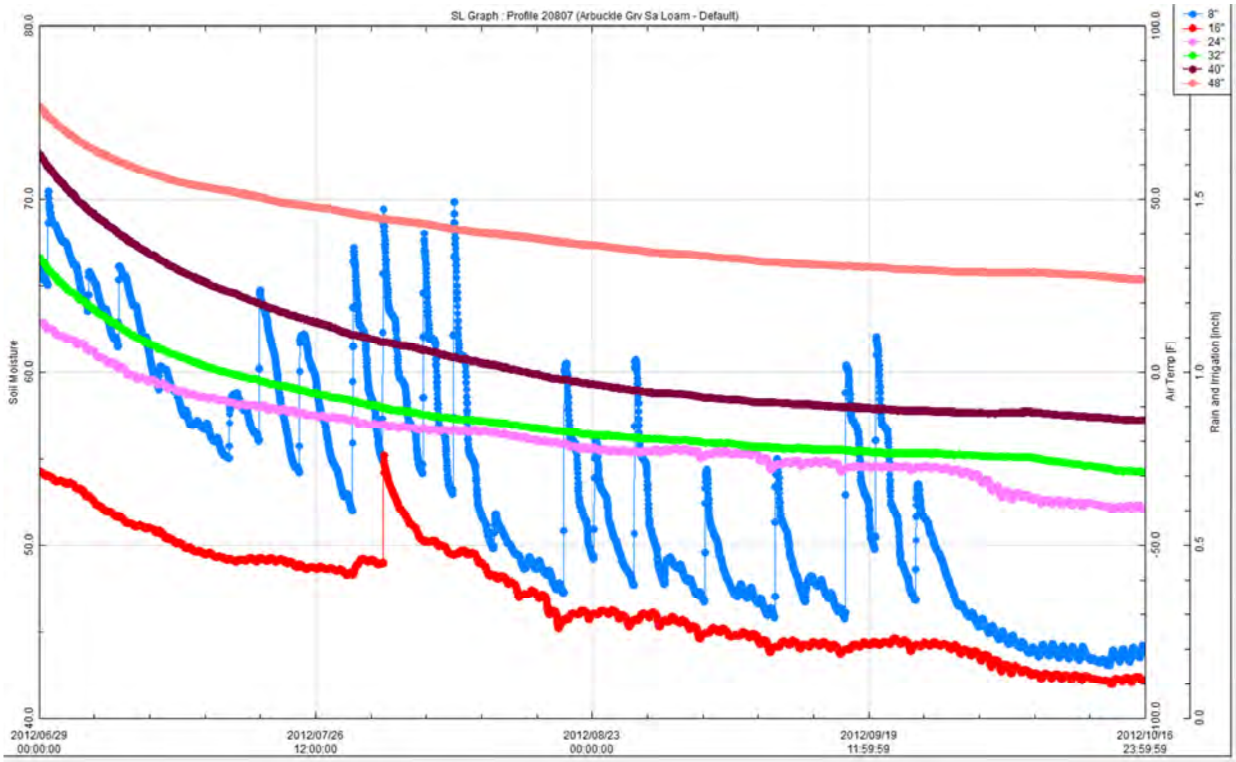


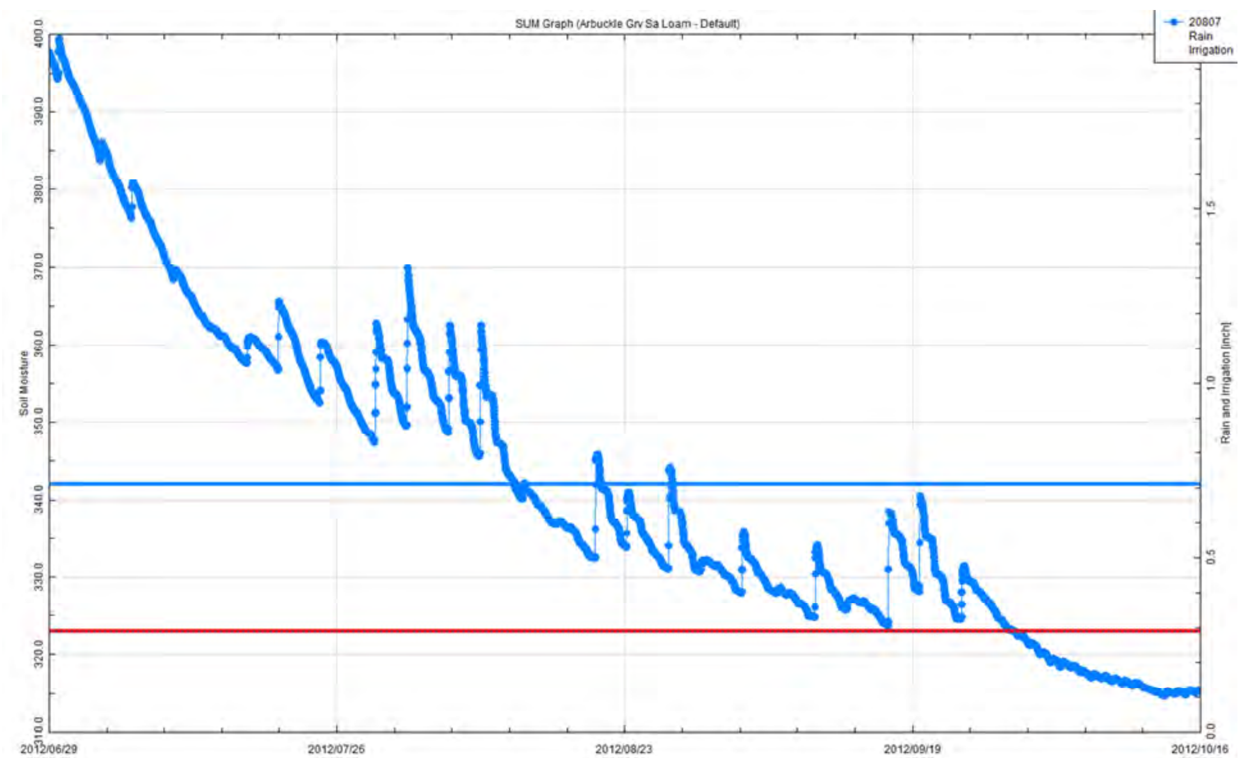
- Viognier
- 1.6 inches total irrigation
- 13% of full ETc (June 29 – Oct. 15)
- Runoff was a problem, so short irrigations best
- Vines were not stressed during the season

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.

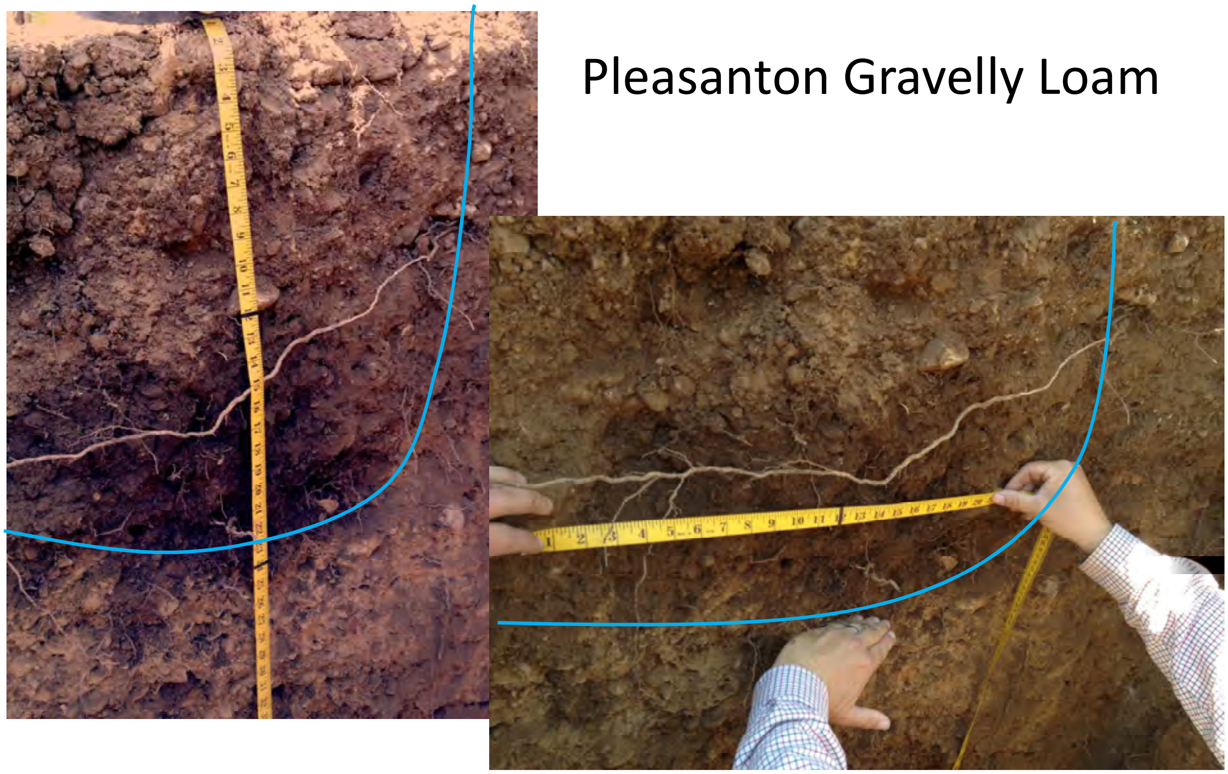
A total of 1.6 inches were applied to the vineyard until October 15, amounting to only 13% of full ETc.





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".

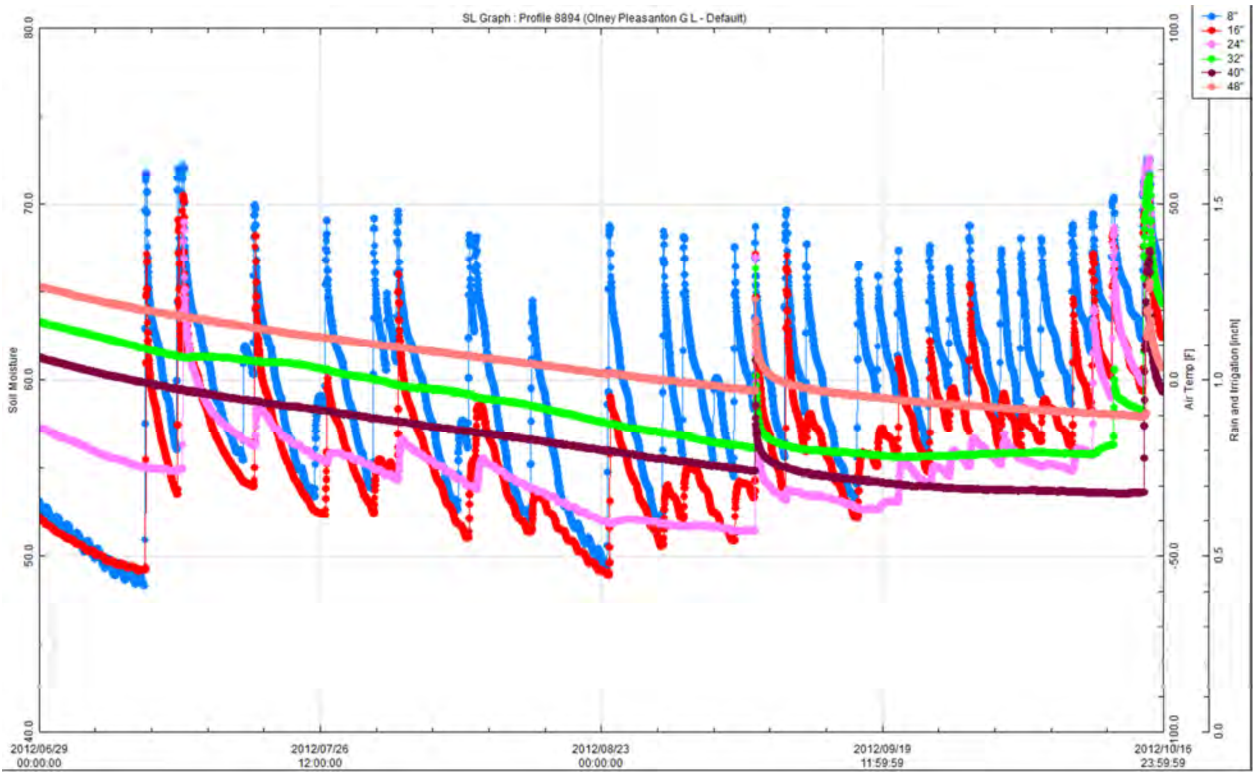
- Chardonnay
- Erratic irrigation due to system problems
- 2.6 inches total irrigation
- 22% of full ETc (June 29 – Oct. 15)
- Irrigation did not percolate below 22” due to soil stratification
- Vines were very slightly water stressed late in the season

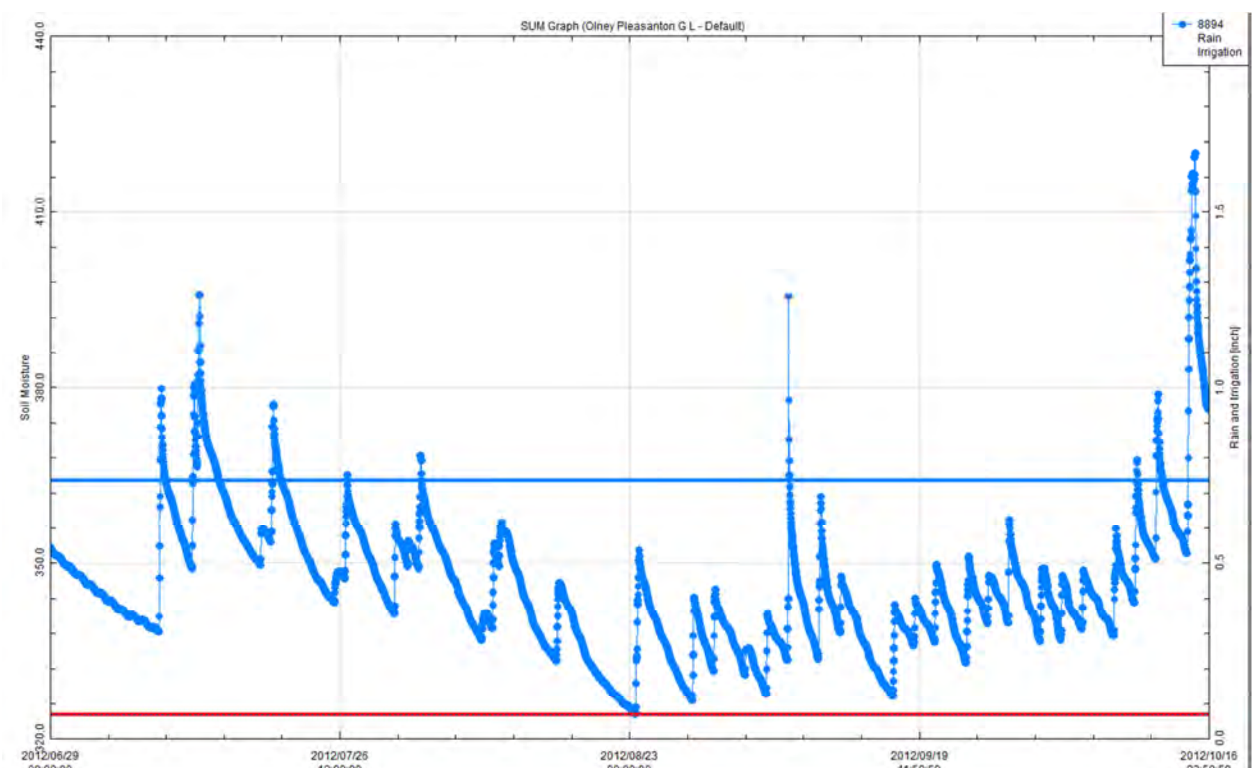
This site, although on a toe slope above the river basin, had some strong soil strata that limited water percolation. The major stratification is at 23 inches depth, where coarse gravel underlies a loam textured soil. That interface was wavy, probably due to soil preparation before vineyard planting. 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





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.

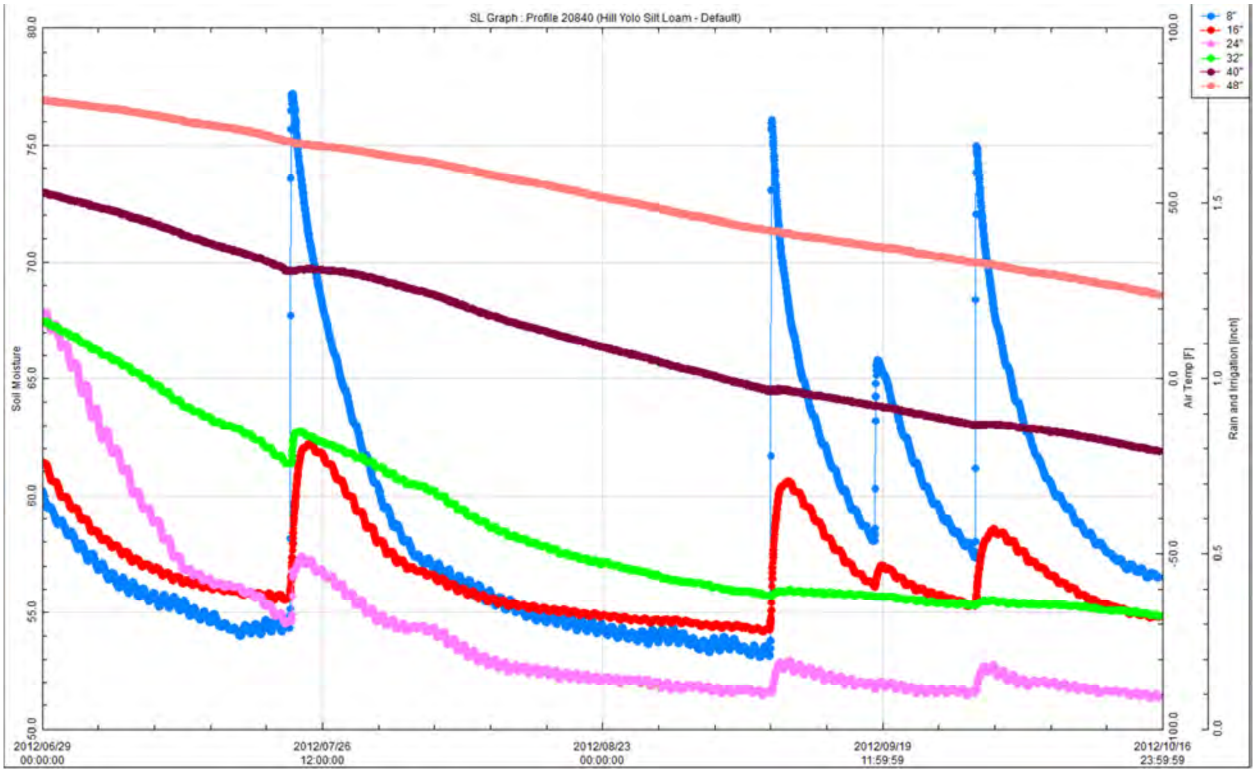
This soil was very deep, though only observed to about 4 feet. Soil was very uniform without strong stratification of soil textures. The recent irrigation had only penetrated to about 15 inches, but was rather wide, with a radius of about 14 inches. While this soil did not exhibit stratification, the 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.

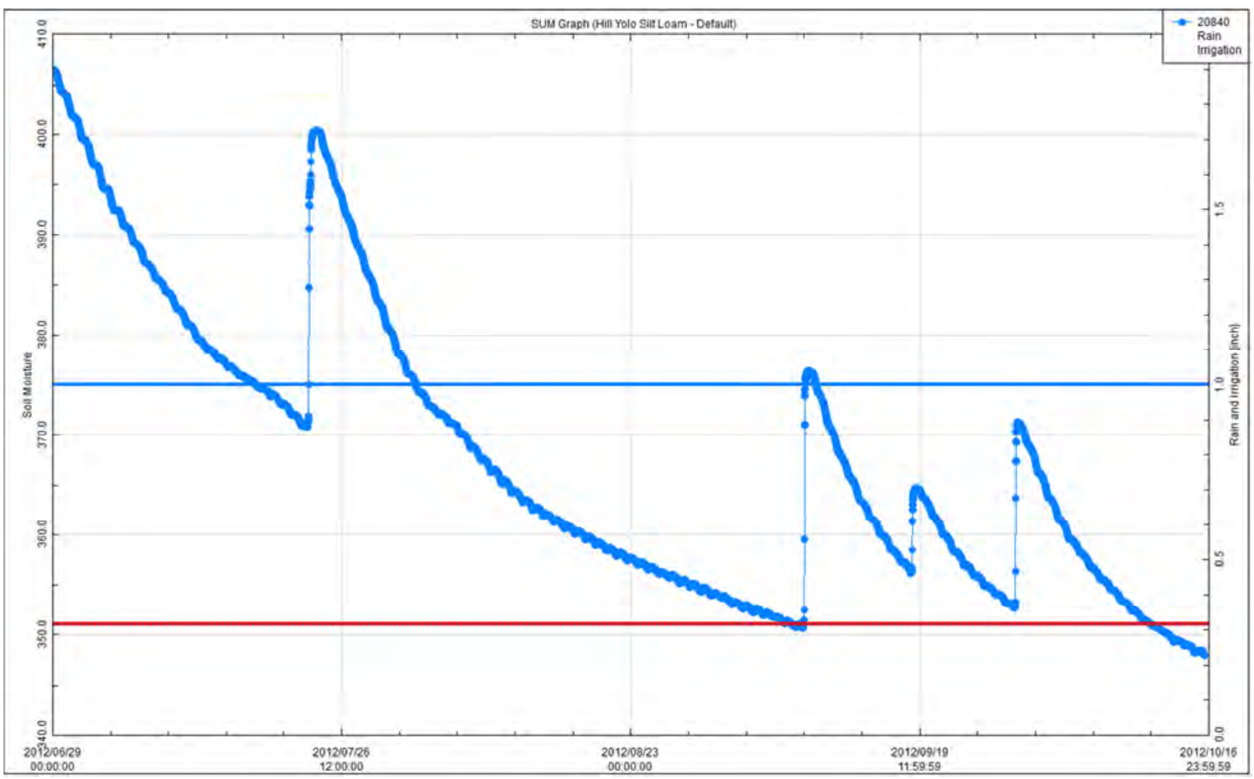
The first irrigation did not reach the 32 inch depth, but did redistribute to that depth, but only slightly raised the soil moisture down there. Subsequent smaller irrigations did not reach the 24 inch depth to a great degree.

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

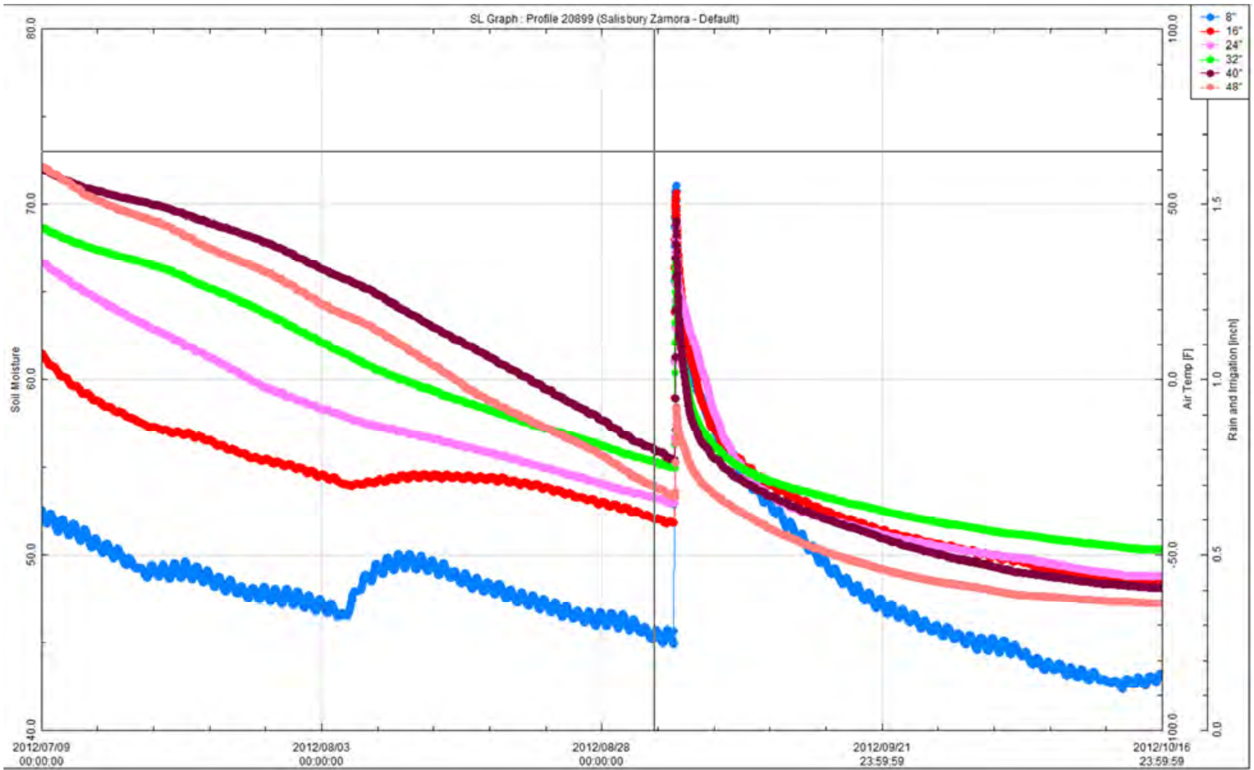
This site was chosen to represent one of the heaviest soils of the region. The soil was heavy, but quite uniform without any strong stratifications, except for a change from the loam texture to a clay/gravel matrix at 31 inches.. Soil was fairly moist at the time of observation and the block had not 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.

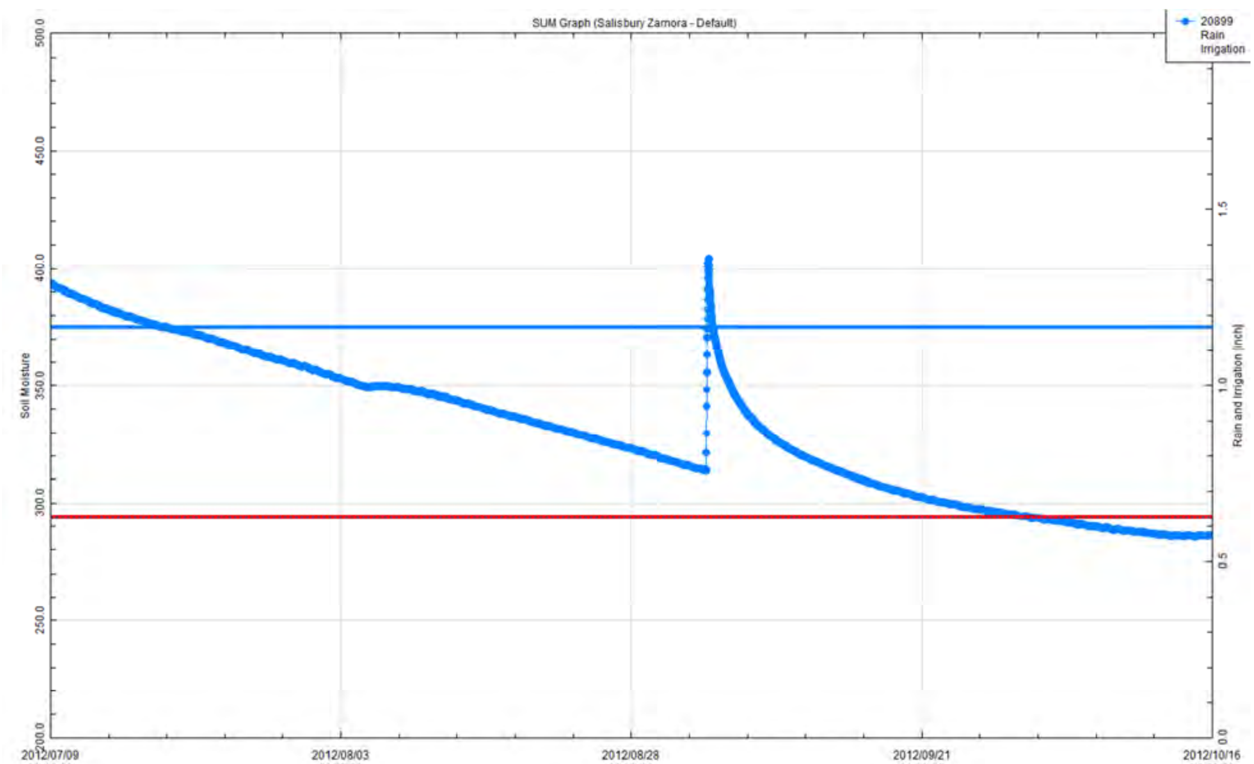
Because this soil is heavy, the wetted plume was not wide, so irrigation about 18 inches away from the drip point did not reach to within the sensing zone of the probe (which only has a radius of influence of about 2-3 inches). The problem was fixed and the subsequent irrigation was sensed clearly by 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.

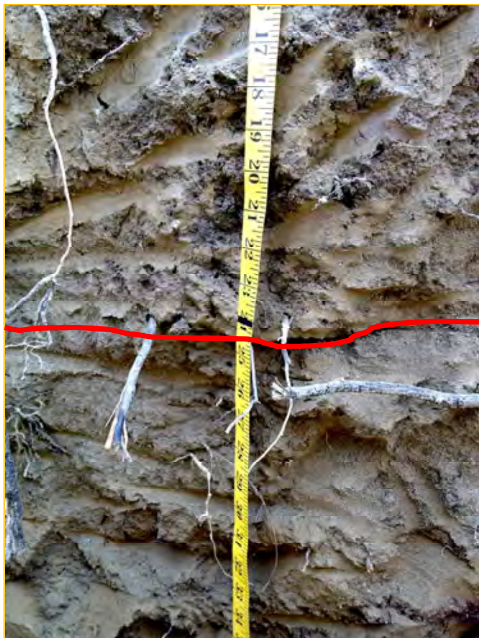
The vineyard had only 0.6 inches of water applied, comprising 5% of full ETc.

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.

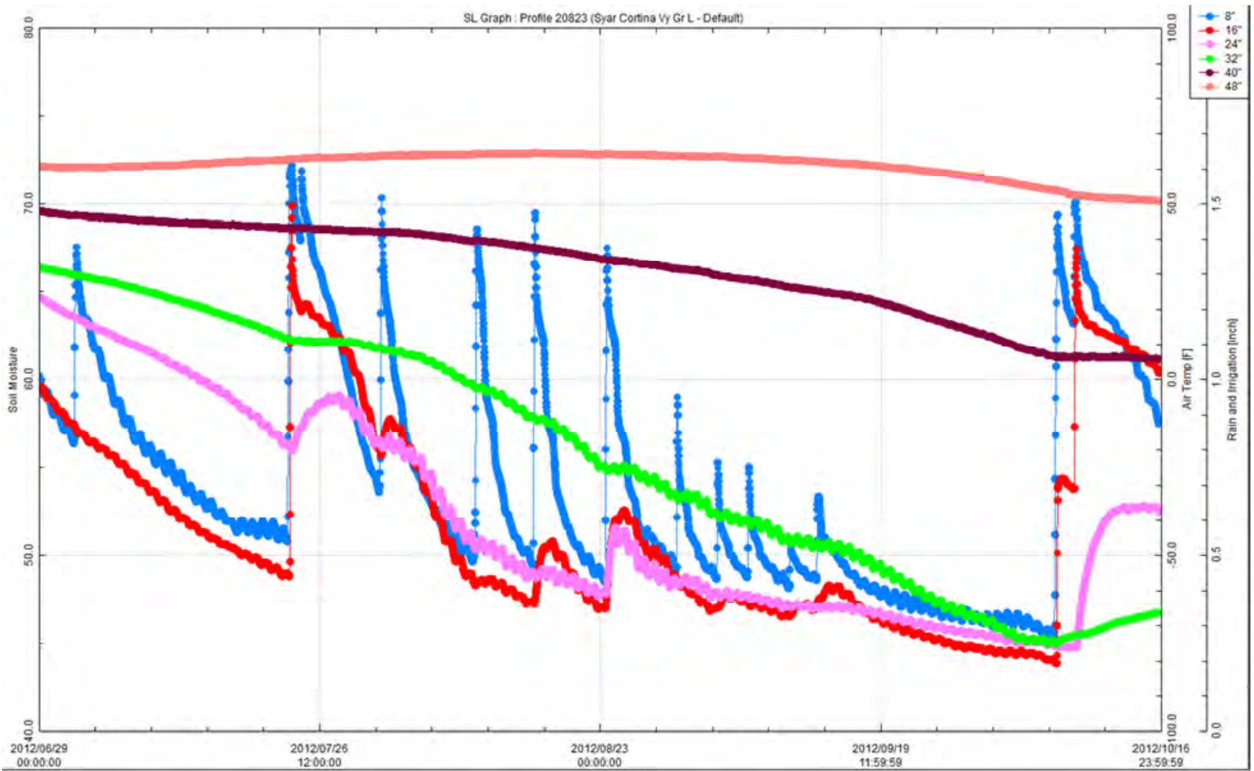
This vineyard was chosen because it was on the coarsest soil in the region, according to the NRCS soil survey. The concern for this site was that heavy irrigation would drive moisture through and below the profile, potentially contaminating groundwater. We did not find this to be the case. There was 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.

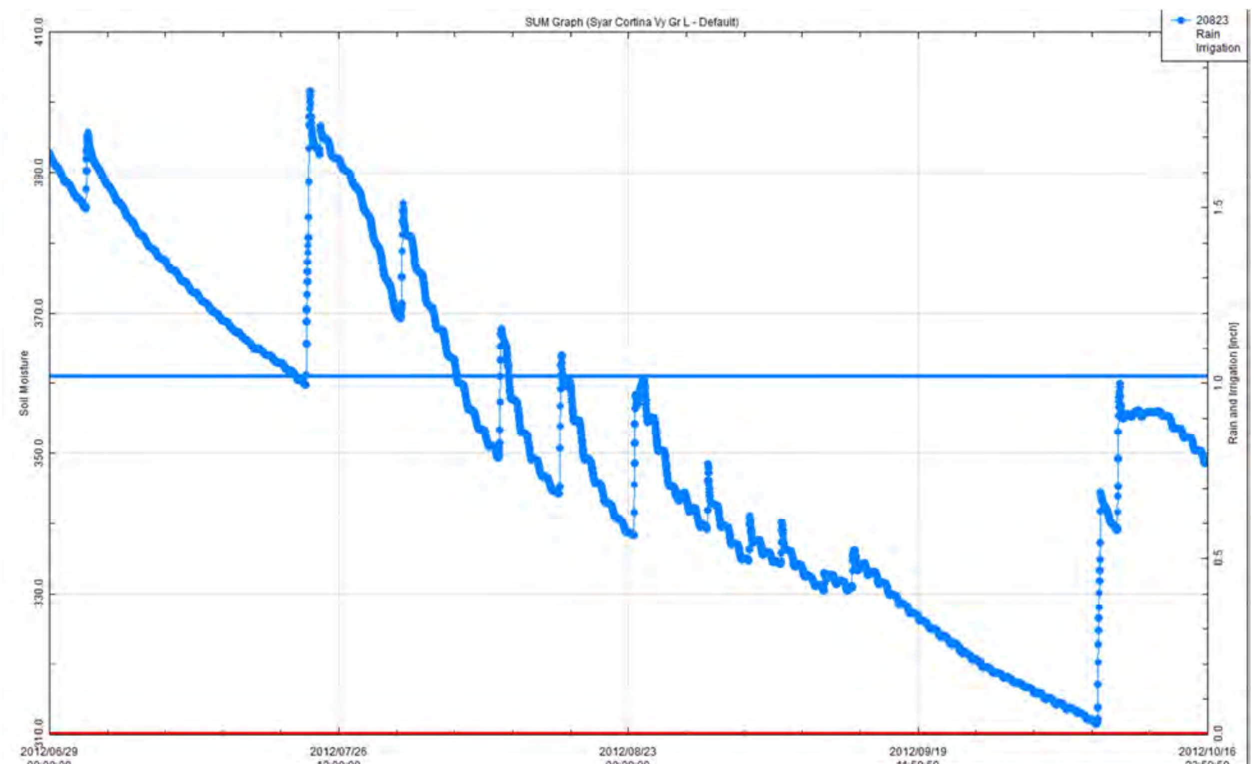
The relatively flat soil moisture curves at 48 inches and to a lesser extent 40 inches indicates that deep soil moisture was not being utilized by the vines.

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.

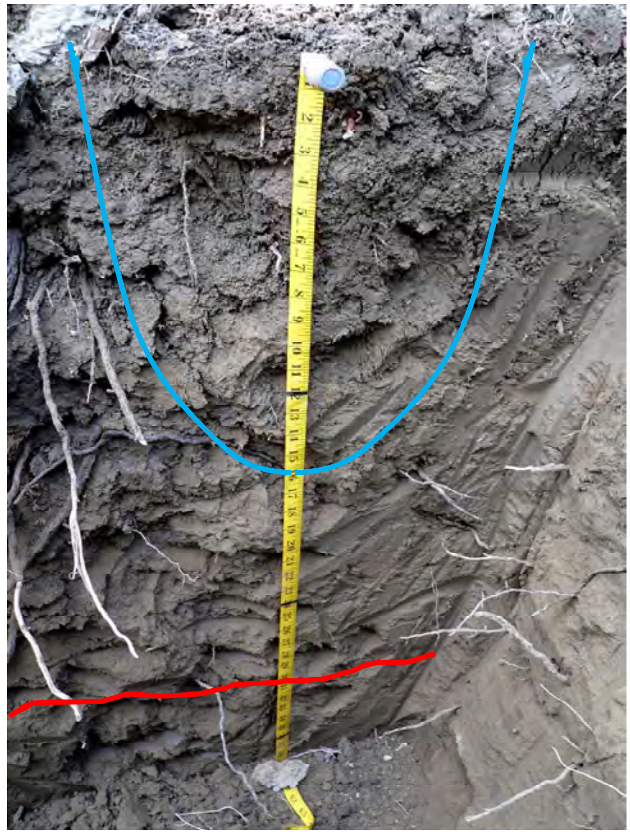
Block at the end of the growing season





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.

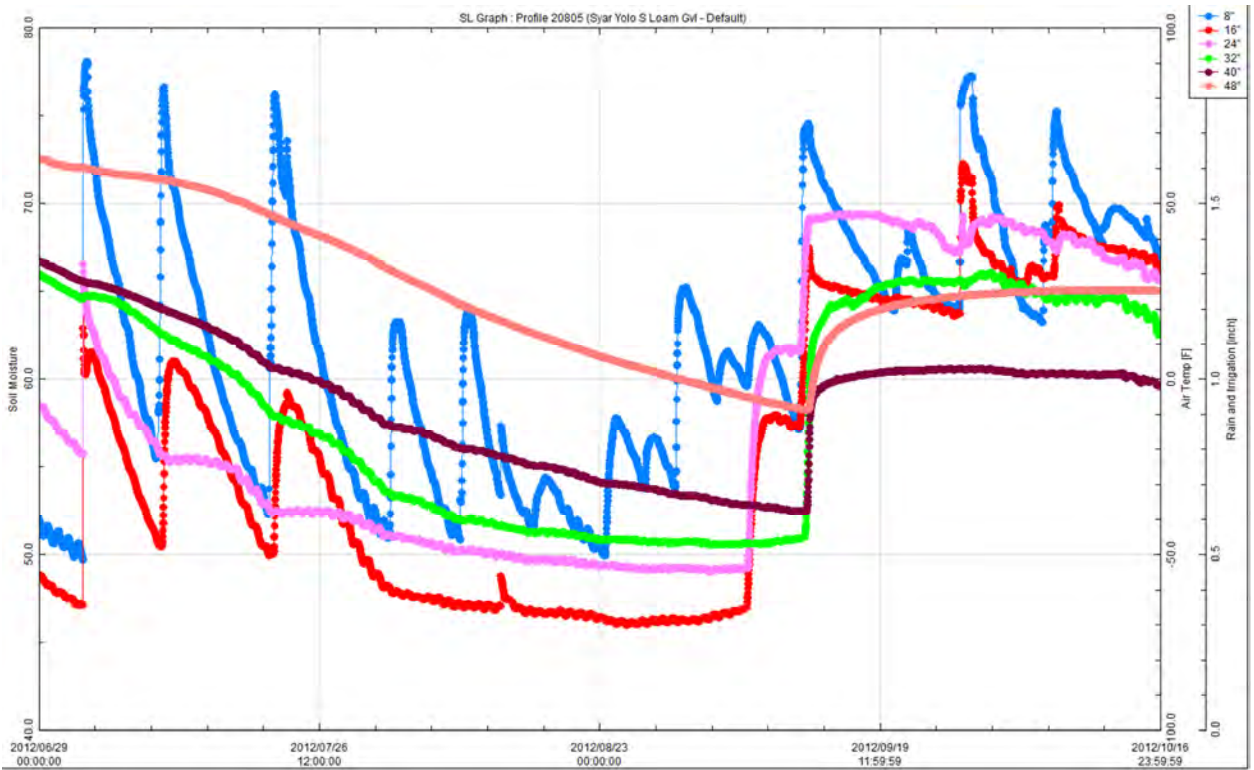
The soil was a sandy loam without any other clear stratification. Nevertheless, moisture was seen to only 16 inches depth during the observation, even though water had ponded at the surface, indicating poor infiltration. Irrigations were not able to raise soil moisture below the 16 inch depth during 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).

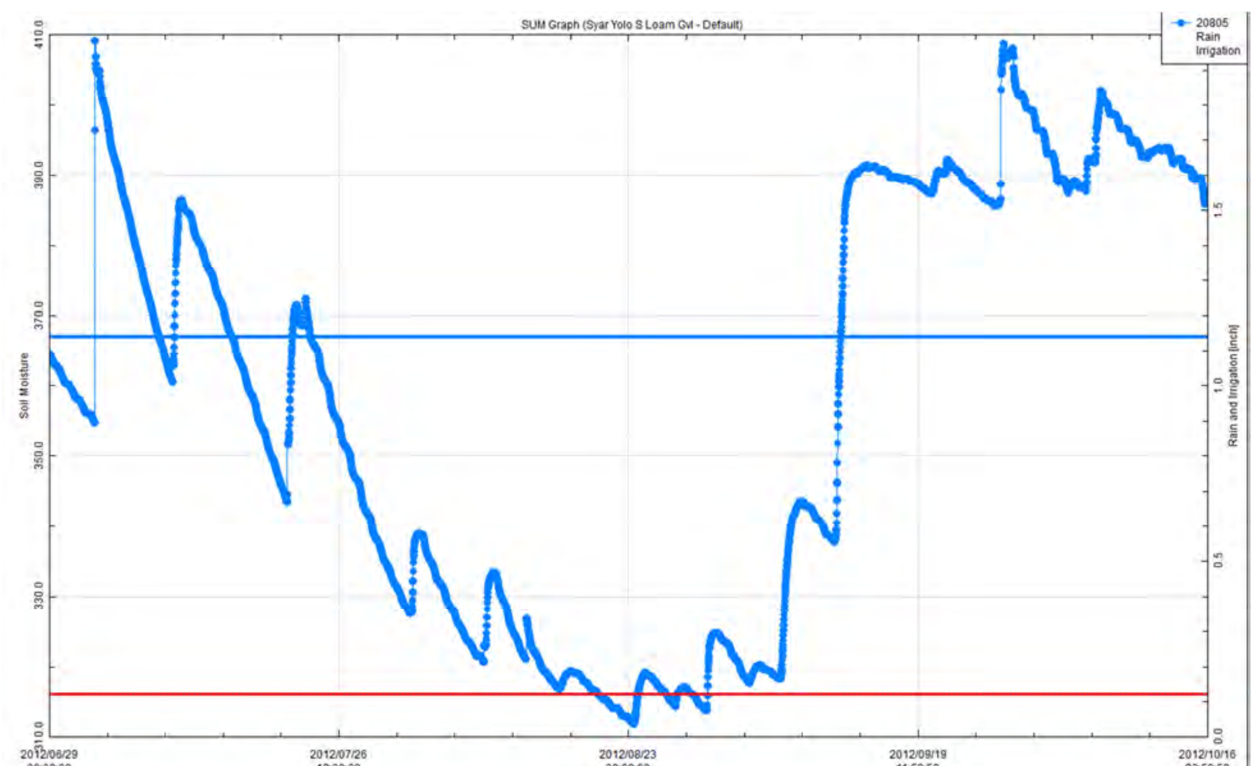
Vines did not reach any level of stress during the season, likely due to the large accidental irrigation. But, early irrigation applications were insufficient to prevent soil moisture deficit and vines may have gotten stressed. However, a more regular pattern of shorter (about 5 hour) irrigations spaced 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.

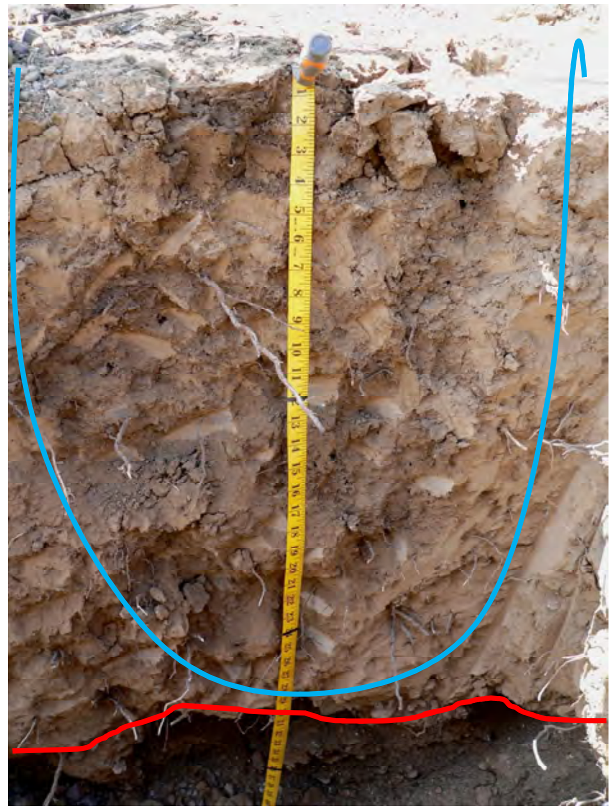
Surface ponding.





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.

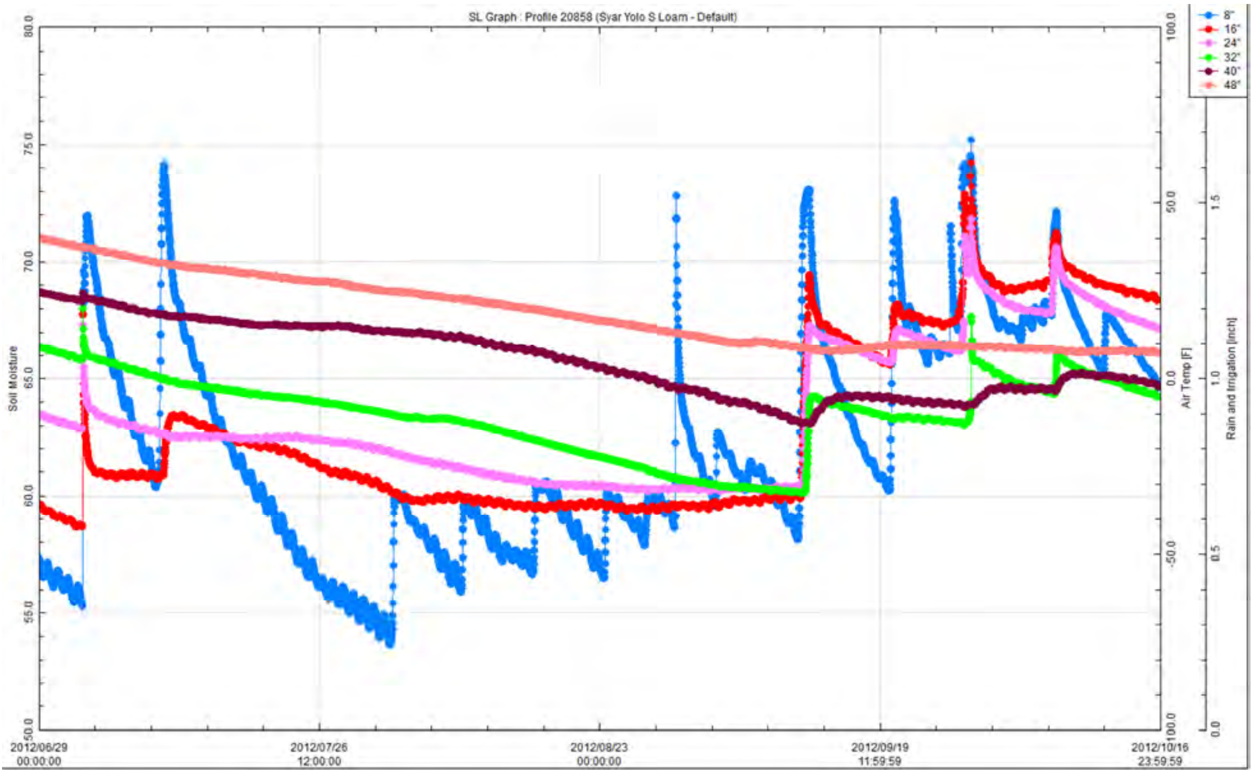
This block was the same blocks at the other Yolo Sandy Loam site, though the soil was considered to be non-gravelly. Indeed, there was little gravel in the profile, except for a transition to unconsolidated gravel at about 32 inches depth. Roots were found to about 36 inches. Like the other Yolo Sandy 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.

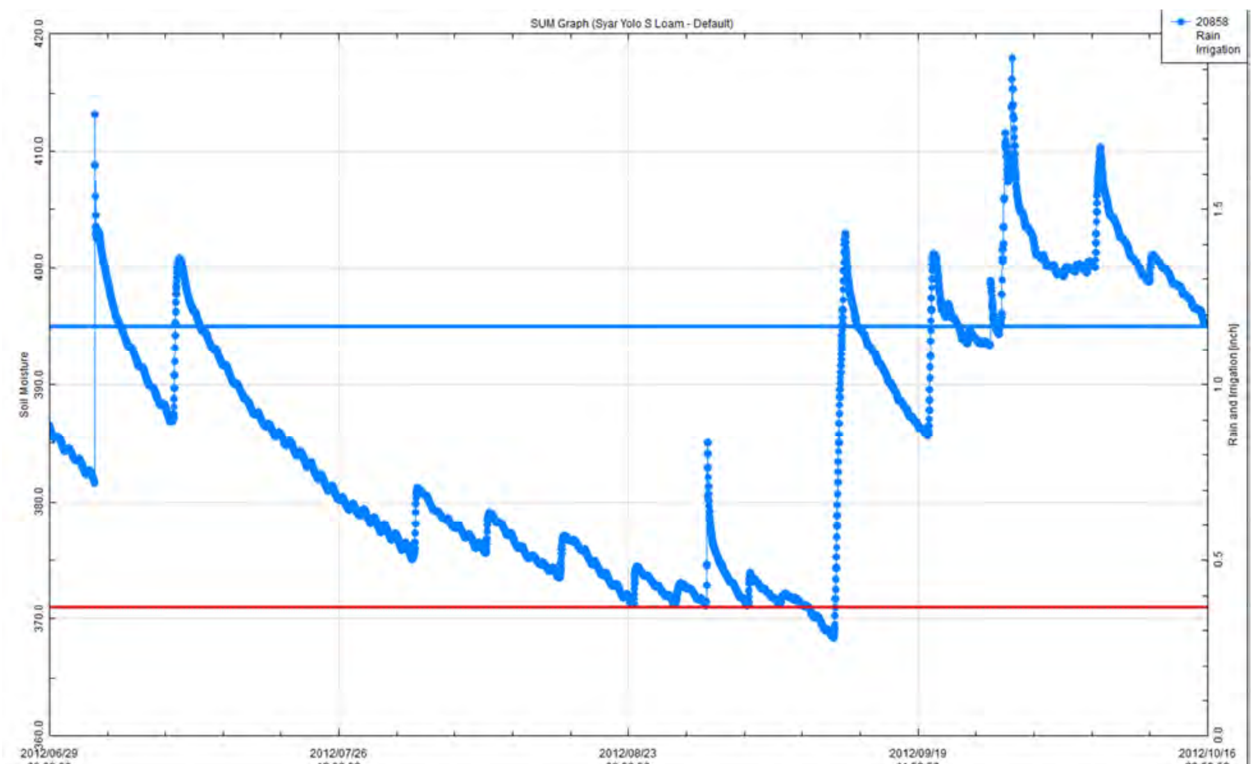
Nevertheless, the accidentally-long irrigation that occurred in the other Yolo Sandy Loam site occurred here as well, as they are the same block. However, this side of the block has only one emitter per vine, so the volume applied was half of that of the other side. The large irrigation was effective 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.

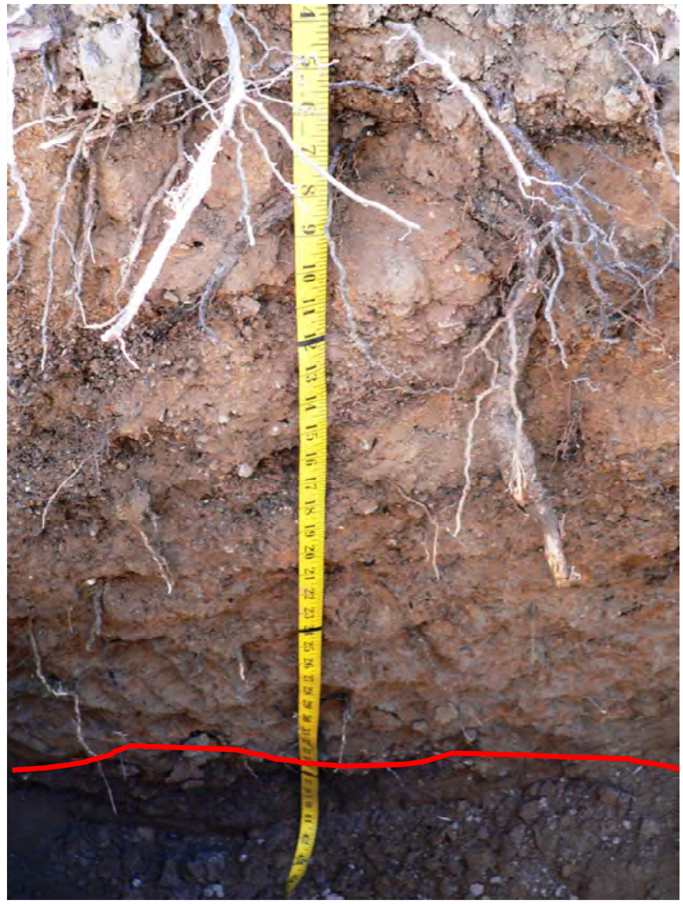
Block at the end of the growing season





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.

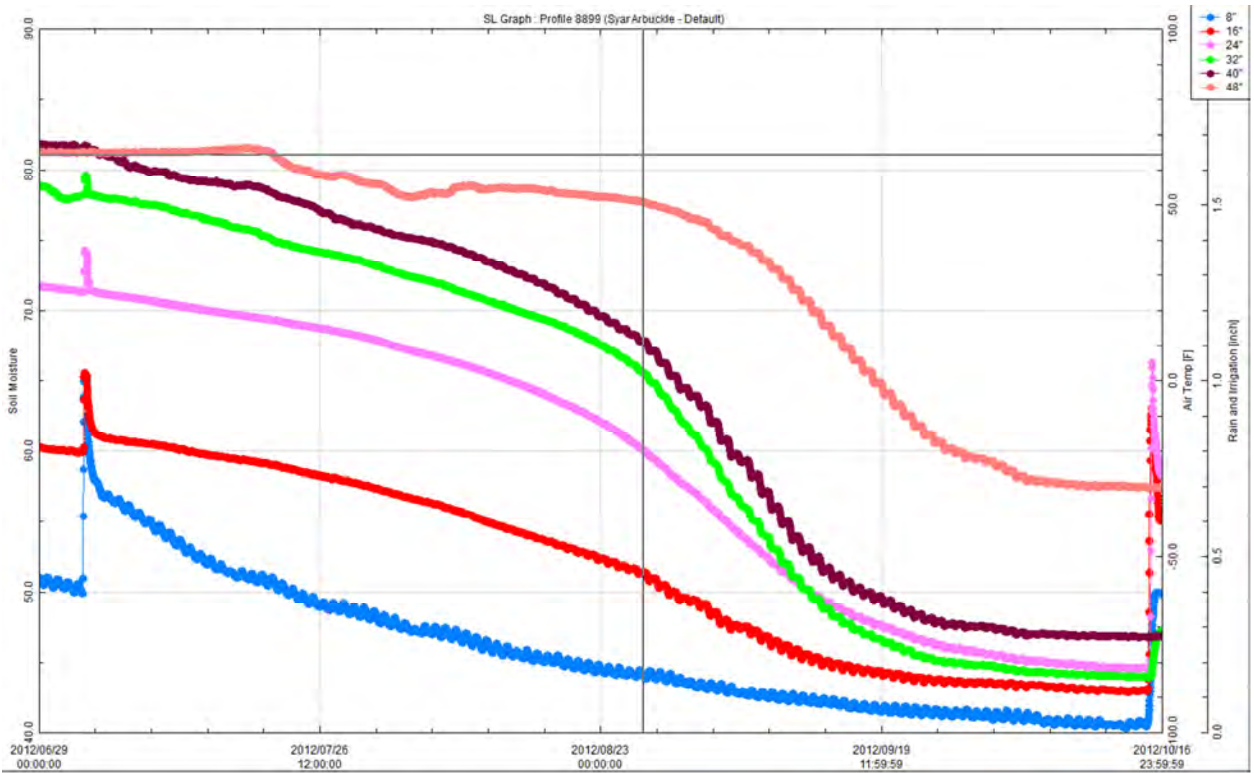
At the time of observation, the soil was waterlogged at about 4 feet depth. There are strong rust mottles, indicative of periodic waterlogging between about 20 inches to the point of soil discontinuity at 37 inches. Below 37 inches, soil transitions to an unconsolidated gravel. Roots were present to 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.

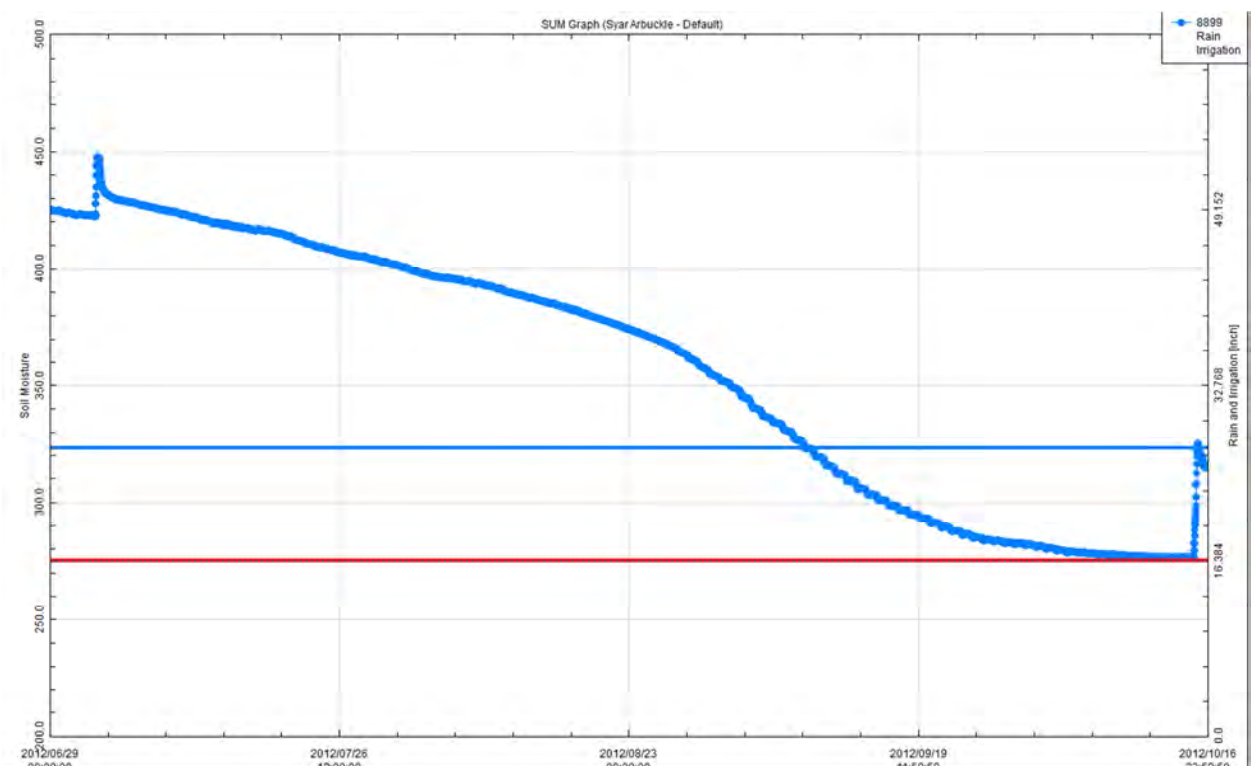
The soil moisture is high in this profile, relieving the vineyard of the need for irrigation. One 8 gallon per vine irrigation was applied on July 3 for the purpose of fertilizer application. No additional irrigation was applied to this site.

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.

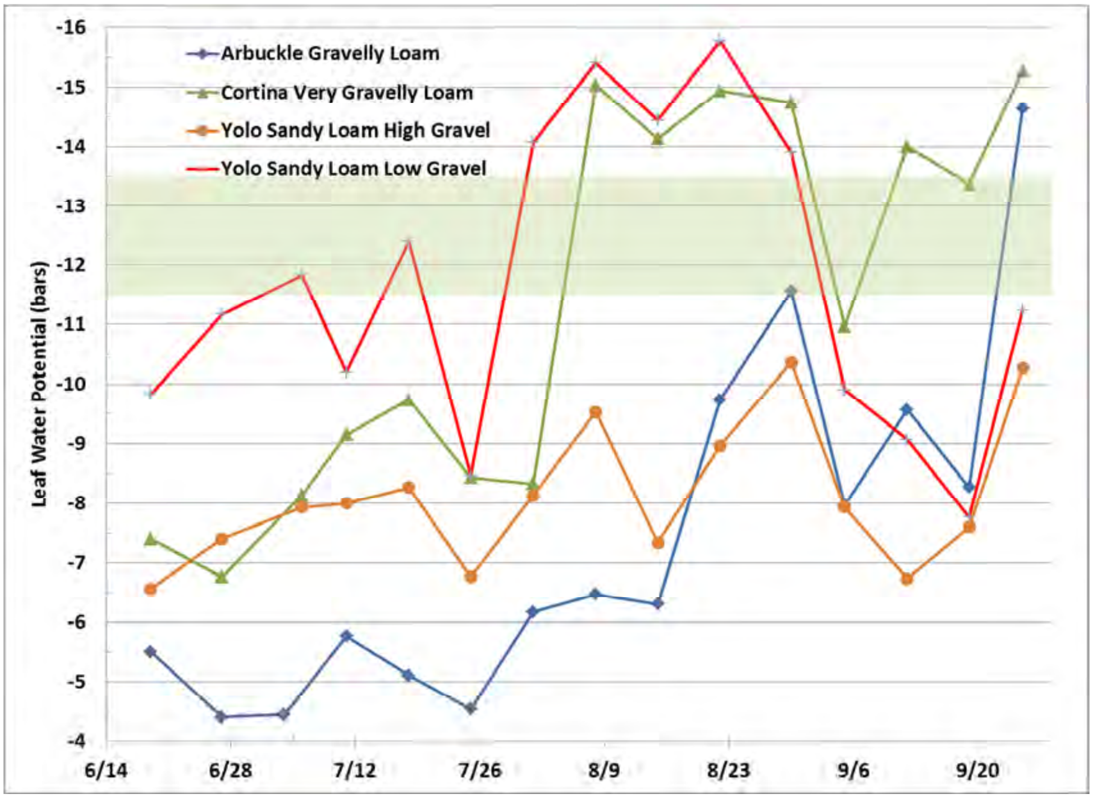
Block close to harvest

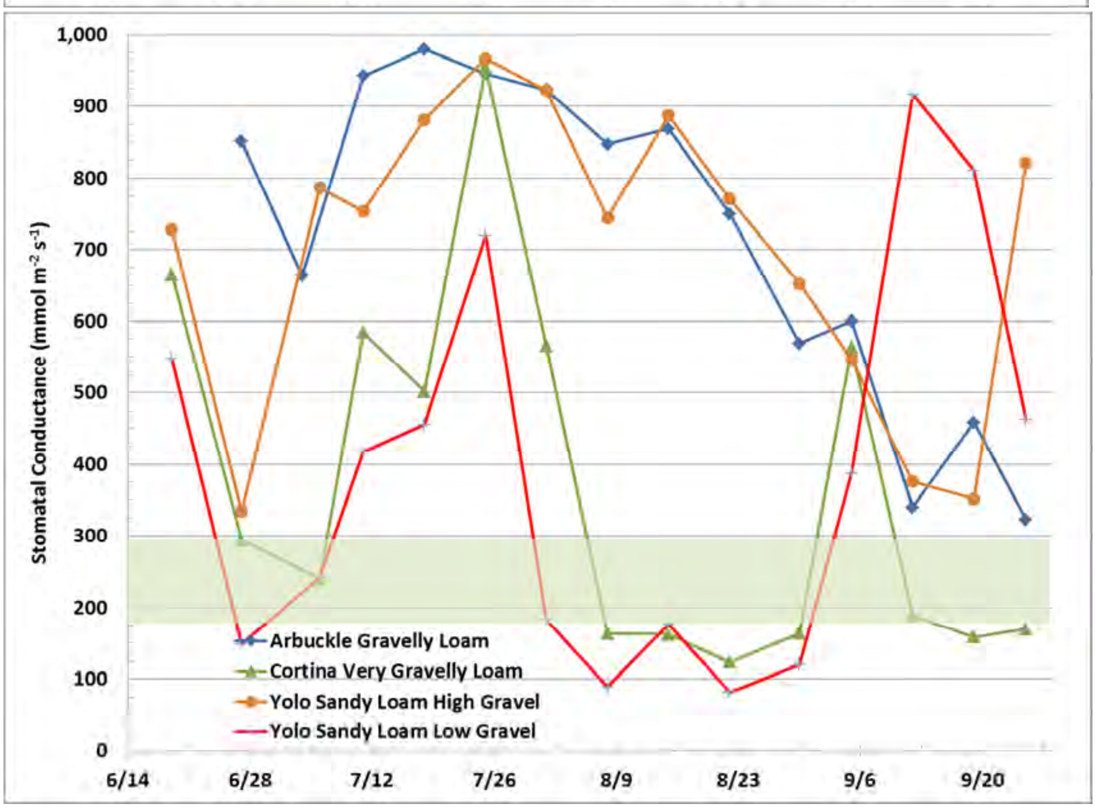




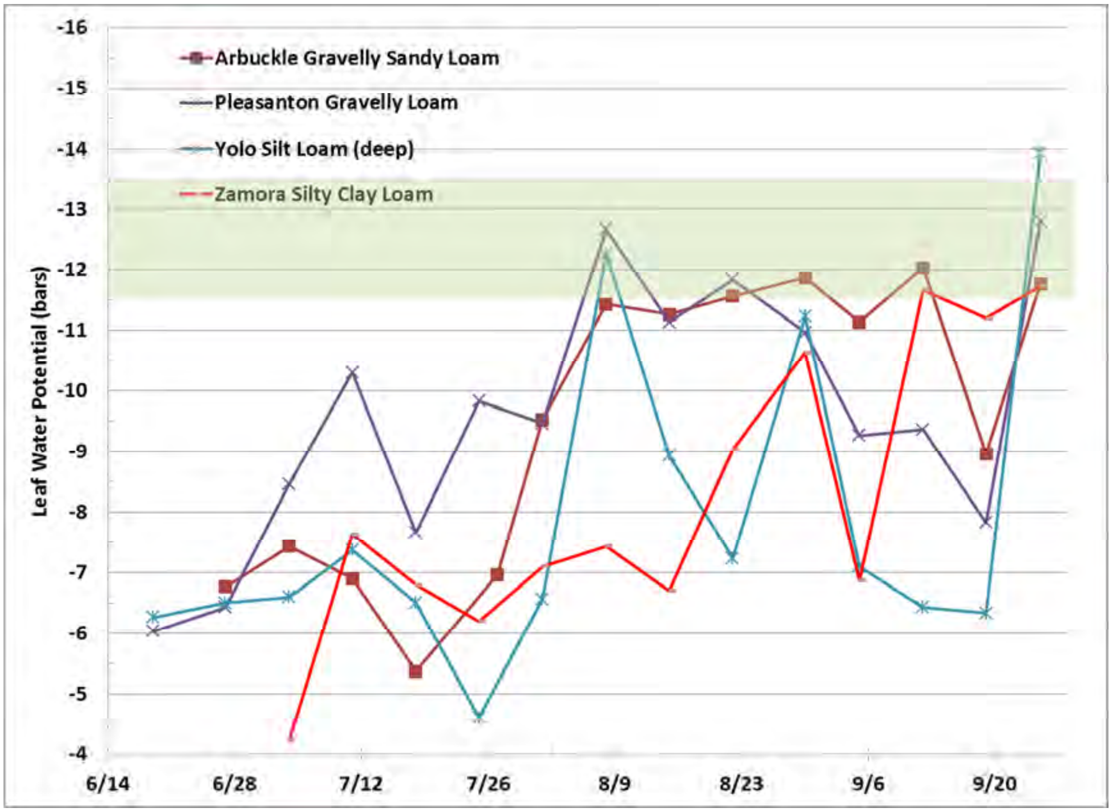
Soil moisture information collected during the irrigation season of 2012 at the Arbuckle Gravelly Loam site. The upper chart shows relative soil moisture content at 6 depths, from 8" to 48" in 8" increments. The lower chart shows a summation of the soil moisture from each level, to indicate the relative 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.

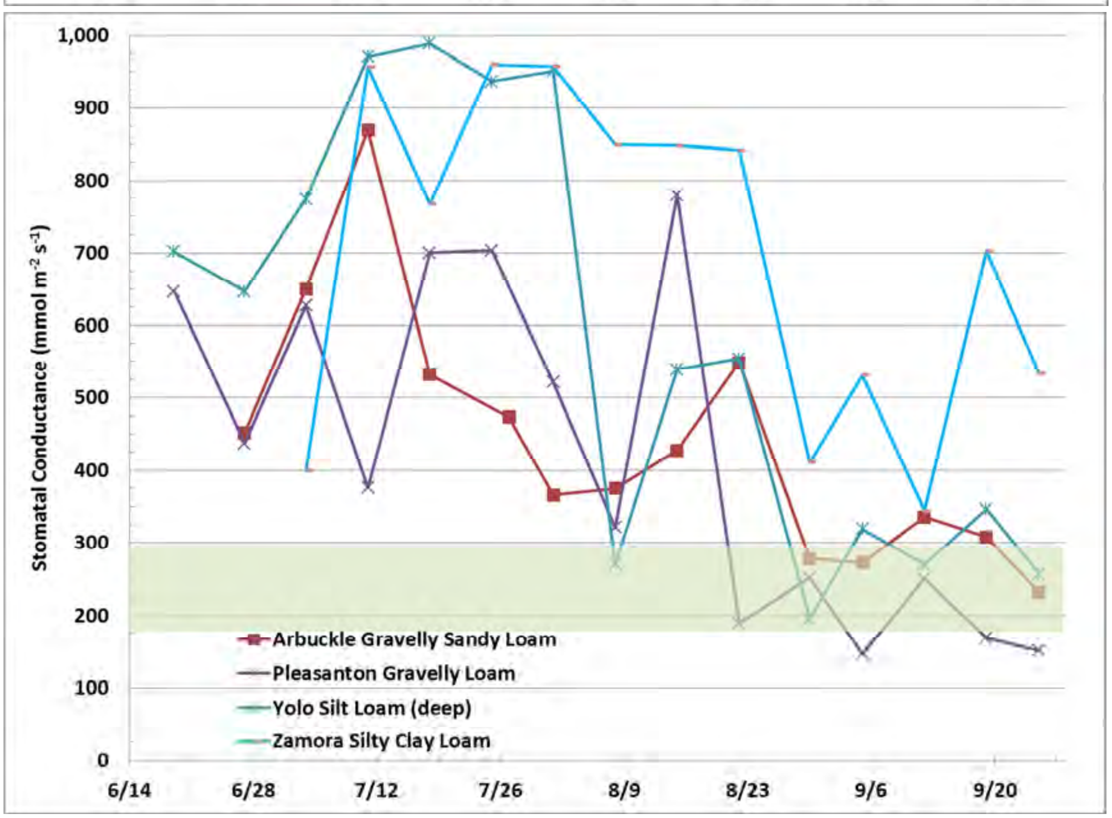
Combined Site Information



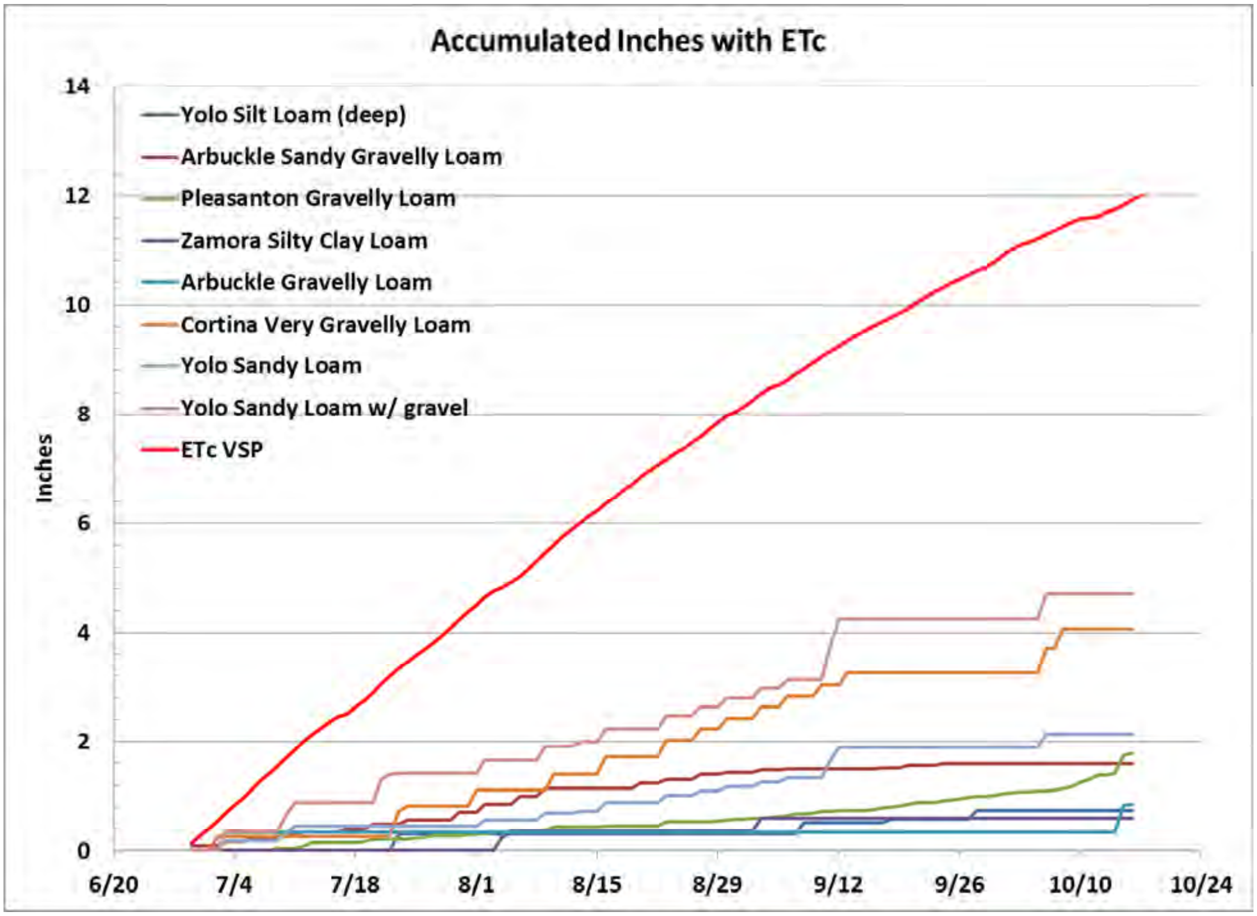


Weekly measurements of vine water status at four of the eight sites. The upper chart shows leaf water potential (pressure chamber measurement) and the lower chart shows stomatal conductance (porometer measurement). Target levels of each measurement are shown by the green shaded areas.





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.

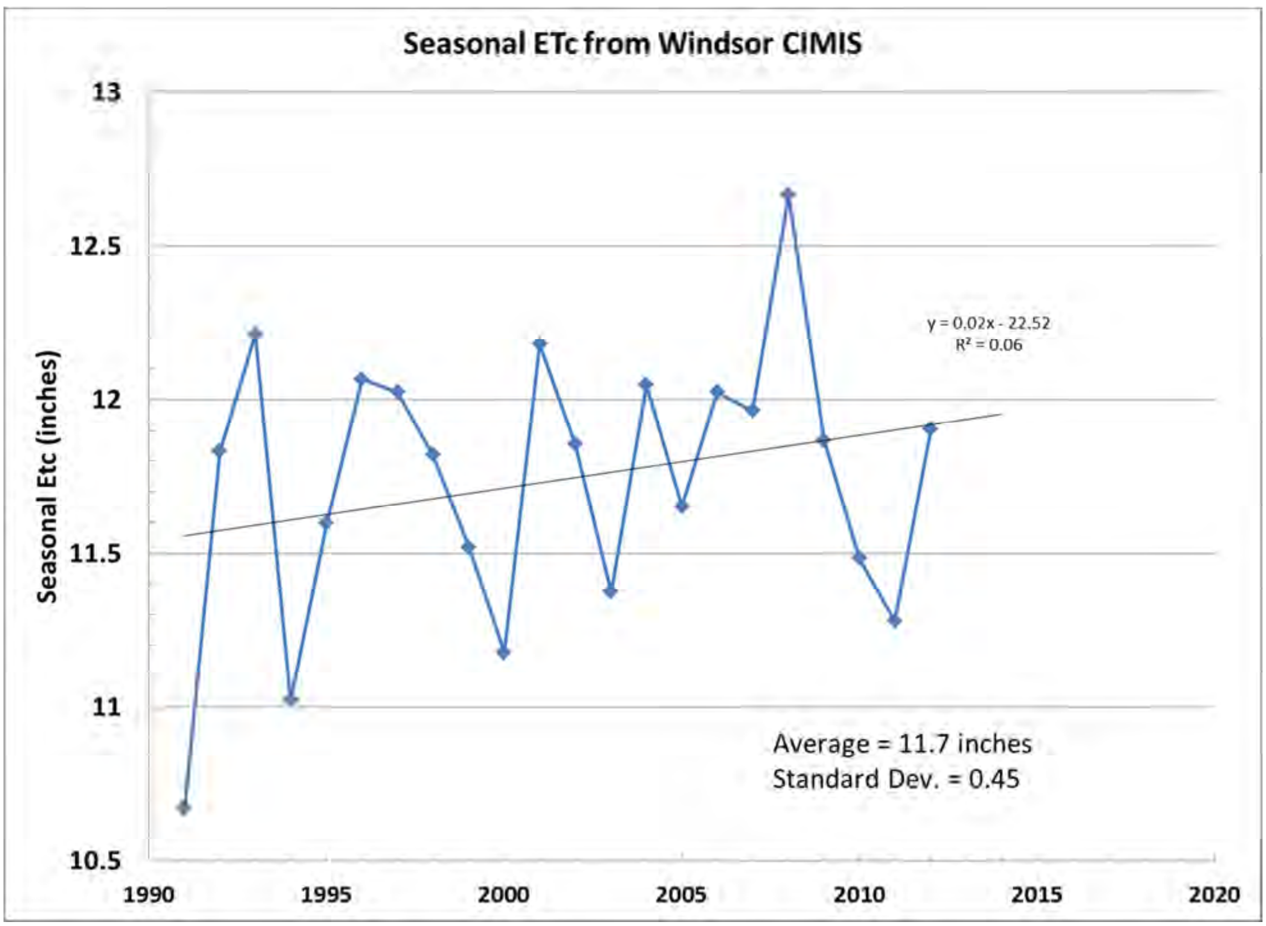


	Yolo Silt Loam (deep)	Arbuckle Gravelly Sandy Loam	Pleasanton Gravelly Loam	Zamora Silty Clay Loam	Arbuckle Gravelly Loam	Cortina Very Gravelly Loam	Yolo Sandy Loam	Yolo Sandy Loam w/ gravel
Gallons/Vine	19	40	44	15	21	101	53	118
Inches	**0.7**	**1.6**	**1.8**	**0.6**	**0.8**	**4.1**	**2.1**	**4.7**
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
Agroalimentaria y Medio ambiente

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 25º 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 25º 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 Agroalimentaria y Medio ambiente

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 25º 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 25º 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).

ATTACHMENT TWO

Gus Yates, Consulting Hydrologist
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April 27, 2009

Mr. David Cuneo
Senior Environmental Specialist
Sonoma County Water Agency
404 Aviation Blvd.
Santa Rosa, CA 95403

Subject: Northern Sonoma County Agricultural Reuse Project, Final Environmental Impact Report: Technical Review of Hydrology and Water Quality Issues

Dear Mr. Cuneo:

I am a registered geologist and hydrogeologist in the State of California, with 25 years experience conducting local and basin-scale investigations of groundwater and surface-water hydrology and water quality. My project experience has included work for Sonoma County agencies preparing environmental impact reports related to winery wastewater, forest conversion to vineyards, and aggregate mining along the middle reach of the Russian River. I recently completed a technical review of a report on Dry Creek Valley groundwater conditions (Johnson 2008) on behalf of the Clean Water Coalition of Northern Sonoma County (CWCNSC). A copy of the memorandum describing my findings and additional analysis is attached. CWCNSC also asked me to review the subject FEIR to determine whether the analysis of hydrology and water quality impacts was complete and adequate. This letter contains the results of that review.

I have found that several important impacts were overlooked and that the analysis of others was cursory or unsubstantiated. As it stands, the FEIR is not an adequate document to fully inform SCWA and permitting agencies of the potential impacts of the proposed project. I recommend that the FEIR not be certified until these deficiencies have been corrected. My concerns are listed below with supporting data and analysis that may be useful in revising the FEIR.

1. New Impact: Use of NSCARP water for frost protection is likely to contaminate surface water and groundwater.

The project description states that frost protection is an allowed use of recycled water (FEIR Vol. 1, p. 2-11). Sprinkling for frost protection occurs on clear nights in spring, when soil moisture is typically near field capacity from winter rains and crop ET demand is low. Under these conditions, surface runoff of applied water is likely and has been observed by rural residents. This runoff—including all of the salts, nitrate, dissolved organic carbon, metals and other pollutants contained in the water—flows without dilution to local creeks and the Russian River. If recycled water is used for frost protection, there will be discharges of recycled water runoff along most of the length of Dry Creek and the Russian River where they cross the proposed NSCARP service area. The potential magnitude of these discharges is not trivial. NSCARP contemplates delivery of recycled water to 21,000 acres of vineyard along the Russian River and Dry Creek. A typical sprinkling rate for frost protection is 0.12 inches per hour (Kaismatis and others 1982). If all of the service area were simultaneously sprinkled on a cold night, the total application rate would be 2,500 cfs. If only 30% of the applied water became runoff, it would amount to 760 cfs of discharge into surface waterways, which is greater than or equal to the mean monthly flow for April in the Russian River at Healdsburg in 29 of the 68 years of record. The impact on fish and downstream municipal supply impacts could obviously be large during frost protection events. The FEIR failed to disclose this potential impact.

Frost protection water that infiltrates instead of running off is an equally large problem. Again, because soil moisture in spring is commonly close to field capacity, additional infiltration tends to simply pass through the root zone via large pores in the soil and percolate to the water table. Thus, most of the frost protection water that does not run off flows fairly directly to the water table, along with the salts, nitrate, metals and organic carbon it contains. This contamination of groundwater creates potentially significant impacts on groundwater salinity (see comment 3), toxics (see comment 4) and surface water quality by way of indirect discharge (see comment 5).

2. Impact HWQ-4: Inadequate analysis of nitrogen impacts on viticulture and groundwater

The discussion under HWQ-4 (FEIR p.3.8-42) dismisses potential nitrate impacts on viticulture and groundwater in two sentences:

> “Nitrate levels in recycled water, applied in accordance with accepted irrigation practices, are below the nitrate requirements of crops. Therefore, nitrate in recycled water would be almost entirely taken up by vegetation with minimal migration beyond the root zone.”

This analysis is inadequate for three reasons. First, the annual nitrogen load from NSCARP water may exceed the annual requirements for wine grapes. At buildout, NSCARP contemplates delivering as much as 20,135 AF/yr of recycled water to 21,521 acres of vineyard and orchard (of which 99% is vineyard; FEIR Vol. 1 Table 2.2 and p. 2-19). This corresponds to an average annual application of 11.2 inches per year. The nitrogen content of the recycled water averages 10.7 mg/L (as N) (FEIR Vol. 1, Table 3.8-2), which leads to an annual load of 27.8 pounds per acre per year. While this is within the normal annual range for table grapes (22-44 pounds [Peacock 1998]), it exceeds what many north coast wine grape growers apply. The University of California/Napa Sanitation District study cited in the FEIR (p. 3.2-26) stated 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…. There are some vineyards that rarely (if ever) receive nitrogen additions. Potential mitigation measures for growers concerned about nitrogen

> in the NSD recycled water include selective use of cover crops and having an additional source of water available for irrigation."

The Lake County Winegrape Growers agree: "grapevines require very little nitrogen, and in some vineyards nitrogen is seldom, if ever, applied" (http://www.lakecountywinegrape.org/growers/suswine.php accessed 3/31/2009).

The second point of inadequacy in the analysis if nitrogen impacts is that it ignores the seasonality of nitrogen utilization by grape vines and the close attention paid by growers to vine nutrient status. Even if the annual total nitrogen content of recycled water is acceptable, use of recycled water for irrigation eliminates growers' ability to manage water and nitrogen applications separately. A brief literature survey quickly turned up scientific and commercial studies confirming the seasonality of nitrogen uptake by grape vines and the impact of incorrect fertilizer timing and quantities on the grape crop and subsequent winemaking (for example, Peacock and others 1998; Keller 2005). Nitrogen uptake increases steadily from bud break to veraison, then declines. Excessive nitrogen applications lead to luxuriant canopy growth which must be pruned back to prevent mildew on the berries. Inadequate nitrogen status can reduce the amount of yeast available nitrogen in the berries, which interferes with fermentation. Nitrogen applications outside the season of uptake have a higher tendency to contaminate groundwater. The inability to manage the timing of irrigation and fertilization separately poses a large and undesirable constraint for growers. This will lead to adverse impacts on winegrape production, or low acceptance of NSCARP water by winegrape growers.

The third weakness of the nitrogen impact analysis is the omission of data for existing nitrate concentrations in groundwater. For example, Johnson (2008) compiled available water quality data for 12 wells in the Dry Creek valley and found elevated nitrate concentrations in three of them. One of two wells that received additional testing had traces of simazine (an herbicide) and trichloromethane (a disinfection byproduct). These results demonstrate that nitrogen and other contaminants can and do percolate past the root zone. Nitrogen concentrations in NSCARP water exceed the drinking water standard (10 mg/L as N). Recycled water applied for frost protection would not experience substantial losses by plant uptake at that time of year, and dilution from other sources of recharge would be diminished by NSCARP (see comment 5, below). Therefore, nitrate concentrations in rural domestic wells would likely increase and could theoretically exceed the drinking water standard.

In light of this additional information, the two-sentence discussion of nitrogen impacts in the FEIR is clearly inadequate.

3. Impact HWQ-4 and Master Response 15: Inadequate analysis of salinity impacts on groundwater

The discussion of impact HWQ-4 in the FEIR (Vol. 1, p. 3.8-42) incorrectly characterizes the impact of irrigating with NSCARP water on groundwater salinity as "minor" and incorrectly implies that such increases are in compliance with State law because of a certain clause in the Water Code. The discussion provides no data or calculations to support the claim that salinity increases would be minor. Master Response 15 estimates that salt concentrations would "double", citing the cumulative impact analysis completed for Santa Rosa's Discharge Compliance Project FEIR (City of Santa Rosa, 2008). A doubling of groundwater salinity is not minor, and can violate water quality standards or jeopardize beneficial uses.

For example, the total dissolved solids (TDS) concentration of groundwater in Dry Creek Valley averages about 200 mg/L (Johnson 2008). Average annual applications on vineyards are approximately 3.3 inches for frost protection (of which an estimated 70% infiltrates) and 10 inches for summer irrigation. Deep percolation of rainfall and irrigation water beneath the root zone averages about 7 inches per year (Johnson 2008; Wagner & Bonsignore 1999). All of the solutes in the applied water are dissolved into the deep percolation. A simple mass balance calculation indicates that the TDS concentration in deep percolation under existing conditions must be approximately 352 mg/L.[1] NSCARP water has an average TDS concentration of 432 mg/L (FEIR Table 3.8-2). Assuming normal irrigation of 11.2 inches at NSCARP buildout plus infiltration of 70% of water applied for frost protection leads to an estimated TDS concentration of approximately 807 mg/L[2]. This concentration is slightly more than double the concentration under existing conditions.

More importantly, 807 mg/L of TDS violates the state drinking water standard of 500 mg/L. The assertion in the FEIR that "The California State Water Code states that minor changes in salinity associated with recycled water projects are acceptable." (FEIR p. 3.8-42) is extremely misleading. First, there is no such statement in the Water Code. The closest similar statement is different in important respects:

> 13523.5. A regional board may not deny issuance of water reclamation requirements to a project which violates only a salinity standard in the basin plan.

Although a Regional Board might have the authority to waive compliance with its own basin plan standards, it would not have the authority to authorize violation of drinking water standards.

Groundwater TDS would be lower than deep percolation TDS if there were dilution with other sources of recharge. However, dilution from one of the major sources of recharge—stream percolation—would substantially decrease under NSCARP (see comment 5 below). Therefore, a domestic well downgradient of vineyards irrigated with NSCARP water would be at risk of pumping groundwater that violates the drinking water standard for TDS.

Master Response No. 15 (FEIR Vol. 3, p. 3-15) relied upon two studies conducted for the City of Santa Rosa's Discharge Compliance Project FEIR. One of the studies contained a significant error and the other involved hydrogeologic conditions very different from those in the proposed NSCARP service area. The first study was the evaluation of cumulative impacts

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[1] [(3.3 in)(0.7)(200 mg/L)+(10 in)(200 mg/L)]/(7 in) = 352 mg/L
[2] [(3.3 in)(0.7)(432 mg/L)+(11.2 in)(432 mg/L)]/(7.25 in) = 807 mg/L. The deep percolation rate assumes 80% irrigation efficiency for irrigation in excess of 10 in/yr (e.g. 20% of 1.2 in = 0.25), which is added to the 7 in/yr of annual deep percolation assumed for 10 in/yr of irrigation.

of the DCP and other projects on the percent recycled water in groundwater at potable supply wells. The analysis included a critical error regarding salt loading of the groundwater system. The analysis assumed that only 11% of applied irrigation water would percolate to the water table, based on an assumed 89% irrigation efficiency (Merritt Smith Consulting 2008, p. 4). The analysis proceeded to calculate the percent recycled water reaching wells, as if the 11% of irrigation water that percolates to the water table contains only 11% of the salts and other pollutants. In fact, deep percolation would contain nearly all of the dissolved constituents in the recycled water, because annual deep percolation is sufficient to flush them from the soil zone (see the University of California/Napa Sanitation District study cited in the discussion of Impact AG-4; FEIR Vol. 1, p. 3.2-27). Thus, although the analysis might have correctly estimated the percentage of recycled water molecules reaching the wells, that percentage grossly underestimates the percentage of recycled water salts that reach the wells.

The second study cited from the DCP EIR monitored groundwater quality near cropland on the Santa Rosa Plain irrigated with recycled water from Santa Rosa's wastewater treatment plant (Winzler & Kelly 2007). The report stated that wells in and downgradient of the application areas "do not appear to exhibit cumulative impacts related to irrigation with reclaimed water and biosolids application." However, this conclusion is not well supported by the data, which were replete with confounding effects. At three of the four study sites, there were noticeable water quality trends in the upgradient wells. Six of the 13 monitoring wells had cracked or damaged seals, and 5 of the 13 wells were thought to be potentially affected by inundation of the wellhead, cattle grazing around the well, adjacent farmyards and adjacent dairies. More importantly, soil and aquifer conditions in the study area were less conducive to contaminant transport than soils in the proposed NSCARP service area. Soils at the four test sites were mainly of the Blucher, Pajaro and Wright series, which have low-permeability layers of clay loam. Beneath the soil zone, the younger alluvium (typically 30-100 feet deep) is characterized as having "low permeability" (DWR Bulletin 118 http://www.groundwater.water.ca.gov/bulletin118/basin_desc/basins_s.cfm#gwb49htm accessed 4-20-2009). In light of these weaknesses and differences, the Santa Rosa study is not a reliable basis for concluding that groundwater containmination is unlikely in the proposed NSCARP service area.

In summary, this comment lists five significant flaws in the analysis for Impact HWQ-4 and Master Response 15. The FEIR should not be certified until the flaws have been corrected and salinity impacts on groundwater have been characterized more realistically.

4. Impact PUB-7 and Master Response No. 9: Inadequate analysis of risks to aquatic and human health from groundwater contamination

The discussions of potential groundwater contamination from irrigation with recycled water (FEIR Vol. 1 pages 3.12-25 to 3.12-26 and Vol. 3 p. 3-11) rely on compliance with generic regulations regarding treatment level and setbacks from wells to conclude that the impacts would be less than significant as long as irrigation applications are not excessive. This analysis is inadequate because it ignores local conditions and studies that indicate a significant risk of contamination. It also ignores regulatory directives that call for additional analysis and restrictions if aquifer vulnerability is high.

The recycled water policy adopted by the State Water Resources Control Board two months ago exemplifies this tiered approach to regulation. Landscape irrigation projects using recycled water may proceed under a general statewide permit unless "unusual conditions" are present (section 7.b.(1)). The example of unusual conditions provided in the policy document is exactly the condition present throughout most of the NSCARP service area: "irrigation over high transmissivity soils over a shallow high quality aquifer".

A second example of regulatory adjustment to reflect high aquifer vulnerability is the Westside Recycled Water Project in western San Francisco (see http://sfwater.org/msc_main.cfm/MC_ID/13/MSC_ID/377). Recycled water used for landscape irrigation in Golden Gate Park and nearby areas will be treated with reverse osmosis in addition to the disinfected tertiary level of treatment normally required for such projects. This additional level of treatment probably reflects the high risk of aquifer contamination due to the presence of dune sand soils and the absence of clay confining layers above the water table.

Groundwater in the proposed NSCARP service area (Alexander Valley, Dry Creek Valley and the Middle Reach of the Russian River) is similarly vulnerable to contamination. The surficial soils (predominantly loams and sandy loams) are more likely to adsorb pollutants than the Sirdrak Sand soils in western San Francisco. However, the soils are not thick and are underlain by exceedingly permeable sands and gravels. Removal of many pollutants in the subsurface is by adsorption onto the surfaces of mineral particles, particularly silts and clays. The lack of such fine-grained sediments is evidenced by the fact that alluvial sands and gravels along the Russian River are very desirable for aggregate mining. At the Syar Industries gravel quarry pits along the Middle Reach, for example, the Yolo Loam "overburden" is typically 10 feet deep and as little as 3 feet deep (ESA 2007). Along Dry Creek, Yolo Loam and sandier soils comprise 80% of the valley floor. In the Alexander Valley, riverwash, sandy alluvial land and Cortina Very Gravelly Sandy Loam are widespread in addition to Yolo Loam varieties. The lack of fines in shallow alluvial materials is further confirmed in the California Department of Water Resources Bulletin 118 description of the basin, which notes that wells only 25-50 feet deep near Healdsburg can yield 200-500 gpm (http://www.groundwater.water.ca.gov/bulletin118/ basin_desc/basins_s.cfm#gwb49htm accessed 4-20-2009). I obtained a drillers log for a well along Dry Creek near Pena Creek that conforms with this pattern. The alluvium is only 44 feet deep and consists of 7 feet of loam over clean sands and gravels. Although the well has only 21 feet of screen, it reportedly produces 1,300 gpm.

Local data also demonstrate that attenuation of pollutants in the subsurface is unusually low. Field and laboratory tests of subsurface transport of pollutants in recycled water were completed for the City of Santa Rosa’s Discharge Compliance Project (Kennedy/Jenks Consultants 2007a and 2007b). The laboratory test involved percolation of recycled water through columns of soils collected from the Russian River floodplain. The field study examined groundwater quality in monitoring wells downgradient of the “Basalt Pond”, which receives effluent from the City of Healdsburg’s municipal wastewater treatment plant. In both studies, transport of copper and nickel and total organic carbon (TOC) was much greater than expected. For example, 38% of the nickel was still present at a monitoring well 5,300 feet from the Basalt Pond. Attenuation of the metals by adsorption was not considered sufficient to meet the California Toxics Rule, which sets numerical standards for those and other pollutants. The tests also found an “unexpectedly low” average TOC attenuation of only 26%.

Additional tests gave support to the hypothesis that the metals failed to adsorb to sediments because they chelated with organic compounds also present in the recycled water. These interactive effects were not considered in prior modeling studies that had indicated low subsurface mobility. The only hypothesis offered for low TOC attenuation was that the concentrations were lower than in typical wastewater to begin with. The fact that the results of the experiments were unexpected is equivalent to an “unusual circumstance” from a regulatory standpoint. The fact that the transport distances were higher than expected undermines the conclusion in the FEIR that small (50 foot) setbacks from water supply wells or surface water bodies are sufficient to protect human and aquatic health.

Thus, groundwater in the NSCARP service area is sufficiently vulnerable to contamination that adherence to standard regulations and setbacks is an inadequate basis for concluding that aquatic and human health will not be impacted.

5. **New Impact: NSCARP will substantially alter local groundwater balances such that all surface waterways in the service area will convert from consistently losing to consistently gaining streams. This will increase contamination of groundwater and surface water by salts and pollutants in recycled water.**

The FEIR fails to describe the fundamental shift in groundwater balances that would result from replacing groundwater with recycled water as the primary source of irrigation supply. One response to comment mentions simply that the Santa Rosa DCP EIR “concluded that reduced groundwater pumping can result in discharge of groundwater to surface water sources” (comment T-5, FEIR Vol. 3, p. 4-32). This grossly understates the impact that NSCARP would have. The decrease in groundwater pumping would be large enough to reverse the current stream-aquifer relationships in summer and eliminate stream percolation as a source of groundwater recharge. Without this recharge, deep percolation beneath irrigated cropland—which would contain concentrated levels of salts and pollutants—would experience little dilution in the aquifers. Without dilution, groundwater at potable supply wells could exceed drinking water standards for salinity (see comment 3, above) and California Toxics Rule limits for copper and nickel (see comment 4, above). Furthermore, constant seepage from groundwater into streams—without the seasonal reversal that occurs under existing conditions—creates a new pathway for chronic contamination of surface waterways by pollutants contained in recycled water. Each link in this cascade of impacts is elaborated below.

A recent USGS study of groundwater conditions in the Alexander Valley used the difference in flow between two gages on the Russian River (Cloverdale and Healdsburg) to demonstrate that the river gains flow along the valley in winter and loses flow in summer (Metzger 2006). In a recent year of normal flow (2000) the cumulative dry season flow loss was 2,800 AF. Assuming 10 inches of summer irrigation on the 6,629 acres of vineyard in the Alexander Valley, current dry-season groundwater pumping is approximately 5,524 AF. Comparing the pumping and flow loss figures shows that concurrent seepage from the Russian River supplies about half of the dry-season groundwater pumping. If NSCARP water replaced all of the groundwater used for irrigation—which is the long-term assumption in the FEIR—the dry-season groundwater balance would shift from negative to positive, and groundwater would seep into the river instead of the other way around. An evaluation of groundwater-surface water interactions along the Russian River completed for the Santa Rosa Discharge Compliance Project EIR reviewed several additional studies that showed that pumping induces seepage from the river and causes losing conditions in summer (Kennedy/Jenks Consultants 2007c).

The same seepage reversal would occur in Dry Creek Valley. Johnson (2008) tabulated flow differences between gages near Warm Springs Dam and the Russian River and found that the average cumulative flow loss during June-October was over 3,000 AF. Groundwater pumping to irrigate the 5,909 acres of vineyard and 188 acres of orchard in Dry Creek Valley is approximately 5,100 AF (again assuming 10 inches of applied water). Thus, as in the Alexander Valley, about half of the dry-season groundwater pumping is supplied by concurrent seepage from Dry Creek. Replacing groundwater with NSCARP water would shift the groundwater balance from negative to positive and would shift the creek from losing to gaining.

Reversing the direction of seepage along Dry Creek and the Russian River has significant water quality implications. First, salts, metals, dissolved organic carbon and other pollutants in recycled water are evaporatively concentrated in the soil following irrigation. The concentrated solutes then percolate to the water table. Under existing conditions, recharge from deep percolation is diluted by induced recharge from the river during the dry season, but with NSCARP this dilution would no longer occur. Other sources of recharge for dilution—such as groundwater inflow from hillsides along the creek and river valleys—are relatively small. This leads to a condition in which solute concentrations in groundwater will gradually approach the concentrations in deep percolation, and under NSCARP those concentrations would exceed drinking water standards and the California Toxics Rule.

Reversing the seepage direction along Dry Creek and the Russian River would also create a new pathway for contaminants to enter those waterways. The waterways intersect the groundwater system at the water table. The shortest and fastest subsurface flow paths for recycled water that has reached the water table is to flow laterally to the creek or river. Deeper flow paths offer much greater resistance to flow because they are longer and because hydraulic conductivity along deep flow paths is much lower due to greater compaction of the alluvium and anisotropy caused by grain orientation and layering of the alluvial deposits. Therefore, recharge from deep percolation beneath cropland under NSCARP would not mix uniformly throughout the groundwater system before discharging to creeks and rivers. Rather, most of it would flow laterally at shallow depth to the discharge point, with little dilution by deeper groundwater.

The short, fast flow paths from the water table beneath vineyards to nearby creeks and rivers provide a conduit for pollutants in recycled water to enter surface waterways during the summer low-flow season. Field studies have demonstrated that some pollutants are only partially removed during flow through aquifers. The field investigation of subsurface transport of wastewater contaminants downgradient of the "Basalt Pond" (which receives discharges from the City of Healdsburgs' wastewater treatment plant) found surprisingly low attenuation of copper and nickel at wells as much as 5,300 feet downgradient. Much of the proposed NSCARP irrigation service area is within 5,300 feet of Dry Creek or the Russian River (Kennedy/Jenks Consultants 2007b), so percolated pollutants from applied irrigation water could reach those waterways.

In addition to elevated concentrations of copper and nickel, the field study found that groundwater derived from infiltrated recycled water was consistently low in dissolved oxygen. This would pose an additional threat to aquatic life when the groundwater discharges into Dry Creek or the Russian River.

To summarize this impact, NSCARP would fundamentally change the dry-season groundwater balance, which in combination with other project effects would create a pathway for concentrated pollutants derived from NSCARP irrigation water to enter surface waterways, with potentially significant impacts on water quality and aquatic life.

Each of the five comments presented above represents a major omission or flaw in the analysis presented in the FEIR. Until those errors have been corrected, the FEIR is not adequate as an informational document to guide decision makers responsible for approving or implementing the NSCARP. I recommend that the FEIR not be certified until the potential impacts described herein are fully evaluated and mitigated.

Thank you for considering these comments. Please do not hesitate to call me if you have any questions.

Sincerely,

Gus Yates

Gus Yates PG, CHg

Attachment: Technical memorandum dated March 9, 2009 reviewing Johnson (2008) report.

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MEMORANDUM

Gus Yates, PG, CHg, Consulting Hydrologist
1809 California Street, Berkeley CA 94703 • Tel/Fax 510-849-4412 • gusyates@earthlink.net

Date: March 3, 2009
To: Fred Corson, Clean Water Coalition of Northern Sonoma County
From: Gus Yates, Consulting Hydrologist
Cc:
Subject: Northern Sonoma County Agricultural Reuse Project: Revised Versions of Nick Johnson's Water and Salt Balance Tables for Dry Creek Basin

As we discussed by telephone, I revised the water balance table (Table 16) and salt balance table (Table 17) in Nick Johnson's December 2008 report "Potential Water Supply Impacts to Dry Creek Valley from NSCARP and a Bypass Pipeline". The purpose of the revisions was to adhere more clearly to well-defined boundaries of the flow system. To that end, I developed a schematic diagram of the hydrologic system in the Dry Creek Valley, including the creek, soil zone and groundwater zone (Figure 1). My water balance is an average annual balance for the groundwater zone.

The revised water balance is shown in Table 1, followed by notes explaining the assumptions and data used to derive various items. I retained Nick's estimates wherever they were consistent with my boundaries and approach, which was the case for most of the flow items. The magnitude of the revised budget (13,400 ac-ft/yr of inflows and outflows) is comparable to the budget in Table 16 (12,300 ac-ft/yr).

In this system, changes in recharge and groundwater pumping are balanced by corresponding changes in seepage to and from Dry Creek. The principal effect of NSCARP on the flow system would be to substantially decrease groundwater pumping, which in turn would convert Dry Creek from a losing stream to a gaining stream in summer. The variations of the project (high or low irrigation rates and optional use of recycled water for frost protection) had the same general effect but with slightly different changes in selected flow items.

The revised water balance table does not include the effects of a bypass pipeline for water deliveries from Lake Sonoma because I do not think a pipeline would cause additional impacts on the water balance. This conclusion is based on the assumption that the pipeline would not be allowed to decrease flows below the levels recommended in the Biological Assessment for steelhead and salmon. The Assessment recommends summer flows of 25 cfs at the mouth of Dry Creek, downstream of the flow gains and losses along Dry Creek valley. Current flow losses are on the order of 11 cfs, and under NSCARP project conditions the creek would gain rather than lose flow. Thus, streamflow in the creek would continue to be able to receive or deliver the flow gains and losses indicated in Table 1 for existing and project conditions.

The revised salt budget table (Table 2) is structured slightly differently than Nick's Table 17, but it retains many of the same assumptions and data. Table 2 calculates the average annual salt inflows and outflows from the basin as mass fluxes (tons per year) rather than as concentrations. The itemization of inflows parallels the diagram and the water balance table. A separate table is shown for existing conditions and each of the four combinations of NSCARP conditions. At the end of each table, the annual increase in salt mass is divided into the estimated total volume of groundwater in the basin to obtain the annual increase in salinity that would result if the net salt load were mixed uniformly throughout the basin. This last assumption is unrealistic, but it provides a basis for comparing the impacts of each project variation and also indicates a general magnitude of the existing and project salinity impacts.

Finally, Table 3 shows the change in TDS concentration of deep percolation below the root zone in a hypothetical vineyard under existing conditions and each of the possible NSCARP project conditions. This analysis shows that the project could double the salinity of deep percolation, which is roughly the same conclusion reached in Nick's analysis.

Dry Creek Basin Groundwater Balance

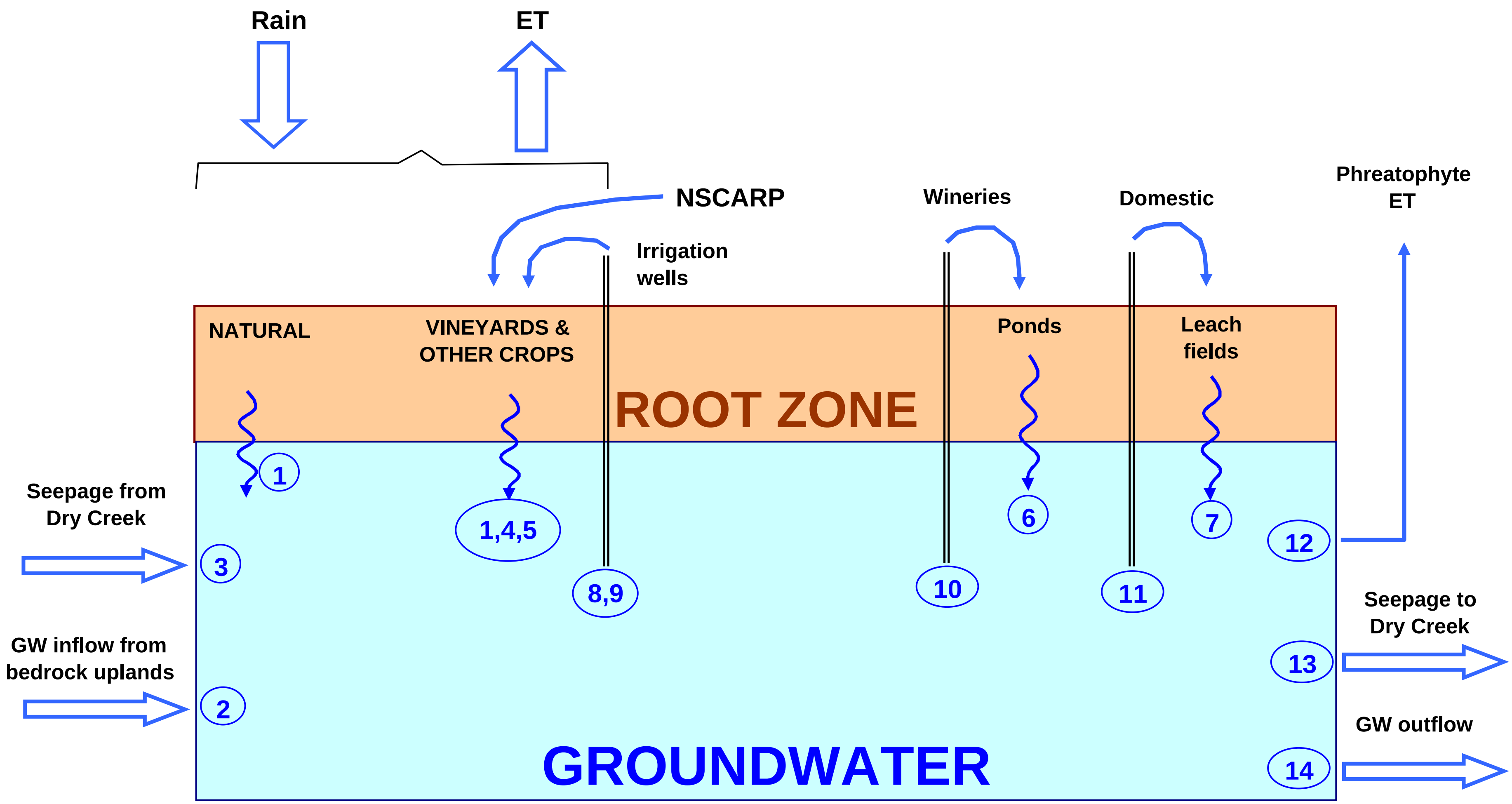

Table 1. Average Annual Water Balance for Dry Creek Groundwater Basin (Acre-Feet per Year)

Diagram Label	Budget Item	Existing	NSCARP, Summer Irrigation Only		NSCARP with Frost Protection	
			Low Irrigation	High Irrigation	Low Irrigation	High Irrigation
	Inflows					
1	Rainfall recharge valley floor	5,658	5,658	5,658	5,658	5,658
2	GW inflow from adjacent bedrock	2,217	2,217	2,217	2,217	2,217
	Percolation from Dry Creek					
3	Summer	4,000	0	0	0	0
3	Winter	0	0	0	0	0
	Irrigation deep percolation					
	Vineyards					
4	Frost protection	1,059	1,059	1,059	1,059	1,059
4	Summer irrigation	0	0	1,017	0	1,017
5	Other crops	160	160	160	160	160
	Other return flows (septic, etc.)					
6	Wineries	125	125	125	125	125
7	Domestic	214	214	214	214	214
	TOTAL	13,433	9,433	10,449	9,433	10,449
	Outflows					
	Groundwater pumping					
8	Vineyard frost protection	1,513	1,513	1,513	0	0
8	Vineyard irrigation	7,800	1,853	1,853	1,853	1,853
9	Other crops	800	800	800	800	800
10	Wineries	250	250	250	250	250
11	Domestic	450	450	450	450	450
12	Phreatophyte GW ET	364	364	364	364	364
	GW seepage into Dry Creek					
13	Summer	0	435	1,452	1,948	2,964
13	Winter	3,434	3,434	3,434	3,434	3,434
14	GW outflow	334	334	334	334	334
	TOTAL	13,433	9,433	10,449	9,433	10,449
	Annual storage change					
	Inflows minus outflows	0	0	0	0	0
	Change in water levels	0	0	0	0	0

Table 1, continued -- Notes on Groundwater Balance

Line No.	Data Sources and Assumptions
Global	Changes in GW pumping are primarily compensated for by changes in GW seepage to and from Dry Creek.
Global	The bypass pipeline would not cause any additional changes in the GW balance beyond those caused by NSCARP because Dry Creek summer flows would still be sufficient to absorb the changes in seepage gains and losses. Proposed summer flows in the Biological Assessment are 25 cfs at the mouth of Dry Creek (i.e. after all upstream seepage gains and losses). The magnitude of the seepage changes under NSCARP are a shift from a flow loss of about 11 cfs during a 6-month dry season to a flow gain of about 3 cfs.
1	Johnson, Table 16. 7 in/yr on 9,700 acres.
2	Johnson, Table 16. 2 in/yr on 13,300 acres of adjacent bedrock.
3	Johnson, Table 16. Existing condition summer percolation is difference between gaged flow in Dry Creek at Warm Springs Dam and at the Russian River. Creek assumed to gain flow from GW seepage in winter. Under NSCARP conditions, GW pumping for irrigation is decreased by 5,100 af/yr. It is assumed that this is first balanced by decreasing percolation **from** Dry Creek in summer (to zero), and the remaining imbalance becomes increased seepage **into** Dry Creek.
4	Vineyard irrigation assumed to be 100% efficient at up to 10 in/yr applied water (Johnson, Section 2.6). Any irrigation in excess of 10 in/yr is assumed to be inefficient and to percolate through the root zone to GW. 2 in/yr x 6100 ac of NSCARP vineyards = 1,107 af/yr.
5	400 ac of orchard and pasture receive 24 in/yr applied water at 80% efficiency (Johnson, Section 2.5.2)
6	Johnson, Section 2.6. Wineries use 250 af/yr, half of which percolates back to GW from wastewater storage ponds.
7	Johnson, Section 2.6. Domestic wells pump 450 af/yr of GW, 50% is used indoors and 75% of indoor use percolates to GW via leach fields. 20% of outdoor water use (irrigation) becomes deep percolation below the root zone.
8	Johnson, Section 2.5.2. 8,000 ac of vineyard use 10 in/yr for irrigation and 5 in/yr for frost protection under existing conditions. NSCARP assumes 6100 acres of vineyard would be irrigated at 7 in/yr (low estimate) or 12 in/yr (high estimate). It is assumed here that the remaining 1,900 ac of vineyards would continue receiving 7 in/yr of GW irrigation. Frost protection is assumed to be 5 in/yr supplied by GW on all vineyards. Thus, the decrease in vineyard irrigation pumping is 6,100 ac x 10 in/yr = 5,083 af/yr.
9	Johnson, Section 2.5.2. 400 acres of orchard and pasture receive an estimated 24 in/yr of irrigation.
10	Johnson, Section 2.6. Wineries pump an estimated 250 af/yr of GW for processing.
11	Johnson, Section 2.6. Rural domestic wells pump an estimated 450 af/yr

12 Johnson, Section 2.5.3. Phreatophyte ET of GW estimated to be 15 miles long x 100 ft wide x 24 in/yr

13 Dry Creek assumed to be losing water along its entire length in summer under existing conditions. The gain in winter derives from Johnson's 800 af/yr of "Groundwater discharge to stream baseflow and riparian ET" (which was calculated as the residual in his budget). In this table, phreatophyte ET and subsurface GW outflow are calculated separately (364 and 334 af/yr, respectively), leaving 800-364-334=102 af/yr. This is rounded upward to 176 af/yr to better balance the budget. Under NSCARP, the decrease in GW pumping for irrigation is first balanced by a decrease in seepage **from** Dry Creek, and the remaining imbalance becomes increased seepage **into** Dry Creek.

14 Subsurface outflow to the Russian River and Middle Reach groundwater basin calculated from Darcy's Law: 60 ft/d x 2 mi width x 50 ft depth x 0.00126 ft/ft gradient.

Table 2. Dry Creek Groundwater Basin Salt Balance

Diagram Label	Salt Budget Item	Existing Conditions Acres	in/yr	AFY	WQ mg/L	Salt load ton/yr
	Salt inputs					
1	Rainfall percolation	9,700	7	5,658	0	0
2	GW inflow from bedrock			2,217	200	547
3	Percolation from Dry Creek			4,000	150	740
	Vineyard irrigation water					
4	NSCARP frost protection	0	0	0	432	0
4	NSCARP irrigation	0	0	0	432	0
4	GW frost protection	5,500	3.3	1,513	200	373
4	GW irrigation	8,000	11.7	7,800	200	1,925
5	Orchard & pasture irrigation	400	24	800	200	197
6	Winery wastewater			125	800	123
7	Domestic wastewater			214	800	211
	TOTAL					4,117
	Salt outputs					
	Well pumping					
	Vineyards					
8	Frost protection	5,500	3.3	1,513	200	373
8	Summer irrigation	8,000	11.7	7,800	200	1,925
9	Orchard & pasture			800	200	197
10	Wineries			250	200	62
11	Domestic			450	200	111
12	Phreatophytes			364	0	0
	GW seepage into Dry Creek					
13	Summer			0	200	0
13	Winter			3,434	200	847
14	GW outflow			334	200	83
	TOTAL					3,598
	Inputs minus outputs					519
Basinwide groundwater TDS trend						
	GW volume (Johnson, Table 2) (AF)					70,000
	Average rate of increase (mg/L/yr)					6

Table 2, continued

Diagram Label	Salt Budget Item	Acres	in/yr	AFY	WQ mg/L	Salt load ton/yr
		NSCARP Low Irrigation, GW Frost Protection				
	Salt inputs					
1	Rainfall percolation	9,700	7	5,658	0	0
2	GW inflow from bedrock			2,217	200	547
3	Percolation from Dry Creek			0	150	0
	Vineyard irrigation water					
4	NSCARP frost protection	0	0	0	432	0
4	NSCARP irrigation	6,100	8.7	4,423	432	2,357
4	GW frost protection	5,500	3.3	1,513	200	373
4	GW irrigation	1,900	11.7	1,853	200	457
5	Orchard & pasture irrigation	400	24	800	200	197
6	Winery wastewater			125	800	123
7	Domestic wastewater			214	800	211
	TOTAL					4,266
	Salt outputs					
	Well pumping					
	Vineyards					
8	Frost protection	5,500	3.3	1,513	200	373
8	Summer irrigation	1,900	11.7	1,853	200	457
9	Orchard & pasture			800	200	197
10	Wineries			250	200	62
11	Domestic			450	200	111
12	Phreatophytes			364	0	0
	GW seepage into Dry Creek					
13	Summer			435	200	107
13	Winter			3,434	200	847
14	GW outflow			334	200	83
	TOTAL					2,238
	Inputs minus outputs					2,028
Basinwide groundwater TDS trend						
	GW volume (Johnson, Table 2) (AF					70,000
	Average rate of increase (mg/L/yr)					23

Table 2, continued

		NSCARP High Irrigation, GW Frost Protection				
Diagram Label	Salt Budget Item	Acres	in/yr	AFY	WQ mg/L	Salt load ton/yr
	Salt inputs					
1	Rainfall percolation	9,700	7	5,658	0	0
2	GW inflow from bedrock			2,217	200	547
3	Percolation from Dry Creek			0	150	0
	Vineyard irrigation water					
4	NSCARP frost protection	0	0	0	432	0
4	NSCARP irrigation	6100	13.7	6,964	432	3,712
4	GW frost protection	5,500	3.3	1,513	200	373
4	GW irrigation	1900	11.7	1,853	200	457
5	Orchard & pasture irrigation	400	24	800	200	197
6	Winery wastewater			125	800	123
7	Domestic wastewater			214	800	211
	TOTAL					5,621
	Salt outputs					
	Well pumping					
	Vineyards					
8	Frost protection	5,500	3.3	1,513	200	373
8	Summer irrigation	1,900	11.7	1,853	200	457
9	Orchard & pasture			800	200	197
10	Wineries			250	200	62
11	Domestic			450	200	111
12	Phreatophytes			364	0	0
	GW seepage into Dry Creek					
13	Summer			1,452	200	358
13	Winter			3,434	200	847
14	GW outflow			334	200	83
	TOTAL					2,489
	Inputs minus outputs					3,132
Basinwide groundwater TDS trend						
	GW volume (Johnson, Table 2) (AF					70,000
	Average rate of increase (mg/L/yr)					36

Table 2, continued

		NSCARP Low Irrigation, NSCARP Frost Protection				
Diagram Label	Salt Budget Item	Acres	in/yr	AFY	WQ mg/L	Salt load ton/yr
	Salt inputs					
1	Rainfall percolation	9,700	7	5,658	0	0
2	GW inflow from bedrock			2,217	200	547
3	Percolation from Dry Creek			0	150	0
	Vineyard irrigation water					
4	NSCARP frost protection	5,500	3.3	1,513	432	806
4	NSCARP irrigation	6,100	8.7	4,423	432	2,357
4	GW frost protection	0	0	0	200	0
4	GW irrigation	1,900	11.7	1,853	200	457
5	Orchard & pasture irrigation	400	24	800	200	197
6	Winery wastewater			125	800	123
7	Domestic wastewater			214	800	211
	TOTAL					4,699
	Salt outputs					
	Well pumping					
	Vineyards					
8	Frost protection	0	0.0	0	200	0
8	Summer irrigation	1,900	11.7	1,853	200	457
9	Orchard & pasture			800	200	197
10	Wineries			250	200	62
11	Domestic			450	200	111
12	Phreatophytes			364	0	0
	GW seepage into Dry Creek					
13	Summer			1,948	200	481
13	Winter			3,434	200	847
14	GW outflow			334	200	83
	TOTAL					2,238
	Inputs minus outputs					2,461
Basinwide groundwater TDS trend						
	GW volume (Johnson, Table 2) (AF					70,000
	Average rate of increase (mg/L/yr)					28

Table 3. Change in Recharge TDS Below a Converted Vineyard

Existing

	Frost	Irrig	Combined
TDS applied water (mg/L)	200	200	
Inches applied water	2.31	10	12.31
Inches deep percolation			9.31
TDS deep percolation			264

NSCARP Low Irrigation, GW Frost Protection

	Frost	Irrig	Combined
TDS applied water (mg/L)	200	500	
Inches applied water	2.31	8.7	11.01
Inches deep percolation			9.31
TDS deep percolation			517

NSCARP High Irrigation, GW Frost Protection

	Frost	Irrig	Combined
TDS applied water (mg/L)	200	500	
Inches applied water	2.31	13.7	16.01
Inches deep percolation			11.31
TDS deep percolation			647

NSCARP Low Irrigation, NSCARP Frost Protection

	Frost	Irrig	Combined
TDS applied water (mg/L)	500	500	
Inches applied water	2.31	8.7	11.01
Inches deep percolation			9.31
TDS deep percolation			591

NSCARP High Irrigation, NSCARP Frost Protection

	Frost	Irrig	Combined
TDS applied water (mg/L)	500	500	
Inches applied water	2.31	13.7	16.01
Inches deep percolation			11.31
TDS deep percolation			708

ATTACHMENT THREE

Dry Creek Watershed: Potential Effects of Contaminants and Emerging Pollutants to Food Web and Salmonids

April 2009

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Davis, CA 95616

Geologic reports by Wilshire 2009 (NSCARP FEIS/EIR made on behalf of the Clean Water Coalition of Northern Sonoma County) and by Yates 2009 suggested that *"Use of the reservoirs proposed by NSCARP is likely to cause contamination of both surface water and groundwater. Because they are interconnected, surface water contamination, for example by frost-protection spraying and leakage of reservoirs, inevitably leads to groundwater contamination. In addition, if recycled water is used for frost protection, there will be discharges of recycled water runoff along most of the length of Dry Creek and the Russian River where they cross the proposed NSCARP service area. This runoff—including all of the salts, nitrate, dissolved organic carbon, metals and other pollutants contained in the water—flows without dilution to local creeks and the Russian River"*. Furthermore, reports by Johnson 2008 and Yates 2009 further suggested that "*Groundwater salinity in some domestic wells could increase to exceed the drinking water standard or other contaminants present in recycled waste water, including metals, organic compounds, and other currently unregulated "emerging contaminants" would become similarly concentrated and impact local groundwater*".

Based upon these evaluations, the objective of this document is to describe the potential long-term effects of surface and groundwater contamination by NSCARP on the aquatic ecosystems in the Dry Creek Valley. The implications of these effects are presented in this report by briefly describing several studies on the potential impacts of emerging or legacy contaminants to the food web and to targeted fish resources in the Russian River-Dry Creek watershed ecosystem. The role of water chemistry parameters, importantly salinity, is outlined briefly as related to contaminant bioavailability, toxicity to aquatic organisms and ecosystem effects. Emphasis on these factors are presented in a context of potential drivers of structure and function of the Dry Creek ecosystem that may be altered or remain stable in the future and how this will essentially relate to its capability to support important fish resources such as the salmonids Coho salmon (*Oncorhynchus kisutch*), Chinook salmon (*Oncorhynchus tschawytscha*) and steelhead trout (*Oncorhynchus mykiss*).

Water Quality

Salmonids are very sensitive to water pollution and sensitivity may vary during the different life stages. As water quality deteriorates, diminished flows may cause crowding and stress that may lead to disease outbreaks (Spence et al. 1996, Nichols and Foott, 2005). In the Klamath River, water quality conditions are highly stressful to salmonids due to increased stream temperatures, decreased dissolved oxygen, high pH and unionized ammonia formation due to nutrient flow dynamics (http://www.klamathwaterquality.com/fish_health.html). Fish are also exposed to other stressors including climate changes and disease agents (i.e. microbial pathogens) throughout their life stages. In wild habitats, climate change can influence global impacts of microbial pathogens and endemic diseases to fish populations (Gozlan et al. 2006) and water temperature may affect the pathogenesis of many important infectious diseases (Snieszko 1974). Environmental stressors including culture conditions, water quality and pollutants affect fish at all life stages and their susceptibility to disease can be overwhelmed with a variety of environmental and internal factors (Schreck 1981, Schreck et al. 1993). Larval fish are generally more sensitive to contaminant and disease stressors compared to adults (Arkoosh et al. 1998, Rolland 2000, Teh et al. 2003, Varsamos et al. 2006) and that stress during early life stages may trigger stress and consequential effects as juveniles (Varsamos et al. 2006).

Water temperature is the most important factor affecting biochemical and physiological processes of individual organisms which also affects contaminant transformation and excretion. Within normal physiological ranges, temperature increases may enhance bioaccumulation and toxicity of metals with more complex effects to organic contaminants (Newman and Unger 2003). Other water chemistry parameters including salinity, pH, hardness, organic carbon concentration and redox potential (for sediments) are important factors affecting complexation and speciation of chemicals and metals such as mercury, copper and selenium (Alpers et al. 2008). For instance, ammonia toxicity is reduced at low pH as the ionized form (NH_4^+) which is produced at low pH, is less toxic than the unionized NH_3 form. Studies to address the potential adverse effects of ammonia/ammonium on the Bay-Delta ecosystem, including effects to POD populations or pelagic organisms in decline, have been recently formulated.

Food Web

Links between food web complexity and ecosystem stability have been an emerging challenge in research of aquatic organisms that has focused from phytoplankton to zooplankton to fish. Various trophic levels are affected by chemical contaminants beginning at the base of the food chain during uptake of specific contaminants by phytoplankton with subsequent uptake by grazers (e.g. zooplankton). Extrapolating how toxic compounds move through the food web is a challenge since quantitative information on transfers is limited. Because of the complexity of ecosystems, there is an enormous potential for interaction among different levels of the food web under varying environmental conditions (http://www.mdsg.umd.edu/programs/gateway/contaminants/toxicsrpt/bioleffects/).

Fish rely for food from other organisms across the food web and are exposed to a bewildering array of natural stressors and low-levels of complex toxicants throughout their life history. As fish can accumulate pollutants in body tissues as they grow, deleterious effects may become apparent only when concentrations in tissues reach a threshold level after several months or years. Alternately, a toxicant present at low levels may be lethal only to very early life history stages. A decline in population due to contaminants may therefore become apparent only several years after a pollution incident when low numbers of a particular year-class is recorded. As suggested by Johnson, Yates, and Wilshire, contaminants will continue to be introduced into the Dry Creek watershed at high concentrations over the years. The cumulative impacts of contaminants to key organisms and to food web species in the environment or through contaminant-induced changes in nutrient and oxygen dynamics will significantly alter the ecosystem function. Pollutants may directly and/or indirectly affect populations and communities and indirect impacts may either reduce or increase population abundance (Fleeger et al. 2003). Indirect contaminant effects have profound implications in environments with strong trophic cascades (indirect effects mediated through consumer resource interactions) such as the freshwater pelagic system with competitive interactions between 'top–down' (predator influence on lower trophic levels) and 'bottom–up' (nutrient/food/prey influence on higher trophic levels) components. The indirect effects of contaminants across trophic levels in the Russian River-Dry Creek watershed may have profound implications as suggested in an excellent review in Fleeger et al. (2003). As the magnitude of systemic effects of contaminants to the ecosystem and to resident aquatic organisms is broad, complex and difficult to assess, contaminant effects may focus on food webs affecting the species of concern in this water system, i.e. the salmonids Coho salmon (*Oncorhynchus kisutch*), Chinook salmon (*Oncorhynchus tschawytscha*) and steelhead trout (*Oncorhynchus mykiss*). Ideally, a coordinated research program with integrated field and laboratory experiments using a variety of methods and endpoints will address the cause and effects of priority contaminants of concern to these key organisms by testing a series of hypotheses.

Emerging Pollutants

Effluents from wastewater treatment plants are significant sources of ammonium including complex mixtures of contaminants that affect reproductive endocrine function (Kidd et al. 2007). As reviewed in Hoenicke et al. 2007, a growing list of emerging contaminants including flame retardant compounds, pesticide and insecticide synergists, insect repellants, pharmaceuticals, personal care product ingredients, plasticizers, non-ionic surfactants and other manufacturing ingredients have not been previously targeted for analysis but polybrominated diphenyl ether (PBDEs) have been detected in water, sediments or biological tissue samples (clams, striped bass, halibut) from the Sacramento and San Joaquin Rivers. Several of these compounds, particularly PBDEs showed concentrations of environmental implications. Although waterborne concentrations are about two orders of magnitude greater than the thresholds for effects observed in laboratory trials (Fent et al. 2006), these compounds may pose a hazard from synergistic effects of multiple contaminants as found in the San Francisco Estuary (Laville et al. 2004). There is a considerable data gap on the cause and effects of emerging contaminants particularly in fish and other aquatic organisms in the Sacramento delta (Thompson et al. 2007).

Endocrine disrupting chemicals (EDCs) are significantly present in wastewater treatment plants that can interfere with the hormonal systems in humans and wildlife that even extremely low concentrations can cause adverse effects on reproduction and development (Kidd et al. 2007). Chronic exposure of fathead minnow to 5-6 ng/l of 17α-ethynylestradiol (EE2, synthetic estrogen used in birth control pills) resulted to near extinction of this species (Kidd et al. 2007). Even after secondary treatments (chlorination), concentrations of up to 4.05 ng/l of 17ß-estradiol (E2, the natural estrogen) and 2.45 ng/l EE2 in the treatment plant effluent were detected (Huang and Sedlack 2001). Most importantly, subsurface transport of EDCs has been demonstrated as a result of landscape irrigation with treated wastewater (Hudson et al. 2005).

Effects of other contaminants to salmonids

As chinook salmon are obligate pelagic (midwater) feeders, they feed almost exclusively in the midwater zone hence are probably more susceptible to contaminants linked to the food web. As top predators, the Chinook salmon are more affected by pollutants even when the contaminant is toxic only to lower trophic levels (Bacelar et al. 2008).
Among five species of Pacific salmon (chinook, coho, sockeye, chum, pink) collected from the Sacramento River, Skeena River in British Columbia and Puget Sound, the highest levels of all types of contaminants were found in chinook salmon which generally feed higher in the food web than other types of salmon (http://wdfw.wa.gov/science/articles/pcb/index.html). Magnification of polychlorinated biphenyls (PCBs) and major organochlorine pesticides (OCPs) were found in lake trout (*Salvelinus namaycush*) and other food web organisms collected from 17 lakes in Canada and the northeastern United States between 1998 and 2001 (Houde et al. 2008).

Chemical contaminants have been associated with salmon declines in the Pacific Northwest. High levels of PCBs (1300 to 14,000 ng/g lipid, in some cases exceeding the threshold for adverse health effects in juvenile salmonids of 2400 ng/g lipid), dichlorodiphenyltrichloroethanes, DDTs (1800 to 27,000 ng/g lipid), and polycyclic aromatic hydrocarbons, PAHs were found in whole bodies of Chinook salmon in the Lower Columbia River. The stomach contents also showed high contaminant levels indicating that the prey is a significant source of exposure (Johnson et al. 2007a, 2007b).

Low concentrations of anthropogenic chemicals such as insecticides (malathion, carbaryl, chlorpyrifos, diazinon, and endosulfan) and herbicides (glyphosate, atrazine, acetochlor, metolachlor, and 2,4-D) separate or combined in low concentrations (2-16 ppb), can affect aquatic communities composed of zooplankton, phytoplankton, periphyton, and larval amphibians (Relyea 2009). Juvenile chinook salmon exposed to sublethal levels of esfenvalerate or chlorpyrifos either alone or concurrently with infectious hematopoietic necrosis virus (IHNV) showed synergistic effects with endemic pathogens to compromise the survival of wild fish populations through immunologic or physiologic disruption (Clifford et al. 2005).

While copper is a necessary trace element for all living organisms, many studies show that copper in small amounts can be lethal and have many sub-lethal effects in fish and zooplankton. In particular, salmonids and their food sources have very low tolerance for copper and sub-lethal effects may include decreased fish survival, production and increased mortality rates. Furthermore, copper can impair salmon's sense of smell that may interfere with normal salmon migration, and since copper is a biological stress agent; it depresses immune system function and compromises fish ability to fight disease (Woody 2007, http://www.fish4thefuture.com/pdfs/Summary%20WoodyReview%20-%20Copper%20Effects%20to%20Fish%20092107.pdf).

Effects of Salinity

Although recent studies confirm that elevated salinities can cause substantial changes to the biological communities of aquatic ecosystems, impacts of irrigation-induced salinity in freshwater ecosystems have not been extensively investigated. As the Dry Creek habitats may be altered with future water movements and hydrologic modifications, the freshwater ecosystem in the Dry Creek may be threatened by the effects of salinity changes because of potential rising saline groundwater (as a result of NSCARP) and reduced frequency of high-flow events (as a result of Dry Creek bypass pipeline). Salinity changes may affect ecosystem function through alteration of abiotic and biotic processes (Nielsen et al. 2003). It is beyond my ability to stress the underlying effects of salinity and would encourage reviewers to refer to Nielsen et al. 2003 for more information on how salinity may impact not only the aquatic biota but also the physical components of aquatic ecosystems. The CUWA 1994 literature review indicated salinity tolerance of Chinook salmon from spawning → eggs → larval stages in the ranges of 0 to 0.5 ppt. The potential significant effects of increasing salinity due to the NSCARP and Dry Creek bypass pipelines remain to be determined.

Summary

In is undoubtedly consequential that the SCWA's proposed NSCARP and Dry Creek bypass pipeline will result in the contamination of both surface water and groundwater. This contamination will have long-term effects on the Dry Creek aquatic ecosystems. Author of Santa Rosa DCP FEIR, Volume 3, Appendix G.3-Ecological Risk Assessment stated "*Regulatory agencies have not developed standards or adjusted existing standards to address nonregulated chemicals due to insufficient data to evaluate potential effects of exposure to the environment. Any regulation of these chemicals will likely not occur for several years, if at all. Given that many xenobiotics are neither regulated nor monitored in recycled water, it is unknown what, if any, contribution recycled water discharges may contribute to the Laguna or Russian River. Available data suggest that accurate measurements of hormones at levels that may adversely affect fish are difficult to attain, but would be necessary to fully evaluate these chemicals"* is encouraged to review the Technical Report submitted by Hudson et al. 2005 demonstrating subsurface transport of EDCs as a result of landscape irrigation with treated wastewater (Hudson et al. 2005; www.llnl.gov/tid/lof/documents/pdf/327864.pdf).

It is important that NSCARP FEIS/EIR take into consideration the long-term effects of the contamination of ground and surface waters of the aquatic ecosystem in the Dry Creek Watershed. Of importance is investigating the potential relationships among contaminant levels and other relevant factors such as: 1) recruitment potential of aquatic organisms, 2) primary and secondary production, 3) nutrient dynamics, and 4) food web structure. Linking these factors to variabilities in contaminants and hydrology may elucidate their effects to biota and ecosystem integrity. Once these relationships are assessed, water allocation may be used as a strategy to manage salinity impacts to the ecosystem and to the species of concern. Disposal and replacement of contaminated salt waters however, should be regulated to minimize potential contaminant distribution in the system.

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