APPENDIX G

CRESCENT CITY RECYCLED WATER SYSTEM

ANTIDEGRADATION REVISIONS

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Anti-degradation Analysis Consistent with Recycled Water Policy Paragraph 9d.(2)

The State Water Board's adopted Resolution No. 68-16 as a policy statement to implement the Legislature's intent that high quality waters of the State be protected to the maximum benefit of the people of the State. The purpose of this report is to document that the groundwater in the proposed service area is not of high quality, is not put to beneficial use, and addition of Title 22 regulated water will have no negative impact on the assimilative capacity of local ground water.

The proposed use area is Beach Front Park. The park is constructed over what was prior to the 1964 tsunami beach areas (Figure 1). The parks were developed for public activities and as a buffer to future oceanic events. See Figure 2 for the location of Beach Front Park and the proposed irrigation areas. While the area is considered as part of the Smith River Plain Basin, basin 1-1 in Bulletin 118 of California Groundwater, it exists at the extreme Pacific boundary where brackish or saline water would normally infiltrate into the basin. As such ground water at the site of proposed irrigation is not of high quality.

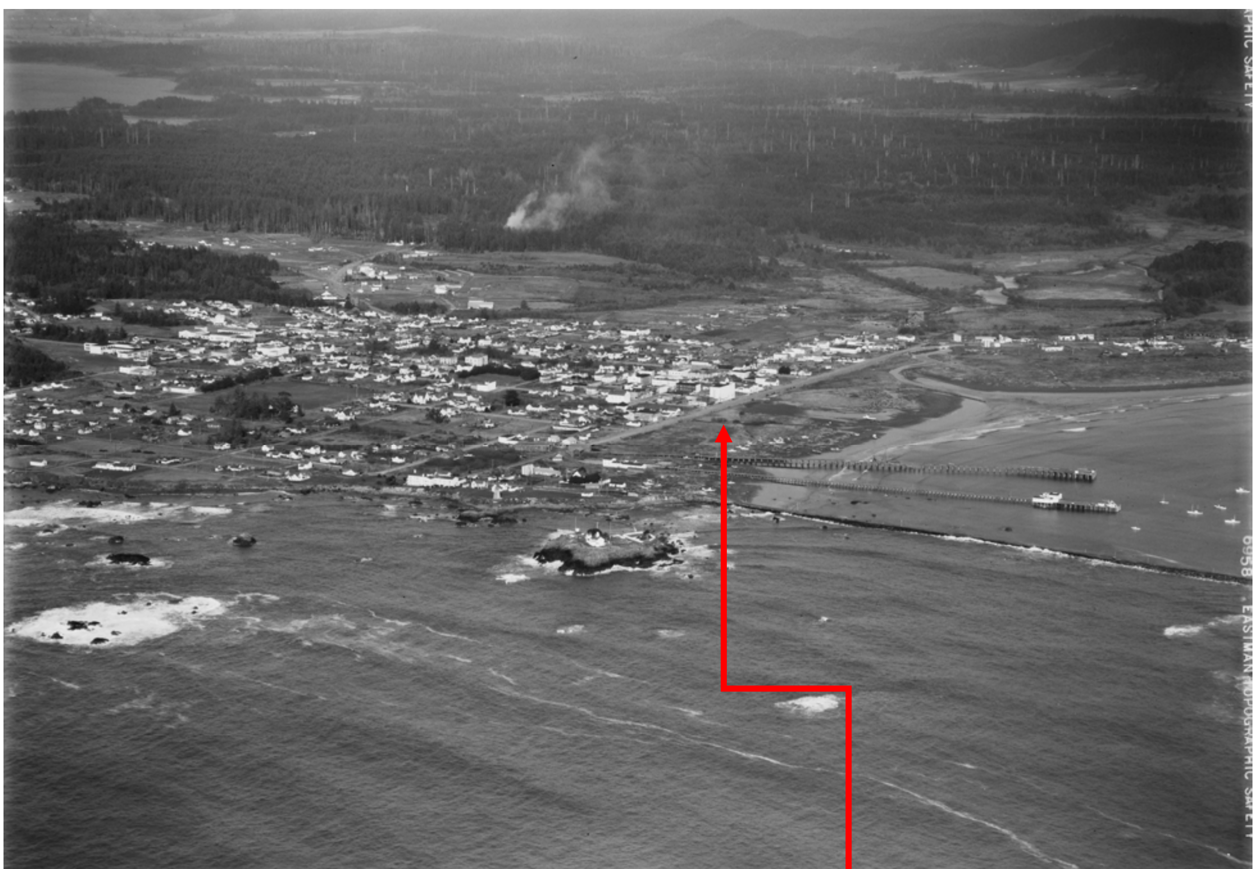

Figure 1. (Photo By: Shuster 12/29/1947 Photo ID:2001.01.0817 Courtesy HSU Library.)
Current Location of Beach Front Park:

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Figure 2. (circa 2005) Beachfront Park Constructed Over Beach Area:

According to the 2005 Urban Water Management Plan for Crescent City, California, Recycled Water was considered for the express purpose of irrigating Beachfront Park. Now the City intends to fulfill its previous idea and put recycled water to beneficial use for the people of the State in accordance with Title 22. Crescent City currently has rights to 3,666 Acre feet per year (AFY) from the Smith River Ranney Collector. The current annual usage is approximately 2,666 AFY and therefore leaves an untapped right of 1,000 AFY. Looking ahead to the year 2025 shows the City and surrounding service districts tapping less than 25% of the 1,000 AFY cushion. This is a strong indicator that ground water wells will not be required in the foreseeable future as a source for municipal water supplies. Insofar as the ground water in the area of the proposed park irrigation is not currently being put to use and is not likely to be tapped in the near or distant future, it is reasonable to say that the ground water which might be affected is not currently being nor likely in the future to be put to beneficial use.

The State Water Quality Control Board's Recycled Water Policy requires that salt/nutrient management plans be developed so that the assimilative capacity of ground water can be identified and monitored. Assimilative Capacity is defined as, "Capacity of a natural body of water (lake, river, sea, underground reservoir, etc.) to receive waste waters or toxic materials,

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without harmful effects and damage to aquatic life and to humans who consume its water." Crescent City indicates in its notice of intent under the general permit for recycled water that it will participate in the development of a salt and nutrient management plan when the effort commences. Title 22 is written with the intent of actually applying recycled waters to land for irrigation purposes and as such dictates levels that must be achieved prior to discharges. The level of treatment that will be accomplished at the Crescent City Recycled Water Treatment plant will meet or exceed the requirements detailed in Title 22 for disinfected tertiary water intended for irrigation. Given the nature of this treated water and the limited use for irrigation, it will not have harmful effects or damage aquatic life and therefore does not require a determination regarding assimilative capacity. The City will use recycled water for irrigation purposes only and does not plan to create any impoundment areas that would be likely to affect ground water. Title 22 specifies that irrigation uses be based on agronomic rates that do not create ponding, i.e. impoundment areas, unless certain criteria are met. Since the particular irrigation project is not a groundwater recharge project as defined in section 60320 of Title 22 it should be exempt from all ground water monitoring in the proposed use areas. Insofar as Bulletin 118 states that drought years create situations where "seawater intrusion can occur causing brackish or saline water to enter" ground water systems, if any recycled waters discharged to the proposed locations where to affect groundwater at all, they will tend to act as a buffer to the Smith River Basin's water from seawater infiltration. As such it must be concluded that none of the ground water's assimilative capacity will be used, and that the assimilative capacity might actually be increased by the irrigation proposed if a groundwater recharge system was to be implemented.

In addition to the above mentioned items the use of recycled water will mean that less or no fertilizer will be spread on the park areas. The decrease in the amount of fertilization that takes place in Beachfront Park is considered to be beneficial to the public, since the costs associated with fertilization will be diminished.

Because of the poor quality of localized ground water due to oceanic infiltration, limited use, and negligible or positive impact to the assimilative capacity of the basin, Resolution 68-18's intent to protect high quality waters for beneficial uses is not triggered and an assimilative capacity calculation is not applicable.

5 November 2010 3838.2

To: Jagroop Khela, State Water Resources Control Board (SWRCB)

From: Jon Olson, Stover Engineering

Subject: Crescent City Recycled Water System- Antidegradation Revisions

In response to Jagroop Khela's August 11, 2010 e-mail request for additional information to complete the application for coverage under the general permit the following information is being submitted.

ANTIDEGRADATION REVISION REQUESTED BY Jagroop Khela:

Below is a copy of item 3 from the above referenced email:

> "A revision to the 'antidegradation section' submitted with your Notice Intent is required. As per today's telephone conference, the Basin Plan of your jurisdiction specifies municipal water supply as one of the designated beneficial uses. You have indicated that there is no current or future anticipated use of the groundwater. Although, partially we agree with your finding(s) that there are no nearby municipal water supply wells near the project site and groundwater quality in the immediate vicinity of the project site is also of poor quality. To effectively and appropriately address the antidegradation section of your application, we would like you to provide additional information on *depth to groundwater at the project site; proximity to the water supply wells; presence of any fractured bedrock; potential impact to the underlying groundwater, and impact to any distant water supply wells or aquifer(s)*. You have indicated that the *recycled water would be of high quality and if any water percolates beneath the root zone would actually enhance the quality of the existing ground water quality.* We would like you to address these assertions more in detail with appropriate supporting document or references. Some of the information could be easily available from the USGS and the Regional Board."

RESPONSE TO REQUEST:

The *italicized* portions of the quoted email are the only parts that are a request for information. In this memo each request was taken on an item by item basis to the extent possible.

Depth to groundwater:
According to GeoDesign Inc's December 2004 *Report of Geotechnical Engineering Services* the groundwater elevation between February and June of 2004 is reported at 12.40' and 11.25' feet above mean sea level. While there was one other well used for ground water level monitoring sited in the report, the piezometer was found to be clogged and is therefore not a reliable source. The Elevation of the use area varies but is approximated at 17.5'; this provides a depth to groundwater greater than 5'.

Proximity to water supply wells:
There are currently no municipal or private water supply wells inside the City limits. Neither the City nor County has maps available showing water wells in Del Norte County. According to GEOTRACKER GAMA, available on the State Water Board's website at, http://www.swrcb.ca.gov/gama/, the nearest water supply well is approximately one mile away from the proposed recycled water use area. According to the 2005 Urban Water Management Plan for Crescent City, California, the City has rights to 3,666 Acre feet per year (AFY) from the Smith River Ranney Collector. The current annual usage is approximately 2,666 AFY and therefore leaves an untapped right of 1,000 AFY. Looking ahead to the year 2025 shows the City and surrounding service districts tapping less than 25% of the 1,000 AFY cushion. This is a strong indicator that ground water wells will not be required in the foreseeable future as a source for municipal water supplies.

Bedrock:
According to GeoDesign Inc's December 2004 *Report of Geotechnical Engineering Services*, "The Battery Formation bedrock was encountered underlying the alluvium and silt layers in all of the borings. The Battery Formation was observed to consist of alternating layers of very soft to soft … siltstone and very soft to hard … fine sandstone. The … (Bedrock) is generally moderately weathered to fresh, moderately close jointed, weak to moderately cemented, and contains trace fine organics. The Battery Formation was encountered between approximately 8 and 18 feet bgs (below ground surface) and extends to depths ranging from 43.5 to 46 feet bgs…. Laboratory testing of selected samples indicates that moisture contents in this formation vary between 13 and 32 percent. The Franciscan Complex was encountered in the two deeper borings … underlying the Battery Formation. The Franciscan Complex consists of very soft … black shale and hard … blue-gray to medium gray sandstone. The shale and sandstone is generally fresh, intensely fractured with some shear zones, and partly healed with white mineral veining. Laboratory testing of selected samples indicates that moisture contents in this formation are approximately 9.5 percent."

Potential Impact to Groundwater and distant water supply wells or aquifers:
Irrigation water applied at agronomic rates does not normally percolate extensively below the root zone; the purpose of applying water at agronomic rates is to supply just enough water to meet crop demand and no more. The water-nitrogen balance analysis memo points out that the

soil plant-water system is natural, biological, and variable in time and space. The responsible party must therefore monitor and evaluate its development and performance. The analysis further suggests that supplying recycled water at agronomic rates will not overload the turf with plant available or other N and therefore will have a negligible to zero impact to groundwater.

The quality of the recycled water which will be used is relatively good when compared to The Worlds Health Organization's (WHO) 2006 "Guidelines for the safe use of wastewater, excreta and greywater." In comparing values of electrical conductivity (EC) and sodium adsorption ratio (SAR) to Table A1.1, Water quality for irrigation, on page 178 in volume two of the book, the indexed values are rated as to degree of restriction on use with respect to salinity. The three listed ratings are None, meaning unrestricted use of irrigation water, Slight to Moderate, or Severe. According to tests of the WWTP effluent performed in February 2010, the EC was found to be 0.54dS/m and the SAR 1.9 meq/l. Looking at EC values in table A1.1 shows that unrestricted use is allowed. If one evaluates both SAR and EC the WHO finds that only slight or moderate restrictions of irrigation need be employed. With the City's plan to irrigate only at agronomic rates, and only when precipitation does not satisfy evapotranspiration needs of the turf (minimization of plant stress), only part of four to five months per year, the City will be meeting the WHO's recommendations on levels of restriction for irrigation with recycled water. In addition when considering total dissolved solids, the WHO puts no irrigation restrictions on water with total dissolved solids (TDS) levels less than 450 mg/L. The proposed recycled water, as reported in the most recent test data, had only 290 mg/L, well below the allowable level for unrestricted irrigation use.

As reported in California's Water Plan Update 2009 Bulletin 160-09 published by the Department of Water Resources, "The Food and Agriculture Organization of the United Nations (FAD) notes that an EC of 700 µS/cm (µmhos/cm) protects the most salt-sensitive crops under normal irrigation operations." This statement reinforces that the proposed recycled water with an EC of 540 µmhos/cm is acceptable for meeting turf irrigation demands over the long term without deleterious effects.

Since recycled water applied at agronomic rates is not likely to impact groundwater at the use area being irrigated, it must be reasoned that it cannot be expected to have any significant impact on distant water supply wells or aquifers.

Address the assertion that *"the recycled water would be of high quality and if any water percolates beneath the root zone would actually enhance the quality of the existing ground water quality."* :

As stated above with respect to impacts to groundwater, agronomic application rates do not have significant impacts on groundwater.

In consideration of enhancing the quality of the existing ground water, the EPA MCL for nitrate in drinking water was set at 10 mg/L nitrate-nitrogen (NO_3-N). Recent test results of filtrate show the nitrate level to be less than 10 mg/l thus meeting the stringent requirement for drinking water. Furthermore, as was discussed in the water-nitrogen balance analysis memo, the N applied would normally all be used by the turf. This shows that with respect to N, recycled water could be put to beneficial use, even as a drinking water source, if discharged directly to groundwater; of course the City does not plan to use the recycled water for groundwater recharge purposes.

The January 2007 Water Quality Control Plan for The North Coast Region has not established a Specific water quality objective for TDS in groundwaters; regardless of this fact the City thought it prudent to evaluate the potential of TDS to negatively impact groundwater. According to the Department of Water Resources the range of TDS in the Smith River basin groundwater is from 50-500mg/l (California's Groundwater Bulletin 118). The TDS in the recycled water was recently found to be 290 mg/l which falls in the middle third of the Smith River Basin's range. The Water Quality Association, in its various publications, defines water with less than 1000mg/l TDS as fresh. Based on the forgoing, the level of TDS does not present a significant risk to any beneficial use of the ground water, especially considering the requirement that recycled water be applied at agronomic rates.

According to the Water Plan Update 2009-Volume 3 -North Coast, "groundwater quality problems in the North Coast region include contamination from seawater intrusion… in shallow coastal groundwater aquifers" (Department of Water Resources). The seawater intrusion mentioned above can occur at the extreme western boundary of the Smith River Basin adjacent to the Pacific Ocean; the proposed use area is at the extreme western boundary. Figures 1 & 2 have been provided below to show the process of intrusion. Seawater conductivity various but many sources use a value of 50,000 µmohs/cm; seawater is approximately 100 times grater than the proposed recycled water. The recycled water could be beneficial used to protect the naturally occurring conductivity levels of groundwater from highly conductive seawater intrusion.

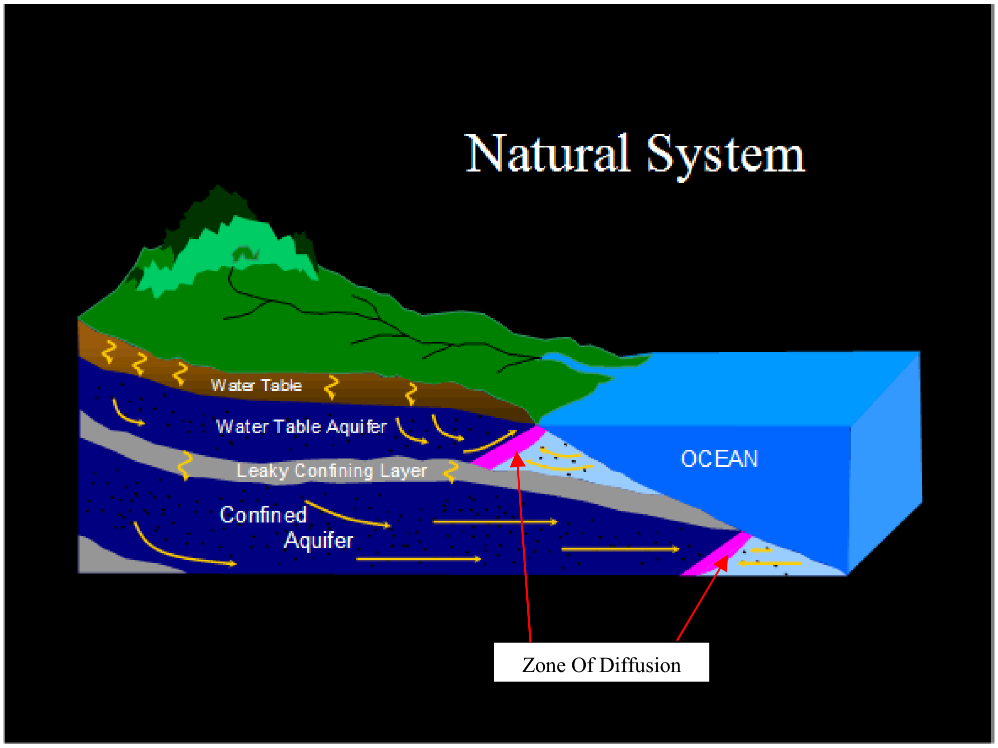

Figure 1. Natural System in Coastal Region (State of Washington Department of Ecology)

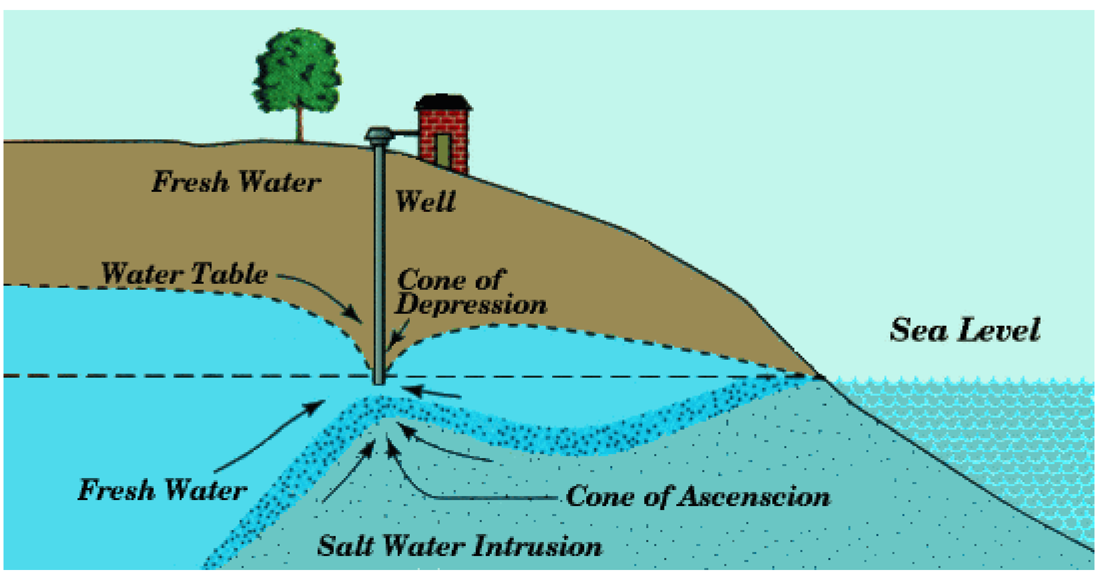

Figure 2. One process by which Seawater intrusion occurs. (Lenntech-The Netherlands)

In "Seawater Intrusion in Coastal Aquifers: Concepts, Methods, and Practices", by Jacob Bear, Shaul Sorek, Driss Ouazar, one recommendation made is to apply water to help increase the depth of groundwater above the zone of diffusion thus limiting intrusion.

According to a June 31st 2007 Science Daily article titled "Seawater Intrusion Is The First Cause Of Contamination Of Coastal Aquifers," Prof. José Benavente Herrera, a researcher from the Water Institute of the University of Granada, Spain, and senior lecturer at the department of Geodynamics provides the following recommendations for preventing or mitigating seawater intrusion.

> "…artificial recharge of aquifers is (a) measure to prevent salinisation, as it stops seawater intrusion and increases freshwater levels. In this sense, for instance, clean water obtained from urban sewage purification can be used for irrigation of crops and golf fields as well as to create a hydraulic barrier against seawater intrusion."

Seawater typically has TDS's which range from 30,000-40,000 mg/l. The proposed recycle water has less than 300 mg/l TDS. Noting that the seawater contains 100 times more TDS than the recycled water, and based on the other above referenced information, seawater intrusion could be mitigated at the proposed recycled water use site if flood irrigation or a groundwater recharge system were introduced. While recycled water applied at agronomic rates is not likely to cause any impacts on ground water, application beyond agronomic rates could be utilized in the future to act as a "barrier" to seawater intrusion and therefore improve or protect the Smith River Plain Groundwater Basin.

APPENDIX H

CRESCENT CITY RECYCLED WATER SYSTEM

WATER AND NUTRIENT BALANCE

5 November 2010

To: Jagroop Khela, State Water Resources Control Board (SWRCB)

From: Jon Olson, Stover Engineering

Subject: Crescent City Recycled Water System- Water and Nutrient Balance

The City of Crescent City (CC) is developing a project in which landscaped and park areas would be served with Title 22 recycled water for irrigation. The purpose of this memo is to discuss the Water and Nutrient Balance in coordination with principal assumptions and processes to which the results are sensitive. Calculations employing ranges of published data and values suggested by the SWRCB are provided. This analysis indicates that the resultant loading of nitrogen associated with meeting the agronomic water needs of the turf grasses in the project area is expected to be substantially (at least 68%) below the crop requirement for nitrogen under all scenarios.

KEY ASSUMPTIONS

The assumptions involved in nutrient loading calculations for new projects are developed based on monitoring of existing projects, performed over a range of environmental conditions to which the parameters themselves are sensitive. References supporting all of the assumptions are found in the subsequent tables attached to this memo. It is important to consider the local environmental conditions in which the project will be operated when planning. While this is common practice when calculating irrigation or water storage capacity requirements, it is frequently overlooked when selecting values of other parameters. When uncertain about a parameter, it is best to define and analyze a reasonable range of possible values. EPA provides useful guidelines for parameter values, but the broader literature often provides a fuller context. Once beyond the planning phase, when the project is operating, standard good practice for monitoring of plant health and soil conditions can be applied to ensure that actual fertilization is in line with actual site-specific requirements. The key assumptions in the analysis are listed below, along with a brief discussion of the sensitivity of each assumption to environmental conditions. An illustration of the nitrogen cycle (Figure 1) shows a schematic of the many inter-relationships of these parameters and processes.

Applied Irrigation Water:

Reuse project planning begins with an analysis of average conditions, but requires analysis of seasonal peaks to properly size pipes. Seasonal and inter-annual variation need to be analyzed to ensure adequate capacity. One luxury of CC's system is that there is no need to assume 100% consumption of potentially available recycled water since filtrate not used for irrigation is disposed of through the CC treatment plant and its permitted outfall to the Pacific Ocean. However, it is a project goal to make beneficial use of the maximum amount of recycled water, within the limits of the permit conditions and good environmental performance. Environmental performance is fully implied by the word "beneficial". Irrigation requirements for this planning-level analysis are therefore based on average climatic conditions. A range of crop coefficients (0.6 to 1) were considered; all of these are within the common range for a wide variety of turf grasses. Ultimate hydraulic loading limits will depend on site-specific irrigation scheduling.

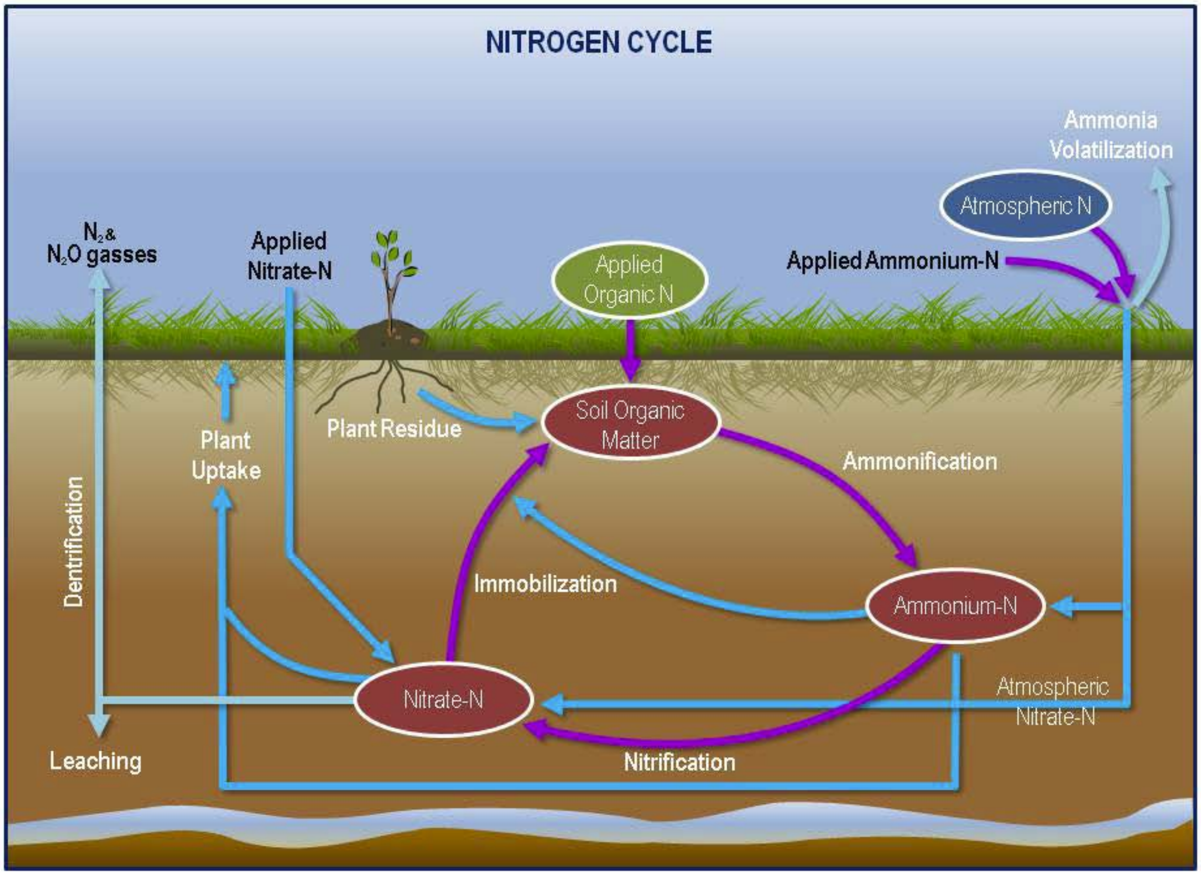

Figure 1. Schematic of the nitrogen cycle, showing principal N sources, sinks, uptake, and loss processes.

Nitrogen (N) Uptake:
Uptake of N can be conservatively calculated as the product of clipping yield and their N content (this is conservative since all unclipped plant parts are ignored, although they too contain N). A range of yield and N content values from the literature were evaluated. A range of values from the lower end of the nitrogen content spectrum (235 to 411 lb/a-y) was employed. Loading calculations were also run with the figure cited by the SWRCB (174 lb/a-y) in correspondence concerning the Delta Diablo Sanitation Districts water recycling project, and with the mean of the two previous values (323 lb/a-y).

Ammonia Volatilization:
Loss processes depend strongly on environmental conditions, so that the best planning is done with a range of values from the literature. Ammonia volatilization depends on pH, weather, irrigation method, and canopy properties. Acid soil conditions that depress volatilization are rare in California, and not present in the proposed use area's soil. A range of 15 to 30% was

analyzed, as was the upper end of the range cited by the SWRCB, (25%), in correspondence concerning the Delta Diablo Sanitation District's water recycling project. There is very little ammonia in the applied recycled water and, while included in the discussion, it has very little to do with plant available N.

Nitrification:
In well-drained soils, water re-distributes shortly after an irrigation or rainfall event, producing conditions favorable to nitrification (conversion of applied NH4-N to NO3-N). The nitrate so produced is subject to denitrification, uptake, and leaching. The goal of irrigation/fertilization management is to minimize or eliminate leaching, and to meet the needs of the growing plant.

Denitrification Rate:
Denitrification depends on soil texture, percent soil saturation (% of soil porosity filled with water), temperature, organic carbon availability, and composition of the microbial community. Even without a saturated profile, periodic saturation at the surface can hasten denitrification. This is particularly so in the presence of adequate organic C supply in the turf, and with the robust microbial community that often results from supplying nutrients in recycled water. A range of 20 to 30% denitrification rate was analyzed, as was the upper end of the range cited by the SWRCB concerning the Delta Diablo Sanitation District's project (25%). A helpful reference regarding the dependencies and ranges of denitrification rates in turf is Mancino et al. (1988).

Ammonification (mineralization)/immobilization rates:
These processes move N into and out of the organic N pool. There is practically no organic N in the recycled water, so the soil organic N pool is composed primarily of plant and microbial biomass in various states of decomposition. In managed parks the organic matter pool, rates of ammonification (conversion of organic to inorganic N), and immobilization (conversion of inorganic to organic N) should be stable and in long-term balance. Therefore, there is little need in a planning analysis to complicate calculations with this equilibrium.

Plant available N:
In this analysis, plant available N is applied N available for uptake after accounting for all loss processes.

CALCULATION RESULTS AND INTERPRETATION

A nitrogen balance was developed assuming that water demand not met by precipitation was met by irrigation with recycled water. Thirty scenarios were calculated considering the ranges of parameters discussed previously. The main index of environmental performance for each scenario is the N deficit, which is defined as the difference between N uptake - plant available N. The results are shown in Table 1. If the N deficit is 10%, the site would be deficient by that % of N if no other N were added to the soil. Negative N deficit results do not imply a potential for overloading the system with N. Rather, they demonstrate potential for the system to be nutrient limited (i.e., the full nitrogen requirement met by recycled water without exceeding the irrigation requirement). However within the range of assumptions documented in the literature, it is quite probable that the system will be hydraulically limited (i.e., the full irrigation requirement met by recycled water without exceeding the N requirement). The expected result, when considering the range of scenarios with varying parameters, is that the recycled water will not fulfill the total crop nitrogen requirement and that supplemental nitrogen will be needed to fully meet the crops needs.

Table 1. Summary of Nitrogen uptake and loading scenarios*					
Item	Scenario set 1	Scenario set 2	Scenario set 3	Scenario set 4	Scenario set 5
Max uptake assumed (lb/a-y):	323	411	411	411	411
Min uptake assumed (lb/a-y):	174	235	235	235	235
Assumed denitrification:	25%	30%	30%	20%	20%
Assumed ammonia volatilization:	25%	30%	15%	30%	15%
Max N deficit	92%	92%	92%	91%	91%
Min N deficit	70%	72%	72%	68%	68%
*Each Scenario includes 6 combinations of high and low irrigation and turf N demands.					

As shown in Table 1, the N deficit varies from 92% -68%. The results show that even while irrigating a site with recycled water, additional N may be required to meet plant demand.
In practice, even if a denitrification, volatilization, and N demand scenario resulting in a nutrient limited condition occurred, the overloading conditions would not occur due to proper management of the site.

Please note that the attached scenarios assume a basic unit of land and can therefore be applied to any area ultimately decided upon for the use of recycled water provided that the soil and grasses are similar to those used in this analysis. The scenarios' results can also be used or compared to actual quantities/values experienced in the field once irrigation is allowed to begin.

The proposed park area to be irrigated is approximately 29.5 acres. Based on historic evapotranspiration rates, during a high water demand condition the park would need 0.22 acre-ft/acre per month, and during a low water demand condition the park would need 0.11 acre-ft/acre per month. This works out to a range of 35k gallons to 70k gallons per day; since the daily usage is based on averages for a month, actual demand will likely vary from 0-140kgallons/day depending on actual conditions.

Examination of this broad range of scenarios is instructive, and serves to remind us that the soil plant water system is natural, biological, and variable in time and space. The responsible party must therefore monitor and evaluate its development and performance. This analysis suggests that the system has adequate capacity for the N in the recycled water.

REFERENCES

This memo was modeled after the February 10, 2010 memorandum by New Fields in there report to the WQCB for the Delta Diablo site; applicable portions of this memo were copied directly from the New Fields memo.

Mancino, C.F., W.A. Torello, and D.J. Wehner. 1988.
Denitrification losses from Kentucky bluegrass sod. Agronomy Journal 80:148-153.

All other references are cited in the following table and Attachment A Scenarios

Turfgrass	N (% DM)		kg N/ha-y			lb/a-y		
Species	Low	High	Low	High	Average	Low	High	Average
Blue	2.36	3.49	263	460	362	235	411	323
Fescue	3.7		413	-	206	369	0	184
Rye	3.34	5.4	373	712	542	333	636	484
Bent	2.4	8.3	268	1,094	681	239	977	608
Mills, H.A., and J.B. Jones. 1996. Plant analysis handbook II. MicroMacro Publishing. Athens, GA.								

Dry matter (kg DM/ha-y)		
Item	Low	High
Clippings	11,158	13,181
http://www.cababstractsplus.org/abstracts/Abstract.aspx?AcNo=20043119594		

ATTACHMENT A

Scenarios used for Water-Nutrient Balance

N Loading and Demand Scenario set 1								Monday, October 11, 2010
Kc	in/in	0.6	0.8	1	0.6	0.8	1.0	http://www.water.ca.gov/pubs/conservation/a_guide_to_estimating_irrigation_water_needs_of_landscape_plantings_in_california__wucols/wucols00.pdf
N uptake	lb/a-y	174	174	174	323	323	323	
Item	Units	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	
Nitrate N	mg/L	9.7	9.7	9.7	9.7	9.7	9.7	CC laboratory tests of filtrate from
Ammonia N	mg/L	0.1	0.1	0.1	0.1	0.1	0.1	(9/23-10/4) Average Value
Organic N	mg/L	0	0	0	0	0	0	
Total N	mg/L	9.8	9.8	9.8	9.8	9.8	9.8	
Net mineralization		100%	100%	100%	100%	100%	100%	Assumes full decay series of organic N mineralizes
	mg/L	0	0	0	0	0	0	
Ammonia Volatilization		25%	25%	25%	25%	25%	25%	Assumes only volatilization of initially applied ammonia. http://digitalcommons.calpoly.edu/cgi/viewcontent.cgi?article=1000&context=cafes_dean;http://cedb.asce.org/cgi/WWWdisplay.cgi?8904892;
	mg/L	0.0	0.0	0.0	0.0	0.0	0.0	= amonia X % volatilization
Denitrification		25%	25%	25%	25%	25%	25%	http://jeq.scijournals.org/cgi/content/abstract/19/1/1; http://www.springerlink.com/content/gf7kttq2hv43tl7q/; C. F.Mancino, W. A. Torello, and David J. Wehner. "Denitrification Losses from Kentucky Bluegrass Sod" Agronomy Journal 80.1 (1988): 148-153. Available at: http://works.bepress.com/dwehner/22.
	mg/L	2.5	2.5	2.5	2.5	2.5	2.5	=(Total N-Mineralization)*denitrification %
	kg/ha-d	0.15	0.20	0.25	0.15	0.20	0.25	http://www.publish.csiro.au/paper/SR9950089.htm
	lb/month-ft^2	0.09097	0.12	0.15	0.09	0.12	0.15	Converted by Xing kg/ha-d X (2.2046/2.54)X30.438/43.56
N available for plant use in irrigation water	mg/L	7.3	7.3	7.3	7.3	7.3	7.3	N total-Net mineralization-Ammonia Volatilization-Denitrification
	lb/cubic foot	0.00046	0.00046	0.00046	0.00046	0.00046	0.00046	Converted by X ing mg/l X (2.2046X10^-6/0.0351
Growing season	months	4	5	5	4	5	5	Assumed growing months May or June to September
Evapotranspiration	in/month[1]	4.1	4.1	4.1	4.1	4.1	4.1	http://www.cimis.water.ca.gov/cimis/pdf/etomap1.pdf
estimate crop evapotranspiration	in/month[1]	2.5	3.3	4.1	2.5	3.3	4.1	ETo x Kc = Etc Per CIMIS Water use calculations
Precipitation	in/month[1]	1.10	1.52	1.52	1.10	1.52	1.52	average rainfall during the same 5 months
Water Needed to meet crop demand	In/month Average	1.37	1.76	2.58	1.37	1.76	2.58	See- Precipitation and Evapotranspiration Worksheet
	ft/Month Average	0.11	0.15	0.22	0.11	0.15	0.22	
irrigation efficiency		85%	85%	85%	85%	85%	85%	
N uptake- Rate of N application needed(conservative)	lb/month-1000 ft^2	0.33	0.33	0.33	0.62	0.62	0.62	1 to 1.5 pounds of nitrogen per 1,000 sq. ft. per month may be applied during the growing season (http://aggiehorticulture. tamu.edu/plantanswers/turf/publications/bermuda.html). 6 lb/1000 sf on tall fescue (http://ucrturf.ucr.edu/UCRTRAC/BTTA/BTTA%20November%201997.pdf).
Total N in applied Irrigation water	lb/month-1000ft^2	0.05	0.07	0.10	0.05	0.07	0.10	=Available nitrogen X Irrigation water needed
Under-fertilization	lb/month-1000ft^2	0.28	0.26	0.23	0.57	0.55	0.52	
Under-fertilization as a percentage		84%	80%	70%	92%	89%	84%	Need to add fertilizer- Demonstrates that there is no impairment risk from nitrogen loading
Notes: 1- Average- # of months varies depending on required demand								

Appendix A
Water-Nutrient Balance

N Loading and Demand Scenario Set 2								Monday, October 11, 2010
Kc	in/in	0.6	0.8	1	0.6	0.8	1.0	http://www.water.ca.gov/pubs/conservation/a_guide_to_estimating_irrigation_water_needs_of_landscape_plantings_in_california__wucols/wucols00.pdf
N uptake	lb/a-y	411	411	411	235	235	235	
Item	Units	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	
Nitrate N	mg/L	9.7	9.7	9.7	9.7	9.7	9.7	CC laboratory tests of filtrate form
Ammonia N	mg/L	0.1	0.1	0.1	0.1	0.1	0.1	(9/23-10/4) Average Value
Organic N	mg/L	0	0	0	0	0	0	
Total N	mg/L	9.8	9.8	9.8	9.8	9.8	9.8	
Net mineralization		100%	100%	100%	100%	100%	100%	Assumes full decay series of organic N mineralizes
	mg/L	0	0	0	0	0	0	
Ammonia Volatilization		30%	30%	30%	30%	30%	30%	Assumes only volatilization of initially applied ammonia. http://digitalcommons.calpoly.edu/cgi/viewcontent.cgi?article=1000&context=cafes_dean;http://cedb.asce.org/cgi/WWWdisplay.cgi?8904892;
	mg/L	0.0	0.0	0.0	0.0	0.0	0.0	= amonia X % volatilization
Denitrification		30%	30%	30%	30%	30%	30%	http://jeq.scijournals.org/cgi/content/abstract/19/1/1; http://www.springerlink.com/content/gf7kttq2hv43tl7q/; C. F.Mancino, W. A. Torello, and David J. Wehner. "Denitrification Losses from Kentucky Bluegrass Sod" Agronomy Journal 80.1 (1988): 148-153. Available at: http://works.bepress.com/dwehner/22.
	mg/L	2.9	2.9	2.9	2.9	2.9	2.9	=(Total N-Mineralization)*denitrification %
	kg/ha-d	0.15	0.20	0.25	0.15	0.20	0.25	http://www.publish.csiro.au/paper/SR9950089.htm
	lb/month-ft^2	0.09097	0.12	0.15	0.09	0.12	0.15	Converted by Xing kg/ha-d X (2.2046/2.54)X30.438/43.56
N available for plant use in irrigation water	mg/L	6.8	6.8	6.8	6.8	6.8	6.8	N total-Net mineralization-Ammonia Volatilization-Denitrification
	lb/cubic foot	0.00043	0.00043	0.00043	0.00043	0.00043	0.00043	Converted by X ing mg/l X (2.2046X10^-6/0.0351
Growing season	months	4	5	5	4	5	5	Assumed growing months May or June to September
Evapotranspiration	in/month[1]	4.1	4.1	4.1	4.1	4.1	4.1	http://www.cimis.water.ca.gov/cimis/pdf/etomap1.pdf
estimate crop evapotranspiration	in/month[1]	2.5	3.3	4.1	2.5	3.3	4.1	ETo x Kc = Etc Per CIMIS Water use calculations
Precipitation	in/month[1]	1.10	1.52	1.52	1.10	1.52	1.52	average rainfall during the same 5 months
Water Needed to meet crop demand	In/month Average	1.37	1.76	2.58	1.37	1.76	2.58	See- Precipitation and Evapotranspiration Worksheet
	ft/Month Average	0.11	0.15	0.22	0.11	0.15	0.22	
irrigation efficiency		85%	85%	85%	85%	85%	85%	
N uptake- Rate of N application needed(conservative)	lb/month-1000 ft^2	0.33	0.33	0.33	0.62	0.62	0.62	1 to 1.5 pounds of nitrogen per 1,000 sq. ft. per month may be applied during the growing season (http://aggiehorticulture. tamu.edu/plantanswers/turf/publications/bermuda.html). 6 lb/1000 sf on tall fescue (http://ucrturf.ucr.edu/UCRTRAC/BTTA/BTTA%20November%201997.pdf).
Total N in applied Irrigation water	lb/month-1000ft^2	0.05	0.06	0.09	0.05	0.06	0.09	=Available nitrogen X Irrigation water needed
Under-fertilization	lb/month-1000ft^2	0.28	0.27	0.24	0.57	0.56	0.53	
Under-fertilization as a percentage		85%	81%	72%	92%	90%	85%	Need to add fertilizer- Demonstrates that there is no impairment risk from nitrogen loading
Notes: 1- Average- # of months varies depending on required demand								

N Loading and Demand Scenario Set 3								Monday, October 11, 2010
Kc	in/in	0.6	0.8	1	0.6	0.8	1.0	http://www.water.ca.gov/pubs/conservation/a_guide_to_estimating_irrigation_water_needs_of_landscape_plantings_in_california__wucols/wucols00.pdf
N uptake	lb/a-y	411	411	411	235	235	235	
Item	Units	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	
Nitrate N	mg/L	9.7	9.7	9.7	9.7	9.7	9.7	CC laboratory tests of filtrate form
Ammonia N	mg/L	0.1	0.1	0.1	0.1	0.1	0.1	(9/23-10/4) Average Value
Organic N	mg/L	0	0	0	0	0	0	
Total N	mg/L	9.8	9.8	9.8	9.8	9.8	9.8	
Net mineralization		100%	100%	100%	100%	100%	100%	Assumes full decay series of organic N mineralizes
	mg/L	0	0	0	0	0	0	
Ammonia Volatilization		15%	15%	15%	15%	15%	15%	Assumes only volatilization of initially applied ammonia. http://digitalcommons.calpoly.edu/cgi/viewcontent.cgi?article=1000&context=cafes_dean;http://cedb.asce.org/cgi/WWWdisplay.cgi?8904892;
	mg/L	0.0	0.0	0.0	0.0	0.0	0.0	= amonia X % volatilization
Denitrification		30%	30%	30%	30%	30%	30%	http://jeq.scijournals.org/cgi/content/abstract/19/1/1; http://www.springerlink.com/content/gf7kttq2hv43tl7q/; C. F.Mancino, W. A. Torello, and David J. Wehner. "Denitrification Losses from Kentucky Bluegrass Sod" Agronomy Journal 80.1 (1988): 148-153. Available at: http://works.bepress.com/dwehner/22.
	mg/L	2.9	2.9	2.9	2.9	2.9	2.9	=(Total N-Mineralization)*denitrification %
	kg/ha-d	0.15	0.20	0.25	0.15	0.20	0.25	http://www.publish.csiro.au/paper/SR9950089.htm
	lb/month-ft^2	0.09097	0.12	0.15	0.09	0.12	0.15	Converted by Xing kg/ha-d X (2.2046/2.54)X30.438/43.56
N available for plant use in irrigation water	mg/L	6.8	6.8	6.8	6.8	6.8	6.8	N total-Net mineralization-Ammonia Volatilization-Denitrification
	lb/cubic foot	0.00043	0.00043	0.00043	0.00043	0.00043	0.00043	Converted by X ing mg/l X (2.2046X10^-6/0.0351
Growing season	months	4	5	5	4	5	5	Assumed growing months May or June to September
Evapotranspiration	in/month[1]	4.1	4.1	4.1	4.1	4.1	4.1	http://www.cimis.water.ca.gov/cimis/pdf/etomap1.pdf
estimate crop evapotranspiration	in/month[1]	2.5	3.3	4.1	2.5	3.3	4.1	ETo x Kc = Etc Per CIMIS Water use calculations
Precipitation	in/month[1]	1.10	1.52	1.52	1.10	1.52	1.52	average rainfall during the same 5 months
Water Needed to meet crop demand	In/month Average	1.37	1.76	2.58	1.37	1.76	2.58	See- Precipitation and Evapotranspiration Worksheet
	ft/Month Average	0.11	0.15	0.22	0.11	0.15	0.22	
irrigation efficiency		85%	85%	85%	85%	85%	85%	
N uptake- Rate of N application needed(conservative)	lb/month-1000 ft^2	0.33	0.33	0.33	0.62	0.62	0.62	1 to 1.5 pounds of nitrogen per 1,000 sq. ft. per month may be applied during the growing season (http://aggiehorticulture. tamu.edu/plantanswers/turf/publications/bermuda.html). 6 lb/1000 sf on tall fescue (http://ucrturf.ucr.edu/UCRTRAC/BTTA/BTTA%20November%201997.pdf).
Total N in applied Irrigation water	lb/month-1000ft^2	0.05	0.06	0.09	0.05	0.06	0.09	=Available nitrogen X Irrigation water needed
Under-fertilization	lb/month-1000ft^2	0.28	0.27	0.24	0.57	0.56	0.53	
Under-fertilization as a percentage		85%	81%	72%	92%	90%	85%	Need to add fertilizer- Demonstrates that there is no impairment risk from nitrogen loading
Notes: 1- Average- # of months varies depending on required demand								

N Loading and Demand Scenario Set 4								Monday, October 11, 2010
Kc	in/in	0.6	0.8	1	0.6	0.8	1.0	http://www.water.ca.gov/pubs/conservation/a_guide_to_estimating_irrigation_water_needs_of_landscape_plantings_in_california__wucols/wucols00.pdf
N uptake	lb/a-y	411	411	411	235	235	235	
Item	Units	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	
Nitrate N	mg/L	9.7	9.7	9.7	9.7	9.7	9.7	CC laboratory tests of filtrate from
Ammonia N	mg/L	0.1	0.1	0.1	0.1	0.1	0.1	(9/23-10/4) Average Value
Organic N	mg/L	0	0	0	0	0	0	
Total N	mg/L	9.8	9.8	9.8	9.8	9.8	9.8	
Net mineralization		100%	100%	100%	100%	100%	100%	Assumes full decay series of organic N mineralizes
	mg/L	0	0	0	0	0	0	
Ammonia Volatilization		30%	30%	30%	30%	30%	30%	Assumes only volatilization of initially applied ammonia. http://digitalcommons.calpoly.edu/cgi/viewcontent.cgi?article=1000&context=cafes_dean;http://cedb.asce.org/cgi/WWWdisplay.cgi?8904892;
	mg/L	0.0	0.0	0.0	0.0	0.0	0.0	= amonia X % volatilization
Denitrification		20%	20%	20%	20%	20%	20%	http://jeq.scijournals.org/cgi/content/abstract/19/1/1; http://www.springerlink.com/content/gf7kttq2hv43tl7q/; C. F.Mancino, W. A. Torello, and David J. Wehner. "Denitrification Losses from Kentucky Bluegrass Sod" Agronomy Journal 80.1 (1988): 148-153. Available at: http://works.bepress.com/dwehner/22.
	mg/L	2.0	2.0	2.0	2.0	2.0	2.0	=(Total N-Mineralization)*denitrification %
	kg/ha-d	0.15	0.20	0.25	0.15	0.20	0.25	http://www.publish.csiro.au/paper/SR9950089.htm
	lb/month-ft^2	0.09097	0.12	0.15	0.09	0.12	0.15	Converted by Xing kg/ha-d X (2.2046/2.54)X30.438/43.56
N available for plant use in irrigation water	mg/L	7.8	7.8	7.8	7.8	7.8	7.8	N total-Net mineralization-Ammonia Volatilization-Denitrification
	lb/cubic foot	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	Converted by X ing mg/l X (2.2046X10^-6/0.0351
Growing season	months	4	5	5	4	5	5	Assumed growing months May or June to September
Evapotranspiration	in/month[1]	4.1	4.1	4.1	4.1	4.1	4.1	http://www.cimis.water.ca.gov/cimis/pdf/etomap1.pdf
estimate crop evapotranspiration	in/month[1]	2.5	3.3	4.1	2.5	3.3	4.1	ETo x Kc = Etc Per CIMIS Water use calculations
Precipitation	in/month[1]	1.10	1.52	1.52	1.10	1.52	1.52	average rainfall during the same 5 months
Water Needed to meet crop demand	In/month Average	1.37	1.76	2.58	1.37	1.76	2.58	See- Precipitation and Evapotranspiration Worksheet
	ft/Month Average	0.11	0.15	0.22	0.11	0.15	0.22	
irrigation efficiency		85%	85%	85%	85%	85%	85%	
N uptake- Rate of N application needed(conservative)	lb/month-1000 ft^2	0.33	0.33	0.33	0.62	0.62	0.62	1 to 1.5 pounds of nitrogen per 1,000 sq. ft. per month may be applied during the growing season (http://aggiehorticulture. tamu.edu/plantanswers/turf/publications/bermuda.html). 6 lb/1000 sf on tall fescue (http://ucrturf.ucr.edu/UCRTRAC/BTTA/BTTA%20November%201997.pdf).
Total N in applied Irrigation water	lb/month-1000ft^2	0.06	0.07	0.10	0.06	0.07	0.10	=Available nitrogen X Irrigation water needed
Under-fertilization	lb/month-1000ft^2	0.27	0.26	0.23	0.56	0.55	0.52	
Under-fertilization as a percentage		83%	78%	68%	91%	88%	83%	Need to add fertilizer- Demonstrates that there is no impairment risk from nitrogen loading
Notes: 1- Average- # of months varies depending on required demand								

Appendix A

Water-Nutrient Balance

N Loading and Demand Scenario Set 5								Monday, October 11, 2010
Kc	in/in	0.6	0.8	1	0.6	0.8	1.0	http://www.water.ca.gov/pubs/conservation/a_guide_to_estimating_irrigation_water_needs_of_landscape_plantings_in_california__wucols/wucols00.pdf
N uptake	lb/a-y	411	411	411	235	235	235	
Item	Units	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	
Nitrate N	mg/L	9.7	9.7	9.7	9.7	9.7	9.7	CC laboratory tests of filtrate from
Ammonia N	mg/L	0.1	0.1	0.1	0.1	0.1	0.1	(9/23-10/4) Average Value
Organic N	mg/L	0	0	0	0	0	0	
Total N	mg/L	9.8	9.8	9.8	9.8	9.8	9.8	
Net mineralization		100%	100%	100%	100%	100%	100%	Assumes full decay series of organic N mineralizes
	mg/L	0	0	0	0	0	0	
Ammonia Volatilization		15%	15%	15%	15%	15%	15%	Assumes only volatilization of initially applied ammonia. http://digitalcommons.calpoly.edu/cgi/viewcontent.cgi?article=1000&context=cafes_dean;http://cedb.asce.org/cgi/WWWdisplay.cgi?8904892;
	mg/L	0.0	0.0	0.0	0.0	0.0	0.0	= amonia X % volatilization
Denitrification		20%	20%	20%	20%	20%	20%	http://jeq.scijournals.org/cgi/content/abstract/19/1/1; http://www.springerlink.com/content/gf7kttq2hv43tl7q/; C. F.Mancino, W. A. Torello, and David J. Wehner. "Denitrification Losses from Kentucky Bluegrass Sod" Agronomy Journal 80.1 (1988): 148-153. Available at: http://works.bepress.com/dwehner/22.
	mg/L	2.0	2.0	2.0	2.0	2.0	2.0	=(Total N-Mineralization)*denitrification %
	kg/ha-d	0.15	0.20	0.25	0.15	0.20	0.25	http://www.publish.csiro.au/paper/SR9950089.htm
	lb/month-ft^2	0.09097	0.12	0.15	0.09	0.12	0.15	Converted by Xing kg/ha-d X (2.2046/2.54)X30.438/43.56
N available for plant use in irrigation water	mg/L	7.8	7.8	7.8	7.8	7.8	7.8	N total-Net mineralization-Ammonia Volatilization-Denitrification
	lb/cubic foot	0.00049	0.00049	0.00049	0.00049	0.00049	0.00049	Converted by X ing mg/l X (2.2046X10^-6/0.0351
Growing season	months	4	5	5	4	5	5	Assumed growing months May or June to September
Evapotranspiration	in/month[1]	4.1	4.1	4.1	4.1	4.1	4.1	http://www.cimis.water.ca.gov/cimis/pdf/etomap1.pdf
estimate crop evapotranspiration	in/month[1]	2.5	3.3	4.1	2.5	3.3	4.1	ETo x Kc = Etc Per CIMIS Water use calculations
Precipitation	in/month[1]	1.10	1.52	1.52	1.10	1.52	1.52	average rainfall during the same 5 months
Water Needed to meet crop demand	In/month Average	1.37	1.76	2.58	1.37	1.76	2.58	See- Precipitation and Evapotranspiration Worksheet
	ft/Month Average	0.11	0.15	0.22	0.11	0.15	0.22	
irrigation efficiency		85%	85%	85%	85%	85%	85%	
N uptake- Rate of N application needed(conservative)	lb/month-1000 ft^2	0.33	0.33	0.33	0.62	0.62	0.62	1 to 1.5 pounds of nitrogen per 1,000 sq. ft. per month may be applied during the growing season (http://aggiehorticulture. tamu.edu/plantanswers/turf/publications/bermuda.html). 6 lb/1000 sf on tall fescue (http://ucrturf.ucr.edu/UCRTRAC/BTTA/BTTA%20November%201997.pdf).
Total N in applied Irrigation water	lb/month-1000ft^2	0.06	0.07	0.11	0.06	0.07	0.11	=Available nitrogen X Irrigation water needed
Under-fertilization	lb/month-1000ft^2	0.27	0.26	0.22	0.56	0.55	0.51	
Under-fertilization as a percentage		83%	78%	68%	91%	88%	83%	Need to add fertilizer- Demonstrates that there is no impairment risk from nitrogen loading
Notes: 1- Average- # of months varies depending on required demand								