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JAGROOP KHELA
STATE WATER RESOURCES CONTROL BOARD
P.O. BOX 100
SACRAMENTO, CA 95812-0100

Job Number: 3838.2

22 February 2011

RE: Water and nutrient balance for Beach Front Park in Crescent City, California

Dear Jagroop,

The purpose of this letter is to explain the detailed analysis of a water and nutrient balance performed on behalf of the City of Crescent City (City). Stover Engineering prepared this letter and attached calculations as the final part of the City's application for coverage under the State Water Resources Control Board's (Board) Order No. 2009-0006-DWQ, the General Waste Discharge Requirements for Landscape Irrigation Uses of Recycled Water (General Permit).

History:

The City of Crescent City plans to irrigate Beach Front Park in Crescent City with disinfected tertiary recycled water as defined in Title 22 of the California Code of Regulations.[1] The permitting authority for recycled water projects is the State Water Resources Control Board.

- on 18 March 2010, the City applied for coverage under the General Permit. This included filing a notice of intent and a Report on the Production and Use of Reclaimed Water for Crescent City. The report went to the California Department of Public Health, and the Water Board.
- On 11 August 2010 there was a conference call between the North Coast Regional Water Quality Control Board, the Board, the City, and Stover Engineering. As a result of the call the Board sent, via email, a list of five additional items that would be required in order to consider the General Permit application complete.
- In a letter dated 1 September 2010, The California Department of Public Health (CDPH) provided a response to the draft Production and Use of Reclaimed Water Report (PURWR).
- On 3 January 2011 the Board requested items were returned via email and the revised PURWR was returned to CDPH for further review.
- On 11 January 2011 the Board asked for additional information regarding three items; Water Balance, Nutrient Balance, and Hydraulic Loading Rate.
- On 24 January 2011 the Board provided additional guidance regarding procedures for analysis for these design parameters.
- On 3 February 2011 Stover Engineering provided a draft background soil sampling plan for the use area. To date there has not been a response to the proposed background soil sampling plan.

1. For full plans and details of the treatment system and proposed use area see the Engineering Report on PURWR dated 11.19.2010 previously submitted to California Department of Public Health and the Board.

Recycled Water System Design:

A Siemens Membrane Biological Reactor treats and filters wastewater at the Crescent City Facility. Filtrate is discharged to a filtrate tank. Normally the filtrate flows from this filtrate tank to a chlorine contact basin and is ultimately discharged into the Pacific Ocean under and a National Pollution Discharge Elimination System permit issued by the Regional Water Board. The City has installed reuse pumps with a capacity to draw up to 1.2 million gallons per day (MGD) from the filtrate tank and pump it through the in-line ultraviolet disinfection system. The disinfected filtrate will then flow through a 12-inch reuse pipeline to the City's irrigation facilities. This plan would put wastewater to beneficial use of the people of the State and comply with the Board's Recycled Water Policy and Title 22 of the California Code of Regulations. The recycled water system does not employ any ponds or storage facilities for recycled water. Any time the City is not irrigating, the filtered wastewater is discharged through the ocean outfall under a separate NPDES permit issued by the Regional Board.

Design Considerations:

The primary consideration employed in development of irrigation limits for Beach Front Park is the concept of using limiting design parameters. Three fundamental parameters were considered as the basis for design limits. First the need for irrigation is shown by comparing rainfall data to crop evapotranspiration demand; if evapotranspiration demand exceeds precipitation then a limiting parameter is the water deficit between the two values. The second parameter considered is a hydraulic loading rate based on soil permeability; site specific soil percolation rates have the potential to limit the application of recycled water. The third limiting parameter is nitrogen/nutrients in the recycled water and the assimilative capacity of the natural biological system to remove nitrogen without significant negative impacts on groundwater; an irrigation limit based on nitrogen concentration in the recycled water, nitrogen uptake rates of the grasses in the use area, and residual nitrogen in percolating irrigation water. By comparing the values of crop demand for water, the soils ability to absorb water, and the natural systems nitrogen assimilative capacity, proper irrigation limits can be set for Beach Front Park.

Irrigation Parameter:

With more than one hundred years of precipitation data available, the limiting design parameter of irrigation based on three precipitation conditions were considered. First is the one hundred year drought condition experienced in 1976 when only thirty-three (33) inches of rain fell. Secondly is the average rainfall calculated from the one hundred plus years of data. Lastly the greatest amount of precipitation in any one year was considered; in 1904 Crescent City experienced one hundred-eight (108) inches of precipitation. These three conditions were used and compared to the crop irrigation requirements.

The crop irrigation requirement was calculated based on Department of Water Resources' guidelines titled "Estimating …Water Use With CIMIS." Crop evapotranspiration is determined by taking the site evapotranspiration and multiplying it by a crop factor. For various grasses and field conditions a crop factor of 0.9 to 1 is recommended. For the purposes of this analysis the conservative factor of 0.8 was selected for all scenarios.

The attached document is broken down into three scenarios and completely analyzed by month; see Table 4 in the Drought, Average, and 100-year precipitation scenarios. The results of the three scenarios are annualized in Table A below. Based on the fact that the City will not be irrigating year around, the annual Hydraulic Loading Rate is the summation of calculated irrigation requirements. Note that only months in which calculated crop demand exceeded precipitation where included in the annualized loading rate. The net demand in Table 4 is reported in (in/year) and must by be multiplied by the use area to develop a total irrigation limit. Please see the attached scenarios for complete calculations.

Table A: The Limiting Irrigation Design Parameter:

Condition	Total Crop Evapotranspiration for months included in calculation of loading rate (in)	Total Precipitation for months included in calculation of loading rate (in)	Annual Hydraulic Loading Rate for 30 Acre Use Area (million Gallons per year)
Drought 1976	18.3	6.5	9.7
Average	13.1	4.4	7.1
100-year max 1907	13.7	5.6	6.6

Soil Permeability Parameter:

The Soil Permeability Parameter is the hydraulic loading rate based on soil permeability, evapotranspiration, and precipitation. The limiting parameter is calculated by subtracting the precipitation rate from the sum of the evapotranspiration rate and percolation rate. The resulting value indicates the maximum rate at which water could be added to the use area without running offsite or ponding.

Soil borings were performed at Beach Front Park and reported by GeoDesign Inc. in a December 2004 report titled "Report of Geotechnical Engineering Services Crescent City Waste Water Treatment Plant". Based on the soils identified in the report you and I agreed to the use of a soil percolation rate of 0.03 feet per day for design purposes which is relatively conservative when compared to percolation rates identified in the basin plan.

The same percolation rate was used in all three scenarios covering drought, average, and 100-year maximum precipitation years. See Table 3 in the Drought, Average, and 100-year precipitation scenarios for complete calculations and monthly data. In Table 3 water losses are reported as negative values and water gains would be reported as positive values. Positive values would indicate ponding. In each of the three scenarios net losses were calculated indicating that no ponding would occur. For convenience all values are summarized in Table B as positive although there are net water losses in the use area.

Table B: The Limiting Soil Percolation Design Parameter:

Condition	Total Crop Evapotranspiration for the year (in)	Total Percolation for the year (in)	Total Precipitation for the year (in)	Annual Hydraulic Loading Rate for 30 Acre Use Area (million Gallons per year)
Drought 1976	33	131	33	106
Average	33	131	71	76
100-year max 1907	33	131	108	46

Nitrogen Loading Parameter:

The hydraulic loading rate based on the Nitrogen Loading Parameter is controlled by two items. First is protection of groundwater by limiting nitrogen concentrations in percolating water. The second is the nitrogen uptake rate of the crop in the irrigated area.

The accepted nitrogen uptake rate approved by you is 174 pounds per acre per year. Your suggested equation was used to calculate the concentration of nitrogen in percolating water; see Table 5 of the attached document in the Drought, Average, and 100-year precipitation scenarios for complete calculations. The calculation of concentration in percolating water includes the following factors: concentration of nitrogen in recycled water, the uptake rate of the crop, precipitation and evapotranspiration rates, volatilization and denitrification, and recycled water application rate.

Two possible recycled water application rates were analyzed for each of the three precipitation scenarios. First recycled water is assumed to be applied at the maximum percolation rate or the limiting soil percolation design parameter. Secondly recycled water is assumed to be applied at the limiting irrigation design parameter. All of the input values were converted to SI units since that is the system of units used in calculating the concentration in percolating water.

Recent analysis of nitrogen in the filtrate/recycled water determined the concentration to be 7mg/L. The low concentration of nitrogen is testament to the high level of treatment provided by the treatment plant. Table C below summarizes application rates and resulting concentration of nitrogen in percolating water.

Table C: Calculated Value of Nitrogen Concentration in Percolating Recycled Water

Condition	Application Rate Of Recycled Water Based On Percolation Limit (in/year)	Resulting Concentration of Nitrogen in Percolating Water-Cp (mg/L)	Application Rate Of Recycled Water Based On Irrigation Rate (in/year)	Resulting Concentration of Nitrogen in Percolating Water-Cp (mg/L)
Drought 1976	131	1.1	11.9	-56
Average	94	-0.9	8.7	-15.9
100-year max 1907	57	-2.8	8.8	-8.5

Negative values for nitrogen shown in the above table should be interpreted as zero nitrogen in percolating water; negative values indicate that all available nitrogen has all been consumed by the crop and that amendments may be required for effective crop growth.

Additional calculations were performed in order to determine a theoretical concentration of nitrogen in recycled water that, when applied to the use area, would not negatively affect groundwater. The EPA has set a maximum contamination level (MCL) for nitrogen in drinking water at 10 mg/L. This MCL was assumed as the maximum concentration allowed in percolating water. Experimental concentrations of nitrogen in recycled water were entered into the suggested formula until the MCL was reached in percolating water. The results of this analysis are presented in the Table D below.

Table D: Theoretical Maximum Concentration of Nitrogen in Recycled Water

Condition	Application Rate Of Recycled Water Based On Percolation limit (in/year)	Theoretical Maximum Concentration in Recycled Water (mg/L)	Application Rate Of Recycled Water Based On Irrigation Rate (in/year)	Theoretical Maximum Concentration in Recycled Water (mg/L)
Drought 1976	131	15.8	11.9	74
Average	94	22.5	8.7	142
100-year max 1907	57	36.7	8.8	182

Conclusions and Recommendations:

Comparing the irrigation design parameter to the percolation design parameter, it is clear that in drought, average, and 100 year precipitation conditions the irrigation rate is substantially lower than the percolation limit. While the City will normally apply water at the irrigation or agronomic rate, the analysis clearly shows that there is substantial hydraulic capacity in the use area. Since the limiting condition is the percolation limit this should be selected as the upper limit for recycled water application in any given year. The data suggests a limit of 106 million gallons per year.

The data sets show that when irrigating at agronomic rates, under all three precipitation conditions, that all applied nitrogen is taken up by the crop. When considering the calculations for the application of recycled water at the percolation limit, only during drought condition was there any calculated nitrogen in percolating water. The method used for calculation of the concentration of nitrogen in percolating water is conservative; both volatilization and denitrification were ignored resulting in higher concentrations in percolating water than would be experienced in the natural environment. During drought conditions it is highly unlikely that the City would choose to apply water to the use are at this advanced rate.

If the City did choose to irrigate to the percolation limit the calculations indicate that the concentration of nitrogen in the percolating water would be approximately 1 mg/L. Since the MCL for nitrogen in drinking water is 10 mg/L there is very little risk of contaminating ground water with nitrogen through this process. Additionally there are no potable water wells in the vicinity of the use area. While the Basin Plan has listed drinking water as a beneficial use of the underlying aquifer, the City is not likely to tap this resource in the foreseeable future; the City uses only half of its allotted water quantity from the Smith River.

Looking at the additional analysis performed to develop a theoretical maximum allowable concentration of nitrogen in recycled water that would keep the concentration in percolating water at or below the MCL of 10 mg/l is instructive. Tables 10.1 through 10.6 in the attached document show the calculations for each of the three precipitation conditions and the two hydraulic conditions. The analysis suggests that if agronomic rates are employed that the maximum allowable concentration of nitrogen in recycled water should be limited to 74 mg/L; this is the most conservative value when irrigating at agronomic rates. If applications are made to the percolating rate then 15.8 mg/L could be selected. The Recycled water policy states that the Water Board will "encourage the use of recycled water, consistent with state and federal water quality laws." Since the calculations suggest that 74 mg/l if applied at agronomic rates would not violate the MCL, you will maximize your encouragement of recycled water use by allowing 74 mg/l.

In summary of the conclusions and recommendations it is clear that application of recycled water to the proposed use area at Beach Front Park can be accomplished while meeting the crop's agronomic water demand and protecting both people and the environment. The City of Crescent City should be provided General Permit coverage for their proposed recycled water operations.

Very truly yours,

STOVER ENGINEERING

Jonathan Olson, P.E.
Project Engineer

QA/QC WK
Enclosure:

REGISTERED PROFESSIONAL ENGINEER
JONATHAN DALE OLSON
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No. C 76887
CIVIL
STATE OF CALIFORNIA

Water/Nutrient Balance Report
Application to State Water Resources Control Board for
General Permit (WQO NO. 2009-0006-DWQ

Table 1 Evapotranspiration

Month	Average Evapotranspiration[1] inches/month (in/mo)
January	0.93
February	1.40
March	2.48
April	3.30
May	4.03
June	4.50
July	4.65
August	4.03
September	3.30
October	2.48
November	1.20
December	0.62

1- California Irrigation Management Information System (CIMIS) (ETo) Zones
http://www.cimis.water.ca.gov/cimis/images/etomap.jpg

Table 2 Precipitation

Month	Average Precipitation[2] (set 1) (in/mo)	1976 Drought Precipitation[3] (set 2) (in/mo)
January	10.90	4.56
February	8.90	9.00
March	8.60	5.25
April	4.80	4.30
May	3.20	0.74
June	1.40	0.51
July	0.60	0.57
August	0.70	3.22
September	1.70	0.35
October	5.40	1.06
November	9.00	2.69
December	10.50	0.96

The second data set was used for calculation purposes. The first data set is included for reference purposes.

2- Table 2 from 2005 Urban Water Management Plan Crescent City, California
http://www.crescentcity.org/Forms/PW/CC_UWMP%202006_FINAL.pdf
3- Average values from CRESCENT CITY 1 N, CALIFORNIA
http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?ca2147

Table 3

Water Balance Calculations:

Water Losses and Gains for the Use Area on a monthly basis with no irrigation: Hydraulic Loading Rate Based on Soil Permeability. (in/year)

Month	January	February	March	April	May	June	July	August	September	October	November	December	TOTAL
Precipitation(1-100) =Average Precipitation[3] *peaking factor=(in/mo)	4.6	9.0	5.3	4.3	0.7	0.5	0.6	3.2	0.4	1.1	2.7	1.0	33
ET(1-100)=Historical=(in/mo)	0.9	1.4	2.5	3.3	4.0	4.5	4.7	4.0	3.3	2.5	1.2	0.6	33
Infiltration= soil perc rate 0.03(ft/day) × days/month × 12in/ft=(in/mo)	11.2	10.1	11.2	10.8	11.2	10.8	11.2	11.2	10.8	11.2	10.8	11.2	131
Hydraulic Loading Rate [Lw(p)]: Net Loss(-) Gain(+) for use area= Rainfall(1-100)-ET(1-100)-Infiltration=(in/mo)	-7.5	-2.5	-8.4	-9.8	-14.5	-14.8	-15.2	-12.0	-13.8	-12.6	-9.3	-10.8	-131

There are no storage ponds used.

Peaking factor = see below
1

While there are calculated losses in February, March, April, October, and November, the City of Crescent City may choose not to irrigate in these months.

Table 4

Hydraulic Loading Rate Based On Irrigation Requirements:				Proposed Irrigation rates based on historical application:									
Month	January	February	March	April	May	June	July	August	September	October	November	December	TOTAL
Crescent City Wastewater Treatment plant Average Historical Plant Flow Rate (MGD) [4]	2.1	2.1	2.3	1.8	1.3	1.1	1.2	1.1	1.1	1.1	1.4	1.9	1.5
Total/month= MGD* days in month = (MG)	63.6	57.4	71.0	54.0	41.5	33.8	36.4	34.9	33.3	34.1	41.3	58.1	559
Proposed Flow to Recycled Water Use Area (irrigation requirement) (MG)	0.0	0.0	0.0	0.0	0.2	2.3	3.2	2.6	1.1	0.0	0.0	0.0	9
Proposed Flow to Ocean Outfall= Total per month - total to Use area= (MG)	63.6	57.4	71.0	54.0	41.3	31.4	33.2	32.3	32.3	34.1	41.3	58.1	550
Evapotranspiration demand of crop (Etc) (common grass) Per CIMIS Water use calculations = Evapotranspiration x demand factor(Kc)0.8 = (in/mo)	0.7	1.1	2.0	2.6	3.2	3.6	3.7	3.2	2.6	2.0	1.0	0.5	26
Precipitation (drought) =(in/mo)	4.6	9.0	5.3	4.3	0.7	0.5	0.6	3.2	0.4	1.1	2.7	1.0	33
Hydraulic Loading Rate Based on Irrigation Requirements (Lw)= Evapotranspirative demand of crop (IR) -Precipitation(drought) = negative values indicate no irrigation demand. Positive values indicate need for irrigation(in/mo)	-3.8	-7.9	-3.3	-1.7	2.5	3.1	3.2	0.0	2.3	0.9	-1.7	-0.5	11.9
There are no storage ponds used.													
4. July 2010 Report of Waste Discharge for the City of Crescent City --Averages were taken for the submitted data.													
Total annual irrigation requirement = Sum of individual months requiring irrigation * use area * conversion factors from (in/year) to million gallons per year	**9.7**	MGY											

Table 5

Cp is Concentration of Nitrogen in Percolating Water:	Assume no Volatilization or Nitrification Conservative approach:					
Lw(n) = (Cp*(Pr-ET)+ U(10))/((1-f)(Cn)-Cp)=(cm/month)						
Solve equation for Cp: Convert all item to SI units.	Concentration of Nitrogen in Filtrate (Cn) (mg/l)	Uptake Rate U (kg/ha-year)	Lw(p) (cm/year)	Lw is sum of positive Lw values from Table 4 (cm/year)	Pr (cm/year)	Et (cm/year)
Inputs	7.0	195	333	30	84	84
Cp= (Lw(Cn)-U*10)/(Pr-ET+Lw)= (mg/l)			1.1	-56.3		
Applying water to the max perc rate results in no nitrogen entering the groundwater						
Applying water at agronomic rates results in all nitrogen in the recycled water being consumed by the crop.						
The above calculations leads us to believe that the majority of nitrogen is consumed by crops and that Scenario 2 Below is the most accurate.						

Table 6.1

Nutrient Balance:

Allowable Hydraulic Loading rate based on nitrogen limits (scenario 1):

Assume majority of nitrogen percolates into ground only 14% is consumed by grasses in use area:

Month	January	February	March	April	May	June	July	August	September	October	November	December	TOTAL
(Cp) Concentration of Total N (mg/L) in Percolating water	6	6	6	6	6	6	6	6	6	6	6	6	6
(Pr) Precipitation rate (in/mo)	4.6	9.0	5.3	4.3	0.7	0.5	0.6	3.2	0.4	1.1	2.7	1.0	33
(Pr) Precipitation rate * 1cm/0.394 in= (cm/mo)	11.6	22.8	13.3	10.9	1.9	1.3	1.4	8.2	0.9	2.7	6.8	2.4	84.3
(ET) Evapotranspiration rate (in/mo)	0.9	1.4	2.5	3.3	4.0	4.5	4.7	4.0	3.3	2.5	1.2	0.6	33
(ET) Evapotranspiration rate * 1cm/0.394 in= (cm/mo)	2.4	3.6	6.3	8.4	10.2	11.4	11.8	10.2	8.4	6.3	3.0	1.6	83.6
(U) Nitrogen uptake rate= 174lbs/acre-year * (specific growing month ET/ total growing season ET which is May to September)= lbs/acre-growing month	0	0	0	0	34	38	39	34	28	0	0	0	174
(U) Nitrogen uptake rate= lbs/acre-month * 1kg/2.2lbs*2.47acres/hectare=(kg/ha-month)	0	0	0	0	38	43	44	38	31	0	0	0	195
(Cn) Concentration of Total N (mg/L) in Filtrate [1]	7	7	7	7	7	7	7	7	7	7	7	7	7
(f) Fraction of applied nitrogen removed by denitrification and volatilization (conservative)	0	0	0	0	0	0	0	0	0	0	0	0	0
[2]Lw(n) = (Cp*(Pr-ET)+ U(10))/((1-f)(Cn)-Cp)=(cm/month)	55.3	115.7	42.2	15.2	332.8	366.8	379.7	370.6	268.6	-21.6	22.7	5.2	1953.2
Lw(n) X 1in/2.54cm=(in/month)	21.8	45.6	16.6	6.0	131.0	144.4	149.5	145.9	105.8	-8.5	8.9	2.0	769.0

1. Average based on data since startup of Membrane Bio Reactor. Filtrate is the source of recycled water.
2. State Water Board Recommended calculation procedure-all values were converted to SI for this calculation.

Table 6.2

Allowable Hydraulic Loading rate based on nitrogen limits (scenario 2):
Assume all nitrogen is consumed by grasses in use area: This is the most restrictive and therefore the Controlling nitrogen load scenario.

Month	January	February	March	April	May	June	July	August	September	October	November	December	TOTAL
(Cp) Concentration of Total N (mg/L) in Percolating water	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
(Pr) Precipitation rate (in/mo)	12.8	10.9	9.9	5.9	3.8	1.8	0.5	0.7	2.0	5.8	10.8	12.9	78
(Pr) Precipitation rate * 1cm/0.394 in= (cm/mo)	32.5	27.7	25.1	15.0	9.7	4.6	1.2	1.7	5.1	14.6	27.5	32.7	197
(ET) Evapotranspiration rate (in/mo)	0.8	1.2	2.1	2.8	3.4	3.8	4.0	3.4	2.8	2.1	1.0	0.5	28
(ET) Evapotranspiration rate * 1cm/0.394 in= (cm/mo)	2.0	3.0	5.4	7.1	8.7	9.7	10.0	8.7	7.1	5.4	2.6	1.3	71
(U) Nitrogen uptake rate= 174lbs/acre-year * (specific growing month ET/ total growing season ET which is May to September)= lbs/acre-growing month	0	0	0	0	34	38	39	34	28	0	0	0	174
(U) Nitrogen uptake rate= lbs/acre-month * 1kg/2.2lbs*2.47acres/hectare=(kg/ha-month)	0	0	0	0	38	43	44	38	31	0	0	0	195
(Cn) Concentration of Total N (mg/L) in Filtrate [1]	7	7	7	7	7	7	7	7	7	7	7	7	7
(f) Fraction of applied nitrogen removed by denitrification and volatilization (conservative)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
[2]Lw(n) = (Cp*(Pr-ET)+ U(10))/((1-f)(Cn)-Cp)=(cm/month)	0.0	0.0	0.0	0.0	54.7	61.1	63.1	54.7	44.8	0.0	0.0	0.0	278
Lw(n) X 1in/2.54cm=(in/month)	0.0	0.0	0.0	0.0	21.5	24.0	24.8	21.5	17.6	0.0	0.0	0.0	110

1. Average based on data since startup of Membrane Bio Reactor. Filtrate is the source of recycled water.
2. State Water Board Recommended calculation procedure-all values were converted to SI for this calculation.

Table 7

Controlling Rates and allowable loading:

Month	January	February	March	April	May	June	July	August	September	October	November	December	TOTAL (per year)
Comparison of Lw(p), Lw, and Lw(n)													0
Hydraulic Loading Rate Based on Soil Permeability (-values indicate soil water loss)	Lw(p)												0
(in/month)	-7.5	-2.5	-8.4	-9.8	-14.5	-14.8	-15.2	-12.0	-13.8	-12.6	-9.3	-10.8	-131
Hydraulic Loading Rate Based on Irrigation Requirements	Lw												0
(in/month)	-3.8	-7.9	-3.3	-1.7	2.5	3.1	3.2	0.0	2.3	0.9	-1.7	-0.5	-7
Allowable Annual Hydraulic Loading Rate Based on Nitrogen Limits	Lw(n)												0
(in/month)	0.0	0.0	0.0	0.0	21.5	24.0	24.8	21.5	17.6	0.0	0.0	0.0	110
Lw(p) is controlling factor for the "x" Months		X	X	X	X	X	X	X	X	X	X		
Lw(n) is controlling factor for the "x" Months	X											X	
Allowable irrigation (in/month)	0	2.5	8.4	9.8	14.5	14.8	15.2	12.0	13.8	12.6	9.3	0	113
Allowable irrigation = (in/month)/12= (ft/month)	0.00	0.21	0.70	0.82	1.20	1.23	1.27	1.00	1.15	1.05	0.78	0.00	9
Allowable irrigation= ft/month *30 acres * 43560 ft^2/acre= (ft^3)	0	270072	913671	1067220	1573605	1610631	1659636	1303533	1497375	1369962	1013859	0	12279564
Allowable irrigation= ft^3 *7.48/10^6 = (MG/month)	**0**	**2.02**	**6.83**	**7.98**	**11.77**	**12.05**	**12.41**	**9.75**	**11.20**	**10.25**	**7.58**	**0**	**92**
Allowable irrigation= gallons per month / days in the month =(gallons/day)	**0**	**72148**	**220460**	**266094**	**379696**	**401584**	**400454**	**314530**	**361302**	**330559**	**252789**	**0**	

Table 1 Evapotranspiration

Month	Average Evapotranspiration[1] inches/month (in/mo)
January	0.93
February	1.40
March	2.48
April	3.30
May	4.03
June	4.50
July	4.65
August	4.03
September	3.30
October	2.48
November	1.20
December	0.62

1- California Irrigation Management Information System (CIMIS) (ETo) Zones
http://www.cimis.water.ca.gov/cimis/images/etomap.jpg

Table 2 Precipitation

Month	Average Precipitation[2] (set 1) (in/mo)	Average Precipitation[3] (set 2) (in/mo)
January	10.90	11.63
February	8.90	9.91
March	8.60	8.98
April	4.80	5.39
May	3.20	3.49
June	1.40	1.63
July	0.60	0.44
August	0.70	0.61
September	1.70	1.84
October	5.40	5.23
November	9.00	9.85
December	10.50	11.71

The second data set was used for calculation purposes because it is more conservative and is based on 100+ years of data.

2- Table 2 from 2005 Urban Water Management Plan Crescent City, California
http://www.crescentcity.org/Forms/PW/CC_UWMP%202006_FINAL.pdf
3- Average values from CRESCENT CITY 1 N, CALIFORNIA
http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?ca2147

Table 3

Water Balance Calculations:

Water Losses and Gains for the Use Area on a monthly basis with no irrigation: Hydraulic Loading Rate Based on Soil Permeability. (in/year)

Month	January	February	March	April	May	June	July	August	September	October	November	December	TOTAL
Precipitation(average) =Average Precipitation[3] *peaking factor=(in/mo)	11.6	9.9	9.0	5.4	3.5	1.6	0.4	0.6	1.8	5.2	9.9	11.7	71
ET(1-100)=Historical=(in/mo)	0.9	1.4	2.5	3.3	4.0	4.5	4.7	4.0	3.3	2.5	1.2	0.6	33
Infiltration= soil perc rate 0.03(ft/day) × days/month × 12in/ft=(in/mo)	11.2	10.1	11.2	10.8	11.2	10.8	11.2	11.2	10.8	11.2	10.8	11.2	131
Hydraulic Loading Rate [Lw(p)]: Net Loss(-) Gain(+) for use area= Rainfall(1-100)-ET(1-100)-Infiltration=(in/mo)	-0.5	-1.6	-4.7	-8.7	-11.7	-13.7	-15.4	-14.6	-12.3	-8.4	-2.2	-0.1	-94

There are no storage ponds used.

Peaking factor = see below
1

While there are calculated losses in February, March, April, October, and November, the City of Crescent City may choose not to irrigate in these months.

Table 4

Hydraulic Loading Rate Based On Irrigation Requirements:				Proposed Irrigation rates based on historical application:									
Month	January	February	March	April	May	June	July	August	September	October	November	December	TOTAL
Crescent City Wastewater Treatment plant Average Historical Plant Flow Rate (MGD) [4]	2.1	2.1	2.3	1.8	1.3	1.1	1.2	1.1	1.1	1.1	1.4	1.9	1.5
Total/month= MGD* days in month = (MG)	63.6	57.4	71.0	54.0	41.5	33.8	36.4	34.9	33.3	34.1	41.3	58.1	559
Proposed Flow to Recycled Water Use Area (irrigation requirement) (MG)	0.0	0.0	0.0	0.0	0.2	2.3	3.2	2.6	1.1	0.0	0.0	0.0	9
Proposed Flow to Ocean Outfall= Total per month - total to Use area= (MG)	63.6	57.4	71.0	54.0	41.3	31.4	33.2	32.3	32.3	34.1	41.3	58.1	550
Evapotranspiration demand of crop (Etc) (common grass) Per CIMIS Water use calculations = Evapotranspiration x demand factor(Kc)= 0.8 = (in/mo)	0.7	1.1	2.0	2.6	3.2	3.6	3.7	3.2	2.6	2.0	1.0	0.5	26
Precipitation (average) =(in/mo)	11.6	9.9	9.0	5.4	3.5	1.6	0.4	0.6	1.8	5.2	9.9	11.7	71
Hydraulic Loading Rate Based on Irrigation Requirements (Lw)= Evapotranspirative demand of crop (IR) -Precipitation(1-100)(Pr) = negative values indicate no irrigation demand. Positive values indicate need for irrigation(in/mo)	-10.9	-8.8	-7.0	-2.8	-0.3	2.0	3.3	2.6	0.8	-3.2	-8.9	-11.2	8.7
There are no storage ponds used.													
4. July 2010 Report of Waste Discharge for the City of Crescent City --Averages were taken for the submitted data.													
Total annual irrigation requirement = Sum of individual months requiring irrigation * use area * conversion factors from (in/year) to million gallons per year	**7.1**	MGY											

Table 5						
Cp is Concentration of Nitrogen in Percolating Water:	Assume no Volitilization or Nitrification Conservative approach:					
Lw(n) = (Cp*(Pr-ET)+ U(10))/((1-f)(Cn)-Cp)=(cm/month)						
Solve equation for Cp: Convert all item to SI units.	Concentration of Nitrogen in Filtrate (Cn) (mg/l)	Uptake Rate U (kg/ha-year)	Lw(p) (cm/year)	Lw is sum of positive Lw values from Table 4 (cm/year)	Pr (cm/year)	Et (cm/year)
Inputs	7.0	195	238	22	180	84
Cp= (Lw(Cn)-U*10)/(Pr-ET+Lw)= (mg/l)			-0.9	-15.2		
Applying water to the max perc rate results in no nitrogen entering the groundwater						
Applying water at agronomic rates results in all nitrogen in the recycled water being consumed by the crop.						
The above calculations leads us to believe that all nitrogen is consumed by crops and that Senario 2 Below is the most accurate.						

Table 6.1

Nutrient Balance:													
Allowable Hydraulic Loading rate based on nitrogen limits (scenario 1):													
Assume majority of nitrogen percolates into ground only 14% is consumed by grasses in use area:													
Month	January	February	March	April	May	June	July	August	September	October	November	December	TOTAL
(Cp) Concentration of Total N (mg/L) in Percolating water	6	6	6	6	6	6	6	6	6	6	6	6	6
(Pr) Precipitation rate (in/mo)	11.6	9.9	9.0	5.4	3.5	1.6	0.4	0.6	1.8	5.2	9.9	11.7	71
(Pr) Precipitation rate * 1cm/0.394 in= (cm/mo)	29.5	25.2	22.8	13.7	8.9	4.1	1.1	1.5	4.7	13.3	25.0	29.7	179.5
(ET) Evapotranspiration rate (in/mo)	0.9	1.4	2.5	3.3	4.0	4.5	4.7	4.0	3.3	2.5	1.2	0.6	33
(ET) Evapotranspiration rate * 1cm/0.394 in= (cm/mo)	2.4	3.6	6.3	8.4	10.2	11.4	11.8	10.2	8.4	6.3	3.0	1.6	83.6
(U) Nitrogen uptake rate= 174lbs/acre-year * (specific growing month ET/ total growing season ET which is May to September)= lbs/acre-growing month	0	0	0	0	34	38	39	34	28	0	0	0	174
(U) Nitrogen uptake rate= lbs/acre-month * 1kg/2.2lbs*2.47acres/hectare=(kg/ha-month)	0	0	0	0	38	43	44	38	31	0	0	0	195
(Cn) Concentration of Total N (mg/L) in Filtrate [1]	7	7	7	7	7	7	7	7	7	7	7	7	7
(f) Fraction of applied nitrogen removed by denitrification and volatilization (conservative)	0	0	0	0	0	0	0	0	0	0	0	0	0
[2]Lw(n) = (Cp*(Pr-ET)+ U(10))/((1-f)(Cn)-Cp)=(cm/month)	162.9	129.6	99.0	31.8	374.7	383.9	377.7	330.8	291.3	41.9	131.7	168.9	2524.3
Lw(n) X 1in/2.54cm=(in/month)	64.2	51.0	39.0	12.5	147.5	151.1	148.7	130.3	114.7	16.5	51.9	66.5	993.8

1. Average based on data since startup of Membrane Bio Reactor. Filtrate is the source of recycled water.
2. State Water Board Recommended calculation procedure-all values were converted to SI for this calculation.

Table 6.2

Allowable Hydraulic Loading rate based on nitrogen limits (scenario 2):
Assume all nitrogen is consumed by grasses in use area: This is the most restrictive and therefore the Controlling nitrogen load scenario.

Month	January	February	March	April	May	June	July	August	September	October	November	December	TOTAL
(Cp) Concentration of Total N (mg/L) in Percolating water	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
(Pr) Precipitation rate (in/mo)	12.8	10.9	9.9	5.9	3.8	1.8	0.5	0.7	2.0	5.8	10.8	12.9	78
(Pr) Precipitation rate * 1cm/0.394 in= (cm/mo)	32.5	27.7	25.1	15.0	9.7	4.6	1.2	1.7	5.1	14.6	27.5	32.7	197
(ET) Evapotranspiration rate (in/mo)	0.8	1.2	2.1	2.8	3.4	3.8	4.0	3.4	2.8	2.1	1.0	0.5	28
(ET) Evapotranspiration rate * 1cm/0.394 in= (cm/mo)	2.0	3.0	5.4	7.1	8.7	9.7	10.0	8.7	7.1	5.4	2.6	1.3	71
(U) Nitrogen uptake rate= 174lbs/acre-year * (specific growing month ET/ total growing season ET which is May to September)= lbs/acre-growing month	0	0	0	0	34	38	39	34	28	0	0	0	174
(U) Nitrogen uptake rate= lbs/acre-month * 1kg/2.2lbs*2.47acres/hectare=(kg/ha-month)	0	0	0	0	38	43	44	38	31	0	0	0	195
(Cn) Concentration of Total N (mg/L) in Filtrate [1]	7	7	7	7	7	7	7	7	7	7	7	7	7
(f) Fraction of applied nitrogen removed by denitrification and volatilization (conservative)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
[2]Lw(n) = (Cp*(Pr-ET)+ U(10))/((1-f)(Cn)-Cp)=(cm/month)	0.0	0.0	0.0	0.0	54.7	61.1	63.1	54.7	44.8	0.0	0.0	0.0	278
Lw(n) X 1in/2.54cm=(in/month)	0.0	0.0	0.0	0.0	21.5	24.0	24.8	21.5	17.6	0.0	0.0	0.0	110

1. Average based on data since startup of Membrane Bio Reactor. Filtrate is the source of recycled water.
2. State Water Board Recommended calculation procedure-all values were converted to SI for this calculation.

Table 7

Controling Rates and allowable loading:

Month	January	February	March	April	May	June	July	August	September	October	November	December	TOTAL (per year)
Comparison of Lw(p), Lw, and Lw(n)													0
Hydraulic Loading Rate Based on Soil Permeability (-values indicate soil water loss)	Lw(p)												0
(in/month)	-0.5	-1.6	-4.7	-8.7	-11.7	-13.7	-15.4	-14.6	-12.3	-8.4	-2.2	-0.1	-94
Hydraulic Loading Rate Based on Irrigation Requirements	Lw												0
(in/month)	-10.9	-8.8	-7.0	-2.8	-0.3	2.0	3.3	2.6	0.8	-3.2	-8.9	-11.2	-44
Allowable Annual Hydraulic Loading Rate Based on Nitrogen Limits	Lw(n)												0
(in/month)	0.0	0.0	0.0	0.0	21.5	24.0	24.8	21.5	17.6	0.0	0.0	0.0	110
Lw(p) is controlling factor for the "x" Months		X	X	X	X	X	X	X	X	X	X		
Lw(n) is controlling factor for the "x" Months	X											X	
Allowable irrigation (in/month)	0	1.6	4.7	8.7	11.7	13.7	15.4	14.6	12.3	8.4	2.2	0	93
Allowable irrigation = (in/month)/12= (ft/month)	0.00	0.13	0.39	0.73	0.98	1.14	1.28	1.22	1.02	0.70	0.18	0.00	8
Allowable irrigation= ft/month *30 acres * 43560 ft^2/acre= (ft^3)	0	170973	507474	948519	1274130	1488663	1673793	1587762	1335114	915849	234135	0	10136412
Allowable irrigation= ft^3 *7.48/10^6 = (MG/month)	**0**	**1.28**	**3.80**	**7.09**	**9.53**	**11.14**	**12.52**	**11.88**	**9.99**	**6.85**	**1.75**	**0**	**76**
Allowable irrigation= gallons per month / days in the month =(gallons/day)	**0**	**45674**	**122449**	**236497**	**307435**	**371173**	**403870**	**383112**	**322150**	**220986**	**58378**	**0**	

Table 1 Evapotranspiration

Month	Average Evapotranspiration[1] inches/month (in/mo)
January	0.93
February	1.40
March	2.48
April	3.30
May	4.03
June	4.50
July	4.65
August	4.03
September	3.30
October	2.48
November	1.20
December	0.62

1- California Irrigation Management Information System (CIMIS) (ETo) Zones
http://www.cimis.water.ca.gov/cimis/images/etomap.jpg

Table 2 Precipitation

Month	Average Precipitation[2] (set 1) (in/mo)	100-year Precipitation[3] (set 2) (in/mo)
January	10.90	7.62
February	8.90	24.84
March	8.60	29.84
April	4.80	6.89
May	3.20	1.96
June	1.40	1.21
July	0.60	1.94
August	0.70	0.00
September	1.70	2.48
October	5.40	6.99
November	9.00	8.46
December	10.50	15.39

The second data set was used for calculation purposes. The first data set is included for reference purposes.

2- Table 2 from 2005 Urban Water Management Plan Crescent City, California
http://www.crescentcity.org/Forms/PW/CC_UWMP%202006_FINAL.pdf
3- Average values from CRESCENT CITY 1 N, CALIFORNIA
http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?ca2147

Table 3

Water Balance Calculations:

Water Losses and Gains for the Use Area on a monthly basis with no irrigation: Hydraulic Loading Rate Based on Soil Permeability. (in/year)

Month	January	February	March	April	May	June	July	August	September	October	November	December	TOTAL
Precipitation(1-100) =Average Precipitation[3] *peaking factor=(in/mo)	7.6	24.8	29.8	6.9	2.0	1.2	1.9	0.0	2.5	7.0	8.5	15.4	108
ET(1-100)=Historical=(in/mo)	0.9	1.4	2.5	3.3	4.0	4.5	4.7	4.0	3.3	2.5	1.2	0.6	33
Infiltration= soil perc rate 0.03(ft/day) × days/month × 12in/ft=(in/mo)	11.2	10.1	11.2	10.8	11.2	10.8	11.2	11.2	10.8	11.2	10.8	11.2	131
Hydraulic Loading Rate [Lw(p)]: Net Loss(-) Gain(+) for use area= Rainfall(1-100)-ET(1-100)-Infiltration=(in/mo)	-4.5	13.4	16.2	-7.2	-13.2	-14.1	-13.9	-15.2	-11.6	-6.7	-3.5	3.6	-57

There are no storage ponds used.

Peaking factor = see below
1

While there are calculated losses in February, March, April, October, and November, the City of Crescent City may choose not to irrigate in these months.

Table 4

Hydraulic Loading Rate Based On Irrigation Requirements:				Proposed Irrigation rates based on historical application:									
Month	January	February	March	April	May	June	July	August	September	October	November	December	TOTAL
Crescent City Wastewater Treatment plant Average Historical Plant Flow Rate (MGD) [4]	2.1	2.1	2.3	1.8	1.3	1.1	1.2	1.1	1.1	1.1	1.4	1.9	1.5
Total/month= MGD* days in month = (MG)	63.6	57.4	71.0	54.0	41.5	33.8	36.4	34.9	33.3	34.1	41.3	58.1	559
Proposed Flow to Recycled Water Use Area (irrigation requirement) (MG)	0.0	0.0	0.0	0.0	0.2	2.3	3.2	2.6	1.1	0.0	0.0	0.0	9
Proposed Flow to Ocean Outfall= Total per month - total to Use area= (MG)	63.6	57.4	71.0	54.0	41.3	31.4	33.2	32.3	32.3	34.1	41.3	58.1	550
Evapotranspiration demand of crop (Etc) (common grass) Per CIMIS Water use calculations = Evapotranspiration x demand factor(Kc)= 0.8 = (in/mo)	0.7	1.1	2.0	2.6	3.2	3.6	3.7	3.2	2.6	2.0	1.0	0.5	26
Precipitation (1-100) =(in/mo)	7.6	24.8	29.8	6.9	2.0	1.2	1.9	0.0	2.5	7.0	8.5	15.4	108
Hydraulic Loading Rate Based on Irrigation Requirements (Lw)= Evapotranspirative demand of crop (IR) -Precipitation(1-100)(Pr) = negative values indicate no irrigation demand. Positive values indicate need for irrigation(in/mo)	-6.9	-23.7	-27.9	-4.3	1.3	2.4	1.8	3.2	0.2	-5.0	-7.5	-14.9	8.8
There are no storage ponds used. 4. July 2010 Report of Waste Discharge for the City of Crescent City --Averages were taken for the submitted data.													
Total annual irrigation requirement = Sum of individual months requiring irrigation * use area * conversion factors from (in/year) to million gallons per year	**7.2**	MGY											

Table 5						
Cp is Concentration of Nitrogen in Percolating Water:	Assume no Volitilization or Nitrification Conservative approach:					
Lw(n) = (Cp*(Pr-ET)+ U(10))/((1-f)(Cn)-Cp)=(cm/month)						
Solve equation for Cp: Convert all item to SI units.	Concentration of Nitrogen in Filtrate (Cn) (mg/l)	Uptake Rate U (kg/ha-year)	Lw(p) (cm/year)	Lw is sum of positive Lw values from Table 4 (cm/year)	Pr (cm/year)	Et (cm/year)
Inputs	7.0	195	144	22	273	84
Cp= (Lw(Cn)-U*10)/(Pr-ET+Lw)= (mg/l)			-2.8	-8.5		
Applying water to the max perc rate results in no nitrogen entering the groundwater						
Applying water at agronomic rates results in all nitrogen in the recycled water being consumed by the crop.						
The above calculations leads us to believe that all nitrogen is consumed by crops and that Senario 2 Below is the most accurate.						

Table 6.1

Nutrient Balance:

Allowable Hydraulic Loading rate based on nitrogen limits (scenario 1):

Assume majority of nitrogen percolates into ground only 14% is consumed by grasses in use area:

Month	January	February	March	April	May	June	July	August	September	October	November	December	TOTAL
(Cp) Concentration of Total N (mg/L) in Percolating water	6	6	6	6	6	6	6	6	6	6	6	6	6
(Pr) Precipitation rate (in/mo)	7.6	24.8	29.8	6.9	2.0	1.2	1.9	0.0	2.5	7.0	8.5	15.4	108
(Pr) Precipitation rate * 1cm/0.394 in= (cm/mo)	19.3	63.0	75.7	17.5	5.0	3.1	4.9	0.0	6.3	17.7	21.5	39.1	273.1
(ET) Evapotranspiration rate (in/mo)	0.9	1.4	2.5	3.3	4.0	4.5	4.7	4.0	3.3	2.5	1.2	0.6	33
(ET) Evapotranspiration rate * 1cm/0.394 in= (cm/mo)	2.4	3.6	6.3	8.4	10.2	11.4	11.8	10.2	8.4	6.3	3.0	1.6	83.6
(U) Nitrogen uptake rate= 174lbs/acre-year * (specific growing month ET/ total growing season ET which is May to September)= lbs/acre-growing month	0	0	0	0	34	38	39	34	28	0	0	0	174
(U) Nitrogen uptake rate= lbs/acre-month * 1kg/2.2lbs*2.47acres/hectare=(kg/ha-month)	0	0	0	0	38	43	44	38	31	0	0	0	195
(Cn) Concentration of Total N (mg/L) in Filtrate [1]	7	7	7	7	7	7	7	7	7	7	7	7	7
(f) Fraction of applied nitrogen removed by denitrification and volatilization (conservative)	0	0	0	0	0	0	0	0	0	0	0	0	0
[2]Lw(n) = (Cp*(Pr-ET)+ U(10))/((1-f)(Cn)-Cp)=(cm/month)	101.9	357.0	416.6	54.7	351.4	377.5	400.6	321.5	301.1	68.7	110.6	224.9	3086.4
Lw(n) X 1in/2.54cm=(in/month)	40.1	140.5	164.0	21.5	138.3	148.6	157.7	126.6	118.5	27.0	43.5	88.6	1215.1

1. Average based on data since startup of Membrane Bio Reactor. Filtrate is the source of recycled water.
2. State Water Board Recommended calculation procedure-all values were converted to SI for this calculation.

Table 6.2

Allowable Hydraulic Loading rate based on nitrogen limits (scenario 2):
Assume all nitrogen is consumed by grasses in use area: This is the most restrictive and therefore the Controlling nitrogen load scenario.

Month	January	February	March	April	May	June	July	August	September	October	November	December	TOTAL
(Cp) Concentration of Total N (mg/L) in Percolating water	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
(Pr) Precipitation rate (in/mo)	12.8	10.9	9.9	5.9	3.8	1.8	0.5	0.7	2.0	5.8	10.8	12.9	78
(Pr) Precipitation rate * 1cm/0.394 in= (cm/mo)	32.5	27.7	25.1	15.0	9.7	4.6	1.2	1.7	5.1	14.6	27.5	32.7	197
(ET) Evapotranspiration rate (in/mo)	0.8	1.2	2.1	2.8	3.4	3.8	4.0	3.4	2.8	2.1	1.0	0.5	28
(ET) Evapotranspiration rate * 1cm/0.394 in= (cm/mo)	2.0	3.0	5.4	7.1	8.7	9.7	10.0	8.7	7.1	5.4	2.6	1.3	71
(U) Nitrogen uptake rate= 174lbs/acre-year * (specific growing month ET/ total growing season ET which is May to September)= lbs/acre-growing month	0	0	0	0	34	38	39	34	28	0	0	0	174
(U) Nitrogen uptake rate= lbs/acre-month * 1kg/2.2lbs*2.47acres/hectare=(kg/ha-month)	0	0	0	0	38	43	44	38	31	0	0	0	195
(Cn) Concentration of Total N (mg/L) in Filtrate [1]	7	7	7	7	7	7	7	7	7	7	7	7	7
(f) Fraction of applied nitrogen removed by denitrification and volatilization (conservative)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
[2]Lw(n) = (Cp*(Pr-ET)+ U(10))/((1-f)(Cn)-Cp)=(cm/month)	0.0	0.0	0.0	0.0	54.7	61.1	63.1	54.7	44.8	0.0	0.0	0.0	278
Lw(n) X 1in/2.54cm=(in/month)	0.0	0.0	0.0	0.0	21.5	24.0	24.8	21.5	17.6	0.0	0.0	0.0	110

1. Average based on data since startup of Membrane Bio Reactor. Filtrate is the source of recycled water.
2. State Water Board Recommended calculation procedure-all values were converted to SI for this calculation.

Table 7

Controling Rates and allowable loading:

Month	January	February	March	April	May	June	July	August	September	October	November	December	TOTAL (per year)
Comparison of Lw(p), Lw, and Lw(n)													0
Hydraulic Loading Rate Based on Soil Permeability (-values indicate soil water loss)	Lw(p)												0
(in/month)	-4.5	13.4	16.2	-7.2	-13.2	-14.1	-13.9	-15.2	-11.6	-6.7	-3.5	3.6	-57
Hydraulic Loading Rate Based on Irrigation Requirements	Lw												0
(in/month)	-6.9	-23.7	-27.9	-4.3	1.3	2.4	1.8	3.2	0.2	-5.0	-7.5	-14.9	-81
Allowable Annual Hydraulic Loading Rate Based on Nitrogen Limits	Lw(n)												0
(in/month)	0.0	0.0	0.0	0.0	21.5	24.0	24.8	21.5	17.6	0.0	0.0	0.0	110
Lw(p) is controlling factor for the "x" Months		X	X	X	X	X	X	X	X	X	X		
Lw(n) is controlling factor for the "x" Months	X											X	
Allowable irrigation (in/month)	0	-13.4	-16.2	7.2	13.2	14.1	13.9	15.2	11.6	6.7	3.5	0	56
Allowable irrigation = (in/month)/12= (ft/month)	0.00	-1.11	-1.35	0.60	1.10	1.17	1.16	1.27	0.97	0.55	0.30	0.00	5
Allowable irrigation= ft/month *30 acres * 43560 ft^2/acre= (ft^3)	0	-1454904	-1764180	785169	1440747	1534401	1510443	1654191	1265418	724185	385506	0	6080976
Allowable irrigation= ft^3 *7.48/10^6 = (MG/month)	**0**	**-10.88**	**-13.20**	**5.87**	**10.78**	**11.48**	**11.30**	**12.37**	**9.47**	**5.42**	**2.88**	**0**	**45**
Allowable irrigation= gallons per month / days in the month =(gallons/day)	**0**	**-388667**	**-425680**	**195769**	**347638**	**382577**	**364455**	**399140**	**305333**	**174739**	**96119**	**0**	

Table 10.1 Theoretical allowable Concentration Drought Condition and percolation limit

Cp is Concentration of Nitrogen in Percolating Water:	Assume no Volatilization or Nitrification Conservative approach:				
Lw(n) = (Cp*(Pr-ET)+ U(10))/((1-f)(Cn)-Cp)=(cm/month)					
Solve equation for Cp: Convert all item to SI units.	Concentration of Nitrogen in Filtrate (Cn) (mg/l)	Uptake Rate U (kg/ha-year)	Lw(p) (cm/year)	Pr (cm/year)	Et (cm/year)
Inputs	15.8	195	333	84	84
Cp= (Lw(Cn)-U*10)/(Pr-ET+Lw)= (mg/l)			9.9		

Table 10.2 Theoretical allowable Concentration Drought Condition and irrigation limit

Cp is Concentration of Nitrogen in Percolating Water:	Assume no Volatilization or Nitrification Conservative approach:				
Lw(n) = (Cp*(Pr-ET)+ U(10))/((1-f)(Cn)-Cp)=(cm/month)					
Solve equation for Cp: Convert all item to SI units.	Concentration of Nitrogen in Filtrate (Cn) (mg/l)	Uptake Rate U (kg/ha-year)	Lw (cm/year)	Pr (cm/year)	Et (cm/year)
Inputs	74.5	195	30	84	84
Cp= (Lw(Cn)-U*10)/(Pr-ET+Lw)= (mg/l)			10.0		

Table 10.3 Theoretical allowable Concentration average Condition and percolation limit

Cp is Concentration of Nitrogen in Percolating Water:	Assume no Volatilization or Nitrification Conservative approach:				
Lw(n) = (Cp*(Pr-ET)+ U(10))/((1-f)(Cn)-Cp)=(cm/month)					
Solve equation for Cp: Convert all item to SI units.	Concentration of Nitrogen in Filtrate (Cn) (mg/l)	Uptake Rate U (kg/ha-year)	Lw(p) (cm/year)	Pr (cm/year)	Et (cm/year)
Inputs	22.25	195	239	180	84
Cp= (Lw(Cn)-U*10)/(Pr-ET+Lw)= (mg/l)			10.0		

Table 10.4 Theoretical allowable Concentration average Condition and irrigation limit

Cp is Concentration of Nitrogen in Percolating Water:	Assume no Volatilization or Nitrification Conservative approach:				
Lw(n) = (Cp*(Pr-ET)+ U(10))/((1-f)(Cn)-Cp)=(cm/month)					
Solve equation for Cp: Convert all item to SI units.	Concentration of Nitrogen in Filtrate (Cn) (mg/l)	Uptake Rate U (kg/ha-year)	Lw (cm/year)	Pr (cm/year)	Et (cm/year)
Inputs	142.0	195	22	180	84
Cp= (Lw(Cn)-U*10)/(Pr-ET+Lw)= (mg/l)			10.0		

Table 10.5 Theoretical allowable Concentration 100 year Condition and percolation limit

Cp is Concentration of Nitrogen in Percolating Water:	Assume no Volatilization or Nitrification Conservative approach:				
Lw(n) = (Cp*(Pr-ET)+ U(10))/((1-f)(Cn)-Cp)=(cm/month)					
Solve equation for Cp: Convert all item to SI units.	Concentration of Nitrogen in Filtrate (Cn) (mg/l)	Uptake Rate U (kg/ha-year)	Lw(p) (cm/year)	Pr (cm/year)	Et (cm/year)
Inputs	36.7	195	145	274	84
Cp= (Lw(Cn)-U*10)/(Pr-ET+Lw)= (mg/l)			10.0		

Table 10.6 Theoretical allowable Concentration 100 year Condition and irrigation limit

Cp is Concentration of Nitrogen in Percolating Water:	Assume no Volatilization or Nitrification Conservative approach:				
Lw(n) = (Cp*(Pr-ET)+ U(10))/((1-f)(Cn)-Cp)=(cm/month)					
Solve equation for Cp: Convert all item to SI units.	Concentration of Nitrogen in Filtrate (Cn) (mg/l)	Uptake Rate U (kg/ha-year)	Lw (cm/year)	Pr (cm/year)	Et (cm/year)
Inputs	182.0	195	22	274	84
Cp= (Lw(Cn)-U*10)/(Pr-ET+Lw)= (mg/l)			10.0		