Nutrient Management Plan

Prepared for

City of Hollister

Updated January 2011

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Acronyms and Abbreviations

AWHC	available water holding capacity
BMP	best management practice
BOD	biochemical oxygen demand
CCRWQCB	Central Coast Regional Water Quality Control Board
CIMIS	California Irrigation Management Information System
COH	City of Hollister
dS/m	deciSiemens per meter
EC	electrical conductivity
ET	evapotranspiration
GIWR	gross irrigation water requirement
K	potassium
LF	leaching fraction
LR	leaching requirement
MCL	maximum contaminant level
MeA	Metz gravelly sandy loam
mg/L	milligram(s) per liter
MRR	Master Reclamation Requirements
N	nitrogen
NH_3-N	ammonia-nitrogen
NMP	Nutrient Management Plan
NRCS	Natural Resources Conservation Service
P	phosphorus
Perma Green	Perma Green Hydroseeding
PO_4	phosphate
ReA	Reiff sandy loam
SBCWD	San Benito County Water District
SEIR	Subsequent Environmental Impact Report

SnC	Sorrento silt loam
TDS	total dissolved solids
TKN	total Kjeldahl nitrogen

SECTION 1
1 Introduction

This Nutrient Management Plan (NMP) has been developed to comply with requirements of the City of Hollister (COH) Master Reclamation Requirements (MRR), Order No. R3-2008-0069, issued in 2008 by the Central Coast Regional Water Quality Control Board (CCRWQCB), which includes the following elements:

- Apply irrigation at a rate that meets the plant evapotranspiration (ET) water demand, with the minimum necessary leaching fraction, and over irrigation does not occur
- Apply nitrogen at a rate and frequency that meets but does not exceed the amount required by plants, and that does not impact underlying groundwater
- Compile data and prepare a report for submittal to the CCRWQCB, in accordance with the MRR Monitoring and Reporting Program requirements

In addition, this NMP is consistent with water quality mitigation measures that were identified in the Subsequent Environmental Impact Report (SEIR) for the COH Reclaimed Water Project (COH, 2008).

Document revisions are described below:

- Original NMP for Brigantino Riverside Park Reuse Site - January 2010
- Revision #1, Adding Airport Reuse Site - January 2011

The following sections address these topics and provide information that the COH will use for irrigation and fertilizer management and recordkeeping.

SECTION 2

2 Reuse Site Characteristics

The COH Reclaimed Water Project SEIR (COH, 2008) evaluated the feasibility of using recycled water to irrigate five potential reuse sites:

- Hollister Airport
- Sod Farm
- Brook Hollow
- Brigantino Riverside Park
- San Juan Oaks

At this time, Brigantino Riverside Park and the Hollister Airport reuse sites are receiving recycled water. This NMP will be updated to include additional reuse sites, when and if necessary.

2.1 Brigantino Riverside Park

Brigantino Riverside Park is located in rural west Hollister, across the San Benito River from the COH Industrial Wastewater Treatment Plant storage ponds (Figure 1). According to the CCRWQCB Water Quality Control Plan (Basin Plan), the park is located within the San Benito River Hydrologic Area (305.50). The park is separated from the river by a berm, which prevents any nonpoint source discharges to the river. Approximately 45 acres at Brigantino Riverside Park are currently planted in turfgrass and are irrigated using tertiary treated wastewater produced by the COH.

2.1.1 Soils

According to the Natural Resources Conservation Service (NRCS) soil survey of the area (Soil Survey of San Benito County, California; NRCS, 2009), the Brigantino Riverside Park site is comprised of three main soil map units, Reiff sandy loam (ReA), Metz gravelly sandy loam (MeA), and Sorrento silt loam (SnC) (see Figure 2a and Table 1). The majority of the reuse area is covered by the ReA map unit, which is the best suited for irrigated agriculture. Soil testing that was performed in November 2007 identified soil textures on the site as being primarily sandy loam, which is consistent with Reiff soils. The other two soil map units have some characteristics, such as slope, excessively rapid drainage, and low available water capacity, that may require special management practices for irrigation.

TABLE 1
Brigantino Riverside Park Soils

Map Unit Symbol	Map Unit Name	Percentage*	Drainage	Permeability	AWHC (in/in)	Runoff	Irrigated Agricultural Capability Class
MgA	Metz gravelly sandy loam, 0 to 2% slopes	22	Somewhat excessively drained	Moderately rapid	0.04 to 0.09	Very low	2w
ReA	Reiff sandy loam, 0 to 2% slopes	69	Well drained	Moderately rapid	0.12 to 0.16	Very low	1
SnC	Sorrento silt loam, 2 to 9% slopes	7	Well drained	Moderate to moderately slow	0.18 to 0.20	Negligible to medium	2e

*Minor soil map units are not identified in this table, but occupy about 2 percent of the site. Percentages are based on acres for each soil type as identified in CH2M HILL (2007).

Notes:
Information from the NRCS Soil Survey of San Benito County, California (NRCS, 2009). Physical soil properties for each horizon are provided in Appendix A-1.

AWHC = available water holding capacity
in/in = inch(es) per inch

2.1.2 Turfgrass Management

The Brigantino Riverside Park site was graded, prepared, and seeded by Perma Green Hydroseeding (Perma Green) of Gilroy, California. Turfgrass seeding was begun on July 1, 2009, using a seed mix containing 70 percent tall fescue and 30 percent perennial ryegrass. The grass is now fully established, and depth of rooting is about 8 to 10 inches. Irrigation is scheduled by comparing crop evapotranspiration requirements with weather and soil conditions (see Section 4.1.6). In response to a request from the Central Coast Regional Water Quality Control Board (CCRWQCB), tensiometers were installed in 2010 to better correlate irrigation with soil moisture status. Grass is typically mowed once per week. Grass clippings are left in place as mulch, to reduce the amount of supplemental fertilization required each year. Typically one application of supplemental fertilizer is applied in spring or fall. Irrigation and fertilizer applications are managed by COH.

To prevent damage to young turfgrass seedlings from residual chlorine in irrigation water, irrigation water deliveries were provided from storage ponds instead of directly from the wastewater treatment plant. The change in water source causes periodic clogging of filters on the irrigation valves, which is being addressed.

2.1.3 San Benito County Water District Test Plot

In 2009, SBCWD conducted a short-term demonstration study at Brigantino Riverside Park to evaluate the effects of using recycled water to irrigate leafy green produce. Baby lettuce and baby spinach were irrigated using only the COH Reclamation Plant's tertiary-treated effluent. The footprint of this plot was 25 feet by 250 feet, located on the northwest side of the Brigantino Riverside Park site, outside the area planted to turfgrass. This demonstration project was of very short duration and did not affect the nutrient balance on the Brigantino site. Results were reported in the 2009 Annual Report and this project is not discussed further.

2.2 Hollister Airport Reuse Site

The City of Hollister owns and operates the Hollister Municipal Airport, which supports general aviation activities. The airport is located on the west side of San Felipe Road at Airport Drive, approximately 5 miles northeast of the wastewater treatment plant at the north end of Hollister (Figure 1b). Approximately 90 acres of turfgrass are currently being irrigated using tertiary-treated wastewater produced by the COH.

2.2.1 Soils

According to the Natural Resources Conservation Service (NRCS) soil survey of the area (Soil Survey of San Benito County, California; NRCS, 2010), the Hollister Airport reuse site is comprised of three main soil map units: Pacheco silty clay (Pe), Clear Lake Clay (Ch), and Willows clay, saline-alkali (Wk). Soil properties are summarized in Table 2 and Appendix A-2, and a soils map is provided as Figure 2b. The majority of the reuse area is Pacheco silty clay (Pe), and all have clay textures. When irrigated, Pacheco and Clear Lake soils are considered to be prime agricultural soils, with only moderate limitations for supporting crops. The Land Capability subclass “w” indicates that water is the dominant hazard or limitation affecting its use; there could be poor soil drainage, wetness, a high water table, or overflow, which would need to be controlled with proper irrigation management. Willows clay soils, which occupy only about 13 percent of the site, are reported to be moderately saline, with a soil EC ranging from 8 to 16 mmhos per centimeter. Turfgrass planted on Willows soils would likely encounter greater salinity than turfgrass planted on Pacheco and Clear Lake soils, and salinity effects may be more pronounced due to the presence of salinity in recycled water used for irrigation.

TABLE 2
Hollister Airport Soils

Map Unit Symbol	Map Unit Name	Percentage*	Drainage	Permeability	AWHC (in/in)	Runoff	Irrigated Agricultural Capability Class
Pe	Pacheco silty clay	53	Somewhat poorly drained	Moderately low to moderately high	High	High	2w
Ch	Clear Lake clay	29	Poorly drained	Moderately low to moderately high	Moderate	High	2s
Wk	Willows clay, saline-alkali	13	Poorly drained	Very low to moderately low	Moderate	Very High	3w

*Minor soil map units are not identified in this table, but occupy approximately 5 percent of the site.
Notes:
Information from the NRCS Soil Survey of San Benito County, California (NRCS, 2010). Physical soil properties for each horizon are provided in Appendix A-2.
AWHC = available water holding capacity
in/in = inch(es) water per inch of soil

Poorly drained soils at the Hollister Airport Site can lead to elevated groundwater levels during and immediately following the rainy season. Limited site-specific groundwater monitoring data indicate groundwater elevations drop during the dry season (see Appendix A-5 of the 2010 Annual Report). It is recommended that groundwater elevations be monitored prior to commencing irrigation in the spring, and that that irrigation be avoided if high groundwater is affecting root zone soil moisture content.

2.2.1 Turfgrass Establishment

The Hollister Airport reuse site was graded, prepared, and planted during 2010. Turfgrass was seeded in August 2010 using a seed mix containing 66 percent bermudagrass and 34 percent perennial ryegrass. Turfgrass establishment was conducted pursuant to COH specifications. The turfgrass is now fully established.

2.3 San Benito County Water District Pilot Project

The information in this section was largely obtained from the San Benito County Water District (SBCWD) Application for Recycled Water Service. In 2010, the SBCWD implemented a sequel to the 2009 small-scale pilot project, in which representative area crops were grown during the 2010 summer growing season, using reclaimed water to irrigate a 2.5-acre plot. The 2010 project was located at 460 Briggs Road (APN 019-020-08); the site is between the DWTP and the Hollister Airport reuse site, along the COH 20-inch recycled water distribution line corridor. The 20-acre parcel is relatively flat, sloping <2 percent toward the north.

The plot layout for the pilot project is shown in Appendix B-2. It includes a 2.5-acre experimental plot irrigated with recycled water; a 4-acre combination over-spray buffer and irrigation control plot surrounding the experimental plot; and a 2.5-acre control plot to be irrigated with groundwater.

Upon receipt of all required approvals, and in compliance with the COH *Reclaimed Water Use Manual & Rules of Service*, SBCWD staff “hot-tapped” into the 20-inch reclaimed water line on the southwesterly property boundary, and installed a 6-inch line extension with the appropriate appurtenances to supply recycled water for irrigation purposes on the 2.5-acre experimental plot.

Both the experimental plot and the control plot included a standard 60-inch raised bed for peppers and tomatoes, and a 40-inch wide raised bed for lettuce and beans. Conventional spray irrigation was utilized to judge salinity effects of recycled water on crops. On-surface irrigation equipment consisted of properly marked conventional agricultural aluminum irrigation lines to apply recycled water to conventional 7/64-inch orifice agricultural sprinklers for beans and lettuce. Drip irrigation equipment consisted of properly marked 7/8-inch low-flow drip tape (with 12-inch spacing) for tomatoes and peppers.

2.3.1 Irrigation and Nutrient Management

SBCWD was responsible for applying irrigation and nutrients at the agronomic rate. No supplemental fertilizer was applied. Irrigation was scheduled following review of daily CIMIS reports to evaluate crop evapotranspiration.

2.3.2 Pilot Project Monitoring

Recycled water was analyzed once per week for the duration of the project. Water quality constituents that were monitored included: chlorine residual; general minerals; boron; and pathogens, including total coliform, general E-coli, E-coli 0157:H7, Salmonella, Shigella, Clostridium erfringens).

Soil samples from the site were obtained pre- and post-project, and monitored parameters included general minerals, metals, pathogens and nutrients.

Groundwater was monitored from three wells: 1 upgradient, 1 downgradient, and 1 on-site (see location of groundwater monitoring wells in Appendix B-3). Baseline monitoring was conducted in June 2010; then quarterly monitoring was conducted in July and October 2010. Monitored constituents in groundwater included: general minerals, metals, nutrients, and certain organic pollutants.

Monitoring results are provided in Appendix B-4 through B-7, and will be described in the 2010 Annual Report.

SECTION 3

3 Irrigation Water Quality

3.1 Effluent Water Quality

Recycled water produced by the COH is used for irrigation at Brigantino Riverside Park and at Hollister Airport site. Water quality meets Title 22 specifications for irrigation reuse on parks, which require a tertiary-level of treatment. Representative water quality was determined by averaging effluent data collected from April through August 2009 (Table 3). These concentrations were utilized for all nutrient calculations and assumptions in this report. Constituent concentrations will be evaluated in the annual report each year, and changes to the NMP will be made if necessary. The 2010 annual average concentrations for select constituents are shown below in Table 4, for comparison.

TABLE 3
Average Effluent Concentrations (April-August, 2009)

TKN (mg/L)	Total N (mg/L)	Ammonia (mg/L)	Nitrate (mg/L)	Nitrite (mg/L)	TDS (mg/L)
2.3	7.2	0.42	3.4	<0.1	1,089
pH (std. units)	**BOD (mg/L)**	**Sodium (mg/L)**	**Chloride (mg/L)**	**Sulfate (mg/L)**	**Boron (mg/L)**
7.6	3.8	238	278	262	0.92

Notes:

BOD = biochemical oxygen demand
mg/L = milligrams per liter
TDS = total dissolved solids

TABLE 4
Average Effluent Concentrations (2010)

Total N (mg/L)	Sodium (mg/L)	Chloride (mg/L)	Boron (mg/L)	TDS (mg/L)
6.1	218	266	0.82	1019

Notes:

BOD = biochemical oxygen demand
mg/L = milligrams per liter
TDS = total dissolved solids

Nitrogen and salinity must be carefully managed at all reuse sites, for reasons that are discussed in the following sections.

3.2 Nitrogen

Nitrogen loading must be carefully managed under recycled water irrigation due to the potential for nitrate-nitrogen to contaminate drinking water sources. If over-irrigation with recycled water occurs, nitrate-nitrogen movement to groundwater through deep percolation can become a problem. Nitrate is a negatively charged ion and is easily leached through the soil profile.

Nitrate and organic-N are the primary form of nitrogen in COH recycled water. However, organic forms of nitrogen that are present in the recycled water will be rapidly converted to nitrate through microbial processes in the soil under aerobic conditions with favorable temperature and moisture. Consequently, all nitrogen present in the recycled water as represented by the total N content is assumed to become plant available and be largely converted to nitrate-N.

3.3 Salinity

Although the irrigation water will generally be of high quality, salinity remains a concern due to high evaporation and crop ET rates. Plants generally exclude salts when taking up water; thus, as soil water is utilized by plants or evaporates from the soil surface, salts are accumulated in the root zone. If unchecked, soil salinity can increase to levels that are harmful to vegetation. Salinity can be managed, however, by applying an irrigation leaching fraction (LF) to periodically flush accumulated salts below the root zone.

Electrical conductivity (EC) and total dissolved solids (TDS) are commonly used indicators of salinity in irrigation water. Vegetation response to salinity is often correlated with EC. EC can be estimated if TDS is known, through the relationship shown in Equation (1):

$$TDS = 640 \times EC \tag{1}$$

where:

TDS = Total dissolved solids (milligrams/liter [mg/L])
EC = Electrical conductivity (deciSiemens/meter [dS/m])

The general irrigation water quality information presented in Table 3 shows an average TDS value of 1,089 mg/L for the period of April through August 2009.

Using Equation (1), the EC of the tertiary treated effluent is estimated to be 1.70 dS/m. This estimated EC will be utilized later in this report to calculate the necessary irrigation leaching requirement (LR). During preparation of the annual report each year, LR will be reevaluated and changes will be made to the NMP, if necessary.

3.4 Specific Ion Toxicity

Chloride and boron concentrations in the effluent fall within the “slight to moderate” degree of restriction category for irrigation to salt sensitive plants while sodium concentrations fall within the “severe” restriction category for salt sensitive plants (Ayers and Westcot, 1989). However, these ions are most often a problem with woody plant species and are less of a concern with turf grasses, since regular mowing and tissue regeneration does not allow the elements to accumulate as rapidly within plant tissue (Carrow and Duncan, 1998). Management of the leaching fraction as discussed above to prevent excessive build-up of salts in the soil will also help to manage chloride, sodium, and boron levels in site soils.

SECTION 4

4 Irrigation Water Management

This section applies to the operation of the Brigantino Riverside Park and Hollister Airport reuse sites, which will be operated in accordance with this plan. The San Benito County Water District Pilot Project was approved on a temporary basis as a pilot project and SBCWD will manage irrigation of the project such that water is applied at the agronomic rate.

4.1 Irrigation Water Budget

A monthly irrigation water budget was developed for average year conditions using climate, crop and soil, irrigation system, and salinity management variables for the Brigantino Riverside Park and Hollister Airport reuse sites. Each of these variables is discussed briefly in the sections that follow.

4.1.1 Climate

Climate data from nearby stations were compiled to estimate climatic factors affecting irrigation requirements at the Brigantino and Airport reuse sites. Monthly ET_o (reference grass evapotranspiration) data from the nearest California Irrigation Management Information System (CIMIS) station (#126, San Benito) were averaged across a 15-year period (June 1994 to September 2009) and monthly precipitation was tabulated from the Hollister 2 National Weather Service station for a 61-year period (July 1948 to April 2009), as shown in Table 5 (CIMIS, 2005). The San Benito CIMIS Station #126 is located 3.8 miles to the east of Brigantino Riverside Park.

TABLE 5
Average Monthly Precipitation and ET_o for Reuse Areas

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
ET_o (inches)	1.43	1.86	3.44	4.56	5.91	6.53	6.89	6.31	4.9	3.6	1.86	1.37	**48.66**
Precipitation (inches)	2.74	2.79	2.12	0.88	0.34	0.06	0.04	0.05	0.31	0.65	1.65	2.06	**13.70**

As shown, evaporative demands exceed precipitation on average during the months of March through November.

4.1.2 Crop and Soil Characteristics

Crop and soil characteristics necessary for development of an irrigation water budget are provided in Table 3. For the cool season grasses, a uniform crop coefficient (K_c) of 0.95 was used. For the warm season grasses, a uniform crop coefficient (K_c) of 0.85 was used.

Respective crop coefficients were used in conjunction with ET_o to estimate plant-specific evapotranspiration rates (ET_c), according to the following equation:

$$ET_c = K_c \times ET_o \tag{2}$$

Rooting depth, depletion factor, and soil AWHC data were utilized for input to soil water stress and irrigation scheduling calculations. At the Brigantino site, the Metz gravelly sandy loam soils are the most limiting soils for irrigation scheduling due to their low AWHC. For this soil, the allowable depletion of stored soil water between irrigation events is estimated at 0.40 inches over an 18-inch rooting depth.

At the Hollister Airport Site, the limiting AWHC is 1.8 in/ft. For an 18-inch rooting depth, the allowable depletion is 1.08 inches as shown in Table 6.

TABLE 6
Crop and Soil Characteristics for the Irrigation Water Budget

Crop	K_c [a]	Depletion Factor [b]	Rooting Depth (in)	Limiting AWHC (in) [c]	Allowable Depletion (in)
Brigantino					
Turf – cool season grasses	0.95	0.40	18	1.3	0.52
Hollister Airport					
Turf – 66% warm season grasses	0.85	0.40	18	2.7	1.08
33% cool season grasses	0.95	0.40	18	2.7	1.08

[a] Ref: Allen et al (1998)
[b] Ref: Allen et al (1998). Represents the fraction of the AWHC that can be depleted without reduction in ET.
[c] Based on the lowest AWHC soil at the site (Metz gravelly sandy loam at Brigantino Park and Clear Lake clay and Willows clay at the Airport site).

Approximately 1.5 years following seeding, observations at the Brigantino site in 2010 indicated that the turfgrass roots have penetrated approximately 12 inches in depth. It is recommended that the actual rooting depth be monitored semiannually until mature establishment is reached. The site-specific effective root zone depth used for irrigation scheduling can be calibrated as needed based field measurements. While adjustments to the effective root zone depth may not impact irrigation water requirements, the recommended irrigation frequency and duration can be impacted.

4.1.3 Irrigation System Characteristics

The irrigation application system equipment, design, and management all play a role in determining the irrigation efficiency and water delivery requirements to meet crop needs. The irrigation systems at Brigantino Riverside Park and Hollister Airport reuse sites consist of pop-up spray rotors designed for turf irrigation (Toro TR70) and are placed on a 50-foot triangular spacing. Irrigation is operated by an automated controller. It is estimated that a well-managed system like this can attain an irrigation efficiency of 80 percent.

4.1.4 Salinity Management Practices

Careful salinity management is important for sustainable irrigation and vegetation production in arid climates and with water of elevated salinity. Important factors to consider in this analysis are the irrigation water salinity, crop salt tolerance, natural precipitation driven leaching, and additional irrigation driven leaching fractions that may be required. Table 7 presents irrigation and salt tolerance parameters that are applicable to the vegetation planted at Brigantino Riverside Park and the Hollister Airport.

TABLE 7
Salinity Tolerance Limits, and Calculated Leaching Requirements at Reuse sites

Turf Species	Salinity Tolerance Limits[a] EC_e	EC_w	Calculated Leaching Fraction[b]
Tall Fescue	3.9	2.6	10%
Perennial Ryegrass	5.6	3.7	6%
Bermudagrass	6.9	4.6	5%

[a] Salinity tolerance from Table 2-10 in (California Plant Health Association, 2002)
EC_e = electrical conductivity of the soil (dS/m)
EC_w = electrical conductivity of the irrigation water (dS/m)

[b] $LF = \frac{EC_w}{5(EC_e) - EC_w}$,

where EC_e is the soil EC tolerance limit shown in Table 5, and EC_w is actual EC of irrigation water, (assumed 1.7 dS/m) *(Ayers and Wescot, 1985)*

Salinity tolerance limits are the estimated threshold electrical conductivities that can be tolerated by the vegetation without any decline in biomass production or crop yield. Based on the information in Table 7, bermudagrass is the most salt-tolerant turfgrass species used on reuse sites, followed by perennial ryegrass and tall fescue. The EC of the irrigation water (EC_w) was previously estimated at 1.70 dS/m, which is below the salinity tolerance of the tall fescue (EC_w= 2.6 dS/m), perennial ryegrass (EC_w= 3.7 dS/m), and bermudagrass (EC_w = 4.6 dS/m). This means that there should be no detrimental soil salinity effects to the turfgrass from irrigation with recycled water as long as an appropriate leaching fraction is supplied.

The LR is the amount of irrigation water that must be applied above and beyond the consumptive use requirements of the crop, to prevent salts from accumulating within the root zone. Salts in the irrigation water are left behind in the root zone as water evaporates from the soil surface and is taken up via plant transpiration. The LR helps to move this salt beyond the root zone to avoid salinity-induced problems with vegetation growth.

Required leaching fractions for each reuse site were calculated based on the salt-tolerance limits of the most sensitive turfgrass species in the plant mix. Thus, values for tall fescue (70 percent of plant mix) will be used as the tolerance limits for the Brigantino site; and values for perennial ryegrass (34 percent of plant mix) will be used as the tolerance limits for the Hollister Airport site. These ratios can be revisited in future years as the grass stand becomes established and the species ratio naturally adjusts.

4.1.5 Irrigation Water Requirements

The CH2M HILL Root Zone Water Balance Model was used to integrate the irrigation, crop, and soil characteristics provided above, and to project the irrigation water requirements and soil water and salinity status with the proposed recycled water irrigation. Detailed tabular and graphic output from this water balance is provided in Appendix C for each reuse site.

Brigantino Riverside Park

The annual irrigation demand for Brigantino Riverside Park is approximately 167 acre-feet of water. This represents 44.6 inches of gross irrigation application per year, applied over 45 acres, or 54.5 million gallons per year. Note that no irrigation is expected to be required during much of the rainy season (December through February). During periods of low demand for recycled water, effluent will be directed to storage ponds at the wastewater treatment plant.

Leaching ratios were assessed to evaluate the soil salinity balance for the site, considering precipitation and irrigation driven leaching. With a gross irrigation water requirement (GIWR) of 44.6 inches, the annual LR is estimated to be between 2.8 and 5.0 inches depending upon grass species. As shown in Appendix C, precipitation-driven leaching (December through February) is estimated at 3.2 inches and irrigation-driven leaching (March through November) is estimated at 2.5 inches, for a total deep percolation of approximately 5.7 inches. Based on the soil salinity balance presented in Appendix C, this level of leaching should be sufficient to maintain the average soil EC_e within the root zone below a maximum of 5.5 dS/m in June and July, which is lower than the EC_e of perennial ryegrass but higher than the EC_e of tall fescue. To date, turf appears to be performing well with no signs of salinity impacts, and irrigation management has been similar to that in Table 7.

Hollister Airport

The annual irrigation demand for the Airport Reuse Site is approximately 294 acre-feet of water, based on average growing conditions. This represents 39.2 inches of gross irrigation application per year, applied over 90 acres, or 96 million gallons per year. Actual irrigation requirements will vary based on real-time weather conditions. Note that no irrigation is expected to be required during much of the rainy season (November through February). During periods of low demand for recycled water, effluent will be directed to storage ponds at the wastewater treatment plant.

Leaching ratios were assessed to evaluate the soil salinity balance for the site, considering precipitation and irrigation driven leaching. With a gross irrigation water requirement (GIWR) of 39.2 inches, the annual LR is estimated to be between 2.0 and 2.4 inches depending upon grass species. As shown in Appendix C, precipitation-driven leaching (November through February) is estimated at 3.7 inches and irrigation-driven leaching (March through October) is estimated at 0.4 inches, for a total deep percolation of approximately 4.1 inches. Based on the soil salinity balance presented in Appendix C, this level of leaching should be sufficient to maintain the average soil EC_e within the root zone below a maximum of 7.8 dS/m in September and October. After management of irrigation at the site for a full year, this level of LF can be reassessed based upon observations of turf health and any visible signs of salinity impact. To date, turf appears to be performing well with no signs of salinity impacts, and irrigation management has been similar to that proposed in Table 7.

4.1.6 Irrigation Scheduling

Careful irrigation scheduling can be more important to actual field irrigation efficiency than irrigation system type and design. Parameters that are considered when developing an irrigation schedule include type and spacing of irrigation heads, nozzle diameters and operating pressures, target gross irrigation application based on vegetation and soils, flexibility of system operations, and desired timing of irrigation application.

Sprinkler irrigation schedules are determined using the sprinkler precipitation rate and the gross irrigation requirement. The following equations will be utilized to determine irrigation duration:

$$P_s = Q_s \times 96.3 \div A_s \tag{3}$$

Where:

P_s = Sprinkler precipitation rate (in/h)
Q_s = Sprinkler flow rate (gpm)
A_s = Effective coverage area of a single sprinkler (ft^2)

$$T = I_G \div P_s \times 60 \tag{4}$$

Where:

T = Irrigation duration required (min)
I_G = Gross Irrigation Requirement (in)

$$I_G = I_N \div E_I \tag{5}$$

Where:

I_N = Net Irrigation Requirement (in)
E_I = Irrigation Efficiency

A typical sprinkler precipitation rate for the irrigation system at Brigantino Riverside Park and Hollister Airport using Equation 3 is provided in Table 8.

TABLE 8
Sprinkler Precipitation Rate for Spray Rotors at Brigantino Riverside Park

Sprinkler Head Type	Flow[a] (gpm)	Approximate Coverage of Single Sprinkler[b] (ft^2)	Sprinkler Precipitation Rate (in/h)
Toro TR70	12	2,165	0.53

[a] As specified in the design drawings for a design operating pressure of 60 psi
[b] Sprinklers on a 50-foot triangular spacing with 50 feet between heads on laterals and 43.3 feet between laterals

Notes:

gpm = gallons per minute

TABLE 8
Sprinkler Precipitation Rate for Spray Rotors at Brigantino Riverside Park

Sprinkler Head Type	Flow[a] (gpm)	Approximate Coverage of Single Sprinkler[b] (ft^2)	Sprinkler Precipitation Rate (in/h)
Toro TR70	12	2,165	0.53

in/h = inches per hour
ft^2 = square feet

Average Year Irrigation Schedule

Irrigation is commonly scheduled by one of two approaches:

1. **Fixed Irrigation Interval – Variable Irrigation Duration:** For this approach, irrigation might be applied every day, and the duration or total minutes of irrigation operation on each zone varies according to changes in net irrigation requirements.
2. **Variable Irrigation Interval – Fixed Irrigation Duration:** For this approach, the duration or total minutes of irrigation operation on each zone are the same each time an irrigation event is conducted, and the interval between irrigation events varies according to changes in net irrigation requirements.

For turf irrigation, the first approach is most common. However, irrigation scheduling at use areas may be conducted by either approach.

Example irrigation schedules for each month have been completed for reuse areas (Table 9) using characteristics of the most common spray rotor head that has been identified for the site.

TABLE 9
Example Irrigation Scheduling Calculations for Average Year Conditions

Month	Gross Irrigation Water Requirement (inches)	Monthly Irrigation Duration (minutes)	Fixed Irrigation Interval – Variable Irrigation Duration		Variable Irrigation Interval – Fixed Irrigation Duration	
			Irrigation Interval (days)	Irrigation Duration per Event (minutes)	Irrigation Interval (days)	Irrigation Duration per Event (minutes)
January	0.00	0				
February	0.00	0				
March	1.44	163	1	5	11	60
April	4.31	488	1	16	3.7	60
May	6.59	746	1	24	2.5	60
June	7.68	869	1	29	2.1	60
July	8.14	921	1	30	2.0	60
August	7.44	842	1	27	2.2	60
September	5.43	614	1	20	2.9	60
October	3.46	392	1	13	4.7	60
November	0.15	17	*	*	*	*
December	0.00	0				
Total	**44.63**	**5,052**				

*Due to the small irrigation requirement in November, irrigation would likely only occur over one short event during the first part of the month in an average year. In wetter than normal years, no irrigation may be required during this month.

The allowable soil water depletion is the primary factor affecting the maximum interval that can be tolerated between irrigation events and/or the maximum irrigation depth that should be applied in any one irrigation event. For example, for turf irrigation on Metz gravelly sandy loam soils on the Brigantino site, the allowable depletion is 0.40 inches over an 18-inch-deep root zone. With a reduced rooting depth of 12 inches as observed during 2010, the allowable depletion would be reduced to 0.35 inches, which is equivalent to the water delivered over a 40-minute irrigation set. Since the daily irrigation requirement during peak water use conditions requires a 30-minute daily irrigation amount, irrigation should be conducted no less frequently than on a daily basis during the peak month of July in order to provide full irrigation.

Scheduling the required irrigation durations will be influenced somewhat by operational requirements of the use areas, such as ease of programming sprinkler system, and days and times during which the system could be operated. To the extent possible, less frequent deeper irrigation events can also be used in place of daily irrigation events to reduce the amount of water lost to evaporation. This practice promotes deeper rooting of the vegetation, thereby enabling the vegetation to be more resistant to drought and salinity but is limited by the water holding capacity of site soils to retain applied water without deep percolation. As shown in Table 7, irrigation events of 60 minutes every other day can be conducted if the turfgrass has an effective rooting depth of 18 inches. Once the turfgrass reaches its full rooting depth, irrigation intervals can be reassessed to determine the best irrigation interval for water conservation and good turf management.

Planned Irrigation Scheduling Procedures

This section provides guidance that will be used for evaluating actual irrigation requirements compared with those predicted in the average year water balance presented. The average year water balance is based on average historical values of ET_o and precipitation. Actual ET_o and precipitation may be higher or lower than the historical average; therefore, actual irrigation water requirements will differ somewhat compared to the values presented previously. To ensure that an appropriate amount of irrigation water is applied to the use areas in response to actual climate conditions, the procedures identified below will be followed.

1. On a weekly basis, ET_o data will be evaluated from the CIMIS Web site for CIMIS Station #126 to project irrigation schedules for the coming week. Daily ET_o variance will be determined for the preceding week to compare current ET_o with historical conditions using the CIMIS ET_o variance report available on the web site (see Figure 3 for an example variance report). Note that the data listed in the variance table in Figure 3 are all ET_o values in units of inches per day. Precipitation (P) values recorded for the previous week will also be downloaded. Based on weekly variance and ET_o predicted for the following week, either frequency or duration of irrigation might be adjusted. The net irrigation requirements (I_N) for the coming 7 day period will be calculated as follows:

$$I_N = 0.95ET_o - 0.7P \tag{6}$$

   The 0.95 factor represents the turfgrass crop coefficients and the 0.7 factor represents an approximate effective precipitation percentage. Gross irrigation requirements and irrigation durations will be subsequently calculated according to Equations 3, 4, and 5.

2. Visual observations of the use areas will also be made to adjust irrigation schedules. On turfgrass areas, brown spots in the landscape or salt crust on the soil surface could indicate that insufficient water is being applied. On the other hand, ponded water, disease, or moss accumulation could indicate that too much water is being applied. Visual indicators, in conjunction with ET_o variance, will be used when appropriate to make adjustments to the irrigation regime.

3. Tensiometers have been installed and will be used to measure matric potential, or how “tightly” the water is being held by the soil. Tensiometers provide good indication of when to start an irrigation, and whether the soil at that location has been refilled to field capacity after an irrigation. Soil moisture should generally be managed between an upper limit of field capacity and a lower limit of the soil moisture at management-allowed depletion. For this application, the lower limit would be the water content at which point about 40 percent of the available water holding capacity has been depleted over the turfgrass rooting depth. In addition to tensiometers, the “feel and appearance method” will be used to evaluate soil moisture periodically throughout the irrigation season on soil cores collected from turf areas. This will generally entail soil cores being collected over the 0-24 inch depth range before and after an irrigation event and

evaluated according to the NRCS procedures (http://www.wy.nrcs.usda.gov/technical/soilmoisture/soilmoisture.html). Soil moisture levels too dry before irrigation indicate that irrigation intervals should be shortened or irrigation durations lengthened. Excess soil moisture penetrating beyond the depth of rooting after an irrigation event indicates that irrigation durations should be shortened.

SECTION 5

5 Nutrient Management

This section discusses the nutrient requirements for turfgrass, with particular emphasis on nitrogen requirements. The MRR states that recycled water shall be applied in an amount that will not cause nitrogen within the root zone to exceed the agronomic demand for nitrogen and result in the leaching of nitrate to groundwater. Typical fertilizer management for turfgrass and estimated supplemental fertilizer requirements for the site are also discussed with consideration of the nitrogen delivered with recycled water irrigation.

This section applies to the operation of the Brigantino Riverside Park and Hollister Airport reuse sites, which will be operated in accordance with this plan. The San Benito County Water District Pilot Project was approved on a temporary basis as a pilot project and SBCWD will manage fertilization of the project such that nutrients are applied at the agronomic rate.

Required Nutrients

Turfgrass requires a variety of nutrients for optimum performance. Nutrient requirements, with elements needed in larger amounts nearer the top of the list, are shown in Table 10.

TABLE 10
Essential Turfgrass Nutrients

	Nutrient Element
Nutrients needed in relatively large amounts	Nitrogen (N)
	Phosphorus (P)
	Potassium (K)
	Calcium (Ca)
	Magnesium (Mg)
	Sulfur (S)
Nutrients needed in relatively small amounts	Iron (Fe)
	Copper (Cu)
	Zinc (Zn)
	Manganese (Mn)
	Molybdenum (Mo)
	Boron (B)
	Nickel (Ni)
	Chlorine (Cl)

Source: Henry et al., 2002

While nearly all managed turfgrass sites require supplemental nitrogen fertilization, fertilizer application of the other essential nutrients shown in Table 10 may or may not be required. If inherent soil fertility and nutrient levels in recycled water and grass clippings are not sufficient to support turfgrass, then supplemental fertilizers will need to be applied.

On an annual basis, 3 pounds of nitrogen per 1,000 square feet per year (132 pounds N per acre per year) are needed to support a healthy stand of cool-season turfgrass for Central Coast sites, while 4 pounds of nitrogen per 1,000 square feet per year (approximately 175 pounds N per acre per year) may be necessary for warm season grasses. No more than 1 pound of N per 1,000 square feet (44 pounds of N per acre) should be applied at any one time using fast-release fertilizers in order to avoid burning (Henry et al., 2002). Turf areas that receive heavy traffic may need higher fertilization rates to promote quick regrowth in damaged areas.

In the Central Coast area, fertilizer applications on cool-season turfgrass are typically performed in May, September, and October for fast-release fertilizers. Up to four fertilizer applications on warm-season turfgrass are typically performed in April, May, September and October. On sandy soils, application frequency can be increased, while reducing the amount being applied, such that the annual application rate is the same as described above.

Because of the presence of sandy soils on the Brigantino site, the use of slow-release fertilizers is recommended for any supplemental fertilization in order to reduce the potential for nutrient leaching below the plant root zone. Manufacturers' labels should be consulted for application rates and timing for slow-release fertilizers (Henry et al., 2002).

5.1.1 Nutrient Sources

Nutrients will be delivered to turfgrass at Brigantino Riverside Park and Airport reuse sites from the following sources:

- Recycled water
- Grass clippings
- Fertilizers

5.1.2 Nutrient Budget

A nutrient budget was developed for normal-year conditions at the Brigantino Riverside Park and Hollister Airport sites, using the CH2M HILL Root Zone Water Balance Model (Appendix C). Both the water and nitrogen requirement of the turfgrass were considered to prevent over-application of either constituent.

The water quality variables (Table 3) that were entered into the model to determine average annual nutrient loading to the system included nitrogen (NO_3-N, Ammonia-N, TKN, and total N) and salinity (TDS). Nutrient loading was calculated based on the agronomic rate of irrigation with recycled water.

5.1.3 Nutrients in Recycled Water

Using the constituent concentrations presented in Table 3, recycled water applied at agronomic rates during a normal year provide less nitrogen than the annual turfgrass requirement for both reuse sites (Table 11). Assuming an annual application of 44.6 inches of recycled water, the estimated mass loading of total nitrogen to Brigantino Riverside Park is approximately 73 pounds per acre per year. Assuming an annual application of approximately 39 inches of recycled water, the estimated mass loading of total nitrogen to the Airport Site is approximately 65 pounds per acre per year.

TABLE 11
Nitrogen Budget for Use Areas[a]

	Brigantino Total N[(b)]	Airport Total N[(c)]
Annual Turfgrass N Demand (lbs/acre)[b]	132	150
Annual Load in Recycled Water[(a)] (lbs/ac)	73	65
Annual Load in Grass Clippings	33	38
Annual Supplemental N Requirement (lbs/acre)	26	47

[a] Based on Average Irrigation Year and Average Irrigation Water Quality (using COH water quality data from April through August 2009).

[b] Annual turfgrass N demand is based on 3 lbs of N per 1,000 square feet for cool season turfgrass per Henry et al. (2002).

[c] Annual turfgrass N demand is based on 3.5 lbs of N per 1,000 square feet for a blend of cool season and warm season turfgrass per Henry et al. (2002).

5.1.4 Nutrients in Grass Clippings

Grass clippings contain about 4 percent N, 0.5 percent P, and 2 percent K on a dry weight basis, in addition to other nutrient elements (Heckman et al., 2006). Thus, by not removing grass clippings, a substantial portion of the nutrient requirement for turfgrass can be met. Research has shown that grass clippings can supply about 25 percent of a lawn's total fertilizer requirements (University of California Cooperative Extension, 2009). By leaving grass clippings on the Brigantino site after mowing, approximately 33 pounds of N per acre could be supplied, thereby reducing the need for additional supplemental fertilization. By leaving grass clippings on the Airport site after mowing, approximately 38 pounds of N per acre could be supplied, thereby reducing the need for additional supplemental fertilization.

5.1.5 Supplemental Fertilization

Nitrogen loading from recycled water irrigation will typically be less than the crop requirement, so the remainder will need to be delivered by supplemental fertilization. Table 11 shows the site-specific typical annual supplemental fertilization requirement.

One supplemental nitrogen fertilizer application should occur in May during the period of highest N demand. If complete fertilizer (containing N, P, and K) is necessary, it should be applied during October (Henry et al., 2002). To avoid encouraging plant growth during times of highest water demand, which could be stressful for cool-season grasses, fertilizer applications should not occur during or immediately prior to the hottest summer months.

Fertilizer should be applied via a mechanical spreader to ensure even distribution. At least two passes of the park should occur, with the second pass perpendicular to the first, to ensure uniform coverage and no "stripes."

5.2 Management Practices to Reduce Nutrient Loading

Best management practices (BMPs) to help ensure appropriate nutrient management on the site include the following:

- Any fertilizer spills on the site will be promptly cleaned and disposed of. No fertilizer will be left on paved surfaces or in locations where it could migrate offsite or discharge to the San Benito River.
- Visual observations will document whether irrigation is causing ponding or turfgrass displays symptoms of insufficient irrigation or nutrient deficiency. Irrigation and amendment applications will be adaptively managed to ensure appropriate hydraulic and nutrient loading.
- Recycled water quality will be monitored regularly and supplemental fertilizer applications will be adjusted accordingly.
- Irrigation events will be carefully managed to reduce the potential for unintentional deep percolation losses.

SECTION 6

6 Monitoring and Reporting

The following monitoring and reporting tasks are designed to comply with the COH MRR Program requirements.

6.1 Recordkeeping

The following information will be obtained and compiled for preparation of the annual report:

- Quantity of recycled water distributed to each reuse site, on a weekly basis
- Quality of recycled water distributed to each reuse site, measured at the frequency stated in the MRR
- Inspection results and adaptive management measures that are proposed and taken. Such measures could include, but are not limited to:
  - Modifying irrigation frequency and/or duration based on observations of soil moisture
  - Applying a complete fertilizer in October if warranted based on turfgrass performance
- Information pertaining to all fertilizer and other soil amendments that are applied to each reuse site, such as:
  - Type of fertilizer/amendment and analysis (e.g., 21-0-0)
  - Application rate

6.2 Recycled Water Use Area Monitoring

COH staff will inspect the use area at least weekly, to verify and document compliance with the MRR. Visual inspections will be noted in a bound inspection logbook, and at a minimum will document proper sprinkler operation, runoff, erosion, saturated surface conditions, and odors. The logbook will be made available to the CCRWQCB and California Department of Public Health upon request. A summary of observations made during inspections, and a brief discussion of corrective actions taken or planned will be included with the annual report.

6.3 Groundwater Quality Monitoring

Groundwater monitoring will be conducted in accordance with the Groundwater Monitoring Plan (GMP) that was developed previously (CH2M HILL, 2009). Implementation of the GMP began in April 2009, and initial groundwater monitoring found that none of the wells in

Brigantino Riverside Park had nitrate concentrations above the primary maximum contaminant level (MCL; 10 mg/L). TDS levels in three out of five of the wells at Brigantino Riverside Park were above the secondary MCL upper range (1,000 mg/L). Chloride concentrations in three out of five of the wells at the park were above the secondary standard (250 mg/L). In addition, sulfate levels were above the secondary MCL (250 mg/L) in four out of five monitoring wells at the park. Data from groundwater monitoring associated with each reuse area will be reviewed annually to evaluate whether irrigation using recycled water is causing or contributing to an increase in concentration of nitrogen in groundwater.

6.4 Annual Report

As required by the MRR, the COH will submit an annual report documenting allowable and actual nitrogen loading to the recycled water application areas. The report will:

- Analyze the contributing sources of nutrients being applied to the recycled water application areas
- Analyze annual nitrogen loading to the basin and individual application areas from each contributing source
- Analyze the allowable nutrient and hydraulic loading (based on limiting nitrogen loading) of recycled water based on characteristic effluent data for nitrogen, other contributing nitrogen sources, and the nutritive requirements of the application areas
- Compare the actual and allowable annual nitrogen loading rates
- Analyze groundwater monitoring data for nitrogen constituents
- Evaluate potential impacts of nutrient loading on the groundwater basin
- Evaluate potential nutrient reduction measures
- Make recommendations and provide a time schedule for implementation of the measures proposed for addressing excessive nitrogen loading (i.e., actual loading greater than allowable loading) as applicable

Annual NMP reports are due January 31 of each year and may be included as part of the annual monitoring report. The first annual NMP report is due January 31, 2010. The NMP will be reviewed and updated annually thereafter as necessary. After 2010, a copy of the revised NMP or statement indicating the NMP has been reviewed but not updated will be submitted to the CCRWQCB as part of the annual monitoring reports.

In the future, the COH will submit a letter to the CCRWQCB, for approval by the Executive Office, requesting that additional annual NMP reports not be required if the following conditions have been met:

- The initial nitrogen loading evaluation indicates that the application of recycled water at appropriate hydraulic rates along with other nitrogen sources will not exceed the nutritive requirements of the food crops, vegetation, or landscaping being irrigated

- Recycled water is not being over applied in an effort to increase disposal that may result in significant soil flushing and runoff
- The NMP is being implemented for the controlled application of fertilizers by landscaping contractors or COH staff maintaining the application areas
- Effluent nitrogen concentrations from COH treated effluent regularly meet or are less than the effluent limitations of the MRR and are stable.

SECTION 7

7 References

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Figures

Appendix A
Physical Soil Properties

Appendix B
Analytical Results for San Benito County Water District Test Plot

Appendix C
Root Zone Water Balance Working Model