I. **Project Title:** Integrated Ecosystem Management: Maui
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Project Staff: Meghan Dailer, Darla White, Robin Knox and Hailey Ramey
Organization: University of Hawaii, Manoa
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II. **Executive Summary**

The Hawaii Division of Aquatic Resources (DAR) established an Herbivore Fisheries Management Area (HFMA) in front of Kahekili Beach Park in West Maui that was effective on July 25th 2009. The basis for the Kahekili HFMA arises from decadal benthic data (collected by DAR and partners since 1994) that shows that coral cover has been declining since 1999, whereas the abundance of algae has sharply increased, especially the abundance of the invasive algae *Acanthophora spicifera* (DAR, unpublished data). Surveys by DAR in December 2006 demonstrated that herbivorous fish biomass at Kahekili is comparable to that of fish communities at other West Maui reefs that are open to fishing. All open fishing locations average around 40% of the total fish biomass observed in the Honolua Bay MLCD, which is the nearest reef closed to fishing. Based on this severe but far from catastrophic reduction in fish biomass due to fishing, we assume that herbivorous fish stocks at Kahekili would increase should the fishing of key herbivores become regulated. Finally discussions between DAR staff and a wide range of resource users, including local fisherman, have shown that all these groups recognize the problems of increased abundance of (invasive) algae and declining reef conditions in West Maui and generally support the idea the HFMA at Kahekili through the protection of key herbivores. The Kahekili HFMA is a high profile project, and the effectiveness of the project will have a significant impact on DAR's future approach to managing reefs; and possibly even more importantly, successful implementation and performance of the HFMA would give DAR much greater credibility, and therefore greater scope to initiate future proactive management programs. DAR has recognized that the integrated management of the ecosystem involves more than fisheries management. DAR has stated that if steps are not taken to return to conditions under which coral can thrive, that it is nearly certain that additional reefs will reach a state of total system collapse, such as that seen at Ma'alaea. According to "Status of Maui's Coral Reefs" (DAR, HCRI 2008) "Recovery of herbivore stocks may be part of the solution at some locations, but without other steps to reduce land-based impacts there is unlikely to be substantial recovery across the island's reefs."

III. **Purpose:**

  A. **Detailed description of the resource management problem(s) to be addressed.**

This project is concerned with the decadal documentation that increased algal abundance results in the decline of original framework building species such as corals and crustose coralline algae on reefs along the coast of Northwest Maui. This project focuses on the potential causative role of (invasive) algae in driving such decline to gain insight in the dynamics that cause algae to become abundant and developing practical approaches to restore the environmental conditions under which corals once thrived. This mission corresponds with that of the state of Hawaii's Division of Aquatic Resources (DAR) that in partnership with researchers from the University of Hawaii, local environmental NGOs and the local community, now prioritizes projects studying the spread and impact of blooms of invasive algae on reef communities along Maui's Northwest coast. In attempts to reverse reef decline in the Kahekili area the Hawaii DAR is in the process of establishing an Herbivore Fisheries Management Area (HFMA) where the taking of key herbivorous fish will be prohibited.

Practical approaches to restoration of environmental conditions under which coral once thrived include the reduction of land-based pollutant loads that have increased sedimentation and nutrient availability in near shore waters. The federal Clean Water Act establishes programs for the management of land-based pollutants from point and non-point sources, as well as, the management of water quality to support aquatic life uses (such as coral reef conservation). These programs are implemented by the Environmental Protection Agency (EPA) and the Hawaii Department of Health (DOH). The specific goals of Clean Water Act programs include a national goal of "water quality which provides for the protection and propagation of fish, shellfish, and wildlife, and recreation in and on the water." Specific relevant goals for the state of Hawaii include conservation of coral reefs and maintaining waters that are free from undesirable aquatic life. These Clean Water Act and state water quality programmatic goals clearly align with those of DAR and HCRI with regard to restoring environmental conditions under which coral can thrive.

An integrated, proactive approach to managing coral reef ecosystems is to reduce land-based impacts through enhanced implementation of these existing pollution control and water quality management programs. Implementation is enhanced by greater interagency communication, improved data sharing, education of scientists and government officials, and building local technical capacity. Dissemination of project information to those responsible for pollution control and land use decisions is key to establishing improved implementation of programs designed to maintain and restore the conditions under which coral reefs thrive.

B and C.   Detailed description of the question(s) asked to answer the resource management problem(s) and overarching goal(s) of the project

1: Can *Ulva fasciata* be used as a bio-indicator of excessive land based nutrients in terms of concentration and source(s) when deployed at the location of concern

for a specified time period? If so, then what time period is necessary to obtain unchanged tissue nutrient composition and $\delta^{15}N$ values?

2: Is it possible to use arrays of *Ulva fasciata* to map the effluent plume from the Lahaina Wastewater Treatment Plant in the Kahekili HMFA?

3: If so, then does the plume expand and contract with high and low tourist occupancy in the area?

4: Is it possible to create a seep sampling device to obtain 100 % seep water from the warmer-than-ambient-water fresh water seeps?

5: Is it possible to make a $\delta^{15}N$ dilution model with nitrogen from agricultural fertilizers and sewage effluent (two major sources of nutrient enrichment on Maui) to observe the change in tissue $\delta^{15}N$ values when the alga is exposed to both sources in different concentrations?

6: How variable is the $\delta^{15}N$ signal in the effluent from the Lahaina Wastewater Reclamation Facility?

7: Can the stronger native alga *Halymenia formosa* respond as quickly as *Ulva fasciata* in terms of incorporating new Nitrogen into their tissues and expressing the new $\delta^{15}N$ signal?

8: Is the benthic community within the Kahekili HMFA changed in the presence of sewage effluent? If so, then does the community structure change with (1) distance from shore, (2) distance from seeps or (3) with the type of coral rubble?

9: Are there microbial indicators of reef health that can be related to land-based sources of pollutants?

10: What are the sources of land-based pollutants (nutrients, sediments/suspended solids, pathogenic organisms) that contribute to undesirable algal blooms and coral reef ecosystem decline?

11: What are pollutant source loading rates (mass/time) and how are they spatially distributed (watershed-based analysis)?

12: Is there a spatial correlation between pollutant sources, watershed-based pollutant loads and coral decline and algal blooms in down-gradient coastal areas?

IV.   Approach:

Using *Ulva fasciata* as a bio-indicator of depleted or enriched nutrient conditions (addressing Question 1-3) Completed and ongoing: Meghan Dailer (UH Botany), Hailey Ramey (UH Botany) and Darla White (DAR)

In January 2009, 32 semi permanent sites were installed in the central portion of the Kahekili HFMA (Figure 1) (the area with the highest $\delta^{15}N$ values in West Maui and within the Kahekili HMFA). The design consists of 6 transects (4 sites each) extending from 1.5 to 6 m depth and an additional 8 sites in the shallow zone with warmer-than-ambient-water fresh water seeps (at 5ft depth) (Figure 2). To grow the marine plant samples in the field we constructed small (4 inches by 4 inches) durable cages and 32 float lines with University of Hawaii Marine Research signs. Algal samples were acclimated to low nutrient water to deplete internal nitrogen reserves and then deployed at the abovementioned sites monthly for seven days. Algal arrays were also deployed at CRAMP sites in May (Figure

3) and at three sites per 100 m transect on three transects parallel to shore at Olowalu (in June and July) and Lanai in July (Figure 4).

Creation of a seep sampling device to obtain 100 % seep water to send for nutrient water chemistry and δ^{15}N analyses (Addressing Question 4) Completed by Meghan Dailer (UH Botany)

Create a seep sampler that allows air to be released from the top of a large (250 ml) cylinder as water flows through an attached funnel that placed over the seep. This allows the water derived only from the seep to fill the cylinder instead of the more general fresh water displacement method which has high potential of sample contamination for obvious reasons.

δ^{15}N dilution model with two sources of nitrogen, agricultural fertilizer and sewage effluent (Addressing Question 5) Will be completed by: Meghan Dailer (UH Botany) and Hailey Ramey (UH Botany)

Future experiments with agricultural fertilizer and sewage effluent in combination and a range of dilutions (see Table 1) will produce a mixing model of δ^{15}N values to explain the range of δ^{15}N values from 7 to 11 ‰ observed in many areas of Maui that are likely impacted by both sewage and fertilizer (as in Maalaea). Three sources of effluent will be used because different effluent sources have different δ^{15}N values reflecting different levels of treatment. Effluent will be obtained from the Lahaina and Kihei Wastewater Reclamation Facilities and from a private wastewater treatment plant in Maalaea (pending collaboration).

Table 1. Proposed mixtures (treatments) of agricultural and sewage Nitrogen to determine changes in algal tissue δ^{15}N values when exposed to both sources likely problematic in Ma'alaea Bay.

Treatment	Fertilizer N	Sewage N	Total Addition
1	No Addition	No Addition	0 %
2	No Addition	10.0 %	10.0 %
3	2.5 %	7.5 %	10.0 %
4	5.0 %	5.0 %	10.0 %
5	7.5 %	2.5 %	10.0 %
10	10.0 %	No Addition	10.0 %

The final volume per treatment will always equal 1.0 L; the actual addition in milliliters is equal to 10 times the percent addition (e.g. 2.5% = 25ml) of fertilizer/sewage to be added. Samples of *Ulva fasciata* (n = 3 per treatment, 64 total) will first be acclimated to low nutrient water for a week to deplete tissue nitrogen storage reserves. Once a nutrient deplete status is obtained the experiment will be performed over 7 days. Measurements will include: (1) tissue nutrient composition and δ^{15}N values on the day of field collection, Day 0 (acclimated) and Day 7 of the experiment, (2) growth determination (wet weights of algal samples on Days 0 and 7), and (3) water chemistry analysis of each

treatment in triplicate on Days 0 and 7 to assure that the concentrations of nutrients remain the same over the course of the experiment.

Monitoring $\delta^{15}N$ values of the Lahaina Wastewater Reclamation Facility to determine signal variation of the source (Addressing Question 6) Will be completed by: Meghan Dailer (UH Botany) and Hailey Ramey (UH Botany)

Since no studies have ever been conducted on how variable the $\delta^{15}N$ values are in the effluent source we will conduct a time series sampling survey of the effluent in the following way: every hour for a day, three times a day every day for a week, then three days a week for a month. This portion of the project was placed on hold as we were waiting for information regarding additional techniques necessary to perform the testing correctly. We have recently received the information and will perform the study in the near future.

Determination of a stronger species to use for real-time $\delta^{15}N$ field experiments in areas with high wave action (Addressing Question 7) Will be completed by: Meghan Dailer (UH Botany) and Hailey Ramey (UH Botany)

Since many samples were lost during the real-time $\delta^{15}N$ experiments at Kahekili due to high wave action and surge, the need for a highly responsive, stronger species is imperative. Sewage effluent addition experiments similar to those in the HCRI 2008 report will be performed on the native algal species *Halymenia formosa*, which has a thicker morphology than *Ulva fasciata*. If *H. formosa* responds to nutrients as fast as *U. fasciata* then it will be the preferred species to use for real-time $\delta^{15}N$ experiments in areas with high wave activity and surge.

Sewage impacts on the benthic community structure of the Kahekili HMFA (Addressing Question 8) Completed by: Meghan Dailer (UH Botany), Hailey Ramey (UH Botany) and Aaron Hartmann (Scripps Institution of Oceanography)

Benthic community structure across the Kahekili HMFA was determined through baseline surveys, bioeroder counts were determined in three areas of Kahekili (Figure 5) and at control sites on Lanai and Olowalu (Figure 4). The bioeroder survey was conducted by Aaron Hartmann as part of his PhD Dissertation. The survey consisted of collecting 20 pieces of rubble along each transect with five 50 m transects parallel to shore. The bioeroder counts are currently being prepared for analysis and will be analyzed with the corresponding $\delta^{15}N$ value of the area. If a correlation is found between high $\delta^{15}N$ values and changes in community structure, then we will determine if this change is due to (1) distance from shore, (2) distance from warmer-than-ambient-water fresh water seeps or (3) type of coral rubble.

Microbial survey (Addressing Question 9)
To be completed by Robin Knox (UH Botany), Meghan Dailer (UH Botany) and collaborators (TBD)

Conduct a survey of marine microbial populations in near shore waters using microbial source tracking techniques such as such as quantitative polymerase chain reaction and standard microbial assays for indicators of sources and pathogens. The survey will look at indicators currently used in water pollution control programs (Enterococcus) and those proposed for future use in Hawaii (*Clostridium perfringens*). The survey will also look for the pathogenic organisms that maybe correlated to the indicator species.

Wastewater inventory (addressing questions 9-12 for point sources of pollutants) Partially completed and ongoing by Robin Knox (UH Botany)

An inventory of land-based wastewater sources on the island of Maui that are sources of nutrients contributing to algal blooms and coral reef ecosystems decline will be developed from readily available existing sources of information including that maintained by EPA, DOH and County of Maui. The inventory will include known information about sources of wastewater including cesspools, individual wastewater treatment systems, publicly-owned treatment works, industrial wastewater treatment, contaminated stormwater; and other wastewaters disposed of via surface water discharge, reuse or injection wells. The inventory will include location, effluent flow rate, level of treatment, and method of disposal. Wastewater source locations will be mapped for spatial comparison to locations of algal blooms or coral reef decline. Based on spatial analysis, gross wastewater nitrogen loading estimates will be developed for selected watersheds of interest.

V.   Results

Using *Ulva fasciata* as a bio-indicator of depleted or enriched nutrient conditions

We have upgraded the capacity of our facility to acclimate more samples at a time, which will also allow us to run experiments while acclimating plants for field deployments. For the sites in the Kahekili HFMA, we acclimated samples to obtain a nutrient deplete status then deployed 96 (3 samples per site) cages with individual samples at the abovementioned sites. All samples were deployed on a float line that hovered approximately 0.5 m from the benthos. The arrays were deployed ever month from February to August. In February, a Kona storm generated wind swell that disintegrated the shallow samples and we recovered about 50% of the samples. In May, this method was also used by Hawaii Division of Aquatic Resources to determine if nutrients are impacting sites that have been monitored for the past decade through the Coral Reef Assessment Monitoring Program (CRAMP). Marine plant samples (180 total) were deployed at 20 CRAMP sites (n= 9 per site) across the West, Central and South Maui regions. Algal arrays (n = 27 per area) were also deployed at Olowalu (in June and July) and Club Lanai (in July). Approximately 1000 samples have been processed and sent to the University of Hawaii Biogeochemical Laboratory for tissue Nitrogen

and Carbon content and δ^{15}N analysis. The algal tissue δ^{15}N results from the Kahekili deployments have been incorporated into a manuscript that is currently in review at the Marine Pollution Bulletin. Generally, deployed samples significantly increase in δ^{15}N values in the shallow region containing the warmer-than-ambient-water fresh water seeps and at the offshore C sites. The highest values were repeatedly found in plants deployed directly over the warm freshwater seeps. The far offshore D sites only had significantly higher values in February when the Kona storm produced a large scale mixing event. The growth rates and percent change in wet weight of deployed samples in the Kahekili HFMA for each deployment are presented in Figures 6 and 7 respectively. Growth rates were highly variable across all deployments. Growth rates and percent change in wet weight were statistically analyzed for each deployment separately. These data were normally distributed and analyzed with an ANOVA with site as the random factor. These analyses revealed no significant differences in growth rates between sites. The highest growth of 250 % increase in wet weight (Figure 7) was observed in March, which was the only deployment that had calm ocean conditions throughout the entire duration of the experiment. Highly variable growth rates of deployed samples are not surprising when additional factors are considered that could inadvertently affect the sample in the field. For example, samples deployed at sites with surge or wave action will likely lose some tissue (or be completely disintegrated) over the duration of the deployment, but at Kahekili, samples deployed at nearshore sites significantly increase in δ^{15}N value, indicating the presence of sewage nitrogen in the area. Therefore, growth of *Ulva fasciata* samples deployed in the field is not a good indicator of the presence of excess nutrients unless the conditions are relatively calm during the duration of the experiment, as they were in March.

The growth rates of samples deployed at CRAMP sites are presented in Figure 8. Regardless of site, samples did not grow more than 50% increase in wet weight during the deployment. The δ^{15}N values of samples deployed at the Honolua Bay North, Kanahena Bay and Kanahena Point CRAMP sites significantly decreased from initial values suggesting that nitrogen with a lower stable isotope ratio of ^{15}N:^{14}N was affecting the samples (Figure 9). The Honolua Bay watershed has had extensive agriculture in the past and portions of the area are still used to raise pineapples. Since the δ^{15}N values decreased in this area it is likely that fertilizers from these practices are affecting the bay. Kanahena Bay and Point are located in a Natural Area Reserve that has not experienced major human impact (i.e. no cesspools, injection wells, septic tanks or extensive agriculture). Since this area has extremely low human impact the significant decrease in δ^{15}N values in this area was likely from naturally occurring nitrogen either seeping through groundwater or from upwelling along the coast. The only samples that significantly increased in δ^{15}N values were those deployed at Kahekili (Figure 9).

Creation of a seep sampling device to obtain 100% seep water to send for nutrient water chemistry, δ^{15}N and microbial analyses

We have created a seep sampler to obtain 100% seep water; this device allowed us to obtain water samples with salinity readings of 5.3 ‰ in an environment surrounded by salinities of 35 ‰. The new method will be used in the upcoming fiscal year to collect samples for nutrient, $\delta^{15}N$ and microbial analyses.

Microbial Survey

Robin Knox gained experience with field and laboratory methods in marine ecology by observing the work of visiting researcher Melissa Garren from University of San Diego, Scripps Institution of Oceanography. Literature reviews were continued and with input from Melissa Garren, refinements to methods are being made in response to specific questions from HCRI. (Regarding HIMB/Toonen proposal) Bio-safety requirements have been met and working arrangements established with Maui Community College and the NOAA Hawaiian Islands Humpback Whale Marine Sanctuary for laboratory facilities and equipment. Testing of sampling and laboratory procedures were initiated. Written laboratory protocols are under development.

Wastewater Inventory

In December 2008 data queries were made to Environmental Protection Agency (EPA) online databases, to the Department of Health (DOH), and to the County of Maui to obtain information on existing wastewater management including location, volume, treatment level, and disposal method. Data was obtained for cesspools, injection wells and other regulated wastewater discharges. In 2009, the data was reviewed, an initial order of magnitude nitrogen loading estimate was developed, data gaps were identified, and a second round of inquiries were made in April 2009. Wastewater and underground injection control data was received from EPA in June of 2009. A preliminary analysis of effluent total nitrogen loading was included in a manuscript submitted to the Marine Pollution Bulletin. Additional inventory and analysis of the types, volumes, and locations of wastewater sources on Maui is continuing with preparation of a draft report entitled "Wastewater Disposal on Maui Island"

Watershed Planning

Ongoing watershed planning efforts were continued including participation in US Army Corps of Engineers (USACE) process to scope a West Maui Ecosystem Restoration project. Comments were prepared regarding the USACE alternatives analysis for flood control project on Iao Stream. Robin Knox participated in USACE scoping meeting on Harbor Improvements for Ma'alaea. In cooperation with the West Maui Soil and Water Conservation District a draft revised proposal for a Clean Water Act 319 (nonpoint source control) watershed planning grant is

under development In cooperation with the Central Maui Soil and Water Conservation District (CMSWCD), Southwest Maui Watershed Advisory Group, Community Work Day, and the County of Maui a grant proposal was developed for monitoring the nutrient load entering and exiting the Laie Wetland, one of the last remaining coastal wetlands in the developed north Kihei area of Maui. .. Robin Knox provided additional technical support to the Central Maui Soil and Water Conservation District (CMSWCD), resulting in the district receiving a Clean Water Act 319 (Nonpoint Source Control) Grant to conduct a two-year long $189,000 watershed planning effort for the southwest slope of Haleakala, including Kihei, Wailea and Makena.

Policy Analysis

Previous policy analysis research was summarized. Comments on rulemaking for revised water quality standards were provided to the Hawaii State Legislature, the DOH and EPA   Researchers participated in the DOH Integrated Water Quality Reporting Workgroup, and Robin Knox prepared the groups recommendations to the DOH (Attachment B, Integrated Water Quality Reporting Criteria for Use Attainment Decisions. Recommendations of the workgroup included using biological data, such as that obtained from the Coral Reef Assessment and Monitoring Protocols in addition to water chemistry when assessing attainment of coral reef conservation and aquatic life uses. The potential for development of algal bioassays as a monitoring tool was identified.

Both informal input and formal testimony were provided to the Maui Island General Plan Advisory Council (GPAC), specifically policy language that identify coral reefs as heritage resources, incorporate ahupua'a management with mauka to makai watershed management requirements specifically tied to sensitive heritage resources.

Additional analysis of the Lahaina Underground Injection Control (UIC) permit was conducted in response to issuance of a revised draft permit by EPA. (http://www.epa.gov/region/water/groundwater/uic-permits.html#lahaina)

It should be noted that the EPA was responsive to comments previously submitted by the research team. The revised draft permit had specific provisions that were rationally supported by project information and testimony submitted by Meghan Dailer, Celia Smith, Robin Knox and echoed by Dan Polhemous (DAR). These conditions include a limit on injection rate (injectate volume), a limit in the total nitrogen mass, phased limits with future nitrogen mass reduction, bacterial monitoring, and the requirement for disinfection to R-1 reuse standards. While this permit is significantly improved, and includes significant reductions over currently permitted waste loads, it does not require a significant reduction in actual nitrogen loading rates. The final mass limits at the end of the proposed

permit term is the same as current levels. Written comments and testimony on the revised draft permit were provided to EPA.

VI.   Dissemination of Project Results:

Two manuscripts have been submitted from portions of the 2008 and 2009 project results.   These results were presented at the Hawaii Conservation Conference in July 2009. The manuscripts were provided as crucial information to the Environmental Protection Agency in August 2009 regarding the Underground Injection Control (UIC) permit for the Lahaina Wastewater Reclamation Facility.

Outreach and Education

The Lahaina Field Station provided working space for three interns (also PhD candidates) from the Scripps Institution of Oceanography from June through September 2009. Two of the interns were directly assisted by Meghan Dailer to organize, plan, design and perform experiments.

South Maui Sustainability Reef Committee (3 meetings- Status of Coral Reefs, information on wastewater treatment and injection, information on Clean Water Act

Maui Nui Marine Resources – continued informal meetings and consultation to answer questions about CWA and control of land based pollution

Work with NOAA Hawaiian Island Humpback Whale National Marine Sanctuary volunteer water quality monitoring program – worked with NOAA intern Brandon Boyd to improve quality control aspects of program and develop Quality Assurance Project Plan.

The sanctuary program sponsored educational talks about marine microbiology (Knox, Garren, Boyd and Alastair Hebbard spoke about marine microbial ecology, how clean water act uses bacterial indicators to protect recreational uses; and an overview of the volunteer monitoring program.
Ocean Awareness Training – taught water quality module with Risa Oram from the Local Action Strategy Land Based Pollution advisory group.

Field Water Quality Days – Offered water quality education on site at Honolua Bay during a Clean up event. Field training for whale sanctuary volunteers (visual assessment, bacteria, colorimetric water quality kits for pH, nitrates, and phosphorus)

Participate as presenter in the "Making a Difference" program sponsored by Project SEAlink

Provide ongoing technical and regulatory education regarding Coral Reefs, land-based pollution, and the Clean Water Act to the DIRE coalition

Meet with Mayor Charmain Tavares to discuss wastewater treatment and injection wells.

Meet with Councilman Mike Molina to provide information about coral decline, algae blooms, and reduction of land-based pollutants.

Table 1 Lahaina Wastewater Reclamation Facilty Total Nitrogen Load

Year	Avg Effluent /Injectate Total Nitrogen (mg/L)	Effluent Average Daily Flow (MGD)	Effluent Total Daily Nitrogen Load (lbs/day)	% injected	Injection Well Volumetric Flow Rate (MGD)	InjectateTotal Daily Nitrogen Load (lbs/day)	Annual Injectate Volume (MG)	Injectate Nitrogen Mass (lbs/yr as TN)
2006	7.38	4.74	292	74	3.49	215	1,273	78,356
2007	6.63	4.54	252	69	3.15	174	1,151	63,609
2008	6.60	4.44	205	76	3.40	187	1,239	68,217
mean	6.87	4.58	250	73	3.35	192	1,221	70,061

Permitted and Actual Discharges	7-day Average Injectate Flow (MGD)*	Daily maximum injecate flow (MGD)	Long Term AverageTN (lbs/day)***	TN (lbs/calendar month)	TN (lbs/calendar quarter)	Annual Load TN (lbs/year)***	TN concentration (mg/L) **
Current Permit Limit **	9	19.8	no limit	no limit	no limit	no limit	10
Revised Permit Limit -effective date	7	10	318	12000	29000	116000	10
Revised Permit Limit -12/31/2011	7	10	241	9000	22000	88000	
Revised Permit Limit -12/31/2015	7	10	164	6000	15000	60000	
Current discharge level *. ***	4.58		192	5838	17515	70,061	
* average flow rate for current discharge is long term average 2006-2008							
** current permit has an action level rather than a limit for nitrogen concentration							
*** these are not permit limits they are load estimates at permitted limits or actiual discharge rates, not actual permit limits							

At the permitted 7MGD average flow, reducing nitrogen by 1 mg/L reduces load by 58 lbs/day (21,309 lbs/year)