State of North Carolina
Department of Environment
and Natural Resources

Michael F. Easley, Governor
William G. Ross, Jr., Secretary

Assessment and Recommendations for Water Treatment Plant Permitting

Water Treatment Plant Workgroup

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Executive Summary

The North Carolina Department of Environment and Natural Resources, responding to concerns raised by various agencies, commissioned a Workgroup to evaluate the permitting process and environmental impacts associated with water treatment plants. Over the course of several months, the Water Treatment Plant Workgroup evaluated existing permitting processes, along with the physical, chemical and biological characteristics of membrane and cationic exchange systems for discharges from water treatment plants.

Process improvements were necessary to meet the Water Treatment Plant Workgroup objectives for prompt and effective communication between interested agencies, improved understanding of environmental permitting by the regulated community, and minimization of agency resources. Evaluating the existing permit processes, the Workgroup found that a proposed water treatment plant project planner must consider the potential applicability of a minimum of 13 permits.

To facilitate communications and guide the regulated community through the permitting process, the Workgroup recommends that the NC DENR Customer Service Center act as the lead agency coordinator by providing early notification services for permitting and resource agencies while assisting permit applicants. The notification process improvements (see Figure 4-1) allow agencies to review proposed projects and provide valuable technical assistance regarding potential environmental impacts during the pre-application phase of the permitting process.

In addition, the Workgroup has provided general guidelines for siting water treatment plants designed to help planners locate suitable water sources and potential disposal sites. Although the Workgroup has provided recommendations for initial siting criteria, the Workgroup is unable to provide specific details on suitable environmental conditions for the disposal of potable water by-product. However, the Workgroup is recommending that the Department continue to support investigations in this area. Historically, disposal of potable water by-product has been a secondary consideration when planning to site a water treatment plant. It is clear from the issues raised by the Workgroup, that the disposal of potable water by-product should be elevated to a primary consideration when planning to site a water treatment plant.

Disposal of potable water by-product through surface water discharge is one of the more common methods of disposal in North Carolina. The increasing number of water treatment plants and the challenge of proper disposal of the residual by-product has resulted in the need to evaluate the environmental impacts and National Pollutant Discharge Elimination System (NPDES) policies associated with these discharges. The Workgroup conducted studies of two water treatment technologies used in North Carolina (membrane and cationic exchange systems). Based on the results of these studies, the Workgroup provided guidance for NPDES permitting of water treatment plants using membrane and sodium cycle cationic exchange systems and discharging to surface waters.

Discharges were highly toxic to freshwater organisms and somewhat toxic to saltwater organisms. Chlorides and total residual chlorine are the most obvious sources of toxicity that must be controlled.

The studies and investigations conducted raised additional issues that the Workgroup was unable to address. Therefore, the Workgroup recommends a continued effort to evaluate the environmental impacts associated with water treatment plant discharges (see Future Initiatives).

1.0 Workgroup

The following individuals served as members of the Water Treatment Plant Workgroup and contributed to the findings and recommendations contained in this report:

David Goodrich, Division of Water Quality (Workgroup Co-chair)
Wayne Munden, Division of Environmental Health (Workgroup Co-chair)
Sara Ward, US Fish & Wildlife Service
Lynn Henry, Division of Marine Fisheries
Doug Hugget, Division of Coastal Management
Melba McGee, Department of Administration
William Wescott, Wildlife Resources Commission
Frank McBride, Wildlife Resources Commission
Dave McHenry, Wildlife Resources Commission
Fred Hill, Division of Environmental Health
Matt Matthews, Division of Water Quality
Mike Bell, Division of Environmental Health
Stephen Lane, Division of Water Quality
Al Hodge, Division of Water Quality

2.0 Introduction

"When the well's dry, we know the worth of water" (Ben Franklin, Poor Richard's Almanac) is an appropriate introduction to the situation facing the public water suppliers in North Carolina. With changes in demographics and the tendency for people to relocate from other areas of the country, many utilities are experiencing unprecedented growth, often in areas that were not prepared with adequate water source, supply or infrastructure.

The need to provide adequate drinking water to North Carolina's growing population has resulted in an increase in the number of water treatment plants across the state. In addition to providing potable water to its users, water treatment also produces residual by-product requiring disposal. Health concerns and North Carolina (NC) Regulations dictate that no more than ten percent of the raw water flow can be comprised of 'potable water by-product'[1]. The increasing number of potable water treatment plants is resulting in more by-product discharges to North Carolina's surface waters.

3.0 Scope and Objectives

This section details the objectives of the Workgroup and how this report contributes to the achievement of these objectives.

3.1 Objectives of Workgroup

The objectives set forth in the original meeting were multifaceted and included the following:

- Identify concerns associated with existing processes.
- Evaluate existing programmatic processes associated with siting, timing, and approval of water treatment plant projects.
- Make recommendations for improvements in programmatic processes considering;
  - Communication among interested agencies.
  - Understanding of requirements by regulated community [Maintain/create a streamlined process].
  - Minimization of agency resources required to implement and maintain process improvements.
- Identify concerns associated with the disposal of potable water by-product.
- Identify and evaluate treatment and disposal options.
- Evaluate the physical/chemical characteristics and toxicity of potable water by-product associated with the different water treatment technologies.
- Evaluate and refine existing National Pollutant Discharge Elimination System (NPDES) water treatment plant permitting strategies.
- Achieve meaningful results in a timely manner.

3.2 Scope of this Report

This report represents the results of the Water Treatment Plant Workgroup's assessment of existing programmatic processes for all such projects. However,

[1] Throughout this document, the term 'potable water by-product' is used to refer to the wastewater generated from water treatment plants.

the technical and environmental evaluations were limited to membrane technology, iron and manganese removal (oxidation and filtration), and sodium cycle ionic exchange water treatment processes often used by public utilities (See Appendix B – Water Treatment in North Carolina).

Recognizing that this report covers a wide subject matter, the report is structured in a modular format that allows the reader to focus on the sections pertaining to a particular project. The report focuses on the recommendations of the Workgroup, with supporting information, assessments of existing programmatic processes, and study results presented in the appendices.

This report details the recommendations for the programmatic processes associated with approval of water treatment plant projects; siting criteria; and NPDES permitting strategies for sodium cycle cationic exchange and reverse osmosis water treatment systems. In addition, the appendices of this report present the Workgroup's evaluation of existing permitting policies; an overview of water treatment in North Carolina; the disposal alternatives and the Workgroup's evaluation of reverse osmosis and sodium cycle cationic exchange water treatment systems.

The assessments and recommendations detailed in this report are not intended to be extrapolated to all water treatment plants. Instead, the recommendations are intended to apply only to those facilities using the referenced technologies. Future initiatives are recommended to address other technologies used in North Carolina.

4.0 Recommendations

4.1 Programmatic Process Recommendations

After a review of several different options for modifying the permitting and SEPA processes to improve initial communications (see Appendix A, Permitting Process Evaluation), the Workgroup recommends a tiered notification approach that relies on the permit coordination expertise of the Customer Service Center. Recommendations for programmatic process improvement for water treatment plant projects are provided below.

The notification process, as illustrated in Figure 4-1, is initiated when a new or expanding potential water treatment plant project is first presented to a permitting agency or the Customer Service Center. When an agency is first contacted, it is the responsibility of that agency to notify the applicant that water treatment plant projects are coordinated through the Customer Service Center, provide the appropriate Customer Service Center contact, and notify the Customer Service Center permit coordinator. Required project details are general at this phase, but must include the following:

1) Applicant contact information (name, address, phone number, and email address).
2) Project location (including proposed site and discharge (if applicable) locations).
3) The proposed design flow rate for the facility (including design flow rates for finished potable water and potable water by-product).
4) The type of treatment process proposed for the plant (i.e. reverse osmosis, pressure filter followed by cationic exchange, etc.).
5) Proposed water source (i.e. Castle Hayne aquifer for a groundwater source or Catawba River for a surface water source).
6) The status of the proposed project (i.e. has site been purchased, status of any permitting requirements, have easements been obtained, etc.).
7) Project schedule.

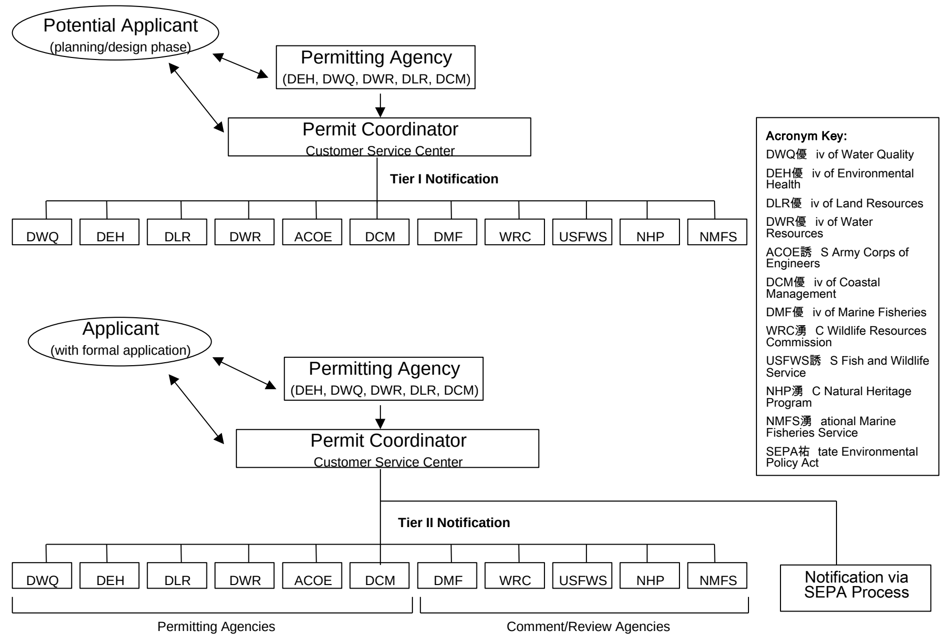
Once the Customer Service Center is contacted, the Customer Service Center will distribute a notice summarizing the proposed project via email to the appropriate agency contacts (see Appendix G for the Agency Contact List).

The Tier I notification should be initiated for new or expanding water treatment plant projects, regardless of the type of treatment proposed or the stage of the project upon initial contact by the project applicant. Following the Tier I notification, each agency will determine its level of involvement based on potential permitting and/or environmental impact concerns.

Tier II notification is initiated when a significant development in the process has occurred (i.e., a permit application has been filed or Environmental Assessment has been submitted). The Customer Service Center's role will follow the same process as in the Tier I notification. Throughout the process, the Customer Service Center will coordinate communication with the agencies and the applicant. Additional notifications by the Customer Service Center permit coordinator may be necessary to update agency representatives of important developments (e.g., permit applications received/approved by a Division) or to coordinate meetings. Again, these various tiers of notification will include only a summary of developments and agency involvement is discretional (e.g., requests for additional details/review materials, development of review comments, participation in meetings, etc.). The notification process for each water treatment plant project concludes once all applicable permits are issued.

Figure 4-1. Water Treatment Plant Notification Flowchart.

Water Treatment Plant Notification Process



4.2 Water Treatment Plant Siting Criteria

To aid planners, consultants and municipalities, the Workgroup developed general guidelines for use when considering siting for water treatment plant projects. The following sections discuss the factors to consider when siting a water treatment plant.

4.2.1 Water Supply and Demand

The selection of the source should include considerations for the following:

- Economic analysis on the site location relative to the location of the distribution system, water source, and disposal alternative.
- Safe yield of the source
- Quality of the source water
- Collection requirements (intake structure, wells, etc.)
- Treatment requirements (including cost and feasibility of residue disposal)
- Transmission and distribution requirements (deliver water to where it's needed)
- Potable water byproduct discharge requirements (see Section 4.2.2)

Considerations also include the ability to deliver both the quality and quantity of water needed continuously. Evaluation of alternative sources includes the cost of treatment, collection and distribution to the consumers, as well as the cost and effects of the water treatment residuals disposal.

These sources must have adequate flow and yield to meet the anticipated demands of the water users. Changes in the source may affect future water system expansion.

Water supply wells should be located in areas protected from existing or potential sources of contamination with minimum separation distances applicable to the contaminant risk. Wells should be separated in order to assure that operations do not adversely affect each other. Additionally, the well should be protected from flooding or standing water on the site. Design and construction standards have been established to protect the groundwater from surface contamination and to insure the integrity for each well. Water quality analyses are required for each new well.

Water from aquifers in eastern North Carolina generally has excellent quality and is highly sought for potable, industrial, and agricultural use. The demand for groundwater has contributed to declining water tables in recent years, especially in the central coastal plains, and the recent designation of a "capacity use area". This designation may restrict the use of existing and future withdrawals for many of our public water systems, ultimately affecting economic growth and development. Several public utilities are beginning to consider alternate sources of water supply, including surface water or ground water from different aquifers, often with water quality that will require significant treatment.

4.2.2 Wastewater Disposal

Historically, disposal of potable water by-product has been a secondary consideration when planning to site a water treatment plant. It is clear from the issues raised by the Workgroup, that the disposal of potable water by-product should be elevated to a primary consideration when planning to site a water treatment plant.

When deciding on an appropriate location for surface water disposal of potable water by-product, the facility should consider the following:

- Receiving waters and effluent characteristics
- Dilution and mixing in the receiving stream
- Aquatic and terrestrial resources
- Outfall design

Adequate siting of a proposed discharge cannot be achieved without an evaluation of the quantity and quality of the source water, wastewater and ambient water quality. This analysis should include a characterization of predominant tidal conditions (lunar and wind), and the dynamics of the proposed receiving waters under low flow conditions (i.e. 7Q10 flow).

When evaluating receiving stream characteristics, compare the characteristics of the discharge (i.e., salinity, temperature, etc.) to the water quality of the proposed receiving stream. Background water quality data may be requested from the Division of Water Quality, United States Geological Survey, Wildlife Resources Commission, and the Division of Marine Fisheries to aid the facility in evaluating the ambient water quality. The Workgroup recommends locating the discharge in areas where the potential for impacts is minimized. Such areas might be where effluent characteristics are similar to existing ambient ranges.

When selecting an appropriate site, an evaluation should be made regarding the possible effects of the proposed facility on aquatic and terrestrial resources. This assessment should consider potential impacts to federal and state-listed threatened and endangered species; protected areas (such as National Wildlife Refuges and Wilderness Areas, National Estuarine Research Reserves, National Parks and Seashores, and State Parks and Gamelands), outstanding resource and nutrient sensitive waters; surface waters classified as public drinking water supplies, etc. Additionally, potential impacts to sensitive environments such as submerged aquatic vegetation beds, intertidal and freshwater marshes, breeding, spawning, and nursery areas (including estuarine nursery areas, anadromous fish spawning areas, shellfish beds, and colonial waterbird nesting areas) should be considered.

The study conducted by the Workgroup has shown that the discharges from ion exchange and reverse osmosis water treatment plants exhibit toxicity. Toxicity concerns coupled with the limitations on suitable treatment technologies for some of the pollutants of concern dictate that all reasonable efforts must be made to find a discharge point that maximizes dilution under low flow conditions. The discharge point, water depth, surrounding bottom contours, and shoreline features all should be considered.

A cost evaluation of discharge options and dilution should be included along with a discussion of the design locations of the source wells, and the treatment plant as it pertains to the chosen discharge point. This cost evaluation should be included in both the Environmental Assessment (if applicable) and the Engineering Alternatives Analysis (required to be provided with the application for a NPDES permit).

The Workgroup is not recommending a moratorium on the freshwater discharge of potable water by product from membrane and cationic exchange water treatment plants at this time. However, freshwater disposal options are extremely limited and although a moratorium has not been proposed, freshwater disposal is discouraged.

4.3 Recommended NPDES Permitting Strategies for Membrane and Sodium Cycle Cationic Exchange Water Treatment Plants

Background

The Division of Water Quality developed and implemented a water treatment plant permitting strategy in 1992, which applied to all water treatment plant discharges regardless of the technology implemented. The Division of Water Quality recognized that this strategy may not be appropriate for membrane technology water treatment plants and initiated a survey of membrane water plants. After the investigation, several issues surfaced that resulted in the Division of Water Quality establishing a permitting strategy for water treatment plants using membrane technology in 1999.

The Workgroup established a technical review subcommittee comprised of members of the Water Treatment Plant Workgroup. The subcommittee first identified the environmental concerns, and then conducted an analytical study, data review, and analysis of several existing membrane water treatment plants in North Carolina. Based on the results of this analysis (see Section 7.3.1), the Workgroup recommends that the following permitting strategy be adopted by the Division of Water Quality for all water treatment plants requesting a new or expanded NPDES discharge permit.

NPDES Permitting Strategy for Membrane Water Treatment Plants

Applicability

This permitting strategy is designed for new water treatment plant projects using membrane technology. This strategy reflects the Workgroup's recommendation that by-product discharge from these systems not be permitted into freshwaters unless it can be shown that the impacts would be minimal or the most environmentally sound of the alternatives.

Permit Development

The parameters identified in Table 4-2 include those pollutants that the Workgroup identified as being present in membrane water treatment plants.

Because of the potential variability associated with these discharges, each permit should be developed based on analytical and other information provided in the permit application. The parameters listed in Table 4-2 require monitoring and/or limits as appropriate (see below). Other pollutants may be identified in the permit application and they should be evaluated to determine the need for monitoring in the permit.

Table 4-2. Potential Water Quality Permit Monitoring Parameters for Membrane Water Treatment Plants.

Water Quality Parameters	
Conventional Parameters	
Flow	pH
Temperature	Oxygen, Dissolved
Alkalinity (as CaCO3)	Salinity
Solids, Total Dissolved	
Toxicants	
Arsenic	Iron
Calcium	Manganese
Chloride	Sulfide, Hydrogen
Fluoride	Zinc
Nutrients	
Ammonia as Nitrogen (NH3-N)	Orthophosphate (PO4-P)
Total Kjeldahl Nitrogen	Total Phosphorus (TP)
Whole Effluent Toxicity	
Acute Pass/Fail at 90% (monitor)	
Biological Monitoring	
Macroinvertebrate Community	
Instream Monitoring	
Dissolved Oxygen	Temperature
Salinity	pH
Conductivity	

Conventional Parameters -Conventional parameters include flow, temperature, alkalinity, salinity, total dissolved solids, pH, and dissolved oxygen. Flow should be limited based on the design reject capacity of the facility. For saltwater classifications, pH should be limited to maximum of 8.5 and minimum of 6.8 (standard units).

Because of the low dissolved oxygen concentrations observed in the effluent from the facilities evaluated, dissolved oxygen monitoring of the effluent is required.

If the facility can demonstrate (over a two year period) that the discharge is not significantly affecting temperature and dissolved oxygen in the receiving stream, the facility may petition the Division to reduce/eliminate either or both the temperature and dissolved oxygen monitoring requirements.

Toxicants - These parameters shall be evaluated and if appropriate limits/monitoring implemented into the permit. The permitting authority should evaluate the information contained in the application. If data indicates the presence of the pollutant in the source water, then the permit writer should evaluate the maximum predicted effluent concentration using "reasonable potential" procedures and a mass balance approach. For tidally influenced water, the permit writer should use the model results in determining an appropriate dilution factor for use in the mass balance. The results of this analysis will determine the need for a limit/monitoring requirement. Where more than one water source is proposed, the data should be combined and collectively used in the evaluation of the maximum predicted concentration.

Note, if source water data are used, the applicant/consultant and the regulatory agency will need to predict an effluent concentration using a mass balance analysis taking into account the design flow rates and design reject ratios.

Nutrients/ammonia - Based on information contained in the permit application, a mass balance approach should be followed to determine if limits for nutrients are appropriate. Similarly, a mass balance approach should be followed to determine the need for ammonia limitations/monitoring.

Whole Effluent Toxicity (WET) Test - The WET test is a measure of overall toxicity of the discharge using a representative indicator organism. The results of the study conducted on toxicity indicate that two of the three plants evaluated exhibited non-chloride related acute toxicity. Time constraints prohibited the evaluation of the toxicity source. Because of the potential toxic effects, the Workgroup recommends that all membrane technology water treatment plants monitor the discharge for toxicity. Discharges to saltwater will receive an acute toxicity limit of Mysid shrimp at 90% effluent. If the facility can demonstrate two years (eight tests on a quarterly basis) of no acute toxicity, the facility may petition for removal of the toxicity limit and monitoring requirement. However, if a facility's toxicity monitoring demonstrates significant failures, the facility will have the option of accepting an acute limit at the end of pipe or a chronic limit at the edge of the mixing zone.

Biological Monitoring - After initiation of the discharge activity, the facility should evaluate the macro-invertebrate community. This evaluation should be conducted during the second year after initiation of the discharging activity. Before conducting the biological monitoring, the applicant should submit a proposed sampling plan to the Division of Water Quality for approval. Results of this evaluation should be reported to the Division of Water Quality. If biological monitoring indicates no significant impacts attributable to the discharge, then additional monitoring is not required.

If impacts are observed, then the facility will be required to submit an additional report to the Division of Water Quality evaluating treatment options. The Division of Water Quality should notify the permittee in writing of this reporting requirement and stipulate a period for completion of the report. In addition to evaluating treatment options, the report should evaluate potential funding sources and propose a schedule for completion of the project. During the second year after completion of the project, the facility will be required to conduct another biological assessment using the same procedures as previously outlined.

Instream Monitoring - After initiation of the discharging activity, facilities will be required to monitor the parameters listed in Table 4-2 under Instream Monitoring.

Monitoring Frequency and Sample Type

Although variability may occur both between plants and within a particular facility, the Workgroup felt that grab samples were adequate to characterize the effluent. Variability within a facility can occur because of differences in characteristics from well to well or changes in characteristics over long periods. The consistency in the individual source water and treatment process overtime suggest that grab samples are appropriate.

Monitoring frequency recommendations are based on the size of the facility. New facilities will initially monitor for the pollutants of concern at the frequencies outlined in Table 4-3.

After sufficient data have been collected (eight to 12 data points over a period greater than one year), the permittee may petition for a reduction of monitoring.

Additives/Significant Changes

The only additives that may be introduced prior to permanent separation of the product water and the reject stream are acids to reduce deposits and corrosion inhibitors.

Prior to implementing any changes that may alter the characteristic or nature of the discharge (including flow), the facility shall obtain prior approval, and if appropriate, request modification of the NPDES Permit. An example of a significant change would be the addition of a new well.

Waters classified as SA (suitable for shellfishing)

SA waters are defined as High Quality Waters. Draft permits proposing a discharge to SA waters must be sent to Shellfish Sanitation for review. Since SA waters are considered High Quality Waters by definition, permit limits shall be calculated at 1/2 the water quality standard. In addition, "reasonable potential" analysis shall be conducted using 1/2 the water quality standard.

Table 4-3. Suggested Monitoring Frequencies for Membrane Water Treatment Plants.

Permitted Discharge Rate (Q_p) (MGD)	**Monitoring Frequency**
Monitoring Frequencies for Conventional Parameters (except Flow[1])	
Qp < 0.5 0.5 ≤ Qp < 1.0 Qp ≥ 1.0	Monthly 2/Month Weekly
Monitoring Frequencies for Toxicants	
Qp < 0.5	Monthly
0.5 ≤ Qp < 1.0	If limited - 2/Month Monitor only – Monthly
Qp ≥ 1.0	If limited – Weekly Monitor only – Monthly
Monitoring Frequencies for Whole Effluent Toxicity	
Qp < 0.5 0.5 ≤ Qp < 1.0 Qp ≥ 1.0	Quarterly Quarterly Quarterly
Monitoring Frequencies for Biological Monitoring	
Qp < 0.5 0.5 ≤ Qp < 1.0 Qp ≥ 1.0	Two[2] Two[2] Two[2]
1. If discharge is continuous, then continuous recording monitoring is required If discharge is intermittent, then instantaneous flow monitoring is required. For instantaneous flow monitoring, the duration of the discharge must be reported. 2. Biological monitoring should be conducted once prior to initiation of the discharge and once during the first permitting cycle, assuming the facility has started discharging (see text).	

NPDES Permitting Strategy for Sodium Cycle Cationic Exchange Water Treatment Plants

Applicability

This permitting strategy is designed for new water treatment plant projects utilizing ion exchange as a primary or secondary component of the treatment system. This includes treatment units commonly known as water softeners. This strategy reflects the Workgroup's recommendation that by-product discharge from these systems not be permitted into freshwaters unless it can be shown that the environmental impacts would be minimal.

Permit Development

The parameters identified in Table 4-4 include those pollutants that the Workgroup identified as being present in membrane water treatment plants.

Because of the potential variability associated with these discharges, each permit should be developed based on analytical and other information provided in the permit application. The parameters listed in Table 4-4 require monitoring and/or limits as appropriate (see below). Other pollutants may be identified in the permit application and they should be evaluated to determine the need for monitoring in the permit.

Table 4-4. Potential Water Quality Permit Monitoring Parameters for Sodium Cycle Cationic Exchange water treatment plants.

Water Quality Parameters	
Conventional Parameters	
Flow	pH
Temperature	Salinity
Solids, Total Dissolved	
Toxicants	
Aluminum	Iron
Calcium	Lead
Chloride	Manganese
Chlorine (Total Residual)	Sulfide, Hydrogen
Copper	Zinc
Whole Effluent Toxicity	
Acute Pass/Fail at 90% (monitor)	
Biological Monitoring	
Macro Invertebrate Community	

Conventional Parameters - Conventional parameters include flow, temperature, and pH. Flow shall be limited based on the design regeneration waste stream flow rate unless additional treatment units (e.g., filter backwash) are provided. For intermittent discharges, the NPDES permit should contain provisions for monitoring the instantaneous maximum flow rate from the facility. For saltwater classifications, pH should be limited to maximum of 8.5 and minimum of 6.0 (standard units) and for freshwater classifications the pH should be limited to a maximum of 9.0 and a minimum of 6.0.

If the facility can demonstrate (over a two-year period) that the discharge is not significantly impacting temperature in the receiving stream, the facility may petition the Division to reduce/eliminate the temperature monitoring requirements.

Toxicants – Extensive information is required to predict effluent concentrations. If data indicates the presence of a pollutant in the source water, then the applicant is required to predict the effluent characteristics in the application. These predictions should be based on the best available information and should reflect volumetric flow between regeneration cycles, volumetric flow used in regeneration cycle, concentration of pollutant in source water, predicted removal efficiencies, and other factors that may affect effluent quality. Based on this evaluation, the regulatory agency will evaluate each parameter and if appropriate, limits/monitoring will be included in the permit. Where more than one water source is proposed, the data should be combined and the maximum reported concentration should be used in the analysis.

In addition to the toxic effects identified in the regeneration wastewater, the study revealed significant toxicity associated with filter backwash water. The primary suspect is chlorine (see Table D-7). The toxicity exerted by chlorine may be masking toxicity from other sources. Chlorine is commonly added to potable water for microbial and viral control. The same properties that makes chlorine effective in control of microorganisms and viruses makes it potentially problematic in the receiving stream. Therefore, if a water treatment plant discharges filter backwash water and uses potable water in the backwash process, the facility discharge should be limited for chlorine at 28 μg/L as a daily maximum. **It is the intent of the Workgroup that this recommendation apply not only to ion exchange systems, but to any water treatment plant (including existing systems) that discharges filter backwash water.**

Whole Effluent Toxicity (WET) Test - The WET test is a measure of overall toxicity of the discharge using a representative indicator organism. The results of the study conducted on toxicity indicated that the regeneration waste stream exhibits significant toxicity. While chloride is the primary suspect, the extremely high levels of chlorine may be masking the toxic effects of other pollutants. Because of time constraints, a complete evaluation of the toxicity source was not possible.

Because of the potential toxicity, the Workgroup recommends that ion exchange water treatment plants monitor the discharge for whole effluent toxicity (toxicity requirements are presented in Table 4-5). For discharges to saltwater, if the facility can demonstrate no acute toxicity over a two-year period (eight tests on a quarterly basis), the facility may petition for removal of the toxicity monitoring requirement. However, if a facility's toxicity monitoring demonstrates significant failures, the facility will be given the option of accepting an acute limit at the end of pipe or a chronic limit at the edge of the mixing zone.

Table 4-5. Toxicity Testing Requirements for New Sodium Cycle Cationic Exchange Water Treatment Plants.

Toxicity Test Description	Receiving Stream Classification	
	Freshwater Classification	**Saltwater Classification**
Pass/Fail Acute Toxicity Test	Intermittent discharge with a discharge frequency of greater than once every two weeks. Test organism: Fathead Minnow	All discharges. Test organism: *Mysidopsis bahia*
Pass/Fail Chronic Toxicity Test	Other discharges not referenced above. Test organism: *Ceriodaphnia Dubia*	Not applicable

Biological Monitoring -- Before and after initiation of the discharge activity, the facility should evaluate the macro-invertebrate community. This evaluation should be conducted no sooner than one year after the start of the discharging activity and prior to the submittal of the application for renewal of the permit. If biological monitoring indicates no significant impacts attributable to the discharge, then additional monitoring is not required.

If impacts are observed, then the facility will be required to submit a report to the Division of Water Quality evaluating treatment options. The Division of Water Quality shall notify the permittee in writing of this requirement and stipulate a time frame for completion of the report. In addition to evaluating treatment options, the report should evaluate potential funding sources and propose a schedule for completion of the project.

Monitoring Frequency and Sample Type

Over the course of the regeneration cycle, the effluent characteristics can experience significant variability. Composite samples should be collected for all parameters except flow, total residual chlorine, temperature, and pH.

Monitoring frequencies are based on facility size. New facilities will initially monitor for the pollutants of concerns at the frequencies outlined in Table 4-6.

After sufficient data has been collected (eight to 12 data points over a period greater than one year), the permittee may petition for a reduction of monitoring.

To determine whether a reduction of monitoring is warranted, the permitting authority conducts a "reasonable potential" analysis. Modification of the monitoring frequencies is allowed if the effluent demonstrates that no "reasonable potential" exist.

Table 4-6. Suggested Monitoring Frequencies for Sodium Cycle Cationic Exchange Water Treatment Plants.

Permitted Discharge Rate (Q_p) (MGD)	**Monitoring Frequency[1]**
Monitoring Frequencies for Conventional Parameters (except Flow[2])	
Qp < 0.5 0.5 ≤ Qp < 1.0 Qp ≥ 1.0	Monthly 2/Month Weekly
Monitoring Frequencies for Toxicants	
Qp < 0.5 0.5 ≤ Qp < 1.0 Qp ≥ 1.0	Monthly If limited - 2/Month Monitor only - Monthly If limited - Weekly Monitor only - Monthly
Monitoring Frequencies for Whole Effluent Toxicity	
Qp < 0.5 0.5 ≤ Qp < 1.0 Qp ≥ 1.0	Quarterly Quarterly Quarterly
Monitoring Frequencies for Biological Monitoring	
Qp < 0.5 0.5 ≤ Qp < 1.0 Qp ≥ 1.0	None Two[3] Two[3]
1. Sampling should be conducted during a discharge event. 2. If discharge is continuous, then continuous recording monitoring is required If discharge is intermittent, then instantaneous flow monitoring is required. For instantaneous flow monitoring, the duration of the discharge must be reported. 3. Biological monitoring should be conducted once prior to initiation of the discharge and once during the first permitting cycle, assuming the facility has started discharging (see text).	

Additives/Significant Changes

The only additives that may be introduced prior to *permanent* separation of the product water and the reject stream are acids to reduce deposits and corrosion inhibitors.

Before implementing any design or operational modifications that may alter the characteristic or nature of the discharge (including flow), the facility shall obtain prior approval and, if appropriate, request modification to the NPDES Permit. An example of a significant change would be the addition of new well.

Waters Classified as SA (Suitable for shellfishing)

SA waters are defined as High Quality Waters. Draft permits proposing a discharge to SA waters must be sent to Shellfish Sanitation for review. Since SA waters are considered High Quality Waters by definition, permit limits shall be calculated at 1/2 the water quality standard. In addition, "reasonable potential" analysis shall be conducted using 1/2 the water quality standard.

5.0 Future Initiatives

In the future, the notification process previously discussed could be enhanced with internet support tools, an online agency contact list could be maintained to facilitate interagency coordination and applicant correspondence with agency representatives. An online project tracking system could be maintained by the Customer Service Center. The workgroup agreed that such a system should not replace routine notification via electronic mail as it is essential to promote agency involvement early in the permitting process.

The reverse osmosis study conducted for this report answered some major questions concerning these discharges. Additional work is required to identify the other source(s) of toxicity.

Additional studies on membrane and ion exchange systems are needed to address the sources of toxicity, assess the variability between plants, and evaluate the environmental impacts. Time and resource constraints prevented the Workgroup from addressing these significant issues in this report. Faced with questions that the Workgroup could not answer with the available information, the Workgroup made conservative recommendations designed to protect North Carolina’s resources. One of the major questions was what impact these facilities were having on the environment. The Workgroup recommends further study to assess the direct and cumulative impacts of water treatment plant discharges on the physical, chemical, and biological characteristics of freshwater and estuarine systems. Some impacts may be extremely site specific depending on the characteristics of the receiving waters and discharge. Information needs and issues/concerns that demand further study are out lined in Appendix F.

The Department should continue to work with professional organizations to publicize concerns and investigate opportunities for enhancing the scientific and engineering communities’ understanding of these systems and their impact on the environment. The Department should also develop an information package and presentation (from pertinent sections of this report) and make this package available to Customer Service Center for distribution to potential applicants, planners, consultants, water authorities, and engineer councils.

The Department should solicit the assistance of Water Resources Research Institute (WRRI) and NC Sea Grant to publicize concerns and information needs associated with water treatment plant discharges and develop a Request for Proposals (RFP) for the next funding cycle. Specific areas of need should be identified (i.e., effects of the discharges on the osmotic balances of local resident and anadromous organisms, including fish larvae).

The recommendations presented in this report focus on new water treatment plant projects using ion exchange systems and reverse osmosis systems. The Workgroup recommends additional investigation into the management of existing facilities (i.e., establish a DWQ committee to formulate a strategy to deal with existing water treatment plants).

The study on ion exchange water treatment plants revealed significant toxicity associated with filter backwash water. The Workgroup recommends a continued effort to evaluate and make recommendations for all surface water discharge plants. In the interim, the Workgroup recommends total residual chlorine limits for filter backwash wastewater.

The Workgroup recognizes that this study raises additional issues and questions. The permitting strategies suggested here are designed to provide adequate information to agencies evaluating proposed discharges until further studies can be conducted. For example, the Workgroup was unable to determine the instream conditions that would cause adverse effects and would recommend additional studies designed to address this issue.

The Workgroup recognizes that surface water discharge of potable water by product may not be a viable option for some communities across North Carolina; therefore, the Workgroup recommends a continued effort of evaluating treatment technologies and disposal/reuse options.

Appendices

Appendix A – Permitting Process Evaluation

Current Approach
Currently, within the Department of Environment and Natural Resources, a proposed water treatment plant project planner must consider the potential applicability of a minimum of 13 permits; submittal of two plans; registration of water withdrawals; reclassification of the waterbody; and the State Environmental Policy Act (SEPA).

Another important finding that influenced the recommendations of the Workgroup was that no single agency was consistently the first agency notified of new proposals. However, one of the *permitting* agencies (Division of Environmental Health, Division of Water Quality, Division of Coastal Management, Division of Water Resources) is routinely the initial contact for new proposals.

A description of the potential permit requirements for the NC DENR is contained in Appendix G. This summary reflects the permitting requirements within the Department of Environment and Natural Resources. Other permits or authorizations may be required by other Federal, State, or Local Agencies.

Process Improvements Considered

Process improvements were deemed necessary in order to meet the Water Treatment Plant Workgroup objectives for prompt and effective communication between interested agencies, regulated communities' better understanding of environmental permitting requirements, and reduction of agency resources required to implement and maintain process improvements. These objectives were set forth in order to establish an improved framework for coordination and communication between permitting and commenting agencies. The notification process improvements allow agencies to review proposed projects and provide technical assistance regarding potential environmental impacts during the pre-application phase of the permitting process.

The Water Treatment Plant Workgroup evaluated several approaches for improving flexibility, timely notification, and interagency coordination in the permitting process. One approach evaluated involved modifying the minimum requirements that would subject a project to SEPA, so that more projects would fall under the SEPA review process. Ultimately, this approach was not selected because:

- Current processes within Division of Coastal Management and Division of Environmental Health do not preclude these agencies from accepting and partially processing the applications (Note: No permits are issued without the Finding Of No Significant Impact, FONSI) even though a FONSI has not been issued.

(Note: No permits are issued without the Finding Of No Significant Impact, FONSI)

- This approach would require changes to North Carolina's Administrative Code that would require significant investments in both time and resources.

Another approach evaluated allowed various permitting processes to occur simultaneously (e.g., Division of Water Quality NPDES permit application concurrent with Division of Environmental Health Water Treatment Plant plan review process) while withholding the final Authorization-to-Construct permit pending resolution of the different agencies concerns. While this approach improves the overall permitting efficiency, it provides a mechanism for projects to gain significant momentum, making it difficult for non-regulatory agencies to effect change.

Finally, the Workgroup considered and is recommending use of the NC DENR Customer Service Center to provide early notification for permitting and resource agencies and assisting applicants. The Workgroup found that an efficient and coordinated notification effort is best achieved through the Customer Service Center. The Customer Service Center would act in a permit coordination role (analogous to the one-stop permit assistance program currently managed by the Customer Service Center). The Customer Service Center would notify agency representatives, assist the applicant in identifying common environmental concerns, assist in determining the required environmental permits, and coordinate pre-application meetings (if necessary). The Customer Service Center also will coordinate communication with the applicant and the agencies to inform all parties of progress in the permitting process. The flowchart in Figure 4-1 illustrates the permit coordination role of the Customer Service Center.

To aid the Customer Service Center with the interagency notification process, the Workgroup developed a contact list approach. Several aspects of the notification process were included to assure its usefulness for all parties. The Workgroup noted that agency notification of a project is crucial to assuring early and meaningful input and coordination between various agencies. An additional benefit is to make the permittee aware of potential problem areas, concerns, data needs, and resources early in the initial planning stages of a project. The Workgroup, in consultation with the Customer Service Center, developed a list of agencies with contacts. The Customer Service Center will notify identified agency contacts upon first knowledge of a proposed water treatment plant project. The contact list emphasizes notification of concerned agencies while not making the process more cumbersome than the existing processes. A complete list of agency contacts and representatives (both in central office and at the regional offices for the Division of Water Quality and the Division of Environmental Health) is provided in Appendix G. A scoping meeting may be appropriate to convey agency information and concerns to the permittee.

Appendix B – Water Treatment in North Carolina

Generally, our drinking water comes from two sources. Rivers, streams and lakes provide "surface" water, while "groundwater" is available from water bearing soils and fractures in rocks beneath the surface of the earth. Regardless of the source of water, treatment is required in order to provide a safe water supply to the public.

Across North Carolina, there is considerable variability in the combinations of treatment technologies and chemical use associated with water treatment. This section outlines some of the more common technologies.

Surface Water

Surface water sources often experience rapid changes in water quality due to heavy rains and runoff, requiring flexible and reliable treatment processes and close operator attention. These sources are more susceptible to accidental spills and contamination that may affect water quality and treatment. Lakes and reservoirs have seasonal changes in water quality, often resulting in tastes and odors and occasionally resulting in increased levels of iron and manganese. Surface water sources usually are selected to provide a larger quantity at a single location and always require treatment.

The NC DENR Division of Water Quality established water quality standards and primary classifications for all surface waters in the state, that define the best uses to be protected within these waters (ex. aquatic life, primary recreation including organized swimming, shellfish harvesting, and drinking water supply). The Division of Environmental Health requires that surface water sources for potable water be classified "Water Supply" (WS) and receive appropriate treatment for removal of dissolved and suspended matter, as well as inactivation of microbiological contaminants.

Typically, treatment for surface water sources follows a "multi-barrier" strategy that includes:

i. Select the best source available (and protect that source),
ii. Add coagulant for improved flocculation and sedimentation,
iii. Remove particulates through filtration,
iv. Provide disinfection and contact time for microbiological inactivation.

Treatment chemicals may include ozone or potassium permanganate for oxidation; polymers, aluminum and/or ferric compounds for coagulation; acids or alkali for pH adjustment; phosphates or silicates for stabilization and corrosion control; fluoride for the control of dental caries; and one of the chlorine compounds for disinfection. Finished water quality is monitored closely, with stringent performance standards for turbidity and minimum disinfectant residuals to help control coliform organisms. Additional water quality standards are applicable for radiological, inorganic and organic chemicals, lead and copper and disinfection by-products.

The sediment and sludge, as well as filter backwash from surface water treatment facilities are considered process by-products and require additional treatment, often through settling, thickening, centrifuge, sand filters, etc. with the supernatant discharged to a sanitary sewer or receiving stream. Due to concerns of re-introducing contaminants into the treatment stream, recycling of the treated supernatant is limited to ten percent (10%) of the raw water flow and should be added during the earliest phase of the water treatment process.

Groundwater

Groundwater is relatively constant in quality from season to season, and often is satisfactory for potable use with minimal disinfection. The quality may be highly variable from one well location to another, depending on the hydrogeological conditions and well construction. The cost of determining available quantity and quality of groundwater is often expensive, as it requires construction of several test wells in the area. Additionally, individual pumps are generally required for each well, whether they pump to a common treatment or storage facility or directly into the water distribution system. Groundwater quality is usually better than surface water with respect to turbidity, microbiological contamination, and total organic concentrations; however, the mineral content may be higher and require specific treatment. Particular concern should be focused on the trace amounts of organic chemicals (pesticides, herbicides and solvents, etc.) that may be contributed by abandoned landfills, storage tanks or special use property or other land uses that may affect groundwater quality.

Treatment technology is available for nearly every quality of groundwater, but the expense of developing, operating, and maintaining these processes may be considerable. Groundwater treatment is often determined by the source water quality and, if a utility is fortunate, only a disinfectant (usually one of the chlorine compounds) will be needed. Public health & safety issues, regulatory standards, aesthetic concerns, and industrial needs may dictate the treatment selection. Several common potable water quality concerns and available treatment options are summarized as follows:

- pH
  - Low pH leads to corrosion of fixtures and plumbing
  - Control measures
    - Calcifiers, or Soda Ash, Lime or Sodium Hydroxide chemical feed systems raise pH
- Iron
  - Stains fixtures, clothes, buildings, walkways, etc.
  - "Metallic" or bitter taste

- Control Measures
  - Pressure filters with sand, greensand or synthetic media
  - Cartridge filters on smaller systems
  - Cation exchange units (NaZeolite)
  - Polyphosphates (sequestering agents - effective up to about 1 mg/l total iron)

  Note: Determine if iron is soluble before selecting treatment

- Hardness
  - Caused by dissolved calcium or magnesium (not manganese!)
  - Affects taste and appearance of beverages, reduces efficiency of soaps and laundry detergents
  - Control measures
    - Cation exchange (NaZeolite)
    - Lime softeners (Calcium precipitation onto catalyst surface)
    - Lime and alum coagulation
    - Nanofiltration

Membrane Technology Water Treatment

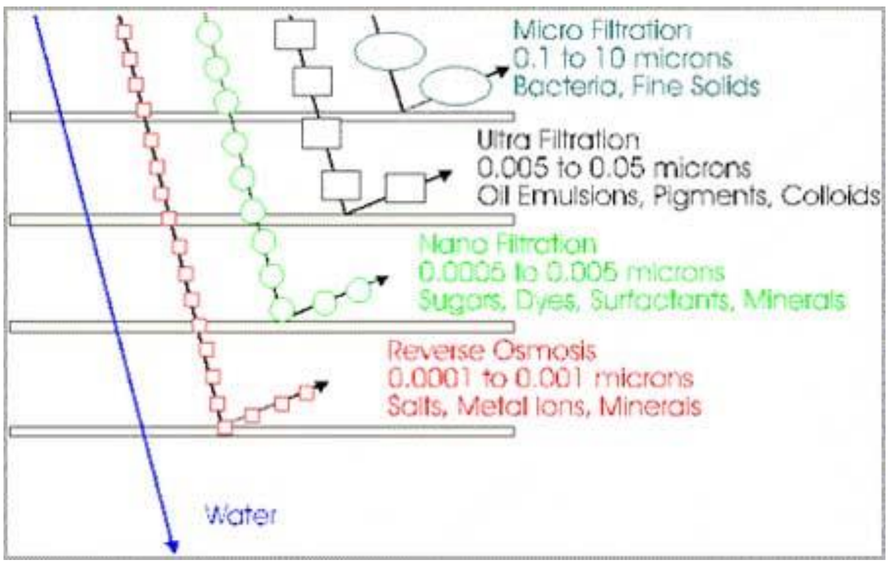
Membrane processes for water treatment include many different alternatives, including reverse osmosis (RO), electrodialysis (ED), electrodialysis reversal (EDR), nanofiltration (NF), ultrafiltration (UF), and microfiltration (MF). The RO and ED/EDR processes are actively used in the municipal water treatment field primarily for desalting or brackish water conversion. UF, MF and NF are emerging technologies for removing particulates, color, trihalomethane (THM) precursors, and some inorganic chemicals (hardness). The common component among these processes is a membrane able to reject or select passage of certain dissolved species based on compound size, shape, and/or charge. (See Figure B - 1)

Membrane processes are usually considered in circumstances such as desalination, brackish water conversion, and for removal of specific ions that are difficult to remove with other processes. Membranes are also frequently evaluated for wastewater reuse applications to provide softening and removal of organics, radionuclides, heavy metals, bacteria, and viruses. ED/EDR systems are appropriate for brackish water conversion but do not provide barriers to other nonionic dissolved species. RO is appropriate for desalting seawater and brackish water and also provides an effective barrier to other dissolved organic and inorganic contaminants as well as bacteria and viruses. UF, MF and NF provide a similar but less effective contaminant barrier because of larger membrane pores.

Proper membrane selection and system configuration for RO, UF, MF and NF are critical and contributes to overall system performance. Pre-treatment for removal of suspended solids, pH adjustment and anti-scalant compounds are usually required to preserve the integrity of the system. Multiple membrane stages provide greater product water recovery and less brine generation when all other process performance factors remain constant. Higher salinity in the feed water requires greater operating pressure and also increases brine production for a given system.

The principal factors influencing the selection of membrane processes in water treatment are costs of construction and operation, the availability of practical options for waste brine disposal, alternative processes available to achieve desired product water quality, and the availability of alternative water supply sources requiring less sophisticated treatment.

Figure B-1. Membrane Filtration Spectrum.



Ref: "Water Quality & Treatment" 4th Edition, AWWA

Ion Exchange Water Treatment

Basic groundwater quality problems are typically associated with high hardness, iron and manganese, usually the result of mineral dissolution from the crust of the earth. Treatment schemes for such sources may include a number of processes, including ion exchange. Ion exchange offers advantages over lime softening for water with variable hardness concentrations and high non-carbonate hardness content. A typical ground water treatment schematic (as found in eastern NC), including ion exchange, is indicated as *Figure D-1.* Treatment to remove iron and manganese, if present in the source water, should precede ion exchange to reduce fouling of the resin. High organic content can also foul certain ion exchange resins.

The most common ion exchange softening resin is a sodium cation exchange (zeolite) resin that exchanges sodium for divalent cations. After the resin has reached its capacity for hardness removal, it is backwashed, regenerated with a sodium chloride solution, and rinsed with finished water. This places the resin back in the sodium form so that it can resume softening. A portion of the source water is typically by-passed around the softening vessel and blended with softened water. This provides calcium ions to help stabilize the finished water.

Anion exchange resins are also used to remove nitrates, sulfates and certain organic compounds that may also be found in groundwater. (Water Quality & Treatment 4th Edition, AWWA).

Appendix C – Disposal Alternatives

There are a variety of potential disposal alternatives for potable water by-product. Surface water discharge, deep well injection, and discharge to a wastewater treatment plant are three commonly used disposal methods. Though other methods of disposal are available, they are not widely implemented because of technical feasibility and economic considerations.

Land-Based Disposal Systems

This method of disposal involves distributing the effluent via a spray, drip, or other method onto or into the surface of the earth. The effluent is applied at rates that allow for percolation into the underlying soils for use by the cover crop. The use of effluents with high salinity may affect the soil properties and affect plant growth through reduced osmotic potential, toxicity of specific ions, swelling, porosity, water retention, and permeability. This results in soils that no longer support plant growth and/or percolation into the soil.

The high chloride and salinity levels present in the effluent from reverse osmosis and ion exchange system present a significant challenge. At this time, the characteristics of the effluent coupled with the available technology for land-based disposal systems make this alternative impractical.

Surface water discharge

Disposal of potable water by-product via surface water discharge has become increasingly more popular in recent years. Part of the reason for the popularity of surface water discharge is that it is comparatively less expensive both in capital and operational costs than other options. The relatively lower costs, along with the availability of surface water, make this alternative attractive to communities as they evaluate the disposal methods.

Prior to surface water discharge of potable water by-product, the facility must obtain a National Pollutant Discharge Elimination System (NPDES) permit. The NPDES program is a federal program administered by the United States Environmental Protection Agency (EPA). North Carolina's Department of Environment and Natural Resources has been authorized by the EPA to manage the NPDES program and is responsible for issuing NPDES permits for water treatment plant discharges.

The NPDES permits issued by the Division of Water Quality must protect the physical, chemical and biological integrity of the receiving water. This is accomplished through toxicity assessments and protection of water quality standards that are set based on the designated uses of the receiving stream. One of the main issues with potable water by-product discharges is toxicity. Potable water by-product discharges frequently fail both acute and chronic aquatic toxicity tests. The potential for toxicity represents a significant issue that is costly to address. The Workgroup initiated a substantial effort designed to assess this issue and this report contains its recommendations.

Deep Well Injection

This method of disposal involves introducing the potable water by-product into underground aquifers through injection wells. Though this method of disposal is used in other states, it is not permitted in North Carolina. In order for this option to become viable in North Carolina, consideration must be given to compatibility of the by-product quality to the injection zone, site-specific geological conditions, well design and construction and stringent design and operational conditions. The Workgroup did not pursue this option because of the deep well injection prohibition and continued opposition to this method of disposal.

Wastewater Treatment Facility

This is the preferred method of disposal and must be considered in the Engineering Alternatives Analysis required as part of the NPDES permit application. This method has the advantage of reducing the cost associated with studying, permitting, designing, constructing, and operating independent concentrate disposal systems. Note the publicly owned treatment facility has responsibility for maintaining pretreatment programs and must evaluate capacity and compatibility before permitting this method of disposal. The Workgroup recommends that new projects proposing this alternative follow the same programmatic permitting process outlined in this report. Other than recognizing that this is the preferred method of disposal, the Workgroup concentrated its efforts on disposal methods that are under the direct authority of the Department of Environment and Natural Resources.

Appendix D – Surface Water Disposal Assessment

Surface Water Disposal

Disposal of potable water by-product through surface water discharge is one of the more common methods of disposal in North Carolina. The increasing number of water treatment plants and the challenge of proper disposal of the residual by-product has resulted in the need to evaluate the environmental impacts and existing policies (Appendix H) associated with these discharges.

After identifying the concerns associated with surface water disposal of potable water by-product, the Technical Subcommittee grouped and summarized the concerns as follows:

- Impact of discharge on the ionic balance of the receiving water.
- Toxicity of discharge.
- Physical/Chemical characteristics of discharge.
- Environmental impacts associated with chemical usage at water treatment plants.
- Impacts of organics and metals potentially present in the discharge.
- Differences between the temperature of the discharge and the receiving stream temperature.
- Impact of discharge on receiving stream dissolved oxygen levels.
- Nutrient loading associated with discharge.
- Turbidity of discharge.
- Immediate and cumulative impacts of temperature and salinity/density stratification and the associated effects (i.e., hypoxia/anoxia, and chemical and physical processes in the ecosystem) on water quality and aquatic life.

These concerns were evaluated for three broad categories of water treatment plants: reverse osmosis, cationic exchange, and surface water plants. This section presents the findings and recommendations for two of the three categories, membrane technology and ion exchange.

Study Purpose

This study on water treatment plants is the first step in what the Workgroup hopes will be a continued effort of assessing all water treatment plant discharges in North Carolina. The goal of this study is to provide the information required to:

- Evaluate and identify toxicity associated with surface disposal of potable water by-product.
- Evaluate the validity of the concerns referenced above.
- For valid concerns, provide the Workgroup with information needed to develop recommendations on how to manage this discharge.

- Provide the Workgroup with the information needed to develop a defensible NPDES permitting strategy.
- Provide the Workgroup with the information needed to develop a strategy for future initiatives.

Membrane Water Treatment Plants

The membrane process takes raw water and produces two streams – the finished water and the concentrate or by-product water. Proper disposal of the by-product water represents a significant challenge and must be considered during every phase of a water treatment plant project (planning, siting, design, construction and operation).

In recent years, there has been an increasing trend in the number of water treatment plants using membrane technology especially in the coastal communities of North Carolina. This trend is likely to continue as communities' struggle with the need to provide adequate drinking water and suitable water supplies. As of May 2002, there were 10 NPDES permitted facilities in North Carolina with two additional facilities in the Environmental Assessment stage.

In order to aid planners and designers, and to provide a sound permitting approach, the Workgroup researched existing information and initiated an effluent quality study of water treatment plants using membrane technology. The Workgroup found that Florida and California had conducted similar evaluations (Appendix I). Although this information is not directly applicable to the brackish North Carolina ecosystems, it was extremely helpful in developing the methodology used in North Carolina's study.

The Workgroup gathered existing data and information on membrane water treatment plants. The information was segregated based on whether it represented technological or analytical data. In developing these recommendations, the Workgroup considered both the technical and analytical information.

Technological Information

The Workgroup relied on expertise within the group to assess the current state and range of water treatment technology and chemical usage across North Carolina. Similar to the Florida Department of Environmental Protection's findings, the variability in technology, chemical usage and raw water quality across North Carolina prevents the use of source water as the sole indicator of potential impacts from concentrate.

Analytical Information

The Workgroup initiated a study designed to assess toxicity and determine the physical and chemical characteristics associated with the concentrate stream from these plants.

Additionally, the study assessed whether to attribute the toxicity to seawater ions or other unidentified sources.

Study Methodology

The conceptual approach used to evaluate the concentrate stream from water treatment plants using membrane technology is:

- Gather and evaluate existing data on the raw water for the water plants used in the study. (Data on plants other than the three referenced were reviewed as supplemental information).
- Gather, summarize and evaluate existing concentrate data. Significant data are gathered as part of the requirements stipulated in NPDES permits. These data are retrieved, summarized and evaluated.
- Identify the most plausible potential causes of toxicity and determine the appropriate concentration of effluent lethal to 50% of the test organisms.
- Collect a wide range of data on the chemical and physical characteristics of the by-product stream. This information is used to evaluate concerns and to provide guidance on siting.

Because of resource constraints, this study was limited to three samples per facility for toxicity and four samples per facility for chemical/physical analyses. The concentrate samples were analyzed for the following suite of parameters:

- Biochemical Oxygen Demand
- Temperature
- Total Dissolved Solids
- Settable Solids
- Organics
- Sulfide
- Fluoride
- Turbidity
- Alkalinity
- Whole Effluent Toxicity
- Ammonia
- Total Suspended Solids
- Dissolved Oxygen
- Metals
- pH
- Hydrogen Sulfide
- Conductivity
- Nutrients
- Salinity
- Total Residual Chlorine
- Major Seawater Ions[2] (Calcium, Sodium, Potassium, Magnesium, Sulfate, Carbonate, and Chloride)

[2] For the purposes of this study, major seawater ions are considered to be those ions that represent greater than one percent of the total molecular weight of seawater as cited in 'Protocols for determining Major-Seawater-Ion Toxicity' (Florida Department of Environmental Protection, 1995). Carbonate was included due to the strong effect on pH and overall chemistry of resulting solutions.

Whole effluent toxicity samples were evaluated at concentrations of 100, 70, 40, 20 & 10 percent using a 48-hr acute *Mysidopsis bahia* toxicity test. The endpoints are LC_{50}'s, the concentration of effluent lethal to 50% of the test organism population. Both Hyde County facilities currently monitor whole effluent toxicity with a chronic *Ceriodaphnia* test and consistently fail. The intent behind conducting the study using *Mysidopsis bahia* was to determine whether there were toxicants present other than the ions (salt) presumed to be the source of toxicity in the *Ceriodaphnia* tests.

Samples were collected and tested from each of the three facilities over a period of 6 weeks. Chemical/physical samples were collected concurrent with toxicity sampling with one additional sample taken before the toxicity sampling. Toxicity and chemical/physical analyses were performed at the North Carolina Division of Water Quality's Environmental Sciences Aquatic Toxicology Lab and the North Carolina Department of Environment and Natural Resources Chemistry Lab, respectively.

In addition to analytical data obtained through sampling and analysis, the Workgroup conducted a review of existing data for the three membrane technology plants. These data were used in conjunction with the data obtained through this study in developing the recommendations contained in this report.

Description of Plants Studied

The concentrate streams from three water treatment plants were sampled and evaluated. Plants were chosen based on whether the effluents had consistently exhibited toxicity to *Ceriodaphnia dubia* (freshwater organism) and *Mysidopsis bahia* (salt water organism). The facilities sampled for this study are all located in Eastern North Carolina coastal communities and include Hyde County's Fairfield Water Treatment Plant, Hyde County's Ponzer Water Treatment Plant and Dare County's Rodanthe –Waves-Salvo Water Treatment Plant.

The Fairfield Water Treatment Plant uses double pass membrane technology (reverse osmosis) to produce approximately 0.385 MGD of finished water and 0.096 MGD (million gallons per day) of concentrate. The raw water obtained from two groundwater wells is pumped through the system at a finished water to concentrate ratio of 4:1 and the potable water by-product (also called reject or concentrate stream) is discharged to a low flow freshwater canal. The existing analytical data for the two wells and effluent is provided in Appendix J.

The Ponzer Water Treatment Plant also uses double pass reverse osmosis technology to produce approximately 0.575 MGD of finished water and 0.144 MGD of concentrate. Raw water is gathered from two groundwater wells and pumped through the system to obtain finished water to concentrate ratio of 4 :1.

The concentrate stream is discharged to a low flow ditch. The existing analytical data for the two wells and effluent are provided in Appendix J.

The Dare County Rodanthe –Waves-Salvo Water Treatment Plant in Rodanthe uses double pass reverse osmosis technology to produce approximately 1.0 MGD of finished water and 0.25 MGD of concentrate. Raw water is gathered from two groundwater wells and pumped through the system to obtain a finished water to concentrate ratio of 4 :1. The concentrate stream is discharged into a boat basin on the shore of Pamlico Sound. The existing analytical data for the two wells and effluent is provided in Appendix J.

Study Results

Toxicity

The Division of Water Quality's Aquatic Toxicology Unit conducted a series of 48-hour acute toxicity tests employing mysid shrimp, *Mysidopsis bahia,* on the three membrane technology effluents. The test methods employed were taken from *Methods for Measuring the Acute Toxicity of Effluents to Freshwater and Marine Organisms, Fourth Edition.* EPA/600/4–90/027F, August 1993. The only deviation from the methods was that analysts fed the test organism artemia (brine shrimp) during the course of the test. The voracious appetites and cannibalistic nature of the mysids made this necessary. The tests were conducted in temperature and light controlled incubators at a temperature of 25 degrees C, plus or minus one degree. The photoperiod was 16 hours light to 8 hours darkness with the light intensity between 50 and 100 foot-candles. Samples for the tests were collected as 24-hour composites.

Table D-1 below summarizes the test results. Note that decreasing LC50's indicate increasing toxicity. The data indicate that, in the case of the Fairfield plant, there likely is a toxicant other than salt present, given the LC_{50}'s of the most recent two tests. The Rodanthe water treatment plant monitors its effluent with *Mysidopsis bahia* acute pass/fail tests and has had periods of noncompliance. The two most recent tests conducted by the Division of Water Quality laboratory indicate toxicity, as expected.

Associated with the toxicity test, total residual chlorine is monitored at the laboratory upon arrival. Total residual chlorine analysis indicated concentrations below 0.03 µg/L for all the samples.

Table D-1.Acute Toxicity Testing Results-Membrane Technology Water Treatment Plants

	LC_{50} (%)		
Test Date	*2/13/02*	*3/13/02*	*3/20/02*
Hyde Co. Ponzer Water Treatment Plant	>100	>100	>100

Hyde Co. Fairfield Water Treatment Plant	>100	87.9	85.7
Rodanthe-Waves-Salvo Water Treatment Plant	>100*	76.8	52.8

(Note: Lower numbers indicate greater toxicity.)

*Conducted 2/20/02

Analytical Chemistry

The North Carolina Division of Water Quality's Laboratory Section conducted a series of chemical analyses on the concentrate from three reverse osmosis water treatment plants (as described in Section 7.3.1.1). Samples were gathered over a period of six weeks from February through March and analyzed in the Division of Water Quality's laboratory in Raleigh, NC.

Data not appearing in the table were excluded because of problems with sample holding times or other quality control issues. The February 11th sulfide analyses for Ponzer and Fairfield could not be conducted because of background interference with the sample. This is denoted with the symbol 'z' in the tables. Data marked with the symbol 'U' has been qualified because the quantity of the parameter detected in the sample was within the error bounds of the method. Samples with no quantifiable concentrations are marked as N/D.

Table D-2 through D-4 below summarizes the results of the chemistry analysis.

Data Review

In addition to the analytical and toxicological study, a review of existing data gathered and reported by the facilities was conducted on both the discharge and source water. The results of the data review on the discharge are presented in Table D-5 and source water data are presented in Appendix J.

A statistical analysis was conducted on the effluent monitoring data from five membrane water treatment plants (Hyde County – Ponzer, Hyde County – Fairfield, Dare County Rodanthe, Ockracoke, and Kill Devil Hills water treatment plants). The analysis consisted of using North Carolina procedures for determining the maximum predicted concentrations[3]. Data reported as "less than" were assumed to equal ½ the quantitation level. In addition, this analysis examines the percentile values for the 99th, 95th, 75th, 50th, 25th, 10th and 1st percentiles. Note that although the maximum predicted concentration is presented, this can be misleading because of the assumed value for quantities reported as "less than". Therefore, when determining pollutants of concern evaluating maximum predicted concentrations alone is not appropriate. Consideration must be given to percent non-detect, percentile values (particularly

[3] As adapted from the EPA's 'Technical Support Document for Water Quality-Based Toxics Controls'(March 1991)

the 50th and 75th), as well as the maximum predicted in determining the pollutants of concern.

The Workgroup evaluated each of the potential pollutants of concern initially identified in determining which of the parameters would be included as a potential monitoring parameter for permitting (see Table 4-2). Potential pollutants of concern were evaluated based on toxicological and analytical data, discharge monitoring report data, source water data, applicable water quality standards/criteria and toxicological effects. Each parameter will be further evaluated during the initial permitting process. At that time, the regulatory agencies will make the final determination regarding monitoring requirements.

Table D-2. Hyde County- Ponzer Water Treatment Plant Chemistry Analyses.

Parameter	Units	Ponzer 11-Feb	Ponzer 12-15-Feb	Ponzer 12-Mar	Ponzer 19-Mar
Aluminum	ug/L	-	<50	<50	<50
Arsenic	ug/L	-	<10	<10	<10
Berylium	ug/L	-	<10	<10	<10
Cadmium	ug/L	-	<2	<10	<2
Calcium	mg/L	-	<160	<160	<160
Chloride	mg/L	650	390	340	440
Chromium	ug/L	-	<25	<25	<25
Cobalt	ug/L	-	<50	<50	<50
Copper	ug/L	-	<2	<2	<2
Fluoride	mg/L	2	2.4	0.8	1.5
Iron	ug/L	-	94	93	140
Lead	ug/L	-	<50	<10	<10
Lithium	ug/L	-	280	280	260
Magnesium	mg/L	-	150	150	160
Manganese	ug/L	-	<10	<10	<10
Mercury	ug/L	-	-	<0.2	<0.2
Nickel	ug/L	-	<50	<10	<10
Selenium	ug/L	-	<5	<5	<5
Silver	ug/L	-	<5	<5	<5
Sodium	mg/L	-	380	380	410
Sulfate	mg/L	320	290	290	360
Sulfide	mg/L	Z	4.7	1	9
Zinc	ug/L	-	32	39	37

Parameter	Units	Ponzer 11-Feb	Ponzer 12-15-Feb	Ponzer 12-Mar	Ponzer 19-Mar
Ammonia	mg/L	1.6	1.3	-	1.6
BOD5	mg/L	0.1	0.3	<2	<2
Dissolved Oxygen	mg/L	4.01	2.38	3.34	3.4
Nitrate/Nitrite	mg/L	0.01 U	0.01	-	0.01
Phosphate	mg/L	0.09	0.1	0.06	0.07
Temperature	Celcius	17.7	18.05	18.07	18.14
Total Kjeldahl Nitrogen	mg/L	4	3.3	-	3.6
Total Phosphorus	mg/L	0.61	0.62	-	0.59
Alkalinity adjusted to 4.5	mg/L	100	950	1000	970
Alkalinity adjusted to 8.3	mg/L	<1 U	<1	<1	82
Bicarbonate	mg/L	100	950	1000	810
pH	S.U.	7.23	7.15	7.18	7.05
Salinity	ppt	1.79	2.08	1.79	1.85
Setteable Solids	ml/L	< 0.1	< 0.1	N/A	N/A
Specific Conductance	umhos/cm	3308	3818	3310	3405
Total Dissolved Solids	mg/L	2300	2300	1000	2300
Total Suspended Solids	mg/L	3.3	2.5	2.5	2.5
Turbidity	NTU	<1 U	< 1	<1	2.6
Organics					
Base/Neutral	ug/L	N/D	N/D	N/D	N/D
Acid extractable	ug/L	N/D	See Report	N/D	N/D
Volatile	ug/L	N/D	N/D	N/D	N/D

Table D-3. Hyde County - Fairfield Water Treatment Plant Chemistry Analyses.

Parameter	Units	Fairfield 11-Feb	Fairfield 12-15-Feb	Fairfield 12-Mar	Fairfield 19-Mar
Aluminum	ug/L	-	<50	57	<50
Arsenic	ug/L	-	<10	<10	<10
Berylium	ug/L	-	<10	<10	<10
Cadmium	ug/L	-	<2	<10	<2
Calcium	mg/L	-	320	290	270
Chloride	mg/L	420	110	160	160
Chromium	ug/L	-	<25	<25	<25
Cobalt	ug/L	-	<50	<50	<50
Copper	ug/L	-	<2	<2	<2
Fluoride	mg/L	0.3	0.6	1.2	1
Iron	ug/L	-	4200	4400	5400
Lead	ug/L	-	<50	<10	<10
Lithium	ug/L	-	230	230	180
Magnesium	mg/L	-	170	150	180
Manganese	ug/L	-	890	920	650
Mercury	ug/L	-	-	<0.2	<0.2
Nickel	ug/L	-	<50	<10	<10
Selenium	ug/L	-	<5	<5	<5
Silver	ug/L	-	<5	<5	<5
Sodium	mg/L	-	350	330	360
Sulfate	mg/L	<5 U	<5 U	<5	<5
Sulfide	mg/L	Z	7.9	23	<10
Zinc	ug/L	-	44	51	41

Parameter	Units	Fairfield 11-Feb	Fairfield 12-15-Feb	Fairfield 12-Mar	Fairfield 19-Mar
Ammonia	mg/L	-	-	-	9.5
BOD5	mg/L	0.4	2.4	13.1	6.6
Dissolved Oxygen	mg/L	3.95	9.24>2.26	4.5	7.94>2.52
Nitrate/Nitrite	mg/L	-	-	-	0.01
Phosphate	mg/L	1.6	1.3	1.3	1.8
Temperature	Celcius	17.7	17.85	18	18.06
Total Kjeldahl Nitrogen	mg/L	-	-	-	13
Total Phosphorus	mg/L	-	-	-	2.7
Alkalinity adjusted to 4.5	mg/L	1900	1700	1800	1900
Alkalinity adjusted to 8.3	mg/L	<1 U	<1 U	<1	<1
Bicarbonate	mg/L	1900	1700	1600	1900
pH	S.U.	7.68	7.52	7.38	-
Salinity	ppt	1.9	2.03	1.9	-
Setteable Solids	ml/L	<0.1	<0.1	N/A	N/A
Specific Conductance	umhos/cm	3498	3717	3500	3299
Total Dissolved Solids	mg/L	1000	2700	2000	2600
Total Suspended Solids	mg/L	3.3	3.3	3	2.5
Turbidity	NTU	5.5	3.5	5.4	5.7
Organics					
Base/Neutral	ug/L	N/D	N/D	N/D	N/D
Acid extractable	ug/L	N/D	N/D	N/D	N/D
Volatile	ug/L	N/D	N/D	N/D	N/D

Table D-4. Dare County - Rodanthe Water Treatment Plant Chemistry Analyses.

Parameter	Units	Rodanthe 18-Feb	Rodanthe 19-Feb	Rodanthe 12-Mar	Rodanthe 19-Mar
Aluminum	ug/L	-	<50	<50	<50
Arsenic	ug/L	-	<10	<10	<10
Berylium	ug/L	-	<10	<10	<10
Cadmium	ug/L	-	<2	<10	<10
Calcium	mg/L	-	40	34	32
Chloride	mg/L	1800	2100	1600	2000
Chromium	ug/L	-	<25	<25	<25
Cobalt	ug/L	-	<50	<50	<50
Copper	ug/L	-	7.7	<2	<2
Fluoride	mg/L	0.96	0.9	6.6	3.2
Iron	ug/L	-	120	75	130
Lead	ug/L	-	<10	<10	<50
Lithium	ug/L	-	Z	400	360
Magnesium	mg/L	-	83	68	66
Manganese	ug/L	-	<10	<10	<10
Mercury	ug/L	-	<0.2	<0.2	<0.2
Nickel	ug/L	-	<10	<10	<10
Selenium	ug/L	-	<5	<25	<5
Silver	ug/L	-	<5	<5	<5
Sodium	mg/L	-	2100	1600	1900
Sulfate	mg/L	14	<5U	84	70
Sulfide	mg/L	4.3	4.3	24	19
Zinc	ug/L	-	38	30	28

Parameter	Units	Rodanthe 18-Feb	Rodanthe 19-Feb	Rodanthe 12-Mar	Rodanthe 19-Mar
Ammonia	mg/L	-	-	-	-
BOD5	mg/L	< 2	< 2	2..1	<2
Dissolved Oxygen	mg/L	3.01	3.2	1.19	2.9
Nitrate/Nitrite	mg/L	-	-	-	-
Phosphate	mg/L	0.24	0.23	0.25	0.24
Temperature	Celcius	20.28	20.39	20.46	20.28
Total Kjeldahl Nitrogen	mg/L	-	-	-	-
Total Phosphorus	mg/L	-	-	-	-
Alkalinity adjusted to 4.5	mg/L	2300	2400	2000	2200
Alkalinity adjusted to 8.3	mg/L	N/A	32	1	1
Bicarbonate	mg/L	-	1900	2000	2200
pH	S.U.	7.7	7.7	7.73	7.62
Salinity	ppt	4.59	5.19	4.51	5.43
Setteable Solids	ml/L	N/A	N/A	N/A	N/A
Specific Conductance	umhos/cm	8196	9219	8072	9616
Total Dissolved Solids	mg/L	5000	5700	3400	5400
Total Suspended Solids	mg/L	3.3	3.3	2.5	2.5
Turbidity	NTU	< 1	< 1	1.3	1.8
Organics					
Base/Neutral	ug/L	See Report	See Report	N/D	N/D
Acid extractable	ug/L	N/D	See Report	N/D	N/D
Volatile	ug/L	N/D	N/D	N/D	N/D

Table D-5. Results of Discharge Monitoring Report Data Review.

Parameter[1]	Arsenic (3)	Beryllium (3)	Cadmium (3)	Chloride (4)	Chromium (4)	Copper (5)	Cyanide (2)	Fluoride (4)	Iron (4)	Lead (3)	Mercury (3)	Nickel (5)	Silver (4)	Selenium (3)	Turbidity (4)	Zinc (4)
Number of Samples	50	41	44	140	88	108	17	68	140	41	49	106	69	44	111	72
Number of Samples with Detectable Quantities	25	1	0	140	14	47	0	68	136	1	2	7	0	0	95	27
% Non-Detectable Samples	50	98	100	0	84	56	100	0	3	98	96	93	100	100	14	63
Maximum Reported Quanitation Limit	5	1	2	N/A	5	10	5	N/A	50	5	0.2	10	5	10	1.5	10
Units	µg/l	µg/l	µg/l	mg/L	µg/l	µg/l	µg/l	mg/L	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	NTU	µg/l
Maximum Reported Value	210	2	<2	6298	111	227	<5	4.42	5136	22	0.47	349	<5	<10	9.8	1350
Minimum Reported Value	<5.0	<1.0	<1	23	<5.0	<10	<5	0.3	<50	<5	<0.2	<10	<5	<10	<1	<10
Average[2]	12.1	<1	<1	919.45	<5	6.9	<5	1.894	253.64	<5	<0.2	<10	<5	<10	3.4	12.2
Median	6	<1	<1	1650	<5	<10	<5	2.6	152.5	<5	<0.2	<10	<5	<10	1.3	<5
Standard Deviation[2]	5.8	1.9	1.35	3.3	1.8	2.6	1	1.8	4.1812	1.6	1.3	2.1	1.4	1.4	2.4	5.5
99th Percentile	204.1	2.5	<1	6049	49.2	77.4	<5	4.2	5015	17.5	2.4	158.6	<5	<10	9.6	46
95th Percentile	185.7	2.5	<1	4804	9.2	29.7	<5	4	4820	3.8	<0.2	11.7	<5	<10	6.1	23.6
75th Percentile	45.5	<1	<1	1990	<5	12.5	<5	3	263.5	<5	<0.2	<10	<5	<10	2.3	<10
50th Percentile	6	<1	<1	1670	<5	<10	<5	2.6	155	<5	<0.2	<10	<5	<10	1.3	<10
25th Percentile	<5	<1	<1	328	<5	<10	<5	1	112	<5	<0.2	<10	<5	<10	<1	<10
10th Percentile	<5	<1	<1	153	<5	<10	<5	0.9	84.8	<5	<0.2	<10	<5	<10	<1	<10
1st Percentile	<5	<1	<1	47	<5	<10	<5	0.3	<50	<5	<0.2	<10	<5	<10	<1	<10
Maximum Predicted Concentration[3]	326.6	12.1	4.1	6309	162.0	283.3	4.6	8.6	5176.2	47.7	4.263	462.9	4.0	6.9	20.3	1890.4
NC Freshwater Aquatic Life Standard[4]	50.0	6.5	2.0	**230**	50.0	**7.0**	5.0	1.8	**1.0**	25.0	0.012	88.0	**0.06**	5.0	N/A	**50.0**
NC Saltwater Aquatic Life Standard[4]	N/A	N/A	5.0	N/A	20.0	**3.0**	1.0	N/A	N/A	N/A	0.025	8.3	**0.10**	71.0	25.0	**86.0**
1/2 Freshwater Final Acute Value (Non Trout)[5]	340.0	N/A	15.0	860.0	1022.0	7.3	22.0	N/A	N/A	33.8	1.4	261.0	1.2	N/A	N/A	67.0
1/2 Saltwater Final Acute Value[5]	69.0	N/A	42.0	N/A	N/A	5.8	1.0	N/A	N/A	221.0	1.8	75.0	1.9	290.0	N/A	95.0

1. Numbers in parentheses indicate the number of facilities used in the analysis.
2. Analysis based on log-normal distribution
3. Analysis based on North Carolina Division of Water Quality's procedures for determining reasonable potential, which is based on the EPA's Technical Support Document for Water Quality Based Toxics Control
4. Bolded standards are action level standards
5. If available a North Carolina Division of Water Quality derived Final Acute Value was used. If unavailable, an EPA Criteria Maximum Concentration was used. N/A indicates that neither an EPA CMC or North Carolina derived Final Acute Value exist.

Ion Exchange Water Treatment Plants

Study Methodology

The general conceptual approach used to evaluate the iron filter backwash, cationic exchange regeneration wastewater, and the combined effluent after treatment in the equalization basin was as follows:

- Gather and evaluate existing data on the raw water for the water plants used in the study.
- Gather, summarize and evaluate existing concentrate data. This data was ultimately of no use because there was extremely limited data available on these types of systems.
- Identify the most plausible potential causes of toxicity and determine the appropriate concentration of effluent lethal to 50% of the test organisms.
- Collect a wide range of data on the chemical and physical characteristics of the three by-product streams. This information was used to evaluate concerns and to provide guidance on siting.

Because of resource constraints, this study was limited to three samples per wastestream for toxicity and four samples per facility for chemical/physical analyses. The concentrate samples were analyzed for the following suite of parameters:

- Biochemical Oxygen Demand
- Ammonia
- Temperature
- Total Suspended Solids
- Total Dissolved Solids
- Dissolved Oxygen
- Settable Solids
- Metals
- Organics
- pH
- Sulfide
- Hydrogen Sulfide
- Fluoride
- Conductivity
- Turbidity
- Nutrients
- Alkalinity
- Salinity
- Whole Effluent Toxicity
- Major Seawater Ions[4] (Calcium, Sodium, Potassium, Magnesium, Sulfate, Carbonate, Chloride and Alkalinity)

Whole effluent toxicity samples were evaluated at concentrations of 100, 70, 40, 20 & 10 percent using a 48-hr chronic *Ceriodaphnia* toxicity test. The endpoints are LC_{50}'s, the concentration of effluent lethal to 50% of the test organism population. The reason for using *Ceriodaphnia* was that a number of the existing system in

[4] For the purposes of this study, major seawater ions are considered to be those ions that represent greater than one percent of the total molecular weight of seawater as cited in 'Protocols for determining Major-Seawater-Ion Toxicity' (Florida Department of Environmental Protection, 1995). Carbonate was included due to the strong effect on pH and overall chemistry of resulting solutions.

North Carolina discharge to freshwater receiving streams, so the Workgroup evaluated the toxicity of these discharges to freshwater organisms.

Samples were collected and tested from each of the wastewater stream over a period of four weeks. Chemical/physical samples were collected concurrent with toxicity sampling with one additional sample taken before the toxicity sampling. Toxicity and chemical/physical analyses were performed at the North Carolina Division of Water Quality's Environmental Sciences Aquatic Toxicology Lab and the North Carolina Department of Environment and Natural Resources Chemistry Lab, respectively.

Description of Water Treatment Plants Studied

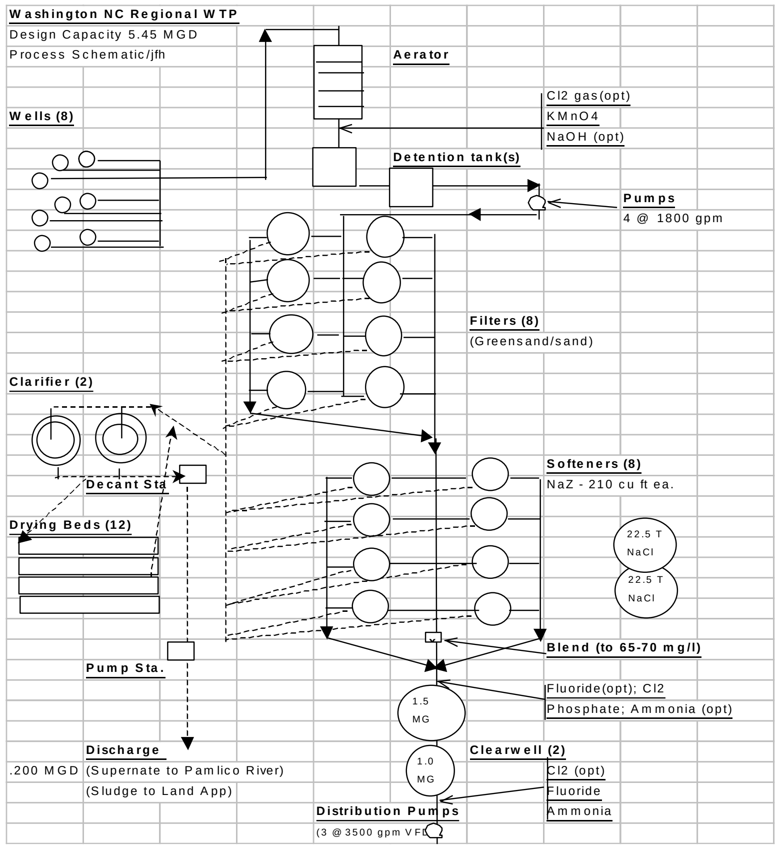
The City of Washington, NC, operates a 5.45 MGD potable water treatment and distribution system serving the residents of Washington and a significant portion of Beaufort County through the Beaufort County Water System. The system is supplied by eight (8) wells drilled into the Castle Hayne aquifer east of the City on the north side of the Pamlico River. This is a prolific aquifer (one of the City's wells can pump over 7000 gpm!), but the water contains small amounts of hydrogen sulfide, iron, manganese and hardness (as $CaCO_3$). Treatment includes the following (as depicted in Figure 7-2);

- Aeration to release hydrogen sulfide (rotten egg smell) and carbon dioxide,
- Potassium permanganate to oxidize iron and manganese,
- Manganese dioxide "greensand" filters (regenerated by the $KMnO_4$) to remove oxidized iron and manganese,
- Cation exchange (sodium cycle) softeners to remove hardness,
- Hydrofluosilic acid for control of dental caries
- Phosphate for corrosion control within the distribution system
- Chlorination for disinfection and microbial control
- Ammonia to form chloramines (before water leaves the plant) to reduce disinfection by-product formation throughout the distribution system(s).

Potable water quality is monitored daily at the treatment facility and in the distribution system. Additional monitoring is conducted according to State regulations, with analyses performed in laboratories certified by the State for potable water examination. Results of this compliance monitoring are published in their annual Water Quality Report.

Potable water process by-products are generated at the Washington facility through filter backwashing (to remove accumulated iron deposits from the surface and sub-surface of the greensand media), and during regeneration of the ion exchange softeners (a salt solution is introduced into the vessel to "re-charge" the resin- note: the salt solution is rinsed thoroughly before the softeners are returned to potable service). These by-product flows combine, go through a clarification process for solids removal, then to a decant chamber before the clear supernatant is ultimately pumped to discharge into the Pamlico River. Settleable solids are applied to sand drying beds, with the filtrate returned to the clarifiers and the sludge land applied at a demolition landfill site.

Figure D-1. Washington water treatment plant Schematic



Study Results

Toxicity

The Aquatic Toxicology Unit conducted three series of toxicity tests on three wastestreams of the Washington Water Treatment Plant, the iron removal pressure filter backwash, the sodium cycle cationic exchange plant, and the combined effluent. The combined effluent represents the actual discharge of the Washington Water Treatment Plant, while the other two wastestreams are representative of similar wastestreams directly discharged at other water treatment plants. These effluents were evaluated using seven-day *Ceriodaphnia* chronic tests employing the Division of Water Quality method, "North Carolina Phase II Chronic Whole Effluent Toxicity Test Procedure," Revised February 1998. These analyses are the most widely used toxicity tests across the state. Should the decision be made to routinely apply toxicity limits to water treatment plant effluents, the analysis would be employed in most cases. The tests were conducted in temperature and light controlled incubators at a temperature of 25 degrees C, plus or minus one degree. The photoperiod was 16 hours light to eight hours darkness with the light intensity between 50 and 100 foot-candles. Samples for the iron filter backwash and cationic exchange regeneration waste effluent tests were "grabs" while the samples for the combined effluent tests were 24-hour composites.

Table D-6 summarizes the results of the toxicity test. Note that decreasing LC50's indicate increasing toxicity. The endpoint employed is the chronic value (ChV), the geometric mean of the LOEC (lowest observed effect concentration) and the NOEC (no observed effect concentration). The combined effluent was the most consistent in its level of toxicity (ChV-28.3%) and was less toxic than the other wastestreams. Since these wastestreams make up the combined effluent, there is some question as to why the combined waste stream was consistently less toxic than either of its two constituent waste streams. One explanation may lie in operation and treatment processes at the City of Washington Water Treatment Plant. Iron filter backwash water, which has high concentrations of total residual chlorine (see Table D-7), is combined with the cationic exchange regeneration wastewater in an equalization basin. As the aqueous chlorine dioxide volatilizes, the toxicity of the iron filter backwash (due to total residual chlorine) diminishes and the backwash water dilutes the toxic effects of the cationic exchange regeneration wastewater. The lower total residual chlorine concentrations in both the cationic exchange water and the combined effluent water (Tables D-8 and D-9) would tend to support this theory.

Table D-6.Chronic Toxicity Testing Results-Washington Water Treatment Plant

	ChV (%)		
Test Date	*4/3/02*	*4/10/02*	*4/24/02*
Iron Filter Backwash	14.1	7.1	3.5
Cationic Exchange Regeneration	3.9	6.1	3.9
Combined Effluent	28.3	28.3	28.3

(Note: Lower numbers indicate greater toxicity.)

Table D-7. Filter Backwash Water Total Residual Chlorine Concentrations.

	Test Started 4/3/02		Test Started 4/10/02		Test Started 4/24/02	
Parameter	1st Sample (4/1/02)	2nd Sample (4/5/02)	1st Sample (4/8/02)	2nd Sample (4/12/02)	1st Sample (4/22/02)	2nd Sample (4/26/02)
Total Residual Chlorine [mg/L]	<0.03	0.924	2.34	3.48	5.94	2.86

Table D-8. Cationic Exchange Regeneration Water Total Residual Chlorine Concentrations.

	Test Started 4/3/02	Test Started 4/10/02	Test Started 4/24/02

Parameter	1st Sample (4/1/02)	2nd Sample (4/5/02)	1st Sample (4/8/02)	2nd Sample (4/12/02)	1st Sample (4/22/02)	2nd Sample (4/26/02)
Total Residual Chlorine [mg/L]	<0.03	0.107	0.030	0.05	0.039	<0.03

Table D-9. Combined Effluent Water Total Residual Chlorine Concentrations.

	Test Started 4/3/02		Test Started 4/10/02		Test Started 4/24/02	
Parameter	1st Sample (4/1/02)	2nd Sample (4/5/02)	1st Sample (4/8/02)	2nd Sample (4/12/02)	1st Sample (4/22/02)	2nd Sample (4/26/02)
Total Residual Chlorine [mg/L]	0.0113	0.122	0.211	0.181	0.221	0.058

Analytical Chemistry

The North Carolina Division of Water Quality's Laboratory Section conducted a series of chemical analyses, on the sodium cycle cationic exchange softener regeneration wastewater, iron filter backwash and the combined wastestream from the City of Washington Water Treatment Plant. The combined waste stream is composed of both softener regeneration wastewater and filter backwash wastewater and was collected after treatment in an equalization basin. Samples were gathered over a period of five weeks during the month of May.

Data not appearing in the table were excluded because of problems with the sample or other problems.

Data marked with the symbol 'U' have been qualified because the quantity of the parameter detected in the sample was within the error bounds of the method.

Tables D-10 through D-12 below summarize the results of the chemistry analysis.

The Workgroup evaluated each of the potential pollutants of concern initially identified in determining which of the parameters would be included as a potential monitoring parameter for permitting. Potential pollutants of concern were evaluated using toxicological, analytical, discharge monitoring report data, source water data, applicable water quality standards/criteria and toxicological effects. Where insufficient data were available to assess a parameter, the pollutant remained as a potential parameter requiring monitoring in the permit. Each of these parameters will be further evaluated during the initial permitting process. At that time, the regulatory agencies will make the final determination regarding monitoring requirements.

Table D-10. City of Washington Water Treatment Plant Sodium Cycle Cationic Exchange Regeneration Waste Stream Chemistry Analyses.

Parameter	Units	Wash-WS 4/1/02	Wash-WS 4/5/02	Wash-WS 4/8/02	Wash-WS 4/12/02	Wash-WS 4/22/02	Wash-WS 4/26/02
Aluminum	ug/L	-	80	82	63	130	79
Arsenic	ug/L	-	<10	<10	<25	<10	<10
Berylium	ug/L	-	<10	<10	<10	<10	<10
Cadmium	ug/L	-	<10	<2	<2	<10	<2
Calcium	mg/L	-	2400	3300	2800	3600	1500
Chloride	mg/L	-	14000	17000	9800	18000	8000
Chromium	ug/L	-	<25	<25	<25	<25	<25
Cobalt	ug/L	-	<50	<50	<50	<50	<50
Copper	ug/L	-	5.2	2.5	4.6	3.8	2.6
Fluoride	mg/L	-	<0.1	<0.1	<0.1	<0.1	<0.1
Iron	ug/L	-	200	110	83	130	110
Lead	ug/L	-	<10	<50	<50	<10	31
Lithium	ug/L	-	820	1100	780	520	360
Magnesium	mg/L	-	180	260	220	230	84
Manganese	ug/L	-	160	140	86	120	45
Mercury	ug/L	-	<0.2	<0.2	<0.2	<0.2	<0.2
Nickel	ug/L	-	<50	<50	<10	<50	<10
Selenium	ug/L	-	<5	<5	<25	<25	<5
Silver	ug/L	-	<5	<5	<5	<5	<5
Sodium	mg/L	-	5000	6000	4100	6100	3200
Sulfate	mg/L	-	48	18	17	43	35
Sulfide	mg/L	-	<1	<1	<1	3	3
Zinc	ug/L	-	110	120	110	140	85

Parameter	Units	Wash-WS 4/1/02	Wash-WS 4/5/02	Wash-WS 4/8/02	Wash-WS 4/12/02	Wash-WS 4/22/02	Wash-WS 4/26/02
Ammonia	mg/L	-	0.66	0.94	1.1	1.2	0.2
BOD5	mg/L	-				2	< 2
Dissolved Oxygen	mg/L	8.08	9.49	8.48	8.32	9.31	8.84
Nitrate/Nitrite	mg/L	-	0.16	0.11	0.12	0.14	0.13
Phosphate	mg/L	-		0.06	0.05	0.07	
Temperature	Celcius	14.14	17.12	17.44	17.74	18.13	17.91
Total Kjeldahl Nitrogen	mg/L	-	0.37	0.64	0.35	1.1	0.2
Total Phosphorus	mg/L	-	0.24	0.12	0.11	0.13	0.11
Alkalinity adjusted to 4.5	mg/L	-	190	180	190	220	220
Alkalinity adjusted to 8.3	mg/L	-	N/A	N/A	1	1	1
Bicarbonate	mg/L	-	190	180	190	200	180
pH	S.U.	7.09	7.37	7.15	7.25	6.72	7.23
Salinity	ppt	28.13	0.27	0.2	18.59	27.97	13.32
Specific Conductance	umhos/cm	43613	36041	40359	30045	43349	22208
Total Dissolved Solids	mg/L	-	24000	29000	27000	30000	14000
Total Suspended Solids	mg/L	-				4	2.5
Turbidity	NTU	-				1.2	< 1
Organics							
Base/Neutral	ug/L	-	SeeReport		SeeReport		
Acid extractable	ug/L	-	SeeReport		SeeReport		
Volatile	ug/L	-	N/D		SeeReport		

Table D-11. City of Washington Water Treatment Plant Iron Filter Backwash Waste Stream Chemistry Analyses.

Parameter	Units	Wash-IF 1-Apr	Wash-I.F 5-Apr	Wash-IF 8-Apr	Wash-IF 12-Apr	Wash-IF 22-Apr	Wash-IF 26-Apr
Aluminum	ug/L	-	87	58	61	68	<50
Arsenic	ug/L	-	<10	<10	<10	<10	<10
Berylium	ug/L	-	<10	<10	<10	<10	<10
Cadmium	ug/L	-	<2	<2	<2	<2	<2
Calcium	mg/L	-	56	63	69	58	51
Chloride	mg/L	-	12	12	13	14	10
Chromium	ug/L	-	<25	<25	<25	<25	<25
Cobalt	ug/L	-	<50	<50	60	<50	58
Copper	ug/L	-	4.8	2.1	4.6	3.2	2.1
Fluoride	mg/L	-	0.4	0.5	0.6	0.7	0.6
Iron	ug/L	-	18000	36000	49000	37000	46000
Lead	ug/L	-	<10	<10	<50	<50	<10
Lithium	ug/L	-	26	25	28	28	25
Magnesium	mg/L	-	3.6	4.6	3.9	3.7	3.3
Manganese	ug/L	-	6900	14000	9300	13000	14000
Mercury	ug/L	-	<0.2	<0.2	<0.2	<0.2	<0.2
Nickel	ug/L	-	<10	<10	<10	<10	<10
Selenium	ug/L	-	<5	<5	<5	<5	25
Silver	ug/L	-	<5	<5	<5	<5	<5
Sodium	mg/L	-	31	25	28	33	32
Sulfate	mg/L	-	<5	-	<5	<5	<5
Sulfide	mg/L	-	<1	33	<1	<1	<1
Zinc	ug/L	-	41	39	40	37	36

Parameter	Units	Wash-IF 1-Apr	Wash-I.F 5-Apr	Wash-IF 8-Apr	Wash-IF 12-Apr	Wash-IF 22-Apr	Wash-IF 26-Apr
Ammonia	mg/L	-	0.05	0.09	0.08	0.04	0.1
BOD5	mg/L	-	2	<2	-	11	< 2
Dissolved Oxygen	mg/L	9.43	9.97	8.87	9.44	7.79	9.22
Nitrate/Nitrite	mg/L	-	0.1	0.08	0.07	0.07	0.07
Phosphate	mg/L	-	-	0.09	0.07	0.3	-
Temperature	Celcius	17.87	17.75	17.35	17.87	18.14	17.88
Total Kjeldahl Nitrogen	mg/L	-	<0.2	<0.2	0.28	<0.1	<0.2
Total Phosphorus	mg/L	-	0.85	1.2	2.3	1.5	2.2
Alkalinity adjusted to 4.5	mg/L	-	210	200	210	230,210	240,210
Alkalinity adjusted to 8.3	mg/L	-	N/A	N/A	1	4	1U
Bicarbonate	mg/L	-	210	200	210	210	210
pH	S.U.	7.98	8.08	7.78	7.57	7.91	7.73
Salinity	ppt	0.14	0.27	0.2	0.2	0.18	0.2
Specific Conductance	umhos/cm	277.9	535.1	396.2	399.9	364.8	401
Total Dissolved Solids	mg/L	-	300	290	290	290	290
Total Suspended Solids	mg/L	-	66	140	140	90	160
Turbidity	NTU	-	50	11	170	140	930
Organics		-					
Base/Neutral	ug/L	-	SeeReport	SeeReport	SeeReport	SeeReport	N/D
Acid extractable	ug/L	-	SeeReport	N/D	SeeReport	SeeReport	N/D
Volatile	ug/L	-		N/D	N/D	SeeReport	N/D

Table D-12. City of Washington Water Treatment Plant Combined Waste Stream Chemistry Analyses.

Parameter	Units	Wash-Com 5-Apr	Wash-Com 9-Apr	Wash-Con 12-Apr	Wash-Com 23-Apr	Wash-Com 26-Apr
Aluminum	ug/L	57	54	50	73	70
Arsenic	ug/L	<10	<10	<10	<10	<10
Berylium	ug/L	<10	<10	<10	<10	<10
Cadmium	ug/L	<2	<10	<2	<2	<2
Calcium	mg/L	570	580	370	490	1100
Chloride	mg/L	2600	2800	2000	3200	4100
Chromium	ug/L	<25	<25	<25	<25	<25
Cobalt	ug/L	<50	<50	<50	<50	<50
Copper	ug/L	<2	<2	<2	3.5	<2
Fluoride	mg/L	0.4	0.5	0.6	0.3	0.2
Iron	ug/L	790	1700	590	2400	660
Lead	ug/L	<10	<50	<50	<50	19
Lithium	ug/L	130	140	110	170	77
Magnesium	mg/L	39	39	28	32	58
Manganese	ug/L	270	620	210	900	240
Mercury	ug/L	<0.2	<0.2	<0.2	<0.2	<0.2
Nickel	ug/L	<10	<10	<10	<10	<10
Selenium	ug/L	<5	<5	<5	<5	<5
Silver	ug/L	<5	<5	<5	<5	<5
Sodium	mg/L	950	880	670	970	1300
Sulfate	mg/L	5	7	6	11	8
Sulfide	mg/L	31	<1	1	2	3
Zinc	ug/L	54	61	46	73	61

Parameter	Units	Wash-Com 5-Apr	Wash-Com 9-Apr	Wash-Con 12-Apr	Wash-Com 23-Apr	Wash-Com 26-Apr
Ammonia	mg/L	0.14	0.18	0.17	-	0.11
BOD5	mg/L	4	-	3	-	< 2
Dissolved Oxygen	mg/L	9.9	6.5	9.15	8.96	9.13
Nitrate/Nitrite	mg/L	0.22	0.19	0.19	-	0.2
Phosphate	mg/L	-	0.09	0.06	0.8	-
Temperature	Celcius	16.72	24.32	19.5	18.51	18.39
Total Kjeldahl Nitrogen	mg/L	<0.2	<0.2	1.1	-	<0.2
Total Phosphorus	mg/L	0.11	0.15	<0.1	-	<0.1
Alkalinity adjusted to 4.5	mg/L	180	180	22	210	230
Alkalinity adjusted to 8.3	mg/L	N/A	N/A	N/A	10	1U
Bicarbonate	mg/L	180	180	190	160	190
pH	S.U.	7.52	7.56	7.75	7.16	7.4
Salinity	ppt	4.87	4.4	3	3.17	5.44
Specific Conductance	umhos/cm	8658	7707	5509	5713	9622
Total Dissolved Solids	mg/L	4600	5400	3800	5000	7700
Total Suspended Solids	mg/L	3.3	9	3	6	8
Turbidity	NTU	3.8	8	3.1	5.4	5.9
Organics						
Base/Neutral	ug/L	SeeReport	SeeReport	SeeReport	N/D	SeeReport
Acid extractable	ug/L	SeeReport	SeeReport	SeeReport	N/D	SeeReport
Volatile	ug/L	N/D	N/D	SeeReport	SeeReport	N/D

Appendix E – Recommended Information Requirements for New NPDES Permits for Membrane and Sodium Cycle Cationic Exchange Water Treatment Plants

Applicability
The information requirements recommended are meant for new water treatment plant projects utilizing either membrane technology or sodium cycle cationic exchange in the treatment process.

New Application Submittal
In order to properly evaluate the potential impacts associated with the concentrate stream from membrane water treatment plants, the applicant/consultant and the permitting authority should consider the following factors:

- Amount of wastewater to be discharged.
- Predicted effluent/discharge characteristics, based on the quality of the source water, treatment processes and chemical usage.
- Ambient or background water quality conditions.
- Dilution or mixing between the effluent and the receiving water.

To aid the regulatory agency and ensure adequate information for the evaluation of the potential impacts, the Workgroup established minimum informational requirements (Table E-1). This information should be submitted with any application for a new discharge permit. Descriptions of these requirements are provided below. This information should also be included in Environmental Assessments submitted under the State Environmental Policy Act. Since SEPA may require additional information beyond what is recommended here, applicants should contact a NC DENR SEPA coordinator for information and additional information requirements (see Appendix G, for contact information).

Table E-1. Minimum Information Requirements for NPDES Permit Applications.

General Description of Information Requirements
➢ Design Flow Rate
➢ Ambient Water Quality
➢ Dilution Modeling
➢ Discharge Location
➢ Treatment Process Description
➢ Cleaning Cycle Procedures
➢ Reject Ratios
➢ Source Water Analysis
➢ Engineering Alternatives Analysis

<u>Design Flow Rate</u> – The design flow rate for both potable product water and the concentrate stream should be identified. In addition, the applicant should indicate whether the discharge will be continuous or intermittent. In most cases, a continuous discharge provides an environmental condition that is thought to be less intrusive to the biota. Therefore, wherever feasible a continuous discharge

should be implemented. If a facility proposes an intermittent discharge then the facility shall submit an evaluation of the technical, economic and operational feasibility of implementing a continuous discharge. If the Division of Water Quality agrees that there are significant, technical, economic, or operational barriers to the Permittee's ability to attain a continuous discharge, then an intermittent discharge will be considered.

Ambient Water Quality – To aid the evaluation of the potential impacts, each applicant should evaluate the ambient water quality and biological community of the receiving stream. Prior to conducting this sampling, each applicant should evaluate existing data sources (see Section 5) and evaluate its applicability to the proposed site. If the Division of Water Quality agrees that the existing data are sufficient to evaluate the potential impacts from the facility, no additional monitoring will be required. If additional data are required, it shall be the responsibility of the permittee to obtain this data and submit it to the Division of Water Quality.

The following guidance is provided to aid applicants and review agencies in evaluating the adequacy of data. DWQ, NCDMF and NCWRC should be consulted to determine the adequacy of location.

Existing Data - Any available existing data should be submitted.

Sample Locations - At a minimum, three sample locations should be used; two monitoring sites should be located within the predicted zone of influence of the proposed discharge, and one monitoring site located at a reference location. These locations will serve to help define baseline conditions, which will be used to compare any water quality impacts attributable to the discharge.

Sample depths – For waters exhibiting density or temperature stratificiation, samples should be collected at the surface (within one meter), mid-depth, and bottom for water quality monitoring. For completely mixed systems, surface samples are appropriate.

Sampling Parameters - dissolved oxygen, temperature, pH, conductivity, salinity and chlorides.

Environmental Conditions – For tidally influenced waters, during sample collection, the Plan should include provisions for noting rainfall, wind direction, and direction and velocity of waterbody flow at each of the sample locations.

Biological Monitoring - The applicant should evaluate the macro-invertebrate community at the proposed outfall location before initiating any discharge activities. This will establish the baseline biological community.

Dilution Modeling – The Workgroup recommends that the facility model dilution using an appropriate model (for example, the Cornell Mixing Zone Expert System (CORMIX)) for use in evaluating the dilution and mixing of the effluent within the receiving stream.

Discharge Location – For tidally influenced waters, the applicant should provide both the plant site and discharge location(s) depicted on a 7 ½ minute topographic map. Give the name of the waterway (at the point of discharge). The application should include the proposed latitude and longitude in degrees/minutes/seconds, along with the invert elevation of the proposed outfall.

Treatment Process Design – Provide a description of the treatment process starting with the source water and continuing through to the outfall. The applicant should indicate the number of passes through the membrane process (e.g., single pass/double pass). If multiple water sources are proposed, describe in general terms how these water sources will be operated (i.e., if multiple wells are used, describe how these wells will be operated). The application should include detailed engineering drawings of the proposed outfall. Additionally, submittal of a flow chart showing all treatment units, chemical additions, and flow rates between treatment units is required.

Chemical Cleaning Procedures (Reverse osmosis water treatment plants only) - If the facility will be conducting periodic chemical cleaning, provide the estimated time between cleaning cycles, chemicals used in cleaning cycle, estimated water usage (both volumetric and rate), and duration of cleaning cycle.

Design Reject Ratios (Reverse osmosis water treatment plants only) - Provide the ratio of potable product water to concentrate.

Source Water Analysis – Applicants for an NPDES permit must provide testing data on the source water. If wells or intakes have not been constructed, the samples should be obtained from a location near each proposed well or intake. For systems that propose more than one water source (e.g. two or more groundwater wells), separate testing data must be provided for each proposed source. In order to provide a statistically robust evaluation eight to 12 data points are required for the parameters listed in Table 4-2 (membrane systems) and Table 4-4 (cationic exchange systems) for each water source. In addition to the data requirements stipulated above, any data collected to satisfy the Division of Environmental Health's new well source water quality assessment must be submitted.

Engineering Alternatives Analysis

With every application for a new NPDES permit, the permittee must evaluate alternatives to discharge. This analysis is used to ensure that surface water discharge is the most environmentally sound of the economically feasible alternatives. Applicants should evaluate connection to existing wastewater treatment facilities, non-discharge alternatives, reuse opportunities, and other emerging/innovative technologies. This analysis should evaluate both the technical and economic feasibility of each alternative.

Appendix F – Information needs and Issues that Require Additional Study

- Thermal and density/salinity stratification and associated potential effects that may;
  a) Generate, increase the frequency of occurrence, or worsen anoxic or hypoxic events. These events may contribute to:
     - increased nutrient availability and cycling,
     - increased metals availability and cycling, and
     - a shift in benthic community composition.
  b) Provide a barrier or impediment to normal movement/migration and utilization by aquatic biota in impacted areas.
- Nutrient concerns
  a) Ammonia concentrations and potential toxicity to aquatic life.
  b) Loading and productivity impacts on sensitive estuarine waters.
- Toxicity evaluation
  a) Ionic composition and concentrations of the major seawater ions in the various waterbodies and salinity regimes (fresh to seawater).
  b) Ion imbalance toxicity potential of the various types and combinations of water treatment plant discharges.
  c) Investigate the utility of incorporating resident and migratory aquatic species at various life stages (eggs, larvae, and adults) in toxicity testing.
  d) Other causes or factors that may be causing toxicity. (Note: In these salt-based water treatment plant discharges, ion imbalance has to be ruled out before other causes of toxicity can be evaluated.)
- Physical and chemical water quality impacts of water treatment plant discharges on various stream flow regimes (e.g., tidal estuarine waters, zero to high flow freshwater streams).
- Aquatic and terrestrial community structure impacts of water treatment plant discharges on various habitats (e.g., tidal estuarine waters, zero to high flow freshwater streams).
- Water quality model development and/or refinement to assess impacts in zero and low flow and tidal environments.
- Determine appropriate ambient and waste stream conditions for various habitats and recommend additional siting criteria that will minimize environmental impacts.
- Evaluate appropriate water quality and benthic sampling methodology for various environments and habitats.
- Evaluate environmental impacts of cleaning cycle chemicals and disposal alternatives.
- *Evaluate alternative discharge or disposal options for discharge solutions.
- *Evaluate alternative uses and recycling options for discharge solutions.
- *Evaluate discharge design modification and/or process to achieve a discharge of consistent quantity and quality.

- Investigate the location, type, and/or modifications to the discharge that would lessen or reduce impacts:
  a) depth (increase mixing and reduce density/salinity stratification)
     1.) shallow (6 feet or less)
     2.) deep (greater than 6 feet);
  b) dilution prior to discharge (with an adequate evaluation of the additional impacts);
  c) devices that would increase diffusion/mixing;
  d) aeration and/or oxidation.

  Note: Items with a * above might should be omitted here and put in the A-G list?

Appendix G - North Carolina Department of Environment and Natural Resources' Potential Permitting Requirements for New Water Treatment Plant Projects

Water Treatment Plant
Permitting & Commenting Agencies

Prior to constructing and operating a water treatment plant, there are several permits that have to be obtained and also comments obtained from different natural resource divisions and agencies. The majority of these are within the North Carolina Department of Environment and Natural Resources (DENR), although there are also a few other agencies involved as well. This document is divided into two sections. The first section identifies potential environmental permits that may be needed and the agency, division and sometime program associated with each of these permits. The second section identifies the natural resource agencies that provide comments on proposed water treatment facility projects because of the projects' potential to impact sensitive natural resources.

Section One - Potential Environmental Permits Needed

- *Department of Environment and Natural Resources*

State Environmental Policy Act

Proposed projects may or may not meet the North Carolina State Environmental Policy Act (SEPA) criteria. If SEPA applies, before submitting permit applications to the various agencies, an environmental assessment and/or an environmental impact statement (EIS) must be prepared and a Finding of No Significant Impact (FONSI) issued or alternatively a Record of Decision (when an EIS is required).

Information Resources:

Web: http://www.envhelp.com/html/sepa.html

NC DENR Contact: Melba McGee in Raleigh at 919-715-4194.

- *Division of Environmental Health (DEH)*

Public Water Supply Section (PWSS)

Water Treatment Facility - Authorization to Construct.

Plans, engineering reports, specifications, etc. for public water treatment systems and their appurtenances must be reviewed, approved and inspected by DEH-PWSS before construction. A NC licensed professional engineer must prepare submittals. Submittals must include an application, engineering report, water system management plan, environmental review as appropriate, authorization to withdraw water for treatment, an appropriate stream classification (surface water) and other agency permits as applicable. PWSS issues a separate approval letter and authorization to construct.

Information Resources:

Web: http://www.deh.enr.state.nc.us/pws/index.htm

NC DEH Contacts: Wayne Munden in Raleigh at (919) 715-3237

Water Treatment Facility - Operating Permit.
This permit must be obtained after the water treatment facility is constructed but prior to operation. This approval is renewed annually.

Information Resources:

Web: http://www.deh.enr.state.nc.us/pws/index.htm

NC DEH Contacts: Wayne Munden
Branch Head, Technical Services Branch
(919) 715-3237

Onsite Wastewater Section (OSWW).
Subsurface Discharge of Wastewater
If a project discharges wastewater or is proposing a system with a design flow greater than 3000 gpd, a permit from OSWW may be needed.

Information Resources:

Web: http://www.deh.enr.state.nc.us/oww/index.htm

NC DEH Contacts: Joe Pearce
Joe.pearce@ncmail.net
(919) 715-3270

Steven Berkowitz
Steven.berkowitz@ncmail.net
(919) 715-3270

- *Division of Water Quality*

Water Quality Section

NPDES Permit.
If the facility proposes a discharge into waters of the State an NPDES discharge permit is required.

Upon submittal of the application for an individual NPDES permit, an Engineering Alternatives Analysis is required. This is an analysis that demonstrates that surface water discharge is the most environmentally sound of the economically reasonable alternatives. In other words, surface water discharge is considered a last resort and it must be shown that other alternatives (discharge to POTW, land discharge, etc.) are not feasible.

Information Resources:

Web: http://h2o.enr.state.nc.us/NPDES/NPDESweb.html

NC DWQ Contacts: Dave Goodrich
NPDES Supervisor
(919) 733-5083 ext. 517

Authorization to Construct.
After receiving an NDPES permit, the facility must obtain an Authorization To Construct permit prior to initiating construction activities for components associated with the treatment of potable water by-products. Engineering plans and specifications for proposed treatment equipment must be reviewed and approved.

Information Resources:

Web: http://h2o.enr.state.nc.us/NPDES/NPDESweb.html

NC DWQ Contacts: Michael Myers
Environmental Engineer
(919) 733-5083 ext. 508

Wastewater Discharge to Publicly Owned Treatment Works (POTWs).
If the facility is planning to discharge to a local POTW, they should contact the local POTW. If the facility represents a Significant Industrial User, the POTW must issue an Industrial User Pretreatment Permit under a DWQ approved Pretreatment Program. Even if the discharge does not represent a SIU, a permit could still be required. The pretreatment unit within the Division of Water Quality normally does not issue permits, but provides technical assistance and approves local POTW pretreatment programs.

Information Resources:

Web: http://h2o.enr.state.nc.us/Pretreat/index.html

NC DWQ Contacts: Tom Poe
Pretreatment Unit Supervisor
(919) 733-5083 ext. 522

Other information resources: Contact the Local Pretreatment Coordinator.

404 Permit and 401 Certification.
If the U.S. Army Corps of Engineers determines that a 404 Permit is required because the project involves impacts to wetlands or waters, then a 401 Water Quality Certification is also

required. The Corps determines which type of permit is applicable to the project, a Nationwide, Regional, General or Individual Permit. For each of the Nationwide, Regional or General Permit, a matching General Certification must be issued by DWQ in order for the federal Permit to be valid. An Individual 401 Water Quality Certification is necessary if an Individual 404 Permit is required. Based on the type of federal permit required a written concurrence/notification may or may not be required. If written concurrence/notification is not required, and the project meets all of the conditions of the General Certification, you do not need to submit a formal application or receive a signed 401 Water Quality Certification for the project. If the General Certification states that written concurrence is necessary, then you will need to submit a formal application for the 401 Certification.

Information Resources:

Web:

Army Corps:	http://www.usace.army.mil/inet/functions/cw/cecwo/reg/ http://www.saw.usace.army.mil/wetlands/regtour.htm
NC DWQ:	http://h2o.enr.state.nc.us/ncwetlands/

Contacts:

Army Corps:	Gwen Dye (910) 251-4494
NC DWQ:	John Dorney 733-9646

Reclassification of Watershed.

The surface water from which the proposed water treatment facility withdraws water must posses a water supply classification. If the proposed water source is not classified as a water supply then the water body must be reclassified to include a WS designation. In addition to the reclassification, municipal and county governments must prepare water supply ordinances or include water supply sections within existing local ordinances.

Information Resources:

Web: http://h2o.enr.state.nc.us/wswp/index.html

NC DWQ Contacts:

Milt Rhodes	milt.rhodes@ncmail.net	(919) 733 - 5083 Ext. 366
Steve Zoufaly	steve.zoufaly@ncmail.net	(919) 733 - 5083 Ext. 566

Groundwater Section

Ground Water Section Permit.

I. Every well in North Carolina must be constructed according to certain standards (15A NCAC 2C.0100s) and approved by the Division of Water Quality (DWQ) - Groundwater

Section (GWS). To facilitate this effort, DWQ-GWS developed and implements a well driller (and pump installer) certification program that instructs and certifies well drillers in North Carolina. The well driller certification program requires well drillers to construct wells according to NC standards. Depending on the project one or more of the following may apply:

- Every well in NC (independent of size and type) has to be drilled by a certified well driller and;
- After every well is constructed, a GW-1 well construction standard form must be submitted to certify that the well has been properly constructed.

II. In addition to item I above, every water supply well must meet additional DWQ-GWS regulations (15A NCAC 2C.0107). If the well is classified as a Public Water Supply, it must meet additional requirements in 15A NCAC 18C (Division of Environmental Health – Public Water Supply).

III. In addition to I (and possibly II) above, if a well meets one or more of criteria from 15A NCAC 2C.0105), then a DWQ-GWS permit must be obtained.

Information Resources:

Web: http://gw.ehnr.state.nc.us/

NC DWQ Contacts: Ted Bush
Ted.bush@ncmail.net
(919) 715-6172

Woody Barnes
Woody.barnes@ncmail.net
(919) 715-6698

- *Division of Water Resources*

Registration of withdrawal from surface or ground waters.

Non-agricultural water withdrawals of 100,000 gpd or greater require registration with the Division of Water Resources. Additionally, any water withdrawal greater than one million gallons per day requires registration.

Information Resources:

Web: http://www.dwr.ehnr.state.nc.us/wsas/regist.htm

NC DWR Contacts: Jim Mead
Jim.mead@ncmail.net
(919) 715-5428

Capacity Use Area permits.

Capacity Use Program requires permits for large-scale users (greater than 100,000 gallons per day) in a capacity use area to protect the ground and surface water supplies from over-pumping and to avoid conflict among users.

Note: Central Coastal Plain Capacity Use Area (CCPCUA) rules become effective August 1, 2002. These rules designate a 15 county area, create a ground water use permitting process and eliminate the need for CUA #1. Water use permitting will no longer exist in Hyde and Tyrrell counties after August 1, 2002. Surface water use permits will not be required when the CCPCUA rules become effective.

Information Resources:

Web:

http://www.dwr.ehnr.state.nc.us/Permits_and_Registration/Capacity_Use/Central_Coastal_Plain/

NC DWR Contacts:

Nat Wilson
Nat.wilson@ncmail.net
(919) 715-5445

Gabrielle Chianese
Gabrielle.chianese@ncmail.net
(919) 715-5370

Local Water Supply Plan.
Governmental units must develop and maintain a Local Water Supply Plan. North Carolina General Statute requires all units of local government that provide or plan to provide public water service to prepare a Local Water Supply Plan and to update that plan at least every five years. A local water supply plan is an assessment of a water system's current and future water needs and the "systems" ability to meet those needs.

Information Resources:

Web:
http://www.dwr.ehnr.state.nc.us/Water_Supply_Planning/Local_Water_Supply_Plan/

NC DWR Contacts:

Woody Yonts
Woody.yonts@ncmail.net
(919) 715-5453

Linwood Peele
Linwood.peele@ncmail.net
(919) 715-5455

Don Rayno

Don.rayno@ncmail.net
(919) 715-3047

- *Division of Air Quality*

Air Emissions.

Any facility that emits five or more tons of pollutants each year may be required to obtain an air quality permit. The "tons" generated by the operation and type of system will determine the permit type required.

Note: In Buncombe, Forsyth, or Mecklenburg counties, the air quality permitting program has been delegated from the state to the county agency.

Information Resources:

Web:	
NC DAQ:	http://daq.state.nc.us/AQ/Offices/Permits/permapps.html http://www.p2pays.org/ref/01/00484.htm (fact sheet)
Local permitting programs:	http://daq.state.nc.us/about/local/
NC DAQ Contacts:	John Evans John.evans@ncmail.net (919)715-5-6252 Don Van Der Vaart Donald.vandervaart@ncmail.net (919) 715-6253

Emergency Generator – General Air Permit.

This permit can be used for all non-exempt emergency generators whose potential to emit pollutants is less than 100 tons/year.

Information Resources:

Web:	http://daq.state.nc.us/Office/Permits/files/genrl/Emgen_app.pdf
NC DAQ Contacts:	John Evans John.evans@ncmail.net (919)715-5-6252 Don Van Der Vaart Donald.vandervaart@ncmail.net

(919) 715-6253

- ## *Division of Coastal Management*

Major, Minor or General Coastal Area Management Act Permit

A development activity within an Area of Environmental Concern in one or more of the 20 coastal counties (listed below) requires a coastal permit, assuming the activity is not exempt.

- Major Permit.
  A major permit is required for projects that require other state or federal permits, cover more than 20 acres, or for construction covering more than 60,000 square feet. Applications for major permits are reviewed by ten state and four federal agencies.

- General Permit.
  General permits are required for routine projects that usually pose little or no threat to the environment.

- Minor Permit. Minor permits are issued for projects (such as single-family houses) that do not require major permits or general permits.

Information Resources:

Web: http://dcm2.enr.state.nc.us/Permits/apps.htm

NC DCM Contacts: Doug Huggett
Manager, Permits and Consistency Section
(919) 733-2293

- ## *Division of Land Resources - Land Quality Section*

Sedimentation and Erosion Control Plan.

Approval is required for all land disturbances of one or more acres. Upon approval of the Sedimentation and Erosion Control Plan, the applicant will also receive coverage under the NPDES stormwater general permit for construction activities for projects that have land disturbances of five or more acres.

Information Resources:

Web: http://www.dlr.enr.state.nc.us/eros.html

NC DLR Contacts: Mell Nevils,
Land Quality Section Chief
(919) 733-4574

Dam Safety Permit.

Approval is required for construction, repair, alteration or removal of any dam that is over 15 feet high and impounds more than 10 acre - feet.

Information Resources:

Web: http://www.dlr.enr.state.nc.us/dam.html

NC DLR Contacts: Tami Idol
Assistant State Dam Safety Engineer
(919) 733-4574

- *Division of Waste Management*

Underground Storage Tanks
Many (but not all) USTs require permits. A tank containing heating oil for consumptive use on premises where stored is not regulated, is non-commercial and does not require a permit.

Information Resources:

Web: http://ust.ehnr.state.nc.us/NewPages/permits.html

NC DWM Contacts: Annette Parker
Annette.parker@ncmail.net
(919) 733-1308

Section Two - Natural Resource Divisions and Agencies

- Division of Marine Fisheries (DMF)

This Division is responsible for stewardship of the marine and estuarine resources of the State of North Carolina. This responsibility includes the administration and enforcement of all statutes and rules governing commercial and recreational fishing in coastal waters. It conducts scientific research, upon which regulatory and developmental decisions can be based. It carries out developmental activities to improve the cultivation, harvesting, and marketing of shellfish and finfish. It is also responsible for the state's artificial reef and submerged land programs. DMF administers programs in commercial and recreational fisheries management and enforcement, fisheries statistics, bottom leasing, submerged land claims, and information and education.

Information Resources:

Web: http://www.ncfisheries.net/

NC DMF Contacts: Mike Street
Habitat Protection Section
(252) 726-7021 or 1-800-682-2632

- North Carolina Wildlife Resources Commission (NC WRC)

The NCWRC works under its own legislative mandate and is associated with the Department of Environment and Natural Resources. The purpose, function and duty of the NCWRC is to protect, develop, conserve, and regulate NC wildlife resources and to administer and enforce the laws relating to the wildlife resources so that a sound, constructive, comprehensive, continuing, and economical wildlife program directed by qualified, competent, and representative citizens who shall have knowledge of and training in the proper use and management of wildlife resources shall exist. WRC administers a variety of permits and wildlife related programs, including the state boating safety program. The Governor, Speaker of the House and President Pro Team of the Senate appoint the 17 WRC members. The approximate 500 members of the WRC's professional wildlife staff are divided into five different divisions: Boating & Fisheries, Law Enforcement, Habitat Conservation, Conservation Management, and Wildlife Management.

Information Resources:

Web:	http://www.ncwildlife.org/
NC WRC Contacts:	Shannon Deaton Manager, Habitat Conservation Section (919) 733-3633 ext. 283

- Division of Parks and Recreation
  Natural Heritage Program (DRP-NHP)

This program inventories, catalogues, and facilitates protection of the most rare and outstanding elements of the natural diversity of our state. These natural diversity elements include rare plants and animals and significant natural communities that merit special consideration as land-use decisions are made.

Information Resources:

Web:	http://www.ils.unc.edu/parkproject/nhp/index.html
NC DRP-NHP Contacts:	Stephen Hall (919) 715-8688

- National Oceanic and Atmospheric Administration (NOAA)
  National Marine Fisheries Service

More than one-fifth of the world's most productive marine waters lies within US territorial waters. An estimated 17 million people enjoy marine recreational fishing, landing almost 300 million pounds of fish each year. Many more fish are caught and released as part of a nationwide angler conservation program. These vast fishery resources and their essential habitats can be rapidly destroyed if harvest is not carefully controlled or their important habitat goes unprotected. But with proper management, healthy stocks can be maintained, and diminished fish populations can be restored to bring greater wealth to the nation's coastal communities. Fisheries that are sustainable over the long term allow United States citizens to reap the greatest economic and social benefit, including a continuing supply of high-quality seafood, and recreational enjoyment. Sound scientific research is the basis for sustainable fisheries. To help ensure productive future harvests, NOAA NMFS scientists study the life history, stock, size, and ecology of economically important fisheries managers to set annual quotas, or the amount of fish that can be harvested each year.

Information Resources:

Web: http://www.nmfs.noaa.gov/

NOAA NMF Contacts: Ron Sechler
National Oceanographic and Atmospheric Administration
(252) 728-5090

- US Fish and Wildlife Service

"The U.S. Fish and Wildlife Service's mission is, working with others, to conserve, protect and enhance fish, wildlife, and plants and their habitats for the continuing benefit of the American people." USFWS is the only agency of the U.S. Government with that primary mission. USFWS helps protect a healthy environment for people, fish and wildlife, and helps Americans conserve and enjoy the outdoors and US living treasures. USFWS' major responsibilities are for migratory birds, endangered species, certain marine mammals, and freshwater and anadromous fish.

Information Resources:

Web: http://www.fws.gov/

US FWS Contacts: Dr. Garland B. Pardue
Ecological Services Supervisor

(919) 856-4520 ext.11

WATER TREATMENT PLANT NOTIFICATION LIST

1. **DWQ- Division of Water Quality**
   Permits Service Branch
   NPDES Supervisor
   Dave Goodrich
   (919) 733-5083 ext. 517
   (919) 733-0719
   davegoodrich@ncmail.net

2. **DEH- Division of Environmental Health**
   Public Water Supply
   Wayne Munden,
   Branch Head, Technical Services Branch
   (919) 715-3237
   (919) 715-4374 (fax)
   wayne.munden@ncmail.net

3. **DLR- Division of Land Resources**
   Mell Nevils
   Land Quality Section Chief
   (919) 733-4574
   (919) 733-2876 (fax)
   mell.nevils@ncmail.net

4. **DWR- Division of Water Resources**
   Woody Yonts
   Water Supply Planning
   (919) 715-5453
   (919) 733-3558 (fax)
   woody.yonts@ncmail.net

5. **ACOE- US Army Corps of Engineers**
   Gwen Dye
   (910) 251-4494
   (910) 251-4025 (fax)
   gwendolyn.r.dye@saw02.usace.army.mil

6. **DCM- Division of Coastal Management**
   Doug Huggett
   Manager, Permits and Consistency Section
   (919) 733-2293
   (919) 733-1495 (fax)

doug.huggett@ncmail.net

7. **DMF- Division of Marine Fisheries**
Habitat Protection Section
Mike Street
(252) 726-7021 or 1-800-682-2632
mike.street@ncmail.net

8. **WRC- NC Wildlife Resources Commission**
Manager, Habitat Conservation Section
Shannon Deaton
(919) 733-3633 ext. 283
deatonsl@mail.wildlife.state.nc.us

9. **USFWS- US Fish and Wildlife Service**
Ecological Services Supervisor
Dr. Garland B. Pardue
(919) 856-4520 ext.11
(919) 856-4556 (fax)
garland.pardue@fws.gov

10. **NHP- NC Natural Heritage Program**
Stephen Hall
(919) 715-8688
(919) 715-3085 (fax)
stephen.hall@ncmail.net

11. **NMFS- National Marine Fisheries Service**
National Oceanographic and Atmospheric Administration
Ron Sechler
(252) 728-5090
(252) 728-8728 (fax)
ron.sechler@noaa.gov

12. **SEPA- State Environmental Policy Act**
Melba McGee
(919) 715-4194
(919) 715-3060

melba.mcgee@ncmail.net

Appendix H - Existing NPDES Permitting Policy

Appendix I - Documents

- FDEP, 1995. Protocols for Determining Major-Seawater –Ion Toxicity in Membrane Technology Water Treatment Concentrate. Tallahassee, FL: FDEP.
- Andrews, Laura. 2001. Concentrate Disposal. American Membrane Technology Association, 2001 Annual Symposium.
- Mickley, Michael, and Briceno, Jorge. 2001. Environmental Concerns: Membrane Drinking Water Plants. Denver, Colo.: AwwaRF and AWWA.
- Mickley, Michael and Briceno, Jorge, 2000. Major Ion Toxicity. Denver Colo.: AwwaRF and AWWA.
- Stanley, Donald, 1992. Evaluation of Brine Discharge Impact on Salinity in the Pamlico River Estuary. Report for the City of Washington, North Carolina Water Facilities Improvements, Washington, North Carolina.

Appendix J - Raw Data

- Examples of Chemical Usage in North Carolina
- Source Water Data
- Discharge Monitoring Report Data
- Chemical/Physical Characteristic Data
- Toxicity Data