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Maine Department of Environmental Protection Bureau of Water Quality Division of Water Quality Management State House Station 17 Augusta, Maine 04333-0017

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Date: January 11, 2019

RE: Chemical and Biological Monitoring Issues Associated with the #ME0002771, APPLICATION OF NORDIC AQUAFARMS, INC. (NAF) MPDES PERMIT

This memorandum addresses chemical and biological issues associated with the above referenced wastewater discharge application. Many of the processes defined in the application may be considered Best Practices or refer to new technologies that may be improvements over traditional land based farming and treatment practices. **My goal is to assure that the best and strongest permit be provided.** There is a case to seek assurances that data can be collected to assure the success of these practices. Monitoring with comprehensive periodic analytical testing can be a useful tool to understand the success of new technologies and learn from these technologies as we go forward. Ultimately, this memorandum requests that considerations described in this memorandum be shared with technical application reviewers and that appropriate conditions be added to any draft permit.

To provide background on my capacity to describe concerns with the application, here is a brief summary of pertinent credentials:

- BS/MS Massachusetts Institute of Technology in Chemical Engineering
- Past Director of Licensing & Enforcement and Past Director of Field Services of DEP Bureau of Oil and Hazardous Materials
- Retired Director of the DHS Health and Environmental Testing Laboratory (HETL)
- Retired Consultant for the Association of Public Health Laboratories
- Retired Consultant for EPA Emergency Response Laboratory Network, through Computer Science Corporation

A major concern with this application is the lack of assurances that there is a complete understanding of all the pollutants from the NAF discharge. I seek additional monitoring of the effluent. Because of the complexity of understanding 3D modeling of NAF discharges to the bay, and how this might affect dispersal in the bay, it is also useful to consider periodic discharge

monitoring of comprehensive parameters as discrete discharges. Only looking at aggregate discharges over longer periods of time and after dilution with 7.7 million gallons/day may not represent true impact.

I have made an effort to provide subtopics.

1. Water Quality-Based Effluent Limits

Since many of the parameters associated with the NAF effluent are experimental in nature, (unique feed, unique RAS, unique treatment, size of operation, uncertain marine water flow parameters and recirculation uncertainties, etc,) there is a need to assess and develop technology based effluent limitations, develop proper effluent water quality-based effluent limits (WQBEL), and finally determine final effluent limitations that meet technology and water quality standards and anti-backsliding requirements. WQBELs involve a site-specific evaluation of the discharge and its effect on the receiving water. A WQBEL is designed to protect the quality of the receiving water by ensuring that State water quality standards are met. Rather than provide a permit with chemical constituents limited for just the few nutrients, additional conditions/limits should be listed:

- To consider unique situations, such as facilities discharging pollutants for which data are absent or limited (pheromones, viruses, trace toxics, treatment errors that may occur for such a large size), making development of technology- or water quality-based effluent limitations (TBELs or WQBELs) more difficult or impossible
- To address foreseeable changes to discharges, such as planned changes to process, products, or raw materials that could affect discharge characteristics.
- To incorporate compliance schedules to provide the time necessary to comply with permit conditions. • To incorporate other NPDES programmatic requirements (e.g., pretreatment, sewage sludge).
- To impose additional monitoring requirements that provide the permit writer with data to evaluate the need for changes in permit limitations.
- To increase or decrease monitoring requirements, depending on monitoring results or changes in processes or products.
- To impose requirements for special studies such as ambient stream surveys, toxicity identification evaluations (TIEs) and toxicity reduction evaluations (TREs), bioaccumulation studies, sediment studies, mixing or mixing zone studies, pollutant reduction evaluations, or other such information-gathering studies

As a new technology and as one that may serve as a template for future land based endeavors there is a need for standards and limits.

This sort of testing is also consistent with the need to better understand the dispersal of the discharge plume. [Only 2 dimensional modeling has occurred and there is a need to understand if surface plumes are developed and the effects of currents and wind shear.] The testing of the chemical parameters in the outflow should be evaluated more thoroughly largely due to the swimming areas at Bayside. There is concern about primary water contact recreation standards.

2. **Monitoring to Assure that New Technologies to Achieve Best Practices Meet Water Quality Needs**

While NAF should be applauded for its use of best practices such as Moving Bed Biofilm Reactor (MBBR) designs, there remain questions regarding its ability to meet desired outflow concentrations of nutrients and set concentrations for other parameters. The flow diagrams of the treatment systems provided are difficult to read and as an example it was difficult to see where in the process that the added carbon for denitrification is introduced. Additional information regarding the treatment of multiple tanks can be helpful in designing response scenarios. There are multiple tanks, some with fresh water, some with seawater, and some perhaps hybrid. Additional information about how each tank will be treated, individually or as mixed is important at the treatment systems and treatment can vary with the salinity of the water and the different wastes that may be present in each.

Because the NAF application represents something that is new and different and claiming to be so much more capable of removing pollutants (pollutants should also include toxics and viruses), there should be more detailed information about the MBBR design. Simply stating that MBBR design is used is not very definitive, since MBBR designs can change significantly. **I am not specifically seeking answers to the questions below or even precise detail on the treatment systems. Instead, I offer these unknowns as reason to request frequent monitoring for multiple parameters.**

- What is the relative size of the clarifier needed after the biological tanks, important because MBBR yields to poor sludge characteristics?
- The application suggests that there is a post-anoxic denitrification process, the influent to the denitrification reactor comes from the nitrification reactor, so the wastewater influent ammonia nitrogen has been converted to nitrate as required for denitrification. How was the 1.5 million gallons/day of Methanol derived and what forms of nitrogen can be expected in the effluent?

- What is the plan to address any washing out of the fixed film media.
- MBBR are known to encounter problems in some calcium rich wastewaters as calcium salts can precipitate on the carriers. This phenomenon, referred to as scaling, can result in clogged carriers, which sink, to the bottom of the reactor - an effect that can be detrimental for the treatment process.
- What are the effects of oil and grease from salmon on the biofilms?
- The STERAPORE Hollow Fiber Membrane Bio-Reactors while also highly acknowledged as effective and state of the art, we need assurances that these too will not be subject to failures that might endanger the discharge waters. While most scientific articles about MBR systems suggest membrane surface fouling as being the main operational limitation for the technology, it is widely recognized by practitioners that clogging phenomena possibly related to inefficient pre-treatment are at least as important. It is also recognized that clogging takes different forms, such as Sludging, Ragging, and Membrane fouling.
- Lastly, there is no discussion of other pollutant contaminants that could exist in discharges; at public hearings, the statement was made without substantiation that there could be no "toxic discharge".

3. Effluent Testing to Include 40CFR part 136 defined parameters

A significant reason to seek testing for multiple chemical and biological parameters in the waste discharge (in addition to those mentioned previously) is the major unknowns associated with the fish feed. There are multiple papers that suggest that some fish feeds used for land based aquaculture have contained toxic chemicals. While the applicant suggests that there will be no toxins in the feed, there is no statement at this time about what the feed may be. In addition, certification standards for fish feed have not been specifically referenced to provide assurance that the feed will not have toxins present; therefore monitoring alone can provide assurances that toxins would not enter the waste effluent as a byproduct of the fish food.

Comprehensive screening analyses of waste streams are a documented process to assure a better understanding of the composition of the waste stream. There is no feed analysis and no known source of feed and there is no requirement through the MPDES application to test for feed ingredients. Effluent testing should not be limited to nutrients, but periodically tested for 40CFR part 136 defined parameters. Refer to Lists of methods by analyte; from 40 CFR 136.3

Table IA: Biological
Table IB: Inorganics
Table IC: Non-pesticide organics

Table ID: Pesticides
Table IE: Radiological (if deep aquifer water with radon is included as input)
Table IF: Pharmaceutical
Table IG: Pesticide active ingredients
Table IH: Ambient Biological

1. Inorganics: including metals, nutrients (available and non-available), BOD, CBOD, pH, TOC, O2, sulfides, temperature, TSS.
2. Non pesticide organics (120 parameters)
3. Pesticides (70 parameters)
4. Pharmaceuticals (33 parameters)
5. Pesticide active ingredients (268 parameters)
6. Microbiology (bacteria and virus detection)
7. Pharmaceuticals and personal care contaminants as defined in method 1698 for steroids and hormones, and include pheromones unique to salmon, and 1694 pharmaceuticals

Screening at low detection limits is for wide ranges of contaminates is recommended. Examples could include ICP/ICPMS scans for metals, GC/MS scans for volatile and semivolatile organics, HPLC/HPLCMS for higher molecular weight, nonvolatile organics.

4. TriHaloMethanes and Bromates

Another test that is recommended is the test for trihalomethanes, THM's. When chlorine is added to water with organic material, THMs are formed. Residual chlorine molecules react with this harmless organic material to form a group of chlorinated chemical compounds, THMs. They are tasteless and odorless, but harmful and potentially toxic.

While ozone is not listed as a backup disinfectant, many treatment systems that disinfect fresh water do use ozone. Ozone reacts with bromine, which is why ozone is typically not used to disinfect seawater. Ozone reacts with bromine to produce Bromates. Bromates are toxic. Should Ozone be introduced into the NAF process, testing of effluent should include Bromates.

5. Other Chemicals Used in the Processing

Chemicals that have been specifically listed in the permit should be tested in the effluent to detection levels that are consistent with toxicity issues for all life affected. If these are not

covered in Section 3 of this memorandum, the applicant should address methods of analysis that are consistent with acceptable toxicity limits for each.

Cleaners Detergents
Aqualife® Multipurpose Cleaner
Gil Save®
Clean in Place (CIP)
Gil Super CIP®
Gil Hydrox®
Disinfectants/Sanitizers
Bleach.
Virkon® Aquatic.
Zep FS Formula 12167® Chlorinated Disinfectant and Germicide.
Therapeutants
Parasite-S, Formalin-F, and Formacide-B. (Formalin).
Finquel® or Tricane-S. (Tricaine methanesulfonate).
Halamid® Aqua. (Chloramine-T). Active ingredients N-chloro, p-toluenesulfonamide and sodium salt trihydrate.
Ovadine® (PVP Iodine).
Compounds Rarely Used Only in Emergency Situations:
Praziquantel.
Potassium permanganate
Terramycin® 200. (oxytetracycline dehydrate, 44% active):
Aquaflor®. (florfenicol; 50% active).
Romet® 30/Romet® TC. (sulfadimethoxine/ormetoprim,
Waste Water Treatment
Formic Acid (85%).
Bleach. Active ingredient: sodium hypochlorite
Methanol

A notable exclusion in the application is the use of Sodium thiosulfate. At the November public hearing NAF discussed the use of sodium thiosulfate to negate high level of chlorine should the need exist, yet sodium thiosulfate was not listed.

6. Testing for Viruses and Bacteria

There is a potential for viruses to be in the effluent. The mesh size of the membrane filters is stated as 0.4microns. This size would capture some but certainly not all bacteria, which

generally range in size between 0.2 to 10.0 microns. Viruses range in size from 0.004 to 0.1 microns in size. Viruses would not be trapped. It is questionable where UV would be effective, given the flow volumes. The ability of UV disinfection deserves more attention, e.g. water color, biofilms, time, temperature and turbulence effects can have significant effects on UV success.

A .4 micron filter will not separate out bacteria. Typically .1 micro filters are needed.
Here is information regarding bacteria and viruses that should be of concern:
This might be of interest.
https://www2.gnb.ca/content/dam/gnb/Departments/10/pdf/Publications/Aqu/AquacultureGrowing.pdf
Viruses:
Infectious salmon anemia (ISA) or ISAv .. (v for virus) is endemic to the Atlantic. See facts here: https://doi.org/10.1111/jfd.12670
Infectious Pancreatic Necrosis (IPN) or IPNv is endemic to Atlantic Canada and therefore probably Maine as well. Fact sheet:http://www.inspection.gc.ca/animals/aquatic-animals/diseases/reportable/infectious-pancreatic-necrosis/fact-sheet/eng/1330099413455/1330099555496
Aeromonas salmonicida is also common in the North Atlantic. https://en.wikipedia.org/wiki/Aeromonas_salmonicida

7. Nitrogen Protein Profile

Another useful test is a nitrogen protein profile in the waste stream. Currently, the permit only mentions nitrogen, but not the form. There is concern that some proteins in this waste might impart either an odor or a taste that would be a concern for other marine life. Total proteins can be tested easily; however, an HPLC analysis of the nitrogen compounds could more accurately provide information about the types of nitrogen compounds in the waste. Testing could also include hormones. This way the presence or absence of pheromones could be more assured. The reason for this test is to resolve any questions about how the presence of pheromones would serve to discourage lobsters from entering waters affected by the NAF discharge.

8. Audiological Issues

There is potential concern for audiological effects of RAS outfall pumps etc on marine life, fish shellfish and mammalian, in receiving waters. Some baseline and follow up data should be provided in this area as well.

9. Total Nitrogen Calculations

The calculations of nitrogen in the effluent are based upon a 1.1kg feed/kg of fish. This ratio is optimistic. Because the feed is not known at this time and because the composition of the feed may have significant effect on the availability of nitrogen in the wastewater, the calculations should instead use a less efficient ratio; 2/1 is not unreasonable. A concern is that if the nitrogen limits suggested in the permit application are based upon unattainable feed/fish ratios then higher levels of nitrogen are likely to be released. (In this case 2.0/1.1 X the expected Nitrogen discharge.) How would an increase in nitrogen discharge affect the permit limitations, since it already appears that maximum dilution in built into the outflow exit?

10. How to Respond to the Event of a Unpredicted Outflow Contamination

Given the size of this facility and lack of data to support how a large facility such as this in a pristine location, there is reason to suggest either a scaled back application or to incorporate special conditions into a permit.

- To incorporate preventive requirements, such as requirements to install process control alarms, containment structures, good housekeeping practices, and the like.
- A chief concern with the treatment process is the need for assurances that mistakes will not cause huge releases to the pristine bay. How will errors in continuous flows be contained before release to the bay? If needed, will containment structures be provided to bypass discharge to the bay?

Thank you for considering these points of interest in the NAF Application. Please drop me a line to assure I got this request to the right people at the right time. Also, please do not hesitate to contact me if you have questions of me or seek clarifications.