New Brunswick Nouveau-Brunswick CANADA

Environmental Management Program for Land Based Finfish Aquaculture in New Brunswick

Version 1.0

Environment and Local Government
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ACCRONYMS AND DEFINITIONS

BMP	Best Management Practices
BOD	Biological Oxygen Demand
CALA	Canadian Association for Laboratory Accreditation
CCME	Canadian Council of the Ministers of the Environment
CHL A	Chlorophyll A
COA	DELG Certificate of Approval to Operate
COD	Chemical Oxygen Demand
DAAF	New Brunswick Department of Agriculture, Aquaculture and Fisheries
DELG	New Brunswick Department of Environment and Local Government
DFO	Department of Fisheries and Oceans Canada
DO	Dissolved Oxygen
EEF	Environmental Effects Monitoring
EMP	Environmental Management Program
EQO	Environmental Quality Objective
EUTROPHIC	Trophic status class for watercourses with high productivity
FCR	Feed Conversion Ratio: ratio of feed fed to weight gain
FIMTA	Freshwater Integrated Multi-Trophic Aquaculture
IGPM	Imperial Gallons per Minute
LAND-BASED AQUACULTURE	Aquaculture conducted within tanks or ponds.
LPM	Litres per minute
MESOTROPHIC	Trophic status class for watercourses with moderate productivity
mg/l	Milligram per Litre
MIXING ZONE	Region in which initial dilution of a discharge occurs.
OLIGOTROPHIC	Trophic status class for watercourses with low productivity
PBS	Performance Based Standard
SRP	Soluble Reactive Phosphorus
SECCHI DEPTH	Measure of water quality reported in metres
SSP	Standard Sampling Procedure
TAN	Total Ammonia Nitrogen
TDP	Total Dissolved Phosphorus
TN	Total Nitrogen
TP	Total Phosphorus
TSS	Total Suspended Solids
ug/l	Micrograms per Litre
WAWA	Watercourse and Wetland Alteration
WMP	Waste Management Plan

1.0 INTRODUCTION

This Environmental Management Program (EMP) applies to land-based finfish tank operations exceeding 2,500 kilograms and pond culture operations exceeding 25,000 fish operating in New Brunswick. The provisions of this program will be enforced through the Aquaculture Approvals program administered by the Department of Environment and Local Government (DELG), under the authority of the *Water Quality Regulation – Clean Environment Act* and by Fisheries and Oceans Canada (DFO) through the *Fisheries Act*.

The overall goal of this EMP is to guide the long-term environmental sustainability of the land-based finfish aquaculture industry in New Brunswick. The EMP will continue to be responsive to evolving science, environmental management techniques, technology, First Nations and the public interest. Review of this EMP will be conducted every five years or as circumstances require as determined by the department.

The program has several components designed to support the overall goal. These components are reflected in the following sections:

- **2.0 Environmental Management Framework** describes the governance system that would be applied to support implementation of a Performance Based Standard (PBS) program. This includes environmental quality objectives, indicators, environmental monitoring program, site classification, auditing, reporting and ongoing future initiatives.
- **3.0 Operational Best Management Practices** are designed to minimize the environmental effect of land-based aquaculture operations.
- **4.0 Mitigation and Remediation** provides information that may be useful in preparing a Mitigation Plan when the facility is not in compliance with the PBS outlined within this document.

Fish culture began in Canada in 1865 while locally it had it's beginnings in 1873 at South Esk, Miramichi for the purpose of enhancement of provincial waters with native salmonid species. Environmental regulatory control of land-based finfish aquaculture in New Brunswick began in 1982 through the authority of the Clean Environment Act, Water Quality Regulation (82-126). In 1989 the Department of Environment committed a full time position to regulate the increasing number of freshwater aquaculture hatcheries through issuance of an Approval to Operate. Both approval class and associated fees were based strictly on the number of fish raised. Settling ponds were the waste treatment of choice and phosphorus was monitored at the edge of a mixing zone to determine compliance with water quality thresholds.

Currently, regulatory management is still administered through the DELG Certificate of Approval to Operate which also include conditions that require limits on the number of fish and/or biomass, rate of water withdrawal and total phosphorus and/or total nitrogen concentration at point of discharge into a watercourse or after a set mixing zone. The approval also contains conditions pertaining to chemical storage and handling, record keeping and recording and noise control. The New Brunswick Department of Agriculture, Aquaculture and Fisheries (DAAF) is responsible for issuing aquaculture licenses which provide the authority to conduct aquaculture at a specific site in accordance with the *Aquaculture Act* and associated Regulations. The licence also specifies the species authorized for cultivation, locations by Property Identification numbers (PID's), a sketch showing the location of activities within the area approved, containment and fish health requirements before movement of fish.

This EMP will clarify as to how facilities are to be regulated within the province by the standardization of sampling and reporting requirements for four separate types of facilities that consider both operation size as well as the receiving body of water type. In doing so this document will introduce a new regulatory framework, performance based standards and supporting measures, regulatory thresholds, best management practices, a guide to mitigation and remediation as well as standardization of sampling methods, reporting and waste management.

2.0 ENVIRONMENTAL MANAGEMENT FRAMEWORK

This section describes the environmental management framework used to ensure the long-term environmental sustainability of land-based finfish aquaculture in New Brunswick. It outlines a Performance Based Standards (PBS) approach regulatory framework (Figure 2.1) that is operationally flexible while providing protection to the environment. This PBS approach is based on the following guiding principles:

- Maintenance of environmental quality with operational flexibility;
- Application of a science-supported environmental management and regulatory process;
- Intergovernmental cooperation; and
- Public accountability

This section also details and defines the environmental quality objectives (EQO's) that will be applied to aquaculture facilities and describes the environmental indicators and monitoring program that will be utilized to determine facility classifications. Both the EQO's and the environmental indicators within this EMP have been established through a scientific literature and regulatory review by the Land-based EMP subcommittee of the Aquaculture Environmental Coordinating Committee (AECC).

2.1 Environmental Quality Objectives (EQO's)

The EQO's utilized within this EMP will evaluate the nutrient and trophic status of the receiving body of water at the perimeter of the mixing zone when compared to that of a control station (i.e. upstream). Trophic status will be determined through the concentration of phosphorus and/or nitrogen as outlined within Table 2.3. All land-based finfish aquaculture sites will be classified based on the calculated trophic status of the receiving water in comparison to that of an upstream or control site. Variables used to calculate the trophic status will focus on concentrations of total phosphorus and total nitrogen but may also include chlorophyll A and/or secchi depth for facilities with outfalls into lakes and ponds. The EQO for this EMP is ultimately to maintain the trophic status of the adjacent watercourse but does allow for some increase in nutrient concentration up to a mesa/eutrophic threshold (Table 2.3). Therefore classifications which meet the EQO include all classes below eutrophic status (i.e. mesotrophic or oligotrophic).

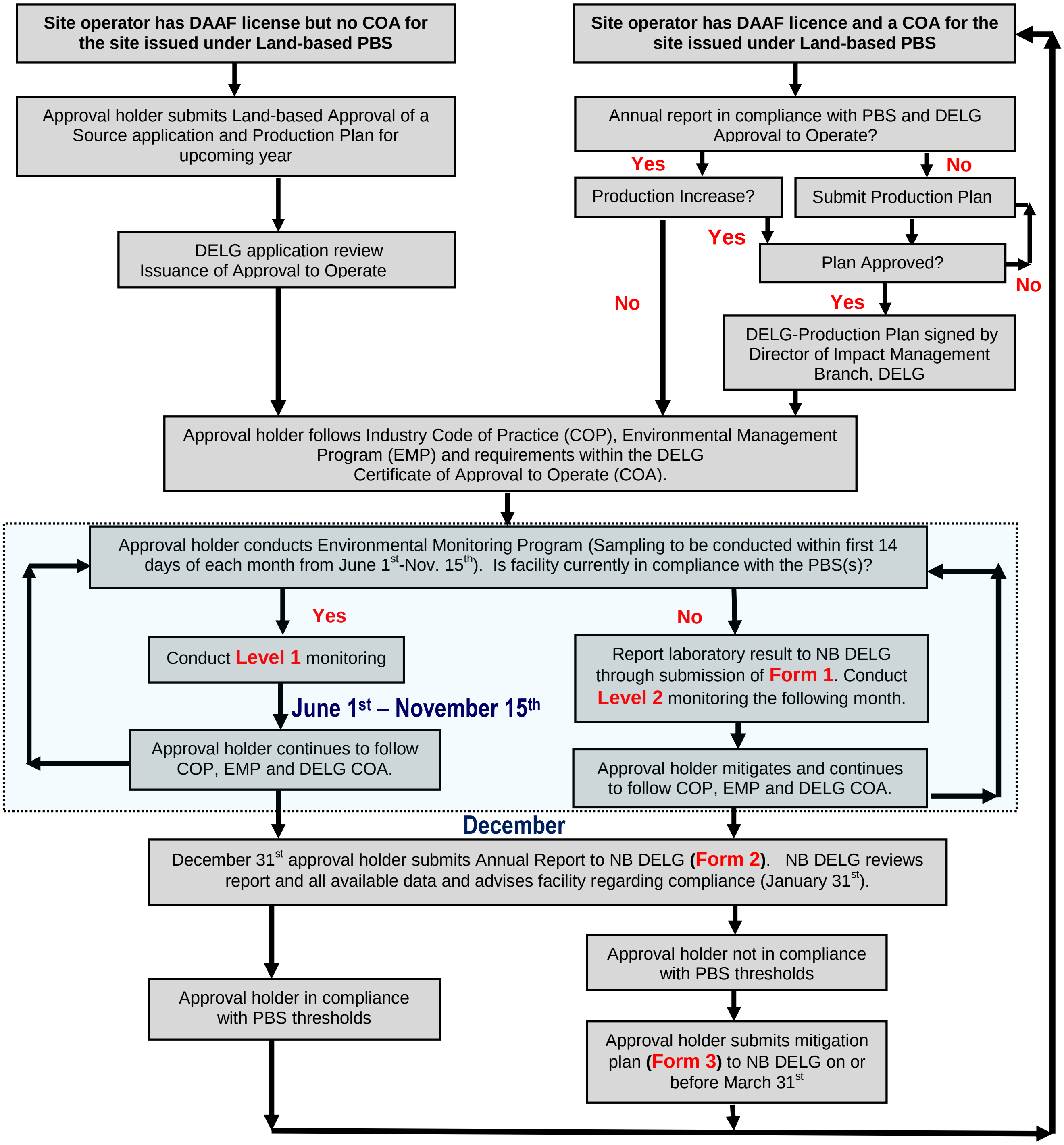

Figure 2.1: Regulatory Framework for Land-based aquaculture facilities in New Brunswick

2.2 Environmental Indicators

Total phosphorus (TP) and Total nitrogen (TN) are the Performance Based Standard (PBS) indicators that have been chosen for this EMP. The reasoning for this is that generally, phosphorus is the limiting nutrient for primary growth (plant and algae) in freshwater while nitrogen is the limiting nutrient in saltwater with the exception of periods of high freshwater runoff (i.e. spring snowmelt) or in areas where considerable nitrogen input results in a switch to phosphorus as the primary limiting nutrient. Total phosphorus and nitrogen are also correlated with other measures and are the key water quality indicators recommended by and commonly utilized as regulatory parameters in other jurisdictions. The criteria for this choice are listed as follows:

- Scientific confidence in the parameters and methods of sampling analysis to describe water quality;
- Repeatability and consistency in sampling and analysis; and,
- Cost effectiveness

Other indicators of water quality will also be used to validate the PBS indicators as well as to provide additional information to evaluate water quality. These include Total Ammonia Nitrogen, (TAN), nitrite (NO_2), nitrate (NO_3), secchi disk depth (SD), dissolved oxygen (DO), pH, temperature and Chlorophyll A (CHL A).

Total Phosphorous (TP)

Phosphorus (P) is found in the form of inorganic and organic phosphates (PO_4) in natural waters. Among the common sources of phosphorous are wastewater and septic effluents, detergents, fertilizers, soil run-off, phosphate mining, industrial discharges, and synthetic materials which contain organophosphates, such as pesticides. Phosphorous concentration is measured either through the concentration of total phosphorus (TP), which is a measure of all the various forms of phosphorus that are found in a water sample or by Soluble Reactive Phosphorous (SRP), which primarily measures the dissolved form known as orthophosphate. Systems designed to facilitate frequent solids removal from the rearing environment along with management practices optimizing feed utilization and waste management should help reduce phosphorus contribution to receiving waters.

Total Nitrogen (TN)

Nitrogen is commonly found in several forms in the aquatic environment. The compounds of greatest concern to aquaculturists are unionized ammonia and nitrite. Ammonia is a direct by-product of aquatic animal metabolism and in the decomposition of organic matter and is present in the form of a gas which dissolves in water to form ammonium ion (NH_4^+) and un-ionized ammonia (NH_3). The toxic, un-ionized fraction varies with pH, temperature, and salinity, increasing as the pH and temperature increase. The proportion of total ammonia in un-ionized form is shown for varying temperatures and pH levels in Table 1. Nitrite (NO_2^-) is an intermediate product in the biological conversion of ammonia to nitrate (NO_3^-), referred to as nitrification. Total nitrogen (TN) is the sum of nitrate-nitrogen (NO_3^-N), nitrite-nitrogen (NO_2^-N), ammonia-nitrogen (NH_3^-N) and organically bonded nitrogen. Total Nitrogen (TN) should not be confused with TKN (Total Kjeldahl Nitrogen) which is the sum of ammonia-nitrogen plus organically bound nitrogen but does not include nitrate-nitrogen or nitrite-nitrogen.

Total Ammonia Nitrogen (TAN)

Ammonia is the initial product of the decomposition of nitrogenous organic wastes and respiration. Thus, the concentration of Total Ammonia Nitrogen (TAN) is positively correlated to the amount of food wastage and amount fed. Total Ammonia Ammonia-Nitrogen (TAN) also referred to as Ammonia Nitrogen (NH_3T), is a parameter that measures both the un-ionized (NH_3) and ionized (NH_4^+) forms of ammonia present (i.e. TAN = NH_3 + NH_4^+). Water quality guidelines for TAN are presented in Table 2.1. Generally, NH_4^+ is harmless and can dissipate into the atmosphere easily; however, NH_3 can be extremely toxic and is directly correlated with temperature and pH. To calculate the NH_3 percentage from TAN; multiply concentration (in mg/L) by the percentage which is closest to the observed temperature and pH of the water sample within Table 2.2.

Table 2.1: Protection of aquatic life water quality guidelines for TAN (mg/L NH_3).

Temperature (°C)	pH							
	6.0	**6.5**	**7.0**	**7.5**	**8.0**	**8.5**	**9.0**	**10**
0	231	73.0	23.1	7.32	2.33	0.749	0.250	0.042
5	153	48.3	15.3	4.84	1.54	0.502	0.172	0.034
10	102	32.4	10.3	3.26	1.04	0.343	0.121	0.029
15	69.7	22.0	6.98	2.22	0.715	0.239	0.089	0.026
20	48.0	15.2	4.82	1.54	0.499	0.171	0.067	0.024
25	33.5	10.6	3.37	1.08	0.354	0.125	0.053	0.022
	23.7	7.50	2.39	0.767	0.256	0.094	0.043	0.021

Source: CCME 2010

* The guideline values and all reported total ammonia concentration are reported in mg/L NH_3; measurements of total ammonia in the aquatic environment are often also expressed as mg/L TAN. The present guideline values (mg/L NH_3) can be converted to mg/L TAN by multiplying the corresponding guideline value by 0.8224

** Values falling outside of shaded area should be used with caution

*** No recommended guideline for marine waters

Table 2.2: Percent un-ionized aqueous ammonia solutions for 0-30°C and pH 6-10

Temperature (°C)	pH								
	6.0	**6.5**	**7.0**	**7.5**	**8.0**	**8.5**	**9.0**	**9.5**	**10.0**
0	0.008	0.026	0.082	0.261	0.82	2.55	7.64	20.7	45.3
5	0.012	0.039	0.125	0.394	1.23	3.80	11.1	28.3	55.6
10	0.18	0.058	0.186	0.586	1.83	5.56	15.7	37.1	65.1
15	0.027	0.086	0.273	0.859	2.67	7.97	21.5	46.4	73.3
20	0.039	0.125	0.396	1.24	3.82	11.2	28.4	55.7	79.9
25	0.056	0.180	0.566	1.77	5.38	15.3	36.3	64.3	85.1
30	0.080	0.254	0.799	2.48	7.46	20.3	44.6	71.8	89.0

Source: Emerson et al. 1975

The ionic strength of the water also has an important influence on the un-ionized ammonia concentration but to a lesser degree (Soderberg and Meade 1991). As the ionic strength increases in hard or marine waters, there is a decrease in the un-ionized NH_3 concentration (Environment Canada 1997; Emerson et al. 1975).

Nitrite-Nitrogen (NO_2^- N)

Nitrite is a by-product of oxidized NH_3 or NH_4^+, an intermediary in the conversion of NH_3 or NH_4^+ into NO_3. This process is completed through nitrification which is done by the highly aerobic, gram-negative, chemoautotrophic bacteria found naturally in the system. The conversion is quick, thus high nitrite concentrations are not commonly found. However, if high levels do occur, it can cause hypoxia, due to deactivation of hemoglobin in fish blood, a condition known as the "brown blood disease". The toxicity of nitrite is dependent on chemical factors such as the reduction of calcium-, chloride-, bromide- and bicarbonate ions, and levels of pH, dissolved oxygen and ammonia.

Nitrate-Nitrogen (NO_3^- N)

Nitrate is formed through the nitrification process, i.e. oxidation of NO_2 into NO_3 by the action of aerobic bacteria. Nitrate not taken up directly by aquatic plants is denitrified in anaerobic sediments and microzones. Generally, it is stable over a wide range of environmental conditions and is highly soluble in water. Compared with other inorganic nitrogen compounds, it is also the least toxic. However, high levels can affect osmoregulation, oxygen transport, eutrophication and associated algal blooms.

Secchi Disk (SD)

Is a circular disk used to measure water transparency or clarity in oceans and lakes. The disc is mounted on a graduated pole or line, and lowered slowly down in the water. The depth at which the pattern on the disk is no longer visible is taken as a measure of the transparency of the water. This measure is known as the **Secchi depth** and is related to water turbidity/clarity.

Dissolved Oxygen (DO)

Measures of dissolved oxygen (DO) refer to the amount of oxygen contained in water, and help to define the living conditions for oxygen-requiring (aerobic) aquatic organisms. Concentrations reflect an equilibrium between oxygen-producing processes (*e.g.* photosynthesis) and oxygen-consuming processes (*e.g*. aerobic respiration, nitrification, chemical oxidation).

pH

pH is defined as the negative logarithm of the hydrogen ion concentration in water. The lower the pH, the more "acidic" the water while the higher the pH, the more "basic" the water. A pH of 7 is considered to be neutral. Alone, pH tells very little about chemistry in a given water sample as it is interdependent with other water quality parameters, such as carbon dioxide, alkalinity, and hardness. It can be toxic in itself at a certain level, but may also influence the toxicity of hydrogen sulfide, cyanides, heavy metals, and ammonia (Klontz, 1993). The pH can also affect fish health. For most freshwater species, a pH range between 6.5 - 9.0 is ideal, but most marine animals typically cannot tolerate as wide range pH as freshwater animals, thus the optimum pH is usually between pH 7.5 and 8.5 (Boyd, 1998).

Temperature

Temperature patterns of aquatic habitats affect the kinds of organisms that can live in them. Salmonids and other cold water biota require specific temperatures for maintenance and reproduction. Water temperatures which fluctuate dramatically or move beyond this optimal range can impart stress reducing production efficiency, increasing disease susceptibility, and altering waste generation within the facility. Temperature is negatively correlated with oxygen solubility in water as solubility decreases as temperature increases. As a result, as temperatures rise oxygen injection is often required to sustain within safe and productive levels. Increases in temperature within the optimum range also result in increased feed intake and waste material which should be considered when designing waste water treatment systems.

Chlorophyll A (CHL A)

Chlorophyll A is a green pigment found in plants that absorbs sunlight and converts it to sugar during photosynthesis. Chlorophyll A concentrations are an indicator of phytoplankton abundance and biomass in lakes, coastal and estuarine waters. They can be an effective measure of trophic status, are potential indicators of maximum photosynthetic rate and are commonly used as a measure of water quality where high levels indicate poor water quality and low levels often suggest good conditions. However, elevated chlorophyll A concentrations are not necessarily always an accurate measure as it is the long-term persistence of elevated levels that is a problem. For this reason, annual median chlorophyll A concentrations are a better indicator of water quality.

2.3 Site Classification

Site classification is based on a comparison of the trophic status of the receiving watercourse downstream when compared to that upstream. Table 2.3 describes a series of classifications defined by total phosphorus and/or nitrogen in addition to other measurements when available.

Class 1

These facilities have limited nutrient loading to the receiving watercourse and are within the same trophic status downstream when compared to upstream. Facility will continue to follow the EMP Operational Best Management Practices and Industry Code of Practice (COP).

Class 2

These facilities have marginal nutrient loading to the receiving watercourse, have a different trophic status downstream compared to upstream but are below the PBS threshold(s). Facility will continue to follow the Operational Best Management Practices and Industry COP.

Class 3

These facilities are likely causing adverse environmental effects to the receiving watercourse and are above the set PBS threshold(s). They will continue to follow the Operational Best Management Practices, Industry COP and implement the Level 2 sampling so as to assist in determining effective mitigation measures.

Table 2.3: Trophic status site classification parameters and threshold limits

Trophic Status	Rivers / Streams		Lakes				Estuary / Marine		
	TP [2] (ug/l)	TN (ug/l)	TP[1,2] (ug/l)	TN (ug/l)	CHL A (ug/l)	SD (metre)	TP[2] (ug/l)	TN[2] (ug/l)	SD (metre)
Oligotrophic	*≤10*	*≤ 300*	*≤10*	*≤ 300*	*≤ 2.0*	*>5.0*	*≤10*	*<260*	*>6.0*
Mesotrophic	*10-20*	*300-500*	*10-19*	*300-500*	*2-10*	*5.0-3.0*	*11-20*	*260-350*	*6.0-3.0*
Meso-Eutrophic	*21-34*	*500-650*	*20-25*	*500-600*	*10-20*	*3.0-1.5*	*21-34*	*350-500*	
Regulatory Threshold									
Eutrophic	*35-100*	*650-1200*	*26-100*	*600-1200*	*20-50*	*2.0-0.5*	*35-100*	*>500*	*3.0-1.5*
Hypertrophic	*>100*	*>1200*	*>100*	*>1200*	*>50*	*≤ 0.5*	*>100*		*≤ 1.5*

[1] Sources: CCME (2004), Environnent Canada (2004), CCME (2007) and Vollenweider (1998).

[2] Performance Based Standard (PBS) variables

2.4 Water Quality Monitoring Program

The primary purpose of the monitoring program is to accurately evaluate the water quality within the receiving watercourse. All facilities are required to conduct the **Level 1** monitoring annually from the beginning of June 1st - November, during the typical period of peak of growth and feeding and when the maximum potential for degradation exists. Operations that are above the PBS threshold are required to conduct **Level 2** monitoring the following month. The purpose of this monitoring is to determine where within the system remedial actions should be focused. All sampling must be carried out in accordance with the *Water Sampling Methodology* outlined within Appendix A of this document. Level 2 monitoring within Tables 2.4, 2.5, 2.7 and 2.9 will not be required in instances where upstream or control stations are greater than 80% of the PBS threshold(s). (i.e. rivers TP ≥28 ug/L, lakes TP ≥20 ug/L) when the facility utilizes the receiving water as the primary water source. Such upstream loading typically occurs annually during spring runoff or may also occur during heavy storm events. As to avoid this time of naturally high TP in the environment, operators are encouraged not sample immediately after periods of heavy precipitation, if possible. If these periods cannot be avoided notes on weather or upstream activity should be noted.

Additional monitoring may be required in some circumstances, as determined by the DELG. For instance, additional sampling may be required to be conducted by the operator within the receiving watercourse, benthic environment or intertidal zone when signs of environmental degradation are present (i.e. high effluent TSS, organic and/or sulphide sediment within effluent outfall mixing zone). The DELG may also conduct both random and targeted sampling in and around land-based aquaculture facilities.

Large facilities with effluent outfall into streams, brooks and rivers

Large tank culture and pond facilities are tank operations that have a maximum standing biomass greater than 20,000 kilograms or pond operations that have greater than 200,000 fish. Large facilities with outfalls into streams, brooks and rivers must conduct annual monitoring as outlined within Table 2.4 and meet the PBS thresholds within Table 2.6. "Lab" samples must be sent to a laboratory accredited by either the Canadian Association for Laboratory Accreditation (CALA) or the Standards Council of Canada (SCC) while "Self" are to be measured by facility staff and reported to DELG with laboratory data. Facilities are required to have a flow meter installed on each intake as required within the Certificate of Approval to Operate and are encouraged to conduct a complete water chemistry analysis for well water once per year as a means of monitoring possible changes in water chemistry (DELG Laboratory Package I* or equivalent). All samples should be analyzed as “surface water” as this analysis type typically contains the lower detection limits required for comparing to protection of aquatic life thresholds.

Table 2.4: Required sampling parameters for large facility outfall into steams, brooks and rivers for sampling conducted monthly between June 1st - November 15th (6 times/year).

Sample Location	Level 1	Level 2[1]
Upstream	**Lab:** TP, and TN **Self:** Temp, DO and pH	**Level 1**
Before solids filtration		TSS and TP
Immediately post solids filtration		TSS and TP
Before septic, settling Pond/pit or wetland		TP
Effluent outfall	**Lab:** TP and TN **Self:** Temp, flow, DO & pH	**Level 1 plus[3]:** TAN & COD
100 m downstream of outfall	**Lab:** TP and TN **Self:** Temp, DO and pH	**Level 1 plus[3]:** TAN
Well[2]	**Self:** Flow and Temp	**Level 1**

[1] Level 2 may not be required in instances where influent is TP ≥ 28 ug .
[2] Full well water chemistry (DELG *I package or equivalent) required once per year
[3] Recirculation facilities may do self-analysis for TAN

Small facilities and pond culture with effluent outfall into streams, brooks and rivers

Small facilities are tank culture operations that have a maximum standing biomass between 2,500-20,000 kilograms or pond culture operations with greater than 25,000 fish. As smaller facilities represent less environmental risk, the sampling required is not as intensive when compared to others. They must conduct annual monitoring as outlined within Table 2.5 and meet the PBS thresholds within Table 2.6. “Lab” samples must be sent to a laboratory accredited by either the Canadian Association for Laboratory Accreditation (CALA) or the Standards Council of Canada (SCC) while “Self” are to be measured by facility staff and reported to DELG together with laboratory data. Operators that utilize well water are required to install flow meters to measure the withdrawal rate from each well. Operators are encouraged to conduct full well-water chemistry analysis once per year as a means of monitoring possible changes in water chemistry (DELG Laboratory Package I* or equivalent). All samples should be analyzed as “surface water” as this analysis type typically contains the lower detection limits required for comparing to protection of aquatic life thresholds.

Table 2.5: Required sampling parameters for small tank culture and pond operations with effluent outfalls into streams, brooks or rivers (3 sampling events/year: June, August, and October).

Sample Location	Level 1	Level 2[1]
25m upstream of effluent discharge	**Lab;** TP **Self:** Temp and DO	**Level 1**
Before settling pond/wetland for small facilities		TP
Water at discharge prior to entry in receiving water course.	**Lab:** TP **Self:** Temp and DO	**Level 1**
100m downstream of outfall	**Lab:** TP **Self:** Temp and DO	**Level 1**
Well[2]	**Self:** Flow and Temp	**Level 1**

[1] Level 2 may not be required in instances where influent TP ≥ 28 ug/L.
[2] Flow meter required. Full well water chemistry (DELG *I package or equivalent) encouraged once per year

Table 2.6: Regulatory threshold and Canadian Council of Ministers of the Environment (CCME) guidelines for facilities with outfalls into streams, brooks and rivers.

PBS Variable	**Threshold**
Total Phosphorus (TP)	35 ug/L
CCME Guidelines[1]	
Unionized Ammonia (NH_3)	19 ug/L
Nitrite (NO^2)	60 ug/L
Nitrate (NO^{3-})	13 mg/L
Reactive Chlorine	0.5 ug/L
Dissolved Oxygen	6.5 mg/L

[1]Canadian Water Quality Guidelines for the Protection of Aquatic Life (CCME 2007).

Facilities with effluent outfall into lakes and ponds

Facilities with outfalls into lakes and ponds must conduct annual monitoring as outlined within Table 2.7 and meet the PBS thresholds within table 2.8. These facilities are primarily different then the two previous in that the receiving watercourse is typically deeper and have a lower turnover rate. “Lab” samples must be sent to a laboratory accredited by either the Canadian Association for Laboratory Accreditation (CALA) or the Standards Council of Canada (SCC) while “Self” are to be measured by facility staff and reported to DELG together with laboratory data. Facilities are required to have a flow meter installed on each intake as required within the Certificate of Approval to Operate and operators are encouraged to conduct full well-water chemistry analysis once per year as a means of monitoring potential changes in water chemistry (DELG Laboratory Package I* or equivalent). All samples should be analyzed as “surface water” as this analysis type typically contains the lower detection limits required for comparing to protection of aquatic life thresholds.

Table 2.7: Required sampling parameters for facilities with outfalls into ponds and lakes for sample events conducted monthly between June 1st – November 15th (6 times/year).

Sample Location	Level 1	Level 2[1]
Control station*	**Lab:** TP **Self:** Temp, DO, pH, secchi depth	**Level 1 plus** TN
Intake	**Self:** Flow	**Level 1 plus** TP and TN
Before filtration		TSS and TP
Immediately after filtration		TSS and TP
Before septic, settling Pond/pit or wetland		TP
Effluent (prior to entry in water course)	**Lab:** TP **Self:** Temp, flow, DO, pH	**Level 1 plus**[3]: TN, TAN & COD
Edge of mixing zone	**Lab:** TP and TN **Self:** Temp, DO, pH, Secchi depth	**Level 1 plus**[3]**:** TAN
Well	Self: Flow and Temp	Level 1

[1] Level 2 may not be required in instances where control station TP ≥ 20 ug/L.
[2] Flow meter required and full well water chemistry (DELG *I package or equivalent) once per year
[3] Recirculation facilities may do self-analysis for TAN

Table 2.8: Regulatory thresholds and Canadian Council of Ministers of the Environment (CCME) guidelines for facilities with outfalls into ponds or lakes.

	Threshold
PBS Variable	
Total Phosphorus (TP)	25 ug/L
CCME Guidelines[1]	
Nitrite (NO^2)	60 ug/L
Nitrate (NO^{3-})	13 mg/L
Reactive Chlorine	0.5 ug/L
Dissolved Oxygen	6.5 mg/L

[1]Canadian Water Quality Guidelines for the Protection of Aquatic Life (CCME 2007).

Facilities with effluent outfall into estuaries or coastal waters.

Facilities with outfalls into estuaries and coastal waters must conduct annual monitoring as outlined within Table 2.9 and meet the PBS thresholds within Table 2.10. The primary change with such facilities is the switch from phosphorus to nitrogen as the dominant limiting nutrient for primary growth (plant and algae). “Lab” samples must be sent to a laboratory accredited by either the Canadian Association for Laboratory Accreditation (CALA) or the Standards Council of Canada (SCC) while “Self” are to be measured by facility staff and reported to DELG together with laboratory data. Facilities are required to have a flow meter installed on each intake as stipulated within the Certificate of Approval to Operate and operators are encouraged to conduct full well-water chemistry analysis once per year as a means of monitoring potential changes in water chemistry (DELG Laboratory Package I* or equivalent). All samples should be analyzed as “surface water” as this analysis type typically contains the lower detection limits required for comparing to protection of aquatic life thresholds.

Table 2.9: Required sample parameters for facilities with outfalls into estuaries and coastal waters for sample events conducted monthly between June 1st – November 15th (6 times/year).

Sample Location	Level 1	Level 2[1]
Control station	**Lab:** TP and TN **Self:** Temp, DO, pH,	**Level 1 plus:** TAN
Intake	**Self:** Flow	**Level 1 plus:** TP and TN
Before solids filtration		TSS and TP
Immediately after filtration		TSS and TP
Before septic, settling Pond/pit or wetland		TN and TP
Effluent	**Lab:** TN and TP **Self:** Temp, DO, pH, flow	**Level 1 plus**[3]: TAN & COD
Edge of mixing zone	**Lab:** TN and TP **Self:** Temp, DO	**Level 1 plus**[3]**:** TAN and pH
Well[2]	**Self:** Flow, Temp, plus conductivity	**Level 1**

[1] Level 2 may not be required in instances where Control station TP ≥ 28 ug/L and/or TN ≥ 500 ug/L
[2] Flow meter required. Full well water chemistry (DELG *I package or equivalent) encouraged once per year
[3] Recirculation facilities may do self-analysis for TAN.

Table 2.10: Regulatory thresholds and Canadian Council of Ministers of the Environment (CCME) guidelines for facilities with outfalls into coastal or estuarine waters.

	Threshold
PBS Variables	
Total Nitrogen (TN)	500 ug/L
Total Phosphorus (TP)	35 ug/L
CCME Guidelines[1]	
Un ionized Ammonia (NH_3)	19 ug/L
Nitrite (NO^2)	60 ug/L
Nitrate (NO^{3-})	16 mg/L
Reactive Chlorine	0.5 ug/L
Dissolved Oxygen	8.0 mg/L

[1]Canadian Water Quality Guidelines for the Protection of Aquatic Life (CCME 2007).

2.5 Site Visits, Inspections and Auditing

Site visits will be conducted on a minimal of 25 % of facilities each year. Visits may include a general discussion with staff regarding chemical storage, biosecurity, standing biomass, feeds and feeding, effluent treatment and monitoring results. Facilities are chosen through a review of water quality monitoring data in addition to other contributing variables and that may be present (i.e. low water and high temperature of receiving waters).

Site inspections and audits will be conducted as felt necessary by DELG inspectors after receipt of notification of non-compliance (Form 1) or as a follow up to previous site visits. Inspections will confirm compliance through a review the BMP's, chemical storage methods, feeds and feeding and effluent treatment. The purpose of the audit is to ensure accurate and reliable information is available for the government agencies and growers and to ensure that the Standard Sampling Procedures (SSP's) for water sampling is being followed.

Audits will consist of one or all of the following four components:

- A site inspection
- A review of the production and environmental water quality data
- Visual observations of the sampling procedures
- Water quality sampling at various control points throughout the system.

2.6 Ongoing and Future Initiatives

A considerable amount of research has been conducted to document the effects of finfish culture on the receiving watercourse. This research has greatly improved our understanding of the factors influencing the effects at the site-specific level. As research continues and additional data becomes available, other indicators of environmental impact may be incorporated into the EMP.

3.0 BEST MANAGEMENT PRACTICES

The following Best Management Practices (BMP's) are designed to minimize the environment effect of land-based aquaculture facilities and are a requirement of all operators requiring a Certificate of Approval to Operate. The primary environmental concerns of land-based aquaculture facilities are associated with water withdrawal and effluent composition. Rate of water withdrawal from surface waters is focused on protection of aquatic habitat while withdrawal from ground water is aquifer depletion and salt water intrusion in coastal properties Effluent discharge from land-based aquaculture facilities can have a significant impact on the receiving environment through oxygen depletion, organic and inorganic loading, chemical and pathogenic wastes and escapes into the receiving waters. Other BMP's contained within include record keeping and reporting, equipment cleaning and disinfection, biosecurity and containment and noise and odour control.

3.1 Water withdrawal

Land based aquaculture facilities require significant water resources with required volumes dependent upon the size and operation type. Size is determined by total holding capacity of water and the required turnover time to maintain water quality. Water volumes required for flow through facilities are highest as water intake is approximately equal to the rate of water output. Re-use systems which include the addition of solids filtration, oxygenation and nitrogen degassing of recirculated water generally re-use 40-50 % of water and therefore typically use half the water of flow-through systems. Recirculation facilities require the least volume of water as 90-95% or more of the water is reused and therefore require 5-10% the volume of flow through facilities. In addition to solids filtration, oxygenation and nitrogen de-gassing, these operations require a biofilter to reduce ammonia and nitrite levels within the recirculated water.

Surface water

The permitted rate of withdrawal from surface water sources is dependent on a number of factors including the historic low flow rates, watercourse status (i.e. fish bearing, spring) and whether or not the water withdrawn will be returned to the same watercourse. The volume permitted shall ensure that the remaining volume is sufficient to maintain aquatic life and required for migration of fishes. For new sites, withdrawal rate shall not be in excess of 10 litres/minute/km^2 of drainage area. Exceeding this volume will require the proponent to submit an application for a **DELG Watercourse and Wetland Alteration (WAWA) Provisional Permit** to the Surface Water Protection section at the DELG (DELG 1990). For existing sites, surface water withdrawal must not exceed that required to maintain historic aquatic habitat within the watercourse in which the water is withdrawn.

Ground water

The permitted well water withdrawal rate is dependent upon the sustainable volume that can be removed from the aquifer. Consideration must be given to the requirement to pump, other users within the aquifer as well as proximity to coastal waters due to the risk of salt water intrusion. For new facilities requiring greater than 50 m^3 per day (≈35 LPM or 7.5 IGPM) are required to conduct a New Brunswick Environmental Impact Assessment which shall include a **Water Supply Source Assessment** (WSSA) so as to determine the maximum safe pumping yield. For existing wells, a WSSA will be required only if the historic withdrawal rate is surpassed.

Regardless of the water source(s) utilized it is suggested that all operators submit samples for a complete water analysis at least once per year as to monitor any change in water quality. Water usage monitoring shall be conducted by flow meter(s) on the intake line(s) and shall be installed within the time frame stipulated the Certificate of Approval to Operate issued by the DELG.

3.2 Feed Management

Developing good feeding practices can eliminate excess amounts of waste feed from entering the system, help achieve better feed conversion (FCR's), and reduce both feed and labour costs. The amount of feed given to the stock should be determined using feed supplier tables as a guideline, and modified according to each facility's specific system. Adjustments to the daily ration amount may be required depending on water temperature, water quality, planned handling events, therapeutant treatments, etc. Delivery of feed can be performed by automatic feeders, hand feeding or a combination of both.

Aquaculture operators shall establish good feeding practices applicable to their facility to ensure maximum feed consumption with minimal feed waste. Good feeding practices should address the following:

- Staff training which shall include good feeding practices and how to
  - determine when to stop feeding.
- Proper feed storage and inventory control
- Proper feed delivery equipment operation and maintenance
- Determining when to reduce or stop feeding
- Determination of feed amounts, type and size

Feed Handling and Storage:

- Site staff and feed delivery personnel should take all reasonable precautions to reduce spills in and around the facility. Should a spill of feed occur, cleanup should occur immediately to reduce the threat of bacterial contamination and biosecurity threats (i.e. other animals).
- The amount of feed on site at any one time be limited to an amount that can properly be stored at the site.
- Feed is handled and stored carefully so as to reduce breakage and creation of excessive fines.
- Feed should be stored within cool dimly illuminated and low humidity (dry) location and bags closed so as to minimize feed spoilage and maintain biosecurity. Any feed that is unusable should be removed and disposed of in an appropriate manner as new feed is delivered.
- Proper feed delivery equipment operation and maintenance. If used, automatic feeders will be routinely checked that they are dispensing the appropriate amount of food
- Where possible, consideration shall be given to the use of low phosphorous feeds that meet CFIA requirements for minimum phosphorous content or are considered a "novel feed" by the CFIA.

The selection of extruded, high-energy feeds is another management tool that can be used to reduce waste as they have been shown to reduce feed conversions without a reduction in growth, thereby reducing waste. The fat content in extruded pellets can be increased without using the coating method, which allows the fat to be introduced before the pellet is formed, thereby giving a more homogeneous mix. Extruded feeds can be made to sink at different rates or float which provides another tool that the manager can use to avoid overfeeding. Uneaten feed will remain visible as evidence of overfeeding. The higher cost of these feeds may be the main reason that some farmers may not use them. However when the waste feed and reduced feed conversion is considered these feeds have proven to be more economical than steam pelleted feeds. By minimizing feed handling and storage time feed conversions can be improved. Regular deliveries and a good inventory system will keep the feed fresh. This is especially important in the hot summer months when the storage life of feed is reduced.

3.3 Waste Management

A Waste Management Plan (WMP) is required to be submitted prior to the issuance of the Certificate of Approval to Operate and will represent Schedule C of the Approval. It is intended to limit, and wherever possible, eliminate the discharge of facility-generated wastes into the environment. A generic waste management plan is included as Appendix 3 which may be used as a template.

For aquaculture facilities, waste is generally defined as the metabolic waste or uneaten food produced through the normal operation of a facility. The types of waste that could be generated from a facility and that would need to be included in the WMP are as follows:

- Operational debris including feed bags, domestic garbage, etc.
- Hazardous wastes including petroleum products, cleaning products, other chemicals used in the facility
- Biological waste including fish and egg mortalities, spawning wastes, etc.
- Solid wastes from sludge tanks, settling ponds/pits, etc.

Metabolic Waste

Metabolic waste comes in two forms: dissolved and particulate. When determining the amount of waste a system will generate, the amount and digestibility of feed used in a system are the most important factors. Feeding rates tend to increase with temperature, so the amount of waste is often greatest in the summer months when feeding rates are highest. Besides choosing a high energy extruded feed with high digestibility for greater assimilation, waste management efforts will be most effective if focused on the quick removal of solids.

Solids Removal

Primary treatment, or solids waste removal, should be done as quickly and gently as possible so as to reduce waste fragmentation which results in increased leaching of nutrients into the water. Water flow within production units are important for waste management to minimize the fragmentation of fish feces and allow for rapid settling and concentration of the settleable solids.

Dissolved Waste

Dissolved waste is another component of metabolic waste and is often measured through biological oxygen demand (BOD) and chemical oxygen demand (COD). BOD is considered a long-term measure of the consumption of oxygen because it may not occur until long after the water leaves the farm. On the other hand COD is a short term measure because the loss of oxygen occurs, for the most part, within the farm. Dissolved waste occurs in many forms: ammonia, nitrite, nitrate (i.e.; nitrogen), phosphorus and organic matter. Ammonia, which is excreted through the gills, is the most toxic form of nitrogen when in the un-ionized form. Naturally occurring bacteria convert ammonia into less toxic forms that are utilized by plants and algae for growth Phosphorus found in fish feed and faeces is broken down into a more useable form (phosphate) through decomposition. It is during the cleaning of tanks or ponds that elevated levels of waste may be released. Frequent removal of solid wastes will reduce the dissolved wastes in the outflow from the farm.

Pathogenic Waste

Water treatment plants often use some form of disinfection to reduce coliform bacteria and other potential pathogen loads that flow from the facility. Fish do not contain coliform bacteria and therefore concerns of water contamination are considerably reduced. The three most common methods to reduce pathogens from water is chlorination, ultraviolet radiation and, ozonation. UV radiation is a surface disinfection method that is not harmful to life downstream but since UV light does not penetrate the surface, fine particulate filtration is recommended prior to UV filter. Both chlorine and ozone are effective but are strong oxidizers and therefore must be monitored regularly as excessive concentrations within the effluent may result in fish kills and degradation of the receiving environment have been responsible for fish kills.

3.4 Record Keeping and Reporting

All large facilities (as defined within Section 2.4) shall maintain detailed records of their operations. It is important to document operational details of activities and conditions at the facility to provide valuable input to management decision-making. Detailed records also help identify potential causes when environmental parameters are exceeded, and allow for the implementation of appropriate responses within the PBS framework.

Environmental monitoring is required to be undertaken as indicated within Figure 2.1 and Section 2.4 as detailed within Tables 2.4, 2.5, 2.7 and 2.9 with the resulting data reported to DELG as required within Figure 2.1. Operators of large facilities are also required to maintain specific records which shall be included within the annual report but must also be available to DELG during site visits and audits. Records that shall be included within the annual report for such facilities will include, but may not be limited to the following:

- Biweekly average weight, number of fish, and biomass
- Average bi-weekly effluent flow (LPM or IGPM)
- Water quality monitoring results (June-November).
- Feed usage and % protein and phosphorus content in feed(s) utilized.
- A list of all chemicals used in the operation of the facility
- Dates of septic, sludge tank, settling pit or pond cleaning
- Results of any effluent treatment system inspection reports
- Results of any internal company audits conducted

- Any operational problems such as out-of-service equipment, equipment cleaning, reduced feeding events, etc.

All facilities are required to submit an Annual Report (Appendix 2, Form 2) at the end of each calendar year. Reporting to DELG is required when a facility is out of compliance with a PBS parameter during the annual environmental monitoring program June 1st – November 15th. Information required at the time of the non-compliance event is outlined in Appendix 2, Form 1); a Remediation Report is also required when the facility is out of compliance as determined by the DELG (Appendix 2, Form 3).

3.5 Equipment Cleaning and Maintenance

All feeding and effluent treatment equipment will be routinely cleaned and maintained to ensure proper working order. Regular cleaning of rearing tanks, filters, etc. shall be performed and scheduled over a period of time (i.e. rather than all at once) so as to minimize any potential impact to the receiving environment. During cleaning, receiving waters shall meet the guidelines established within the Canadian Council of Ministers of the Environment (CCME) Canadian Water Quality Guidelines for the Protection of Aquatic Life (CCME 2007).

- When not being used, the disinfectants shall be stored such that any spill is contained and not released to the environment. All reasonable precautions will be taken to avoid releases due to spills during use.
- The disinfection of the tanks should be spread out over a number of days to reduce the potential for impacts from the disinfectant residues.

3.6 Biosecurity and Containment

Sustainable freshwater farm operations require the development of a culture which recognizes that strict adherence to the principles and practices of facility biosecurity and fish health management are critical components of day-to-day operations. All facilities should maintain the services of a veterinarian who routinely visits and monitors the fish, will diagnose health issues and direct the appropriate response. Farms operate in accordance with Best Management Practices, first to minimize the risk of a disease incidence, and second, to respond effectively should an infectious disease be identified. Such practices should include:

- Directives on how to maintain a pathogen-free, healthy rearing environment including restricted access, visitor logs, footbaths, hand wash stations, quarantine areas, year class separations
- Careful handling of fish and monitoring their behaviour for signs of stress and disease
- Routine disease screening and treatment of life stages maintained on the farm
- Proper storage, handling and administering of approved therapeutants and chemicals
- Emergency procedures to be followed in the event of an incidence of an infectious disease
- Mortality sampling and disposal in an approved manner, especially in the event of a mass mortality

Preventing the escape of fish from freshwater farms into surrounding water-courses is important to ensure there is no interaction between farmed and wild fish. As such, farms shall have containment procedures which ensure all exit water channels are provided with approved containment devices at critical control points to recover any fish that may have inadvertently escaped from the tank in which they were being grown. Such fish are euthanized and disposed of in an approved manner to prevent the transfer of pathogens which may have been encountered along the channels of escape. In addition, it is advisable that operators make themselves aware of the potential impact of escaped farmed fish on wild stock. **All**

fish escapes that enter adjacent waters <u>shall be reported</u> to the Aquaculture Approvals Officer at the DELG.

3.7 Noise and Odour Control

Noise

Aquaculture companies operating land-based aquaculture facilities shall ensure that all necessary measures are undertaken to minimize noise emission impacts to off-site receptors. The maximum sound permitted on aquaculture sites is assessed at potential noise-sensitive receptors which may include properties of nearby residences, daycares, schools, hospitals, places of worship, nursing homes, and First Nations communities. For the purpose of this program, significant noise impacts are interpreted to be sound levels greater than 3 dB(A) $L_{eq,1hr}$ above the average background equivalent continuous sound level ($L_{eq,1hr}$) at any noise-sensitive receptor. Background level assessment shall be conducted by Department of Environment and Local Government (DELG) staff during a one hour period adjacent to a one hour measurement when excessive noise is thought to be occurring. In instances where the measured average noise level ($L_{eq,\ 1hr}$) exceeds the average background level ($L_{eq,\ 1hr}$) by between 3-5 dB (A), the site operator shall investigate potential solutions and implement additional measures in an attempt to reduce the sound level below the maximum threshold permitted. The measures taken to reduce the sound originating from the aquaculture site shall be submitted to the DELG within seven calendar days of notification of the exceedance. In instances where the measured operational noise level ($L_{eq,1hr}$) exceeds the average background noise level ($L_{eq,1hr}$) by greater than 5 dB(A), the operation shall undergo an acoustical assessment by a third party consultant using methods that are recognized as the industry standard. The acoustical assessment of noise exposure on human receptors located near the project site will include the following:

- Sound meter make, model, calibration, assessment methods utilized and relevant weather parameters present at the time of assessment.
- A delineation of the distance of aquaculture operations to potential receptors using maps that indicate noise levels at various distances from the aquaculture site.
- The identification of potential noise-sensitive receptors.
- The identification/assessment of baseline sound levels at the receptor locations.
- The identification and measurement of all potential noise sources on the aquaculture site during construction, operation and decommissioning.
- A comparison of baseline noise levels with measured or predicted noise levels at sensitive receptor locations during construction, operation, and/or decommissioning before and after mitigation, if warranted.
- The expected duration of noise due to operational activities.
- Identification of mitigation measures to limit noise from identified sources.
- Noise management and noise monitoring plans, including complaint resolution,
- if applicable.

After completion of the acoustical assessment, the aquaculture company shall submit to DELG for review and approval prior to implantation, an action plan to mitigate the noise sources within thirty calendar days of being notified of the 5 dB(A) exceedance.

Odour

The issue of odours is very complex because odour, which is the sensation that is caused by a complex mixture of odorants, is very subjective and therefore difficult to measure. Various measurement techniques, such as gas chromatography or open-path Fourier transform infrared spectroscopy, have been developed to measure odour; however, such instruments measure only the concentrations of different odorants, which are then compared to odour threshold values, developed using human odour panels. Thus, to date, the best instrument for measuring odour is still the human nose.

Some individuals have far more sensitive noses and therefore will detect an odour at much lower concentrations than others. In addition, one person may find an odour to be objectionable while another may not. To completely describe the nuisance characteristics of an odour five different dimensions, commonly referred to as **"FIDOL"**, are frequently considered:

- **F**requency – the number of times an odour is detected during a time period,
- **I**ntensity – the concentration or strength of the odour,
- **D**uration of the period in which the odour remains detectable,
- **O**ffensiveness or hedonic tone of the odour, and
- **L**ocation of the odour.

4.0 MITIGATION AND REMEDIATION

Environmental management of land-based aquaculture facilities requires that action be taken in response to monitoring results indicating that the performance based standard is not being met. This section provides some background as to serve as a guide to the operator in preparing and implementing a plan of action for operations that are repeatedly or excessively out of compliance.

4.1 Enhanced Feed Management

Since the volume of feed offered is positively correlated with the waste produced, on farm waste management begins with feeds and feeding. In reviewing feed quality it is necessary to check freshness (production or best before date), pellet stability and % fines and ensuring the area of feed storage is cool and dry. It may also be advisable to speak with the company nutritionist from whom you purchase feed as to ensure you are feeding the proper feed for the species and size(s) being reared.

4.2 Waste Removal

Tank Design

Proper initial system design can be an economical means of controlling the wastes from a fish operation. The primary goal in effluent treatment is effective solids removal. This is accomplished through properly engineered facilities which gently deliver solid waste for mechanical removal, with minimal breakage and as quickly as possible after exiting the tank. Round tanks have been designed with self-cleaning designs, for example, dual effluent areas where high volume-low solids flow, can exit the tank from the upper perimeter while a low volume-high solids pipe, in the center of the tank has been found to remove most settleable material.

Filtration

The type of facility (i.e. flow through, re-use or recirculation) is an important factor in determining the filtration process employed. Historically, settling ponds have been used to remove settable solids as a means of reducing the organic and inorganic loading from a facility. If utilized, these ponds should be sized to the facility operations and cleaned regularly as to avoid anoxic conditions within the sediment. While effective in reducing settable solids, it may become net producer of nutrients if the pond is not cleaned with the required frequency as to remain effective. Cleaning of ponds is often labour intensive and depending on the frequency required can be quite costly. When adequate land is not available for settling ponds or a less labour intensive method is desired, producers may employ various alternate means of solids removal. Common methods employed include swirl separators, radial flow separators, rotary drum filters, belt filters and bead filters. Rotary drum and belt filtration size may change between facilities but generally range between 40-100 microns with an average around 60 microns. To enhance solids removal, polymers and/or flocculants may be added so as to coagulate the solids, however this is typically limited to low flow recirculation facilities due to cost. Much like ponds, solids removal infrastructure must be sized to the flow rate and level of production employed.

Radiation / Ozone

Ultraviolet radiation may be used for disinfection of water. For UV treatment to be effective the solids must be removed before treatment as it cannot penetrate the interior of solids. UV systems are a low maintenance, low risk method of disinfection. Low levels of ozone dissolved in the water will also remove most pathogens, improve particulate filtration and reduce the dissolved organic waste in the water. However low levels of ozone in the air are detrimental to human health and residual ozone in water is toxic to fish at low levels and should be constantly monitored.

4.3 Waste Transformation

Recirculation systems re-use the majority of the water within the system. Prior to reuse, biofilters are used to transform harmful nitrogenous wastes into less harmful forms. Biofilters accomplish this by housing bacteria that transform ammonia to nitrite followed by a further transformation to nitrate. Although nitrate is much less toxic to fish it is the form which is readily available for vegetative growth and therefore secondary treatment should be considered to further reduce nitrate concentration within the effluent. Phosphorus in the dissolved form also requires a form of secondary treatment to reduce its concentration within the final effluent.

Artificial wetlands are frequently used for waste water treatment in aquaculture operations where dissolved nutrients are removed by grasses and other aquatic plants. When utilized as primary treatment, wetlands will plug up with organic matter requiring the removal of excess material and reconstruction of the wetland. With this is mind, wetlands are best considered as a form of secondary treatment with a primary function of removing the dissolved nutrient fraction as opposed to the solid fraction. Factors that impact the nutrient removal rate in wetlands are: hydraulic retention time, vegetation type, solar radiation, microbial activity, and temperature. Constructed wetlands must only use native plants that should include hardy varieties and be harvested so as to minimize organic loading from dead vegetation.

There are two main types of constructed wetlands used for water treatment; surface flow and subsurface flow. Surface flow systems can treat large volumes, and subsurface flows generally are used for smaller flows but also eliminate the mosquito breeding area. Because each system is highly site specific due to the slope, soil, shade, elevation, temperature, and other variables, the construction costs may vary considerably. By alternating between wet and dry conditions within the substrate, BOD, ammonia, and phosphorus reduction may be maximized.

Freshwater Integrated Multi-Tropic Aquaculture (FIMTA) also known as aquaponics offers another means of further reducing nutrient concentration. In such systems nutrients are removed from the discharge and transformed with the help of common plants and bacteria while growing secondary products. Such additions to effluent treatment systems may also allow for increased primary production so long as other regulatory thresholds are not exceeded (i.e. approved water withdrawal rate).

4.4 Waste Utilization

Aquaculture sludge waste comprised of uneaten feed and fecal matter concentrated within septic tanks and areas of settlement may be utilized in much the same way that agriculture waste is used to amend the soil for crop production. Timing and locations for field applications and rates utilized are determined by many factors which include proximity to watercourses, slope, soil type, precipitation, temperature, nutrient content, and plant type and stage etc. The Province of New Brunswick does permit the application of aquaculture waste as it does within the agriculture industry and has developed a guideline which is available from DELG: Guidelines for issuing Certificates of Approval for the Utilization of Wastes as Soil Additives 1996.

Another option for waste utilization may include the production of compost for garden application and is considered a useful way of utilizing the dead fish, as a nitrogen source to be mixed with sawdust, or another carbon source, for the production of compost. In the case of acute or chronic mortalities, dead fish need to be disposed of in a proper manner as outlined within the submitted Waste Management Plan (Section and Appendix 3) and as required by the Canadian Food Inspection Agency (CFIA) and the New Brunswick Department of Agriculture Aquaculture and Fisheries. Facilities undertaking such methods of waste transformation should consult both the *CCME Guidelines for Compost Quality* as well as the *Guidelines for the Site Selection, Operation and Approval of Composting Facilities in New Brunswick.* Webpage Links to both documents are:

NB Guideline:

(http://www2.gnb.ca/content/gnb/en/departments/elg/environment/content/land_waste/content/composting/guidelines_for_compostingfacilities.html)

CCME Guideline:

(http://www.ccme.ca/assets/pdf/compostgdlns_1340_e.pdf)

5.0 ANNUAL SCHEDULES

Dates and time frames are established to ensure that a Remediation Plan is prepared by the grower, reviewed by the department, approved by the Minister, and implemented such that an optimal result is obtained. All parties are responsible to ensure that the goals of this EMP are fulfilled. Below is a listing of key dates and time frames as they pertain to this EMP:

June 1st – November 15th (Annual Monitoring Level 1 Monitoring): Required by all Approval Holders. The site operator conducts monthly Level 1 water quality monitoring as outlined within the regulatory framework (Figure 1) and Table (2.4, 2.5, 2.7 or 2.9).

December 31st Annual Report deadline: Requirements as outlined within Appendix 2 Form 2.

January 31st DELG response to Annual Report: Government response to Annual Report directing operators of site classification, compliance and remedial action that may be required.

March 31st Remediation Plan due date:

Within 3 working days of receiving a PBS variable above threshold limit: Required when the results from required monitoring program in excess of PBS threshold (Tables 2.4, 2.5, 2.7 and 2.9). Operator must contact DELG, complete Form 1 and send to DELG approvals officer.

Immediately report all non-fully functioning effluent treatment infrastructure to DELG. Information provided should include specific effluent treatment equipment in question, estimated time to return to full functionality and alternative measures taken during down time. Site operator shall report to DELG once equipment has been repaired or replaced.

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APPENDIX 1
Standard Sampling Procedures

Sampling and the type of analysis required for this EMP are broken down into "self" and "laboratory". Self-monitoring and analysis is conducted onsite so as to minimize expense and/or the inability to be properly measure at the laboratory (i.e. temperature). All laboratory analysis must be completed by laboratories with accreditation from the Standards Council of Canada (SCC) and/or the Canadian Association of Laboratory Accreditation (CALA). Minimum detection limits required are 0.005 mg/litre (5 ug/l) for total phosphorus (TP_L) and 0.3 mg/litre (300 ug/l) for total nitrogen (TN).

Sample Location

Prior to sampling, the sample location must be marked by measuring the distance from the point of effluent outfall to the location upstream and downstream within the receiving water course. Location shall be visibly marked with ribbon with sample station location and GPS co-ordinates (i.e. 100 m downstream). For sample locations within lakes and coastal environment, DELG will mark locations using land reference sites and GPS coordinates. Permanent markers (buoys) are not permitted for safety purposes.

Sampling Methodology

Sampling must be conducted with the direction of the flow of water through the facility so as to maintain biosecurity standards (i.e. inflow samples taken first with progressing to edge of mixing zone which are taken last).

Sampling Protocol

Collect samples only in the proper size and type of bottle as supplied by the laboratory employed and for the parameters measured. For operators using the DELG laboratory, sample bottles may be acquired from the Regional Environment offices or Service New Brunswick offices. If unsure as to the required bottle type or if you have any questions, please call the N.B. Department of Environment Laboratory at 453-2477.

Sampling Instructions:

Self-Analysis

1. Ensure monitoring equipment is stored and calibrated properly as outlined within equipment instructions for the particular make and model utilized.
2. Ensure samples are tested and recorded immediately for such parameters as flow, temperature and dissolved oxygen. pH must be measured and recorded during day of sampling.

Laboratory analysis

1. **Do not** rinse the bottles.
2. Identify each bottle clearly, using labels and waterproof ink or pencil, with:
   - **a)** facility name (i.e. XYZ Hatchery)
   - **b)** sample time (i.e. 10:00 AM)
   - **c)** sample location description (i.e. 100 m downstream not Sample Station 3),
   - **d)** analysis required (i.e. TP_L)

3. Take care not to touch the inside lip of the bottle or the inside of the cover.
4. Carefully fill the bottle(s) to the shoulder and cap immediately.
5. Complete the sample submission form supplied. It is required that the date and time of sampling be included. Identify each bottle clearly, using labels and waterproof ink or pencil, with site identifier or your name and address.
6. Samples must be kept cool to ensure sample integrity. Refrigerate or use a cooler with freezer packs.
7. Samples must arrive at the laboratory as soon as possible after sampling (preferably within 24 hours). Transport to the laboratory employed to conduct the analysis or the nearest Regional Environment office or Service New Brunswick office if using the DELG laboratory on the morning the sample was taken. Do not ship samples on Fridays unless same day delivery is ensured. Ensure that samples are kept cool during transport, and that they do not freeze in winter. Do not allow samples to be immersed in ice or melted ice water. For shipment, please pack sample bottles such that they are not at risk of breakage.

If the Department of Environment and Local Government Lab is utilized for analysis of samples, ship to:

Analytical Services Laboratory
N.B. Department of Environment
12 McGloin Street
Fredericton, N.B.
E3A 5T8
Telephone: (506) 453-2477 FAX: (506) 453-3269

Table A1-1: Sampling bottles[1] required large facility outfall into steams, brooks and rivers.

Sample Location	Level 1	Level 2
Upstream	**TP & TN**: 1-500 ml (B)	**TP &TN:** 1-500 ml
Before solids filtration		**TSS:** 1-500 ml (B) **TP:** 1-500 ml (B)
Immediately post solids filtration		**TSS:** 1-500 ml (B) **TP:** 1-500 ml (B)
Before septic, settling Pond/pit or wetland		**TP:** 1-500 ml (B)
Effluent outfall	**TP & TN:** 1-500 ml (B)	**TP, TN, TAN:** 1-500 ml (B) **COD:** 1-500 ml (B)
100 m downstream of outfall	**TP & TN:** 1-500 ml (B)	**TP, TN, TAN:** 1-500 ml (B) **pH:** 1-125 ml (D)

[1]Sample bottles letters See Appendix 1 Figure A1

Table A1-2: Sampling bottles[1] required for small tank culture and pond operations

Sample Location	Level 1	Level 2
25m upstream of effluent discharge	**TP:** 1-500 ml (B)	**TP:** 1-500 ml (B)
Before settling pond/wetland for small facilities		**TP:** 1-500 ml (B)
Discharge prior to entry in receiving water course.	**TP:** 1-500ml (B)	**TP:** 1-500ml (B)
100m downstream of outfall	**TP:** 1-500ml (B)	**TP:** 1-500 ml (B)

[1]Sample bottles letters See Appendix 1 Figure A1

Table A1-3: Sampling bottles[1] for facilities with outfalls into ponds and lakes.

Sample Location	Level 1	Level 2
Control station*	**TP:** 1-500 ml (B)	**CHL A:** 1- 1 litre (A) **TP & TN:** 1-500 ml (B)
Intake		**TP & TN:** 1-500 ml (B)
Before filtration		**TSS:** 1-500 ml (B) **TP:** 1-500 ml (B)
Immediately after filtration		**TSS:** 1-500 ml (B) **TP:** 1-500 ml (B)
Before septic, settling area or wetland		**TP:** 1-500 ml (B)
Effluent (prior to entry in water course)	**TP:** 1-500 ml (B)	**TP, TN, TAN:** 1-500 ml (B) **COD:** 1-500 ml (B)
Edge of mixing zone	**TP & TN:** 1-500 ml (B)	**CHL A:** 1- 1 litre (A) **TP, TN, TAN:** 1-500 ml (B) **pH:** 1-125 ml (D)

[1]Sample bottles letters See Appendix 1 Figure A1

Table A1-4: Sample bottles[1] for facilities with outfalls into coastal or estuarine waters.

Sample Location	Level 1	Level 2
Control station	**TP & TN:** 1-500 ml (B)	**TP, TN & TAN:** 1-500 ml (B)
Intake		**TP & TN:** 1-500 ml (B)
Before solids filtration		**TSS:** 1-500 ml (B) **TP:** 1-500 ml (B)
Immediately after filtration		**TSS:** 1-500 ml (B) **TP:** 1-500 ml (B)
Before septic, settling area or wetland		**TP & TN:** 1-500 ml (B)
Effluent	**TP & TN:** 1-500 ml (B)	**TP, TN, TAN:** 1-500 ml (B) **COD:** 1-500 ml (B)
Edge of mixing zone	**TP & TN:** 1-500 ml (B)	**TP, TN, TAN:** 1-500 ml (B) **pH:** 1-125 ml (D)

[1]Sample bottles letters See Appendix 1 Figure A1

Tests that can be performed per individual sampling bottle

A 1 L	B 500 ml	B 500 ml	B 500ml	C 125ml (with label)	D 125ml
CHL A	TN TP TAN	TSS	COD	NO_3 NO_2	pH

Annual well sample: DELG *I or similar package – B, C & D (3 bottles total)

Figure A1: Sample bottle types utilized for annual water quality monitoring program
Source: DELG Laboratory 2013

APPENDIX 2

Form 1: PBS non-compliance incident

Form 2: Annual Report

Form 3: Remediation Report

New Brunswick Land-based Aquaculture
Environmental Monitoring Program
FORM 1
PBS NON COMPLIANCE

The following information is to be sent to DELG after each PBS non-compliance incident during the monitoring season (June 1st - November 15th). Level 1 and 2 monitoring results are to be forwarded to DELG within three working days of receiving results from laboratory.

1. Date, time, biomass and amount fed (kg) on date of Level 1 monitoring.
2. Date, time, biomass and amount fed (kg) during Level 2 monitoring.
3. Feed Types used: pellet size, % protein and % phosphorus.
4. Effluent Treatment system inspection (i.e. size and condition of RDF screen, flocculent dosing rate, settling pond organic load, constructed wetland etc.).
5. Date of last clean out of septic, settling pit or settling pond.
6. Date of next expected reduction in biomass.
7. Mitigation measures chosen to bring operation back into compliance.

New Brunswick Land-based Aquaculture
Environmental Monitoring Program
FORM 2
ANNUAL REPORT

Below is the information required within the Annual Report (Due: December 31st).

1. Company and facility name
2. Average weight, bi-weekly biomass, feed fed and % protein and phosphorus content of feeds
3. Average weekly effluent flow (lpm or IGPM)
4. Reporting requirements contained within the DELG Certificate of Approval to Operate.
5. Environmental Monitoring Program results received from laboratory* and self-monitoring.
6. Date of last clean out of septic, settling pit or settling pond
7. Results of any effluent treatment system inspection reports
8. A copy of reports as a result of any audits conducted
9. Comment on planned production plan for upcoming year.

*Includes a copy of the laboratory report results

New Brunswick Land-based Aquaculture
Environmental Monitoring Program
FORM 3
REMEDIATION

Below is the information to be contained within the remediation report (Due: March 31st).

1. Review of annual production data and environmental monitoring results
2. Review of effluent treatment employed at facility.
3. Effluent treatment system inspection results
4. Review of mitigation measures available to correct non-compliance issue(s).
5. Facility mitigation response(s) chosen and timeline to complete.
6. Conclusions

APPENDIX 3

Waste Management Plan Template

To serve as Schedule C of DELG Certificate of Approval to Operate

Waste Management Plan

Company Name

Facility Name & COA Number

1.0 Operational Debris

- All debris generated during the day-to-day operations of the facility is collected and stored in ________________________.
- Waste material will be placed in designated waste dumpsters tended by an approved waste collecting company. Items such as pop cans and other recyclable materials are sent for recycling where such a facility is available.
- Fish feed bags (20-25kg) are emptied directly into the feeders. Once empty, feed bags will be placed in recycle container, until an amount warrants pick up or delivery to a plastic recycling company.
- Feed pallets will be reused or returned to______________________.
- Any construction related materials or waste created during regular facility maintenance or construction is collected and stored until proper disposal/recycling can be arranged.
- No debris is purposely released into the environment.

2.0 Mortalities

- Mortalities will be collected daily, and disposed of in an appropriate method, such as compost, incinerated, etc.
- Mortality boxes are designated for use for mortalities only, and are to be disinfected after each use.
- In case of a large mortality event, the same procedures should be followed for mortality containment, transport, and disposal.
- At no time will dead or moribund fish be released into a watershed.

3.0 Feed and Feces

- Feed will be inventoried and properly stored in a secure facility.
- All waste generated from feeding operations, such as 25kg finfish feed bags, will be recycled where facilities are available.
- Spilled or waste feed will be composted.

4.0 Chemical Disposal

- All hazardous materials including, but not limited to, petroleum products, grease tubes, used paint cans, paintbrushes, waste disinfectant, and containers will be separated from the regular garbage and collected in designated containers for proper disposal.
- Where applicable, chemical and hazardous materials are disposed of as per the manufacturer's instructions on the product labels.
- Any wastes considered hazardous are taken to an approved facility for disposal. This includes such items as waste fuel, copper-based paints, waste disinfectants, *etc*. The document entitled "Hazardous Waste Services" produced in 2007 by DENV will be used as a reference.
- Used engine oil, oil filters, and other oil related garbage are disposed of in a dedicated waste oil disposal station.