Manitoba Agriculture, Food and Rural Initiatives
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Fish Farm
Technical Training Manual

Prepared by Manitoba Agriculture, Food, and Rural Initiatives
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Background Information

This document assumes that the user has a similar system and components to the Manitoba-Canadian Model Aqua-Farm (M-CMAF) and all shared knowledge and protocols therein is reflective of that assumption. This Manual was formed as a direct result of the Manitoba-Canadian Model Aqua-Farm Initiative.

Acknowledgements

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Disclaimer

Introduction

RAS (recirculating aquaculture system) farming is an intensive form of food production. Many of the principals of operation of an RAS system can be seen in other food production models (e.g., conventional hog farming biosecurity principles) and in other industrial production models (e.g., widget production planning). It is important, however, to note that RAS farming has many unique characteristics as well (e.g., tailoring feed delivery to filtration capacity).

RAS systems are generally designed to provide an artificial habitat specific to the aquatic species being produced while using as little incoming water as possible to maintain a low environmental footprint and to conserve energy.

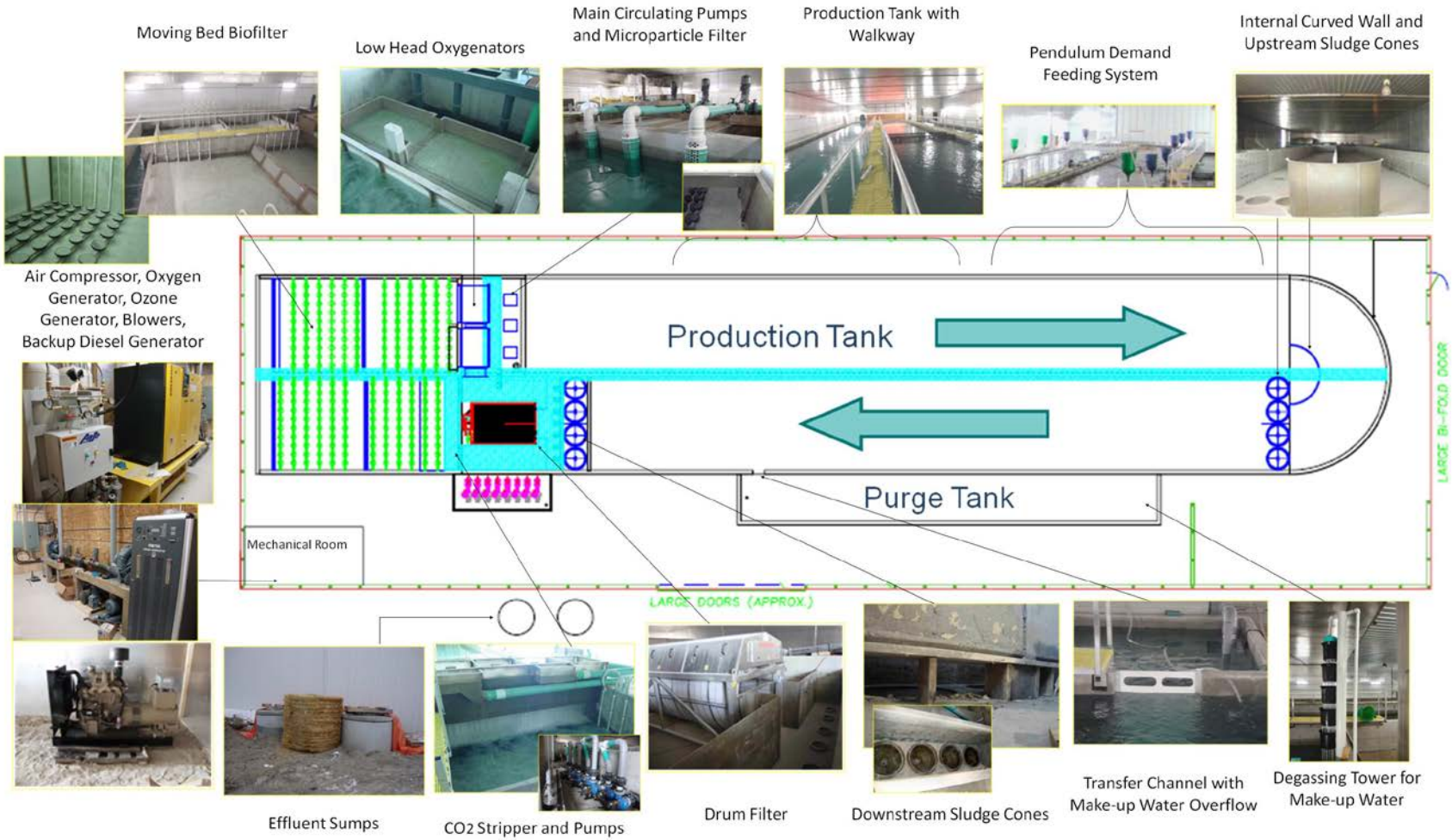
Developing a positive proactive culture on a fish farm, with respect to biosecurity, maintenance and harvesting will yield higher profitability and operational longevity. Prior to construction it will be essential to have performed economic analyses and business planning reflective of current marketing realities and long term vision. It may also be important to consider addressing social licence as part of your business plan through tours, word-of-mouth within the municipality and through various media outlets to foster community enthusiasm and eventually brand loyalty.

This Manual is comprised primarily of protocols developed and implemented during the Manitoba-Canadian Model Aqua-Farm Initiative. The Manitoba-Canadian Model Aqua-Farm Initiative comprised the development and construction of a state-of-the-art commercial land-based freshwater aquaculture production system intended to be the basis for a standardized approach to freshwater aquaculture production. The operation was specifically designed to fit into conventional agriculture buildings to capitalize on the availability of latent infrastructure. The anticipated outcome was a model for a ‘turn-key’ freshwater aquaculture operation that will catalyze the development of a sustainable freshwater aquaculture industry in Canada.

A table of licensing and permitting requirements for Manitoban fish farmers can be found in the *License and Permitting* section of this Manual.

> Note: The licence and permitting requirements for new fish farm entrants and currently operating fish farms are continually being updated at the national and provincial levels. It is highly recommended that anyone seriously considering fish farming not rely solely on the table provided (see *Licenses and Permitting* section) and that they exercise their own due diligence to ensure that they are meeting or exceeding all regulatory, permitting and licensing requirements.

Manitoba-Canadian Model Aqua-Farm Schematic



System Startup

Once the facility has been constructed it will be important to implement biosecurity protocols and not to stock fish into the system too quickly. Add water to the system and begin testing of all equipment. Develop a keen sense of normality for each component of the system taking note of temperature at operation and vibration presence or absence. Familiarize yourself with factory recommended maintenance regimes for each piece of equipment as required. Evaluate outputs of equipment to ensure that they meet design specifications before that equipment is needed.

Once staff members have been familiarized with equipment sufficiently enough to perform regular maintenance duties it is time to implement a water quality monitoring program (refer to *Water Quality Monitoring* section). During this phase of startup it is important to objectively document as many water quality parameters as possible including qualitative observations regarding water clarity, colour, and odour presence or absence. Consultation with knowledgeable industry peers/professionals regarding data collected is recommended for new entrants whom are not likely familiar with the relevance of the specific parameters documented.

Based upon water quality findings it may be necessary to flush the system multiple times or to allow a period of time to elapse to leach the rearing area of any deleterious substances (e.g., fibre glass residue) with a final flush prior to biofilter establishment and finally fish introduction.

Depending on water chemistry and in consultation with an industry professional it may also be necessary to treat incoming well water during the start up phase.

Biofilter Establishment

Once a water quality monitoring program has been implemented and the current state of the water looks ready for fish it is time to add or bring ‘on line’ the biofiltration process. The M-CMAF used a series of moving bed biofilters to achieve its biofiltration needs but there are several choices available on the market place and each one has advantages and disadvantages.

Biofiltration is a process of establishing colonies of beneficial bacteria (i.e., *Nitrosomonas* and *Nitrobacter* spp.) and using those colonies to oxidize metabolic waste from the rearing area to less toxic forms as the fish begin to produce waste from feeding activity. Beneficial bacteria containing products come in a powdered and liquid form and are available commercially for purchase.

Addition of the bacteria to your system is termed *seeding* and if done correctly will also help to establish a helpful biofilm on the tank walls that will serve as additional filtration capacity while simultaneously excluding potential pathogens. It is recommended that seeding occur early following the final system flush detailed in the above section. Seeding can occur at any point within the rearing system and should not be solely done in

the biofiltration area to establish dominance of wanted bacteria throughout the system (i.e., in the form of biofilm).

In order to maintain *Nitrosomonas* and *Nitrobacter* spp colony integrity it will be necessary to 'feed' the bacteria. Ammonium chloride was used at the M-CMAF with success. Determine the desired concentration of ammonium chloride to be used in consultation with an industry professional and monitor ammonia daily to maintain adequate levels until fish are to be added to the system.

Nitrification is a two step process where ammonia is first oxidized to nitrite and then nitrite is oxidized to nitrate. These chemical equations show the basic chemical conversions occurring during oxidation by *Nitrosomonas* and *Nitrobacter:*

Nitrosomonas spp
$2\ NH_3$ (Fish metabolic waste) + $3\ O_2 \rightarrow 2\ NO_2^-$ (Nitrite) + $2\ H_2O$ + $2\ H^+$

Nitrobacter spp.
$2\ NO_2^- + 1\ O_2 \rightarrow 2\ NO_3^-$ (Nitrate)

As indicated by the above equations, some H+ is released in the nitrification process, which tends to lower the pH of the water, making it more acidic. Treating the incoming well water with $CaCO_3$ to increase the buffering capacity of the water was not necessary at the M-CMAF facility because the source water was naturally high in $CaCO_3$ and had a pH close to 8 (i.e., a future farmer may have additional costs to treat incoming water if the source water is not ideal).

Once the seeding process is underway daily *Water Quality Monitoring* program readings of ammonia should steadily increase until it reaches a maximum, at which point it will decrease and nitrite should in turn follow a similar pattern eventually giving way to elevations in nitrate.

If using a moving bed biofilter such as at the M-CMAF begin introducing biomedia very slowly and consider loading the biofilter only as the fish grow and additional filtration capacity is required (i.e., because you are feeding more and more). Once the biofilter begins to show signs of being active, such as relatively quick ammonia dissipation then the system is fully ready for fish.

> Note: maintaining a backup supply of liquid or powdered biofilter seed on site is highly recommended in the unlikely event that reseeding is needed. Storage of the biofilter should be consistent with manufacturer recommendations.

First Fish Introduction / Stocking Fish

Obtaining fish from a certified *Disease Free* hatchery will be important to maintain your pathogen free environment. Ensure that you are aware of what environment the fish are accustomed to and what environment they are being transported in keying specifically on

temperature differences. Depending on the degree of difference between your system's current operating water temperature and the incoming fish's it may be necessary to allow for a period of acclimation ranging from 30 minutes to an hour. Typically the use of a small pump to add rearing system water to the transport tank would be used in the acclimation process.

The first two cohorts of rainbow trout were brought in at the same time for the M-CMAF from a hatchery in Ontario to save transportation costs. The fish were taken off feed for five days prior to transportation and were not fed for three days following introduction to ensure that any elicited stress response was not exacerbated.
Ensure that the fish to be introduced are of sufficient size to not be a problem in the system and/or ensure that the system is ready to receive the introduced fish. In either case if the fish are too small there is a high likelihood that they will escape and become ubiquitous within the system. Any escapees from pens will become a problem later necessitating the use of unplanned labour to catch the fish before cohorts can mix and worse, before they get caught in an unfriendly piece of equipment (e.g., a pump). It will also become necessary to utilize less than ideal feeding strategies to maintain the health of escapees decreasing the overall efficiency of the system and again labour requirements.

Take time before the transport truck arrives to formulate a plan specific to the type of fish transport system that is arriving. Take into account differences between deck height of the transport trailer or truck and the tank height. If the transport system is taller than the height of the rearing tank than delivery into the rearing area can be easily achieved using a sufficiently long piece of pipe, for example, via gravity.

Daily Operations

Daily operations at a fish farm should always consist of feeding, removal of mortalities, performance of maintenance checks, water quality and due diligence with respect to biosecurity.

Always refer to the system designer or engineer supplied manuals as required and try to integrate information from those sources into the facility's operating procedures. For example, two protocols named *Pump Operations* and *Biofilter Bypass Protocols* were supplied by the system designers and were used by M-CMAF staff as needed to supplement daily operations.

M-CMAF Daily Operations Protocol

**This protocol is to be used to initiate ALL staff (including volunteers) of typical daily operations at the Manitoba-Canadian Model Aqua-Farm;*
**It is also assumed that before work commences ALL staff have reviewed and understand the following documents: Emergency Response Protocol, Biosecurity Protocol, and Power Outage Protocol;*
** When necessary it may also be appropriate to consult all Standard Operating Procedures related to Canadian Food Inspection Agency Issued Licensing and/or the Fish Inspection Manual*

Upon Arriving (after taking necessary biosecurity precautions; SEE BIOSECURITY PROTOCOL):

1. Perform 'Walk Around' of Facility
    a. Take note of abnormal sounds/vibrations
    b. Observe Main Circulation pumps looking for indications that at least 2 are running.
    c. Observe fish behaviour
    d. Observe biomedia cell walls for excessive bowing.
    e. Observe amount of head on top of LHO.
2. Feed
    a. Record previous days feeding and mortality data from the whiteboard onto the appropriate spreadsheet for each cohort. Erase the whiteboard once all data/relevant notes have been properly transcribed.
    b. Weigh out appropriate feed rations based upon the previous days' feeding regime.
    c. Be aware of the stock of fish you are feeding and what feed size they are currently prescribed (see whiteboard)
        - Rainbow trout are gape limited (i.e., they can only eat what they can fit in their mouth); An error in feed size will lead to starvation of smaller fish and a spike in mortality
    d. Always hand feed to satiation unless told to do otherwise (i.e., that means don't stop any single feeding until the fish have visibly stopped feeding and feed is observed to be on the bottom of the raceway)

- Exceptions to this rule occur when feeding to satiation means releasing an amount of feed high enough to cause a spike in toxic metabolic compounds (e.g., ammonia or NH3-N) or a drop in oxygen below 6 ppm (mg/L).

e. Always feed the smallest fish first (i.e., they have the highest metabolism).
f. Always HAND FEED before filling autofeeders or in conjunction with (i.e., reduces competition for the autofeeders).
g. When feeding by hand ensure that feed is cast evenly over the surface of the water (i.e., do not throw a handful of feed into one spot)
h. Stop casting feed periodically to observe the fish taking in the feed

3. Pull and record fish mortalities onto whiteboard.
   a. Most fish mortalities (aka 'morts') will collect at the back of the designated pen for a given cohort.
   b. Most of the morts will be located on the bottom of the rearing tank in normal conditions.
   c. When removing morts if an exceptionally old carcass or similar biosecurity hazard is removed. It would be prudent to rinse the hand net with water and then dip it into the Virkon® net bath to sterilize.
   d. Be aware of moribund fish (i.e., close to death) swimming near the surface and remove them from the rearing area as well. Humanely stun them before placing them into the mort pail.
   e. Repeat for purge tank.
4. Equipment Check
   - Using the *M-CMAF Equipment Check* spreadsheets on the wall near the mechanical room. Ensure that all equipment is running normally by checking equipment history (i.e., yesterday and so forth) against current numbers if unsure of "normal" operating conditions.
5. Daily System Monitoring (OPTIONAL)
   - Using the "M-CMAF Daily System Monitoring" measure and record all necessary data.
     - This should only be a requirement during specified times and will likely only be performed by knowledgeable staff.
6. Pull stand pipes at least twice per day
   a. Hold stand pipes firmly in hand for no more than 10 sec after pulling
   b. Watch for overflow pump (within dirty water sump) to turn on (indicated by red light)
   c. Wait for overflow pump to turn off before continuing to pull stand pipes
   d. Upstream sludge clone valves should be opened for 20 sec at a time to ensure adequate flushing of the line and because each valve controls the function of two sludge cones (i.e., lines are paired).
7. Fill Footbaths with Virkon Aquatic®
   - Performed using 20 L carboys as storage vessels for the Virkon Aquatic® mixture (i.e., do not use Virkon Aquatic® in powdered form for footbaths).
     i. ALL FOOTBATHS SHOULD BE FILLED DAILY OR EARLIER AS NEEDED.

ii. When handling Virkon Aquatic®
    1. Refer to MSDS before handling powder
    2. Refer to container for dilution instructions
    3. Always use latex free nitrile gloves
    4. Using a small bucket and the feed scale weigh out the appropriate amount of powdered Virkon
    5. Always handle Virkon in a well ventilated area (i.e., do not weigh or prepare the stock solution in the work shop or other similarly enclosed area; do not breathe directly overtop of powdered Virkon)

iii. Once a week footbaths should be removed, taken to the *Loading Area* near a drain and thoroughly washed prior to adding additional Virkon Aquatic®.

8. Sanitize all nets and brooms that were used throughout the course of the day.
    - Via the Virkon Aquatic® bath near the main door.
9. Be conscious of abnormal odours or a build-up of organic material in net baths nd replenish at least weekly or earlier as required.
10. If harvest ready fish are present in the purge tank ensure that 'dead zones' within the purge tank are adequately cleaned on a daily basis to prevent the buildup of off-flavor causing organic material.
    - The 1 inch siphon located on the wall of the *Loading Area* (as defined within *Fish Export SOP*s) is the ideal tool for removing buildups of organic material.
        i. To engage the siphon (without sucking on it), place the entire siphon in the water at the intended siphoning location.
        ii. Cap the end of the siphon hose using the palm of your hand.
        iii. Quickly lower the capped hose end to a level lower than that of the adjacent tank water level and release your palm.
            - Water should now be flowing freely.
        iv. Try to ensure that all solids/organic material laden effluent from the siphon is directed towards drains located in the *Loading Area*.
        v. Sterilise the siphon with Virkon Aquatic® before hanging it up.
        vi. Clean up the *Loading Area* in accordance with *Loading Area Cleaning SOP*

Biosecurity and Fish Health

It is recommended that all people entering the facility for the first time receive a brief meeting which covers the fish farm's biosecurity protocol (s). It is also recommended that biosecurity protocols be routinely revisited and comprehensively reviewed by farm management. New protocols should be reflective of any operational changes, regulatory changes and latest industry standards or best practices. To meet those goals an independent fish health expert could be contacted to perform an audit at the discretion of farm management. The general idea of any biosecurity program should always be to limit potential exposures through due diligence and a proactive biosecurity culture.

If a serious fish health problem arises it will be necessary to consult a fish a health professional. Diagnosing a fish health problem can be extremely difficult and might involve submitting water samples to an accredited lab or the fish health professional, performing *In Situ* water quality testing (i.e., via a probe) or taking photos of the affected fish to name a few. Below are some examples of information that a fish health professional may ask for:

- Are the fish exhibiting signs of distress or abnormal behaviour for the species or when compared against previous stocks (e.g., heavy respiration, flashing, etc.)?
- Do the sick fish share a common problem? For example, the presence of lesions:
    - Do <u>all</u> sick fish have similar lesions (i.e., if lesions are noted)?
    - Are the lesions located in the same general area on the fishes' body?
    - What percentages of the mortalities have similar lesions relative to the infected or affected fish?
- Have there been any recent documented changes to water quality?
- Are daily mortalities currently much higher than normally observed daily averages? Is there any data with respect to mortality?

The number one thing that all fish farmers must minimize on a day-to-day basis is stress on the fish. Daily operations should always take into account the potential for stress to be created through changes to the fish's environment both acute and long term. Continuous exposure to stressors can have serious complications for fish health, fish growth and subsequently profitability.

Potential Stressors include:

- Poor water quality including acute and chronic
- Changes to water quality (e.g., temperature, pH, oxygen levels, nitrogen levels)
- Pathogen activity
- Feeding (i.e., poor feeding technique can be stressful for the fish)

- Placing equipment/foreign objects into the water
- Sudden changes in light
- Loud noises or vibrations

Note: If a fish jumps out of the tank onto the facility's floor it would be consistent with sound biosecurity principles to euthanize that fish, place that fish into the mortality bin and record it in the mortality data set. Fish jumping out of the tank may also be an indication of a water quality problem (i.e., jumping out of the tank may be an escape response).

M-CMAF General Biosecurity Protocol

1. Upon entering the facility all visitors and employees MUST step into footbaths before proceeding or changing foot wear.
    a. All staff should have a change of footwear which remains at the facility.
    b. Any precautions to minimize in-and-out transitions through Biosecurity control points should be taken.
2. Preferably a personalized set of overalls, lab coat or rain gear will be kept at the farm for all staff to put on prior to entering the facility. Visitors should be questioned before entering as to recent contacts with other fish farms and asked to wear gear as deemed necessary.
    a. It may be prudent to deny access to other fish farmers whom come from disease impacted facilities.
    b. Take note if `wet work`(e.g., work that involves splashing fish) is to be done and take appropriate precautions including sterilization of rain gear or waders before and after the job is done especially if entering the tank or making unavoidable contact with rearing area water.
3. Inspect and fill footbaths with Virkon Aquatic®
    - Performed using 20 L carboys as storage vessels for the Virkon Aquatic® mixture (i.e., do not use Virkon Aquatic® in powdered form for footbaths).
        i. ALL FOOTBATHS SHOULD BE FILLED DAILY OR EARLIER AS NEEDED.
        ii. When handling Virkon Aquatic®
            1. Refer to MSDS before handling powder
            2. Refer to container for dilution instructions
            3. Always use latex free nitrile gloves
            4. Using a small bucket and the feed scale weigh out the appropriate amount of powdered Virkon
            5. Always handle Virkon in a well ventilated area (i.e., do not weigh or prepare the stock solution in the work shop or other similarly enclosed area; do not breathe directly over powdered Virkon)
        ii. Once a week footbaths should be removed, taken to the *Loading Area* near a drain and thoroughly washed prior to adding additional Virkon Aquatic®.
4. After stepping into footbaths hand sanitizer MUST be applied.

5. All visitors to M-CMAF must be accompanied by qualified staff for the duration their visit.
    - If a large group is present no more people shall be given a tour than can be safely managed at a time (max is 6 per 'tour guide')
6. All visitors are required to SIGN IN including contact info and phone number.
7. NO HANDS in the tank.
8. Do not allow anything which could be considered a deleterious substance to have contact with tank water.
    a. Any material not comprised of PVC, aluminum, stainless steel must be approved for use within the tank by M-CMAF Management
    b. Oils (e.g., hand creams, engine oil) will not be permitted on-site unless specific to equipment.
    c. Virkon Aquatic® is the only disinfectant to be used at M-CMAF for sterilizing nets, brooms, rain gear, waders, foot baths and totes. Any other disinfectant could potentially harm fish.
    d. Ensure that Food Safe Grease (i.e., NLGI 2 – Nevastane(R) HT/AW 2) is the only lubricant used in association with the *Drum Filter*.
9. All morts (i.e., fish mortalities) are to be placed in a designated container
    a. Nets used to remove morts from the tank are to be immediately sterilized after.
    b. If morts were touched by hand and/or excessive splashing was observed during removal of moribund fish, the use of hand sanitizer is MANDATORY after the task of removing all of the daily mortalities is accomplished.
    c. Sanitize all nets and brooms that were used throughout the course of the day.
        - Via the Virkon Aquatic® net baths.
10. Removing feed from decking utilizing a broom must be performed every feeding day or earlier as needed.
11. When opening the *Loading Area Main Overhead Door* (as defined within Fish Export SOPs) ensure that all efforts are taken to maintain the integrity of the area and clean and sterilize according to *Loading Area Cleaning SOP*.
    - At specific times (e.g., replenishment of backup oxygen packs) it will be necessary to drive the Bobcat® into the barn.
        i. Rinse the two front tires first as the Bobcat® operator slowly drives forward onto the *Loading Area*.
            - Ensure that all mud, dirt and grime is sprayed off to a point deemed reasonable.
        ii. As the Bobcat® operator pulls forward repeat for the rear set of tires.
12. For specific SOP information regarding harvesting refer to *Fish Export Operations SOPs*.

M-CMAF Parasite-S® Treatment Protocol

** This protocol should be used solely in coordination with veterinarian oversight. Where directions from the veterinarian and this protocol differ, advice from the veterinarian should guide your decision making process.*

"PARASITE-S is an approved parasiticide for the control of external Protozoa and Monogenetic Trematodes on all fin fish. It is also approved as a fungicide for fin fish eggs. See the "Directions for use" [on their website] for approvals and directions for use [reference to the website]. To use PARASITE-S to treat additional diseases or species not covered on the current label, a licensed veterinarian may be able to prescribe the legal extra-label use.

PARASITE-S is manufactured in FDA and Health Canada approved and inspected production facilities. The use of other grades of formaldehyde on fish may be in violation of regulations.

PARASITE-S is classified as a dangerous good and it must be shipped and handled according to the DOT Transportation of Dangerous Goods regulations. Please call our office for additional delivery information. New users are encouraged to seek advice from a fish health professional prior to using this product. Refer to the Directions for Use, and MSDS (above) [reference to the website] for details on directions for use prior to treating fish of any life stage, as well as limitations and cautions for all uses."

1. In consultation with a knowledgeable veterinarian determine the following:
    a. If Parasite-S® is the optimal treatment for addressing your fish health problems.
        - Obtain written recommendation/prescription from the veterinarian you've been consulting.
    b. What are the dosage and treatment frequencies recommended to achieve your desired fish health goals?
        i. See next section for an example of an *M-CMAF Parasite-S© Post Treatment Report*.
        ii. This will determine how much Parasite-S© you need to order.
    c. If Transportation of Parasite-S© is to be done during colder periods.
        i. During winter months it will need to be transported in a thermally controlled environment
        ii. If Parasite-S© is subject to temperatures lower than 4^{o}C para-formaldehyde will form which is extremely lethal to fish.

        Note: Upon receiving the Parasite-S©, Inspect the bottom of the container looking for white crystal precipitate. The presence of

which can be used as a coarse indicator of para-formaldehyde presence.

d. What safety, handling, and treatment administration equipment needs to be updated or ordered so that staff can safely (i.e., for personnel and fish) administer the desired treatment (s)?

Note: Formalin (i.e., diluted formaldehyde) is the active ingredient in Parasite-S© which is an organic acid (i.e., low pH predominately carbon base chemical).

i. Personnel Safety List Should Include:
   1. CSA approved organic acid proof gloves
   2. CSA approved organic acid proof goggles
   3. CSA approved organic acid proof lower body protection
      - Boots and Pants.
   4. CSA approved organic acid proof upper body protection
      - Coat with hood and/or equivalent top-of-head protection.
   5. CSA approved ventilation or respiration equipment for use with Organic acid.

ii. Safe Handling List Should Include:
   1. Low pH drum pump for safe handling of Parasite-S© from the main storage drum to a smaller vessel (i.e., like a bucket).
   2. Designated treatment vessel (i.e., like a bucket) that can safely and briefly store Formaldehyde.
   3. Identification of ideal location for storage and use of Parasite-S© preferably as close to the *treatment introduction point* (to be defined later) as possible.

iii. Treatment Administration List Should Include:
   1. Stop watch
   2. Formalin test kit for tracking of treatment dissipation
      - Kit will need to be refrigerated in between uses.
   3. Thermometer
   4. Dissolved Oxygen Meter
   5. Note pad or prepared treatment admin sheet

2. In preparation for treatment administration ensure that the fish have been taken off feed for at least one day prior to treatment to reduce the stress response from the fish during the procedure and do not feed the fish for one day following treatment.
3. Ensure that the building is properly configured for maximum ventilation.
   a. If possible open the main loading door on the west side of the building.
   b. Set all fans and louvers to maximum for 24 hr following treatment to remove fumes.

4. Ensure that the fish have plenty of oxygen and maintain steady observations of oxygen levels during the formalin treatment. Stressed fish will consume more oxygen than normal but the introduction of any formaldehyde based chemical (i.e., such as formalin) also has the potential to lower oxygen levels.
5. Refer to the treatment plan in Step 1 (b).
6. Immediately following the last dose of the treatment begin tracking of formalin dissipation through the use of the test kit.
    - Testing intervals should be relatively frequent for the first 4 hr and can be steadily lessened until final results show zero formaldehyde presence, which could reasonably take more than 24 hr.

M-CMAF Post Parasite-S® Treatment Report

Date: MM-DD-YYYY *Report Prepared By: XXXXXXX*

Summary Details:

Date treatments administered: MM-DD-YYYY and MM-DD-YYYY, etc.
Volume administered: 25.5 L (1.7 L every 5 minutes for 75 minutes; Desired concentration = 25 ppm)
Location administered: in pump sump, at pump 2

MM-DD-YYYY		***MM-DD-YYYY***	
Start Time:	*11:25*	*Start Time:*	*8:30*
Water Temp (oC)		*Water Temp (oC)*	
Before:	*15.8*	*Before:*	*15.42*
After:	*15.7*	*After:*	*15.39*
Incoming Water (gpm):	*40.7*	*Incoming Water (gpm):*	*39.8*
System pH probe		*System pH probe*	
Before:	*7.21*	*Before:*	*7.20*
After:	*7.36*	*After:*	*7.18*
Blackstone pH probe		*Blackstone pH probe*	
Before:	*7.59*	*Before:*	*7.68*
After:	*7.62*	*After:*	*7.65*

Overall, these treatments progressed much more smoothly than the previous July 18th treatment. Mortality progressively decreased throughout the week from the initial treatment on Tuesday August 16, 2011. During both treatments fish behaviour remained active with fish showing the most dramatic improvement after the initial Aug 16 treatment. No signs of distress (e.g., 'piping') were observed at any time.

This marked improvement in fish response to the formalin treatment can likely be attributed to several factors:

1. *Concentration of Parasite-S® used was significantly decreased (from ~ 120 ppm July 18th to 25 ppm) to take into account the previous negative response and the known, elevated, toxicity of formalin at temperatures greater than 15°C*
2. *System operation remained normal (i.e., we didn't utilize the drum sump bypass, main circulation pumps did not cycle on/off, etc…) during both treatments (@ 2 pump operation)*
    - *as a result no pulse of white precipitate/flocculent was observed post/during treatments*
3. *Weakest fish were culled in July 18th treatment*

Procedural Notes:

The following were discussed and implemented as per M-CMAF management team recommendations:

- *Both treatments would be applied at the pump sump at pump # 2 (not running) for maximum mixing*
- *Treatment would occur without changing system parameters:*
  - *CO2 stripper pumps remained on*
  - *Ozonator remained on*
  - *Biofilter bypass (located at downstream end of drum sump) was not utilized*
  - *Incoming water via the primary well remained at constant/unchanged flow to maintain temperature during treatments*
- *Significantly reduced dose would be applied for both treatments*
- *Parasite-S® would be applied to the purge/harvest tank (4.75 L total) during the Aug 18 treatment for a desired concentration of 50 ppm*
  - *Due to lower temperatures in the purge tank (~ 7-10^{o}C) it was deemed necessary to increase the treatment concentration*
- *All dip nets and net containers would be treated with Parasite-S® for a minimum of 12 hr*

Formalin Concentrations Utilizing Sodium Hydroxide + Test Strips/Methodology

Time	***Date***	***Location***	***Colour***	***[Estimated Conc]***
12:48	*Aug 16*	*Tank Head*	*Light Purple*	*~ 20 ppm*
13:50	*Aug 16*	*Tank Head*	*Light Purple*	*~ 20 ppm*
14:43	*Aug 16*	*Tank Head*	*Light Purple*	*~ 20 ppm*
16:01	*Aug 16*	*Tank Head*	*Light Purple*	*< 20 ppm*
09:54	*Aug 17*	*Tank Head*	*Light Purple*	*0-10 ppm*
08:22	*Aug 18*	*Tank Head*	*Pink*	*~ 0 ppm*
09:47	*Aug 18*	*Tank Head*	*Light Purple*	*> 20 ppm*
11:23	*Aug 18*	*Tank Head*	*Light Purple*	*~ 20 ppm*
12:51	*Aug 18*	*Tank Head*	*Light Purple*	*~ 20 ppm*
16:06	*Aug 18*	*Tank Head*	*Light Purple*	*> 10 ppm*
08:13	*Aug 19*	*Tank Head*	*Light Purple*	*0 – 10 ppm*
09:53	*Aug 18*	*Purge Tank*	*Light-Dark Purple*	*< 40 ppm*
11:19	*Aug 18*	*Purge Tank*	*Light-Dark Purple*	*< 40 ppm*
12:43	*Aug 18*	*Purge Tank*	*Light Purple*	*> 20 ppm*
16:01	*Aug 18*	*Purge Tank*	*Light Purple*	*0 – 10 ppm*
08:22	*Aug 19*	*Purge Tank*	*Pink*	*~ 0 ppm*

Feeding, Growth Tracking and Sampling

Special attention should be paid to feeding, growth tracking and sampling. The below sections are meant to educate and provide a basis of understanding that goes beyond the M-CMAF *Daily Operations* and *Biomass Sampling* protocols. It is recommended that any fish farm planning to intensively feed have a **water quality monitoring program** (see *Water Quality Monitoring* section of this Manual) in place well before peak loading rates (i.e., according to total biomass fish and total feed delivery) have been reached.

General Feeding Strategy

Feed delivery planning and daily feeding are extremely important tasks. Time should be allocated during feeding to observe the fish and to ensure that they are consuming all the feed to avoid wastage and to get any clues about a potential fish health problem (i.e., sick fish are usually oblivious to the presence of feed).

Feeding strategy should always take into account the presence of overly aggressive fish with the goal being that all the fish get to eat. The easiest way to ensure that all of the fish get to eat is to feed to *satiation*. That means that every feeding ration should always be to the point when the fish cease feeding or have become much less interested in the feed being presented to them (i.e., it will take a judgement call and some experience to know just when to stop). This rule has one important exception; depending on what stage of production the facility is at (i.e., total biomass and size of fish taken into consideration), and by association, total feed being delivered daily it will be very important to monitor water quality and to adjust feeding as necessary once the facility beings to approach full intended capacity (i.e., by biomass and feed). This may mean that you are in fact not able to feed to satiation because of the potential for:

- Significant and sudden drops in oxygen concentration (below 5 ppm; mg/L)
- Immediate spikes (within 1-2 hours) in Ammonia (NH_3 and TAN, 0.0125 ppm for Salmonids and < 1.0 mg/L respectively)
- Prolonged spikes (several hours) in Nitrite (NO_2^-, <1.0 ppm hard water)
- Longer term elevated levels of total phosphorus (P, 0.01 to 3.0 ppm) and Nitrate (NO_3^- , 0 to 400 ppm)

Always keep in mind that rainbow trout generally stop feeding when they are full, especially after successive days of satiation feeding. If the fish are not taking the full calculated ration (i.e., a theoretical number) don't panic and DO NOT continue to feed as excess feed build up on the bottom of the tank not only costs money but also creates serious water quality problems. If the fish go off feed completely or are only taking in a limited ration look for signs of distress and/or other fish health related issues.

Feed Selection Considerations

When making decisions about what brand of feed and/or type of feed to select for your fish it is important to take into account what type of grow out operation you have (e.g., cage culture versus flow-through versus recirculating), what species of fish you are growing (e.g., rainbow trout require a high protein diet), what sizes of fish you are intending to introduce (e.g., fry physiologically require a different diet than more advanced life cycle stages), and what your operation's overall objectives are (e.g., meeting low phosphorus targets).

Generally, low quality fish feeds are not suitable for use in a recirculating aquaculture system because of the amount and form of waste they generate when consumed by fish. Spending more on a high quality feed should improve profitability of your operation because of higher conversion ratios and because of an overall increase in the health of the fish.

Calculating a Feeding Regime

If you are unaware of what the fish should be eating in terms total weight of feed per day to maintain satiation levels there are several ways to approach the calculation.

Feed tables can be easily obtained from most feed manufacturers which usually relate the temperature of the water and the size of the fish to a predetermined percent (e.g., 1.20 %). The percent, known as percent of bodyweight per day (i.e., % BW/day), can be used to calculate or verify feeding regimes. It is important to note that feeding tables supplied by feed companies encourage over feeding but generally represent the true theoretical maximum that fish of your selected size would uptake at your specified temperature. To use % BW/day use the following example:

0.80 % BW/day x 1 kg average size x 200 fish = 1.6 kg of fish feed

FCR (feed conversion ratio) tends to be more accurate than % BW/day but will not likely be useful during the early stages of grow out as it should be calculated from your own data set. Farmed rainbow trout typically have FCRs lower than 1 when they are smaller than 1 kg in size. That means that if I feed 1 kg of high quality feed that I could actually grow more than 1 kg of rainbow trout because they incorporate so much water into their biomass during the early stages of their life cycle. In the right hands a well run fish farm could expect FCRs for market ready fish to be as low as 1.1. Calculating FCRs for each stock of fish on a monthly basis (e.g., during data entry, aka "data housekeeping") is the best way to forecast future feeding requirements and to track feed delivery performance. To calculate FCR use the following equation:

$$FCR = \frac{\text{total feed delivered over a given period}}{\text{total weight of fish growth} + \text{total weight of fish mortalities during the same period}}$$

Fish Sampling Introduction and Background

Sampling is an extremely important task that has implications for every facet of a fish farming operation. A main goal of any kind of sampling, fish or otherwise, is always to reduce bias and experimental error to the lowest point possible so that results have actual meaning and are not being lost in the 'noise' created by poorly recorded and/or extremely biased data. This means that in a perfect world, sampling (i.e., for the purposes of this document) would always be conducted literally blindfolded. Being aware of this aspect is important as it could guide your actions when sampling.

Biomass sampling is the most common form of fish sampling you are likely to encounter on a fish farm. The goal is to be able to accurately determine what the average weight of your fish currently is so that you can calculate feeding regimes and stocking density. Having accurate weights will also allow you to make marketing decisions and to plan from an operations stand point when new fish could be added to the system or when dividers need to be adjusted. Continually selecting the largest fish or the smallest during sampling could have disastrous implications.

Sampling one fish a time for fork length and more accurate individual weights can be extremely useful for calculating condition factor and other metrics but is not likely to occur on each and every fish farm because of the necessity for use of an approved anaesthetic (i.e., approved for use with food fish) and the subsequent requirement to segregate any anaesthetized/sampled fish for the duration of the anaesthetic's withdrawal period.

Attention to detail during the data collection stage will have implications during the data entry stage. Errors in the number of fish sampled, for example, *will* appreciably affect average weights and standard deviations gleaned from the data.

M-CMAF Biomass Fish Sampling Protocol

**Fish sampling is best done in pairs; with one person as the data recorder/quality control/fish counting person and the other person as the netting specialist.*

1. Ensure that the fish to be sampled have **not** been fed in the last 24 hr to allow them time to digest their food. This ensures that during sampling fish mass is being weighed and not *feed mass*. Taking the fish off feed prior to sampling also reduces the stress response during sampling and will help ensure that any sampled fish survive the sampling process.
2. Ensure that densities of the fish to be sampled are high enough to easily catch a representative number of fish. If densities are too low you will likely only catch the slower and smaller/unhealthy fish which will lead to an underestimation of biomass.
3. Gather all required materials close to the sampling area:
    - Scale
    - Sterilized Garbage Barrel (95 L) or Similar Vessel with a Lid
    - Clean Water Transfer Bucket
    - Clipboard and Writing Utensil
    - Data Collection Sheet
    - Hand Dip Net
4. Zero the scale prior to adding any weight to it.
5. Place the garbage barrel onto the scale and fill with the same water the fish to be sampled originate utilizing the designated bucket. Record the weight of the barrel, water, and lid in one column.
6. Begin catching fish as randomly as possible by targeting groups to avoid typical ‘farmer’s bias’ of mainly going after the largest fish.
7. Ensure that fish additions to the barrel are accurately recorded and/or tallied.
8. While adding fish to the barrel ensure that water loss and additions are kept at a minimum via use of the lid. Covering the fish in between sample nets will also calm the fish further reducing the stress response.
9. Frequently stop and observe the fish looking for any signs of distress such as gasping or a loss of motor control as this likely means that there is low dissolved oxygen present in the barrel and the fish need to be quickly added back to their rearing area.
10. Once the barrel is full record total number of fish added and the final weight of the barrel, water, lid, and fish.
11. Gently put the sampled fish back into the rearing area, preferably a reasonable distance from the sampling area.
12. Repeat steps 5-12 until the desired minimum number of fish have been sampled (e.g., 100).

M-CMAF Fish Sampling Data Collection Sheet

Date: Stock ID: Date: Stock ID:

Sample #	# of fish	Weight Before (kg)	Weight After (kg)	Sample #	# of fish	Weight Before (kg)	Weight After (kg)
1				1			
2				2			
3				3			
4				4			
5				5			
6				6			
7				7			
8				8			
9				9			
10				10			
11				11			
12				12			
13				13			
14				14			
15				15			
16				16			
17				17			
18				18			
19				19			
20				20			
		*includes sample container, lid and water	*includes weight of fish etc.			*includes sample container, lid and water	*includes weight of fish etc.

Comments

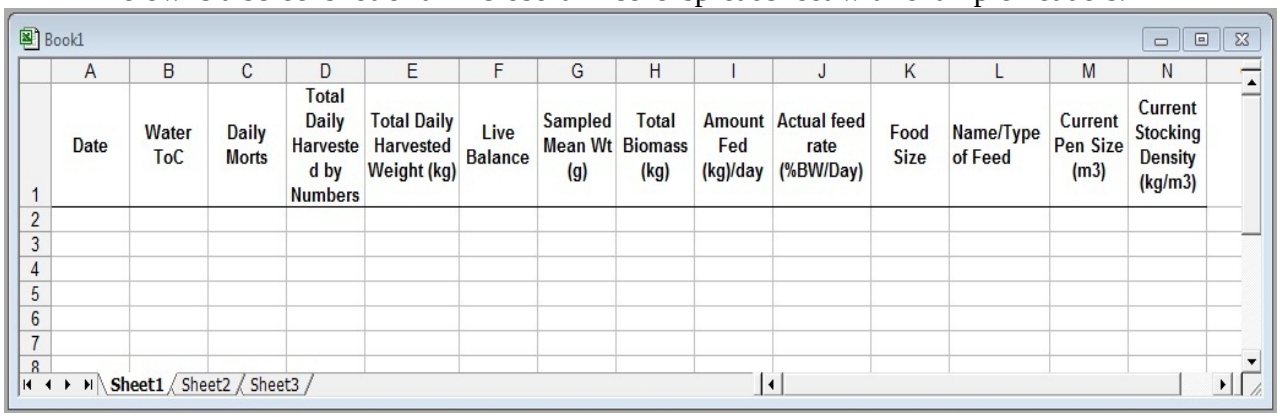
Growth Tracking

Growth tracking can be done through a variety of means and does not necessarily require the use of a computer. Entering all growth sampling data onto a computer based spreadsheet allows for quick comparisons to be made between this year's stock and previous years' and in the hands of a confident user can become a powerful management tool. Growth tracking, and by association growth curve formulation (not covered here) could increase operational efficiencies with regard to profit forecasting, feed cost forecasting, disease implication forecasting and subsequently future labour requirements just to name a few. The following sections are meant to provide the basic knowledge required to begin use of Microsoft Excel© for Growth Tracking related data entry.

Data Entry Basics using Microsoft Excel©

Microsoft Excel© is a program that can be used for a wide variety of purposes and is well suited for data entry and the types of analysis normally encountered in a fish farm setting. Typically the date is entered into column 'A' followed by successive columns of daily mortalities, daily feed, temperature, etc. Starting off on the 'right foot' is key to avoiding data entry errors and/or problems in general as time goes on and the data set begins to grow. Proof reading of data immediately following entry into your spreadsheet should become a habit as doing so after successive months of "lazy" data entry without proofing can be extremely time consuming. Errors made during the data entry phase can also have a magnified effect should any analysis or embedded equations rely on that same data set.

Below is a screenshot of a Microsoft Excel© spreadsheet with example headers.



Microsoft Excel© Spreadsheet Formula Use

Once feed or growth data has been collected and entered into a dedicated spreadsheet it will become useful to learn how to utilize some basic functionalities of Microsoft Excel© to avoid having to do calculations by hand. Take note of how spreadsheets within Excel© are organized with columns that move left to right labelled alphabetically (i.e., A-Z, AA-ZZ etc.) and rows that move top to bottom labelled numerically (i.e., 1-9999, etc).

To enter an equation into Excel© select the desired cell where you want the result to appear. First type an '=' sign. This will prompt the desired cell to accept whatever is entered after the '='sign as part of the equation. To practice try selecting a cell and entering '=1+1', upon hitting 'ENTER', the cell you selected should now contain the number '2'.

To use an equation to calculate something more useful that utilizes your actual data you will have to take into account which columns and rows are associated with the calculation. Then select the desired cell where you want the output to occur as in the above paragraph. Type an '=' sign as before to initiate the equation then enter in the specific cells to be used to calculate the output utilizing the appropriate mathematical symbols in the equation.

Example:

Today's Inventory (aka "Live Balance") = Yesterday's Inventory – Today's Mortalities – Today's Harvested Fish by Numbers

Entered into cell 'F3' would look in Excel© like (see Figure 1 for reference*):*

= F2 – C2 – D2

M-CMAF Daily Feed and Mortality Data Collection Sheet

Date	Daily Morts	Kg by Hand	Kg by autofeeder	Total Amount Fed (kg)	Pellet Size (mm)	Initials	Date	Daily Morts	Kg by Hand	Kg by autofeeder	Total Amount Fed (kg)	Pellet Size (mm)	Initials

Water Quality Monitoring

The M-CMAF Water Quality Monitoring Program relied upon the collection of data through three main 'avenues': 'In-house' sampling via various portable/hand held instruments, submission of samples to a certified lab (ALS Laboratory Group) and collection of *In Situ* data via the automated monitoring system. Each of these sampling avenues required a different set of considerations for sampling and data collection. The following is intended for use by fish farmers to develop their own water quality monitoring programs so that they can directly compare their results against industry thresholds.

'In House' Water Quality Monitoring

'In house' water quality monitoring should be done via colourimetric analysis or spectrophotometer and hand held probes separate from an *In-Situ* monitoring system to allow for verification and redundancy. Photometric testing should always be conducted in a temperature regulated area with sufficient bench top space and allowing for safe disposal of used and extremely toxic liquid reagents.

In-house sampling should be viewed as a primary management tool. If a stressful event (i.e., fish are stressed) occurs or the fish seem to be off feed then water quality should be the first suspect. The M-CMAF had on-site hand-held oxygen, total gas pressure, pH meters and temperature probes which can all be used to rule out possibilities if a problem is observed or the accuracy of *In Situ* monitoring system probes is suspect. Frequently cross reference data from the hand held instruments and familiarize yourself with calibration, cleaning and maintenance indicators for each of the probes (e.g., the Oxy Guard® Polaris II hand held oxygen probe will actually tell you when the membrane needs replacing).

Colourimetric analysis generally involves using a blank of sample water with no reagent, taking a reading, then adding a reagent and comparing results between the two samples. Any difference is calculated by the spectrophotometer (i.e., as long as you've got a modern unit) and the concentration of the desired analyte is inferred. The reaction, created by reagent introduction, is generally proportionate to the concentration of the analyte thus the more analyte present in the sample the more intense the colour formation. The spectrophotometer will then measure the incidence/refraction of light as it passes through the sample within the cuvette and subtracts the refraction measured during the 'zeroing' phase. Refer to your spectrophotometer's Manual for more in-depth explanation as well as detailed methodologies for each analyte of interest. While performing each test it is important to note that there is a relatively high potential to receive false or misleading results due to systematic and methodological errors (e.g., temperature, agitating the sample too much/not enough/inconsistently, not wiping cuvette in between samples, not properly cleaning the cuvette after use, not lining up the dot of the cuvette lid up with the spectrophotometer's dot, etc.). During sampling it is also important to be aware of interferences for each test which are listed in the Manual (e.g., ammonia low range test can give false highs if aldehydes are present which would be the

case after Parasite-S© treatment). Triple rinsing cuvettes prior to using them for sampling is a good idea and would be consistent with sound environmental sampling practices.

Certified Lab Sample Submissions

A certified lab sample submission should be considered when troubleshooting a water quality problem or when trying to compare your water quality results against outside sources (e.g., primary literature). For the purposes of this document there are two categories of samples which can be submitted to an institution or commercial laboratory for analyses: composites and grabs. Composites are samples where the sample submitted is in fact a series of samples combined into one vessel (e.g., while berry picking instead of submitting one berry at a time you submit a basket). Grab sampling could be thought of as a 'snap shot' in time. Grab samples can be useful for determining the accuracy of *In Situ* and in-house instrumentation and can also be compared with 24 hour composite data. Both methods have merit depending on the desired outcome.

Samples submitted to a commercial lab can be done on a weekly, bi-weekly, monthly, and as required basis (e.g., trying to determine nature of flocculent/precipitate). A COC (Chain of Custody) must accompany any samples submitted to the lab so that the proper analysis' are carried out in a timely manner and to relinquish possession of the samples to the lab as a legal/liability requirement of getting the lab to perform the analysis. Analysis codes represent all required analyses expected of each sample and are a quick way to communicate to floor level lab technicians any special treatments or time sensitivities associated with the samples you are submitting. Frequently used analysis codes can be grouped and included as part of an analysis package prepared by your commercial lab of choice (e.g., ALS Laboratories: DFO-FFWATER-WP; represented all typically required weekly analysis from 10 L carboys used by the M-CMAF) and each package can be tailored to analysis' performed according to a weekly, biweekly (i.e., every two weeks) and monthly regimes. For samples collected outside of the normal sample collection regime (e.g., white precipitate containing samples) it is important to contact a representative of the commercial lab to confirm analysis codes.

At the M-CMAF weekly samples generally consisted of at least two 24 hour composites and an additional grab sample based upon direction from the M-CMAF management team. As the name suggests, results from a 24 hour composite sample represented an average concentration over 24 hours of a particular analyte at the station the sample was collected. The 24 hour composite samples were collected via the HACH DS900 autosampler whereby 150 ml of water was drawn via peristaltic pump into a 10 L polypropolyne carboy every 15 minutes over the course of 24 hours. Location, autosampling unit number, and bottle set were recorded every week in conjunction with any changes to autosampler program parameters which include: liquid sensor calibration, line length, frequency, etc. It should be noted that any changes to location of a particular autosampling unit required recalibration of its liquid sensor which operated utilizing ultrasonic signals. Any change, specifically, in the amount of suspended solids or oxygen content dramatically effected accuracy of each 150 ml sample.

Prior to placing the 10 L carboys into the HACH DS900 autosampling unit, care was taken to wash the carboys utilizing lab grade phosphate-free soap. Each carboy was then triple rinsed with clean water and then triple rinsed again with site water in accordance with sound environmental sampling practices. It was also necessary to periodically acid wash bottle sets which visibly started to accumulate residues. Nitrile gloves were worn at all times during sample collection to avoid contamination and for safety purposes.

Some analyses require the use of preservative (e.g., sulphuric acid) to fix a sample just after it is collected so that the most accurate result is reported. When collecting a grab sample, all bottles (and buckets if sampling from an awkward location such as the transfer channel) should be triple rinsed with site water prior to sample collection (this also includes the lids of each bottle). Nitrile gloves were worn at all times during sample collection to avoid contamination and for safety reasons when handling preservative. An MSDS (Material Safety Data Sheet) was reviewed prior to handling any unfamiliar preservatives or reagents.

Typically used sampling codes for use on COC's submitted to *ALS Laboratories* during the M-CMAF Water Quality Monitoring Program included:

Code	**Sample Type**	**Period**
DFO-FFWATER-WP	Regular 24 hr comp ONLY (tank water)	Weekly, Biweekly
DFO-FFSLUDGE-WP	24 hr comp ONLY (retention Ponds)	Weekly, Biweekly, Monthly, As Required
DFO-FFWATER-BW-WP	Regular 24 hr comp ONLY (tank water)	Biweekly Only (offset with DFO-FFWATER-WP)
ROU1W+MET-TOT-LOW-WP	Grab (Standard Routine Analysis + Metals Scan)	Monthly, As Required
NH3-L-COL-WP	Grab (Nitros via colourimetric)	Monthly, As Required
TC, FC-MPN-WP	Grab (Total Coliform/Faecal Coliform via Most Probable Numers Method)	As Required ONLY
TC, EC-QT51-WP	Grab (Total Coliform/*E.coli* via Quanti Tray Method)	As per QMP/SQA and related Protocols
ROU4W	Grab (used to document WQ during white precipitate events)	As Required ONLY

**italics = grouped analysis package*

In Situ Monitoring System Data Collection

In Situ data collection is performed via several different probes located at specific locations within the facility. The M-CMAF positioned probes at the main rearing tank, the drum filter sump, LHO (Low Head Oxygenator) transfer channel, main circulation pump sump and the monitoring control panel itself. Data was collected 24/7 on the following parameters: dissolved oxygen concentration (i.e., 5 different locations), inside ambient temperature, outside ambient temperature, water temperature of the rearing system, inside ambient humidity, dissolved CO_2 pre drum filter, dissolved CO_2 post filtration, pH, ORP pump sump, ORP head-of-tank and amperage draw from all significant equipment (e.g., air compressor).

All water quality probes had to be frequently wiped down with paper towel and/or cotton swabs to remove fouling on the probes. It was important to gently remove all fouling from the probes without applying excessive force/pressure due to the risk of damaging the glass electrodes, tearing membranes, or in the case of the pH probe, scratching its microchip. All probes and most monitoring system components were manufactured by Campbell Scientific®.

Specific probes and monitoring system components were also designed to trigger an alarm call-out when appropriate (i.e., low dissolved oxygen). This functionality was important in providing some reassurance during off hours to the owner/operators whom would have otherwise had to have a person standing over the tank 24/7 to monitor the system.

M-CMAF In House Water Quality Monitoring Data Collection Sheet

Date	Time (24hr)	pH (colour)	T°C	NH_3-N	NH_3	NH_4^+	NO_2	NO_2-N	$NaNO_2$	NO_3^--N	NO_3^-	Alk (CaCO3)	P (total)
				ppm									

Effluent Management

Routinely obtaining a sediment sample and a water quality sample from the effluent retention pond (s) is highly recommended. Once nutrient levels have been determined it is possible to implement a manure management plan. The M-CMAF had two distinct effluent ponds: one smaller pond for solids effluent and another larger pond for over-winter retention of treated water. The solids containing effluent pond received inputs directly from key solids removal points within the M-CMAF facility. Managing effluent could be done, albeit far less efficiently, in one pond. Permitting requirements for discharge in a one pond scenario might be significantly different than in a scenario similar to that of the M-CMAF. For more information regarding manure management consult a manure management specialist.

Note: The M-CMAF's *Water Rights Licence* did not permit discharging of the treated water effluent into the municipal drainage system during freezing conditions due to ice damage concerns. This necessitated the construction of a larger over-winter treated water effluent retention pond.

Maintenance and Equipment

Maintenance regimes defined by the manufacturer should always be adhered to and routinely reviewed. Warranties and support services may or may not be available if maintenance schedules are not kept in line with manufacturer recommendations.

The M-CMAF critical equipment list included a backup diesel generator, a rotary screw air compressor, a pressure swing absorption oxygen generator, an ozone generator, several air blowers, three main vertical thrust induction pumps, several centrifugal pumps for operation of the CO_2 strippers, a large *In situ* drum filter, and a state-of-the-art automated monitoring system with an alarm call-out function to name a few. Maintenance of the above equipment included daily checks according to Manual specifications but also included additional parameters specific to the M-CMAF facility. Manuals from manufacturers tended to be relatively general and did not necessarily reflect the unique circumstances equipment was put into when the technology was adapted from other industries. Developing a keen sense of what is 'normal' for each piece of equipment is critical and should be reflected through routine equipment maintenance checks.

Backup generator

The backup generator is essential for maintaining the operation of all equipment on the farm in the event of a power outage. Ensure that the backup generator is sized to support all pieces of equipment on the farm and is equipped with an automatic transfer switch such that in the event of a power outage the generator it will function properly. Backup diesel generators need to be routinely started to maintain the integrity of solenoid starter. Fuel conditioner should be added to the fuel tank if the tank is located outside of the building to prevent the diesel from coagulating/gelling in the tank at extremely low temperatures. Ensure that the exhaust from the generator is directed outside of the building and if possible ensure that the radiator is also set up to vent externally for prolonged generator operation. This may necessitate the installation of additional louvers vents in the building to facilitate air flow to the generator.

Ensure that daily maintenance logs of the backup generator include checks such as: Time of day, how full is the diesel fuel tank, last time diesel was added, last service date, last start, last emergency start (see *M-CMAF Maintenance Logs Sheet 3 of 3*).

Air Compressor

An air compressor is a key component of many oxygen generation systems. They are generally the first major component in line prior to the oxygen generator. If the air compressor is having problems and is releasing oil into the line it has the potential to do serious damage to the oxygen generator which has very sensitive components. As such it is recommended that an air compressor serving an oxygen generator always be serviced by a knowledgeable technician without deviation from the maintenance/service schedule defined by the manufacturer.

The M-CMAF air compressor worked by generating air pressure via a rotary screw which routinely cycled off and on between 95 - 115 psi according to demand from the oxygen generator. The air compressor ran 24 hours a day 7 days a week and if problems occurred it was usually associated with temperature (i.e., ambient temperatures were too hot or too cold) or with its frequent operation including starts and stops during normal cycling.

To prevent air compressor down time and normal component wear-and-tear it was recommended by the air compressor service company to install a larger air receiver in line ahead of the oxygen generator. This would've allowed the compressor to charge the air receiver and then cycle off for longer durations at a time lengthening the lifespan of consumable components such as valves, sensors and diaphragms.

Ensure that daily maintenance logs of the air compressor include checks such as: Time of day, current operating temperature, current operating hr, current load hr, cooling oil level, last time oil was added/service performed, condensate light is green, minimum pressure during pressure cycle, maximum pressure during pressure cycle and last time the air filters were cleaned (see *M-CMAF Maintenance Logs Sheet 3 of 3*).

Oxygen Generator

The M-CMAF oxygen generator relied on the pressure swing absorption (PSA) method to 'generate' oxygen. To help others understand the function of this kind of oxygen generator it would probably have been better for the industry to name them 'nitrogen excluders'. PSA oxygen generators work by utilizing pressurized air from an air compressor and by introducing that air into a cylinder containing a molecular sieve (looks like a bunch of blue glass beads). The oxygen gets retained by the sieve at a specific pressure in the cylinder and nitrogen gets exhausted leaving behind the oxygen. The cylinder, laden with oxygen, then depressurizes off gassing the trapped oxygen into the line where it flows to an oxygen storage tank (i.e., oxygen receiver), after the oxygen generator. From the oxygen storage tank the gas can be delivered to the ozone generator (aka ozonator), the low head oxygenator (LHO) or directly to the harvest tank via oxygen stones as required/prompted by the monitoring system.

The oxygen generator at the M-CMAF was relatively maintenance free relative to the air compressor. The oxygen generator does however have some consumable components such as solenoid valves, timers, fuses and an inflow regulator that will likely require replacement or general maintenance at some point.

It is recommended that anyone attempting to diagnose a problem with an oxygen generator obtain an in-air oxygen analyzer to perform purity profiles of waste gas (i.e., how much nitrogen is being off gassed relative to ambient?) and purity profiles of stored gas in the oxygen receiver (i.e., What percent of the stored gas is oxygen?). Any troubleshooting operations should be done in consultation with the oxygen generator manufacturer.

Ensure that daily maintenance logs of the oxygen generator include checks such as: Time of day, during pressure cycling pressure swing does not exceed set maximum pressure, operate the manual drain looking for signs of oil, record the pressure of the oxygen receiver tank and record the pressure of the oxygen being delivered to the system (see *M-CMAF Maintenance Logs Sheet 1 of 3*).

Backup Oxygen

Backup oxygen, if utilizing an oxygen generation system similar to the M-CMAF, is essential for performing regular maintenance of the oxygen generation system but also to supply oxygen in the event of a power outage or critical equipment failure. M-CMAF's volume of backup supply was determined by calculating average delivery needs over 48 hours and then ordering that amount of oxygen through the supply company. Backup oxygen was configured to off gas oxygen into the delivery line passively in the event of a drop in pressure below the regulator setting should the air compressor or oxygen generator go down with no alarm system call out (i.e., if everything else failed the oxygen would be delivered to the fish regardless). A high to low pressure regulator, adopted from the welding industry, was used to regulate flow to the fish keeping pressures in the 6 - 20 psi delivery range.

Ensure that daily maintenance logs of the backup oxygen supply include checks such as: Time of day, current backup supply pressure and look for signs of a leakage/frosting (see *M-CMAF Maintenance Logs Sheet 1 of 3*).

Low Head Oxygenator

The low head oxygenator or LHO at the M-CMAF was custom designed to allow the specific amount of flow generated by the main circulation pumps, at the M-CMAF, maximum oxygenation at the delivery point immediately after filtration and just prior to the main rearing area. LHO's have two main zones: the water column on top of the distribution plate and the gas delivery area containing baffles. In lay terms an LHO is designed to create 'gas sandwich' to maximize gas transfer (aka mixing) into the water.

LHO efficiency is determined by the amount of head (measure of the height of water) on top of the LHO, the water flow rate though it and the flow rate/pressure of gas into the internal baffles. Any unexplained (e.g., the air compressor and oxygen generator appear to be running smoothly) drops in oxygen within the main rearing area are likely due to changes in efficiency of the LHO and could be attributed to changes to main circulation pump flow, changes to head on top of the LHO, changing height of the water below the LHO (i.e., if configured similarly to the M-CMAF; clean water sump pump not keeping up and water rising in main pump sump) and changes to pressure and/or purity of oxygen gas being delivered.

The M-CMAF LHO was also configured to operate at lower main circulation flows through the use of 'blanking plates'. Blanking plates are fibre glass sheets that were placed over top of the perforated distribution plate on top of the LHO. These sheets

allowed the LHO to operate at low flows but with enough head to maintain a high amount of gas transfer (i.e., super saturation of oxygen).

Ozone Generator

Use of ozone has become an important aspect of modern water treatment methods that goes well beyond aquaculture. Ozone can be used at high concentrations to sterilize and at low concentrations to oxidize potentially harmful chemical compounds into less toxic forms (e.g., nitrite to nitrate). The M-CMAF's ozone generator was intended to provide the water quality benefits only. It should be noted however, that even at low concentrations (i.e., < 250 mV ORP), M-CMAF staff have noticed that ozone has a moderate sterilizing effect.

The M-CMAF's ozone generator utilized the Corona discharge method. Ozone generation in this method is pulsed through the use of an electric arc into main oxygen gas flow where the oxygen/ozone mixture is then delivered to the LHO.

A similar model of ozone generator to that of the M-CMAF should only require minimal maintenance with occasional fill ups of the cooling water reservoir. Quartz tubes and other internal plumbing may need replacement over time.

Ensure that daily maintenance logs of the ozone generator include checks such as: time of day, pressure setting of incoming oxygen supply, level of cooling water reservoir, last time reservoir was filled, presence/absence of any warning lights, current output settings and flow rate of gas being delivered through the unit (see *M-CMAF Maintenance Logs Sheet 2 of 3*).

Air Blowers

The air blowers used at the M-CMAF were not specialized for the aquaculture industry and were used to supply air to the biofilter and purge tank. Air blowers are used to generate a high amount of air flow (i.e., volume per sec) but not at high pressure. Air blowers generally require bearing replacements/refurbishments, periodically, dependant on use and manufacturer recommendations. Through experience it was determined that the M-CMAF air blowers required intake sock cleaning/maintenance every six months or earlier as required.

Air blower intake sock cleaning may also be necessary following harmful exhausting from other equipment. For example, following an air compressor failure where the compressor exhausted vaporized oil, the blower intake socks became saturated forcing the blowers to work much harder to intake air than normal.

It was noticed at the M-CMAF facility that significant amounts of condensation would build up in the air blower line over time. To remove the water condensate from the line a valve along the purge tank was periodically opened to force the water out.

It was also noticed at the M-CMAF that temperature and humidity appear to play a role in the operation of the blowers, and by association, pressure in the air blower line.

Ensure that daily maintenance logs of the air blowers include checks such as: time of day, listening for abnormal sounds or vibrations, pressure of the air delivery line and the last time the intake socks/filters were cleaned/checked (see *M-CMAF Maintenance Logs Sheet 2 of 3*).

Main Circulation Pumps and Motors

The three M-CMAF main circulation pumps were solid shaft vertical thrust induction pumps with a turbine electric motor. The pumping setup was designed to produce 5400 GPM (1800 GPM per pump) of main circulation flow. This pumping rate was designed to support peak loading rates of fish within the main rearing system including filtration capacity, solids containing effluent removal, biofilter passes and oxygen delivery capacity. Making decisions to increase or decrease flows via modifications to main circulation pumping should not be made lightly because of the potential ramifications for the system as a whole.

Pay special attention to the main circulation pumps just after start up taking note of heat and vibration so that you will know in the future if there is a problem. The main circulation pumps and motors were greased with high quality lithium based grease every 6 - 8 months or earlier as needed. Amperage draw meters were used and current amp draw was routinely compared against 'as new' amperage readings from the first 3 months of operation. When amperage readings became elevated (i.e., > 1 amp difference) grease was applied in accordance with manufacturer recommendations. The main circulation pumps (i.e., not the motors) had only one bearing, below the motor to shaft coupling, that required grease. The other sets of bearings down the shaft were water lubricated. The pump motors had two areas that required greasing as well.

Ensure that daily maintenance logs of the main circulation pumps include checks such as: time of day, last time grease was applied to the pumps, current amperage draws and presence or absence of vibration (see *M-CMAF Maintenance Logs Sheet 2 of 3*).

> Note: Continual starts and stops of the main circulation pumps have a high potential to damage the pump and more specifically the bearings. Any protocols or SOPs regarding 2 to 3 pump increase in pumping capacity should reflect a keen understanding of the sensitivity of the main circulation pumps.

CO_2 Stripper and CO_2 Stripper Pumps

The operation of the M-CMAF CO_2 stripper was directly tied to the monitoring system. An increase in CO_2 levels (i.e., because of feeding activity or stress) detected by the monitoring system beyond a specific set point would prompt a PLC (programmable logic control) to initiate a pair of CO_2 stripping pumps to turn on thereby pumping water up and into the CO_2 stripper. As water is pumped onto the top of the stripper (primarily

constructed of fibre glass) it trickled down through a perforated plate and into the stripper cell which by design passively separated water and CO_2. The M-CMAF strippers released the CO_2 directly into the ambient air but there were tentative plans to force vent the strippers in the future to maximize CO_2 removal out of the building when desired.

The CO_2 stripper pumps at the M-CMAF were electric driven standard centrifugal design and were virtually maintenance free. Pressure gauges, mounted near the pump outlet, were checked on a biweekly (i.e., every two weeks) basis and associated valves were adjusted as necessary. The pumps were designed to work at low pressures (i.e., 4 - 6 psi) any more of which has the potential to make the pumps overdraw amps tripping the associated electrical breaker or overworking the pump.

Ensure that daily maintenance logs of the CO_2 stripper pumps include checks such as: time of day, current amperage draws and presence or absence of vibration (see *M-CMAF Maintenance Logs Sheet 2 of 3*).

> Note: There is some evidence which suggests that force venting of CO_2 may only be advantageous in the summer/warmer months as trapped CO_2 may create a greenhouse effect at humidity levels documented at the M-CMAF facility artificially increasing temperature and by association fish growth.

Drum filter

The drum filter at the M-CMAF was used to remove suspended solids smaller than 60 μm just prior to biofiltration. Two fibre glass wing walls diverted all system flow into the drum filter. As the screen on the inside of the drum filter clogged with solids the water level in the drum filter would rise. Once the rising water level was high enough to trigger a float switch within the drum filter it would then be prompted to rotate via a PLC which would also activate a backwash pump which sprayed the outside of the filter with high pressure nozzles that ran the length of the drum. Within the drum directly under the spray nozzles was a trough which was designed to collect the effluent from the nozzles. The trough was plumbed directly to the solids sump.

The drum filter operated continuously and autonomously 24 hours a day 7 days a week. It required greasing biweekly (i.e., every two weeks) via food safe grease because it was placed *In Situ*. Greasing points included the wheels at the front of the drum and the main bearing at the back of the drum. The electric motor which turned the drum via chain drive required yearly maintenance as per manufacturer recommendations that included measuring and adjusting the chain tension as required. Additionally, it was recommended by the drum filter supplier, to check the rubber gasket at the front of the drum for pinching or misalignment periodically through the use of an underwater camera.

The backwash pump was a multistage high pressure design adopted from the manufacturing industry and was supplied with the drum filter. The M-CMAF backwash pump required maintenance one time to clean the stages, the shaft and other internal components after two years of continuous operation but was otherwise maintenance free.

In line after the pump was a coarse cartridge filter just prior to the spray nozzles that required cleaning, typically, on a monthly basis.

If there is a problem with the drum filter or backwash pump it may be necessary to temporarily take off a screened panel of the drum filter to allow water to flow through the drum without being filtered and to stop the non-functional drum filter from backing up system flow. To do this, turn the backwash and drum filter settings to the OFF position at the motor control panel. Remove the outer aluminum coverings to reveal the drum filter panels. Using a crescent wrench or socket set, remove the bolts holding the desired filter panel in place. The panel should then 'spring' out of position and can be set aside. Proceed to the motor control panel and rotate the drum using the MANUAL switch until the section of the drum where the panel was removed is fully submerged. Once the necessary repairs have been completed work backwards from the above to safely install the panel. Allowing the system to operate without the drum filter for multiple days will have serious implications of the biofilter and overall system performance. Taking the drum filter off line, as detailed above, should not be done unless absolutely necessary.

Ensure that daily maintenance logs of the drum filter include checks such as: time of day, observations of the spray bar and screen looking for signs of spray nozzle malfunction, pressure of backwash delivery line, presence/absence of abnormal sounds, last time chain drive as greased and checked for tension and the last time the rubber gasket at the head of the drum filter was observed with the underwater camera looking for pinching or proper seating (see *M-CMAF Maintenance Logs Sheet 1 of 3*).

> Note: Make regular checking of backwash pump line pressure part of the daily maintenance routine. Too high of pressure (see manufacturer recommendations) could potentially blow out the drum filter screen and too low of pressure could indicate a pump problem.

Biofilter

The M-CMAF was equipped by the system designers with a moving bed biofilter. The biofilter was divided into four different cells and turnover within the each cell was driven primarily by the air blowers (refer to *Air Blowers* section of this Manual). Each cell was designed to contain 26 - 28 m^3 of biomedia. Biofilters are implemented in aquaculture applications to reduce nitrogen from very toxic forms (i.e., ammonia) to less toxic forms (i.e., nitrite followed by nitrate). The primary drivers of a moving bed biofilter include metabolic waste (e.g., ammonia), air availability, fluidity of bed mass and alkalinity.

Biomedia is the term used to describe the small plastic components which promote the growth of beneficial bacteria that are primarily responsible for the nitrification process. If the biofilter is not operated with adequate air supply to drive the oxygen consuming bacterial process than non-beneficial forms of bacteria can be expected to establish.

If operating a moving bed biofilter, like that at the M-CMAF, it will be important to collect biofilter performance data qualitatively (e.g., 'cell is turning over well and no

build up of biomedia next to the wall') and quantitatively (e.g., head loss from cell 1 to cell 4 was 10 cm) to be able to accurately determine if there has been a change over time. An important measure of biofilter performance involves water quality monitoring (see the *Water Quality Monitoring* section of this Manual) to determine if the biofilter is oxidizing nitrogen according to anticipated design specifications based on current fish biomass and feed load data. Monitoring alkalinity levels via the M-CMAF water quality monitoring program was also routine.

Microparticle Filter

The M-CMAF microparticle filter was positioned (i.e., in terms of process flow) within the system after the main circulation pumps and relied on water being diverted through it. It contained the same biomedia as the biofilter but the biomedia in the microparticle filter (also known as a fixed bed biofilter) was not mobilized through air action. The purpose of the microparticle filter was to trap microscopic particles travelling with treated oxygen saturated water from the main pump sump (i.e., post LHO and biofiltration) just prior to introduction to the fish.

Cleaning schedules of a microparticle filter should be defined on a facility to facility basis with cleaning occurring as soon as flow through the filter becomes noticeably hindered or there are fish health concerns regarding the potential build up of pathogens and/or vectors for disease in the filter. The M-CMAF microparticle filter was initially cleaned every two weeks as a precautionary measure to facilitate the removal of a white precipitate thought to be leaching from the newly formed concrete tank walls. As the precipitate disappeared microparticle filter cleaning became a more scheduled process every month regardless of water flow observations through the filter.

To clean the M-CMAF microparticle filter the diversionary flow from the main circulation pumps was turned off. The large green 6'' stand pipe was pulled and the water level was dropped roughly 3''. Air valves from the air blower line were then opened allowing air to enter the microparticle filter cell, agitating the biomedia. This process was timed for 30 minutes to allow for all trapped material contained within the biomedia to become liberated. The microparticle filter standpipe was then pulled slowly over 45 minutes to allow the solids sump pump time to maintain levels without backing up the line or overflowing (see the *Effluent Sumps* section of this Manual for more details). Once the microparticle filter had been completely evacuated of effluent, a hose was then used to wash down the walls of the microparticle filter and was placed at the corner farthest from the standpipe which allowed for flow from the hose to carry leftover material to the solids sump. Upon inspection of the underflow wall and floor of the filter, with a flash light (looking for 'dirty' water), water from the nearest main circulation pump was then diverted (i.e., by opening the valve one notch) back into the microparticle filter.

During filling of the M-CMAF microparticle it was important to maintain awareness of main pump sump level which would draw down during the microparticle filter filling process. If the diversionary valve was opened too much, the pump sump level (i.e., head)

would drop fast triggering the safety float switches for the main pumps and turning off main circulation flow and cycling the main pumps off and on which is not recommended (see *Main Circulation Pumps and Motors* section of this Manual). It was always important to maintain a watchful eye when filling the microparticle filter. Once the microparticle filter was filled, all diversionary valves were returned to their previous position. When positioning the valves/altering diversionary flow it was important to balance flows into the microparticle filter against the potential for air to be drawn into the siphon breaks at the head of the main circulation pumps.

Sludge Cones

The term 'sludge cone' refers to conical depressions on the floor of the main rearing area located at two key points within the M-CMAF rearing system. There were two sets of four sludge cones that were the primary means of heavy solids removal. Sludge cones at the M-CMAF were opened daily to facilitate the movement, via gravity, of collected material to the solids sump where it was then pumped to the solids containing effluent pond.

The upstream cones were paired off such that one valve opened two cones. The upstream sludge cone valves were opened for a minimum of 20 seconds (10 seconds per cone) on average to facilitate flushing of the line. If additional material was spotted in the cones they were simply opened longer. Stainless steel perforated coverings were placed on top of the upstream sludge cones because they were trapping mortalities and were not adequately flushing properly resulting in a fish health issue.

The downstream cones, located directly in front of the drum filter, had stand pipes which were pulled on average for 10 seconds each to facilitate adequate flushing. Configuration of nearby riser pipes (i.e., located under decking in drum filter sump) appeared to effect the efficiency of the downstream cones ability to trap solids which should be taken into account if altering the height of the riser pipes.

Effluent Sumps

The M-CMAF had two sumps located outside and adjacent to the facility that were used to pump water from the treated water effluent line and the solids containing effluent lines to two separate effluent ponds. The solids from the solids sump was stored year round in the smaller of the two ponds and was intended to be used in accordance with typical manure management best practices. For more details see the *Effluent Management* section in this Manual.

The M-CMAF's treated water effluent outlet was located at the main circulation pump sump. This meant that if the treated water sump pump could not keep up with discharge amounts that water would backup in the line. Problems with treated water sump pumps had real implications, in terms of main circulation pump sump water height (i.e., defined as 'head'), for oxygen levels in the system because of the relationship between the amount of head in the main pump sump and the efficiency of oxygen exchange at the

LHO. For more details of how the LHO operates refer to the *Low Head Oxygenation* section of this Manual.

Malfunction of the dirty water sump pumps had less serious implications but still had the real potential for creating problems within the main facility. Any backing up of the solids line meant that removal of solids from sludge cones and the drum filter was much slower and less efficient.

It was determined through experience at the M-CMAF that periodic (i.e., every 6 months) removal of settled solids/waste at the bottom of the solids sump (i.e., via septic truck/services) would be necessary to maintain efficient pumping to the solids retention pond.

Eventually a pipe was installed to connect the two sumps to prevent/slow down the backing up of either line in the event of a pump failure.

Primary Well Pump

The primary well pump at the M-CMAF was a typical submersible well pump. Maintenance of the pump included periodically checking amperage draws but was otherwise maintenance free. By altering the main valve on the primary well pump line incoming water flow rate was adjusted to increase or decrease the of amount incoming water as desired. It was noticed at the M-CMAF that water temperature and other water quality parameters (e.g., alkalinity in $CaCO_3$ equivalents) were appreciably affected by incoming water flow rate. Depending on the season and the situation, incoming flow rates were routinely adjusted.

Monitoring System

The M-CMAF monitoring system was designed to fulfill the needs of the *M-CMAF Initiative* and would not likely need to be fully duplicated for a commercial grow out setting to have success. For more information regarding the purpose of the monitoring system and the monitoring program refer to the *Water Quality Monitoring* section of this Manual.

Maintenance of monitoring system components typically involved cleaning probes and calibrating as needed. Longer term maintenance should include changing out membranes and electrolytic solutions of specific probes in accordance with manufacturer recommendations. Consult with the manufacturer or equipment supplier as required.

M-CMAF Maintenance Logs Sheet 1 of 3 (Drum Filter, Backup O2, Oxygen Generator)

		Drum Filter						Backup O_2		Oxygen Generator				
Date (mm/dd/yy)	Time (24 hr)	Observe spray bar + screen for discoloration	Pressure of spray bar filter (psi)	Listen for Strange Sounds	Chain Greased/Gear Box Maintenance (yearl; last time performed: mm/dd/yy))	When was the unit last greased (mm/dd/yy)?	Rubber gasket at head of drum filter is not pinched/requires replacement – last time checked via under water camera (mm/dd/yy)	Current Pressure (psi)	Listen for signs of gas leak	Pressure during pressure swing does not exceed 80 psi	Observe Manual Drain looking for signs of Oil	pressure at relief valve of oxygen receiver (psi)	Pressure of oxygen being delivered to the system (psi)	Notes

M-CMAF Maintenance Logs Sheet 2 of 3 (Ozone Generator, Blowers, Pumps)

		Ozone Generator									Blowers			Main and CO_2 Pumps					
Date (mm/dd/yy)	Time (24 hr)	Incoming O_2 regulator set at 5 psi?	Level of H_20 coolant reservoir	Last time reservoir was filled? (mm/dd/yy)	Any Warning Lights? Which one (s)?	Set at Low or High output?	Output estimate (%)	Output (amps):	Output (volts):	Flow Rate (LPM) [both flow meters combined]	Listen for vibrations /strange sounds	Pressure of air line (in of H_2O)	Last time intake socks were checked (mm/dd/yy)	Last time main circ pumps greased	CO_2 stripper pumps + Sump pumps operating normally?	Amperage Draws within normal limits?	Virbations/ strange sounds?	Notes	

M-CMAF Maintenance Logs Sheet 3 of 3 (Air Compressor, Backup Generator)

		Air Compressor									Backup Generator					
Date (mm/dd/yy)	Time (24 hr)	Operating Temp (^oF)	Operating Time (hr):	Load Time (hr):	Check Cooling Oil Level	Last time oil was added (mm/dd/yy)	Condensate drain light is green	Min Pressure during cycle (psi)	Max Pressure duing cycle (psi)	Last time air filters were cleaned (mm/dd/yy)	Has full tank of diesel?	Last time diesel was added/exchanged (mm/dd/yy):	Last time serviced (mm/dd/yy):	Last time started (mm/dd/yy):	Last emergency start (mm/dd/yy):	Notes

M-CMAF Equipment List and Specifications

Equipment Description	***Model Number / Equipment Specifications***	***Manufacturer/Supplier***
Backup diesel generator	Family No.: 6JDXL06.8041 Model: 40455TF275D, Power: 64kW@1800 RPM, D: 4.5 L	John Deere
Rotary screw air compressor	Model: AS-25T HP:25 CFM:111 psig: 125 Hz:60 V:575 FLA: 29 Phase:3	Kaeser Compressors Canada Inc.
PSA oxygen generator	Model: AS-G (320) V:110/120 A: 3.0 Hz:50/60	AirSep Corp.
Backup O_2 (99 % pure)	16 pack of 55'' cylinders (~ 2100 psi)	Praxair Canada Inc.
Ozone generator	Model: RM700A VAC: 208 Hz: 50-60 A:3x15	Azco Industries Ltd.
Air Blowers	Model: AM132MRA2 HP: 15.0 Hz: 60	Lafert
Vertical thrust induction main circulation pumps	Model: 10 RPM: 1760 GPM: 1400-2900	van Ness Lo-Lift Pumps
Main circulation pump motors	Model: 5k2135SAE6021 Frame: L213TP 10 HP: 7.5 A: 8.7 Hz: 60 Phase: 3	General Electric
Centrifugal CO_2 stripping pumps	Model: 3656 IMP/DIA: 5 ½ Size: 5x 5-6	Goulds ITT
CO_2 stripping pump motors	CAT No: JMM3554T-5 Frame: 145JM Hz: 60 HP:1.5 V:575 RPM: 1740 Phase: 3	Baldor Reliance
Submersible centrifugal sump pumps	Model: WE1037H HP: 1 RPM: 3450 V:575 MaxA: 2.8	Goulds ITT Pumps
Well pump	Model: WE1037H HP: 1 RPM: 3450 V:575 MaxA: 2.8	Goulds ITT Pumps
In-situ drum filter	HDF 2010; 22.5 m^2, 60 *u*m screen	Hydrotech
Drum filter backwash pump	Grundfos MTR Model	Grundfos Canada Inc.
Pool style vacuum pump	Model: JWP/5SEC-2A3 HP: 1 V:15, with strainer	STA-RITE
Monitoring system and alarm call-out	O2, pH, CO2, Water Temp, Ambient Air Temp, and Ambient Humidity Probes, , + numerous other components	Campbell Scientific Inc. (primarily)
Fibre glass Model Farm Components	CO-1 CO2 Stripper, Biofilter Walls and pre-fabricated solids capture cones	HE Products / Water Management Technologies
Handheld Oxygen Probe / Meter	Polaris II	OxyGuard International A/S
Various Specialized Parts	Point Four System Oxygen Delivery Stones, Footbaths, Nets	Aquatic Ecosystems Inc.
Harvesting hand dip nets	Various	Leckie's Lakefish Net and Twine
Auto samplers for 24 hour composite sampling	Hach SD 900	Hach Sales and Service Canada Ltd.
Spectrophotometer for In-house sampling	HI 83200 Multiparameter Photometer	Hanna Instruments Canada

Emergency Response

There are two main types of emergencies that M-CMAF emergency protocols aimed to address: personnel emergencies and catastrophic equipment failures including power outages.

Refer to http://www.safemanitoba.com/ for more details regarding workplace safety and health.

Emergency response to personnel emergencies, catastrophic failures and power outages should be taken seriously and rehearsed on a regular basis. Take the time to train all staff and to have a check-in/check-out and 24 hour response person identified and within 15 minutes at all times.

M-CMAF ALARM RESPONSE PROTOCOL

** assumed that No Full Time staff are safely within a 15 minute response time*
** assumed that Alarm Responders have received minimal training and will act as the "eyes and ears" of full time staff*
** assumed that cell phones will be usable onsite via a cell phone signal booster*
** This sheet has been distributed to all potential responders and staff*

1. If an alarm condition exists the monitoring system will call full time staff sequentially until someone stops the call-out by pressing the # key.
2. Full time staff whom are contacted by the alarm system but are not within 15 minutes of the farm should initiate the ALARM RESPONSE PROTOCOL by calling the following phone numbers in order until a remote responder has been contacted and can proceed to the farm:

Alarm Responders	**Phone #**
Full names and numbers provided by Management	xxx.xxx.xxxx

3. After confirming that an alarm responder is en route. The full time staff member who initiated the ALARM RESPONSE PROTOCOL should proceed directly to the farm.
4. Alarm Responders should take note of whether or not the lights are on upon entering the facility.

   a. If they are off the diesel generator has not likely started.
   b. A flashlight should be near the main door on the boot rack.
5. Alarm responders should then ensure that oxygen is being delivered to the fish by:
   a. Observing oxygen pack
      i. Looking at the delivery pressure of the oxygen pack regulator
         - i.e., one side is for bottle pack pressure which could be ≤ 2100 psi and the other side is oxygen delivery pressure which should be ≤ 32 psi).
      ii. Listening for the sound of flowing gas (must be within 3 ft).
      iii. Regulator should have frost build up after a short period of time if oxygen is flowing freely.
   b. Visual inspection of the in-tank oxygen diffusers. If gas can be observed bubbling up in the water than everything should be OK!
6. Any information or observations should then be relayed to the now en route full time staff member via cell phone. At such time, any additional instructions to the alarm responder will be relayed. Things to relay to the en route responder include but are not limited to:
   a. Obvious reasons for an alarm (e.g., water flowing out of the tank onto the production floor).
   b. The fish appear to be reacting erratically and violently at the surface (e.g., indicative of low dissolved oxygen situation).
   c. How many main pumps are running (i.e., look for stream of water coming out of 90^{o} elbows at the head of the tank).

M-CMAF Emergency Response Plan - WORKING IN PAIRS

**This protocol is to be used in the event of injury when working with others and should be read and understood by ALL staff (including volunteers) with M-CMAF*

1. Immediately identify who is injured and the severity of the injury.
2. If the injured person does not require immediate 1st Aid **CALL 911**
   a. "The farm is located here"
   b. "We're in the central large barn with *X* vehicles outside the main door"
3. If it is safe to do so without further injury and the victim can walk on their own power, take them to ***Medical Center Name*** **(XXX.XXX.XXXX; SEE MAP BELOW)** via the Perimeter Highway.

[INSERT MAP HERE]
******show primary route and alternate route to nearest medical centre******

M-CMAF Emergency Response Plan - WORKING ALONE

** assumed that any staff whom are working alone have read the following document and understand it*

1. Establish check-in/check-out times with someone who is aware that you will be working alone.
2. Ensure that your contact will **CALL 911** within 30 min of trying to reach you by phone and/or email (if phone service not active within the building).
3. Ensure that your contact is aware of the location of the farm and can communicate directions to Emergency Responders
    a. "The farm is located *here*"
    b. "He/She's likely in the large barn with *these* vehicles outside the main door"

M-CMAF Power Outage INITIAL RESPONSE PROTOCOL

**assumed that all 3 main circulation pumps are currently operating*

1. Observe time (24:00) of outage and record (use of whiteboard is encouraged)
2. Call Farm Manager or designated contact.
3. Record pressure of O_2 tanks once every hour to confirm O2 bottle pack has come online and is working. Are the lights back on?
4. Did all main circulating pumps restart?
5. Observe Sump
    - Is water flowing normally?
6. Is Oxygen <u>actually</u> being delivered to the main tank?
    a. Observe oxygen diffusers
    b. Observe oxygen levels within main tank
        i. utilize monitoring panel of main computer
        ii. confirm monitoring panel O_2 levels utilizing handheld oxygen probe
    c. If operation is running based off 2 main pumps the Air Compressor / Oxygen Generator will <u>not</u> likely trip off due to amperage load (i.e., it is possible that oxygen is being delivered NORMALLY, watch and observe the air compressor and oxygen generator).
    d. Is there an adequate level of oxygen in the backup bottle packs?
        - Lower than 500 psi and it is time to review how to switch bottle packs. Review the specified section in the SECONDARY RESPONSE PROTOCOL (next page) if you are unfamiliar with how to do this.
7. Equipment Room Check
    a. Check Air Compressor / Oxygen Generator to ascertain which oxygen delivery system is in use (i.e., in a 3 pump operation the system is designed to kick off the air compressor/oxygen generator combo based on amperage draw)

   b. 2 blowers operational
   c. Generator is running smoothly:
      i. Excess fumes/smoke from exhaust
      ii. Extra Diesel on hand to re-fill generator as needed
8. Monitor biomedia cells
   a. Observe walls for excessive bowing
   b. Look for additional rafting
9. Observe fish and prepare to modify feeding regime
   - Look for signs of erratic behaviour that could be related to low oxygen levels. Verify oxygen levels.
10. If more than **4 hr** of time have elapsed without power coming back on proceed to SECONDARY RESPONSE PROTOCOL (Next Page)

Note: Initial Response protocol should be viewed as normal operating procedure as much as possible with preparations for feed changes and potentially a different O_2 source to the system. The decision to maintain the pumps and blowers was made such that the overall system would see **minimal operational changes**, which is the right mentality.

M-CMAF Power Outage SECONDARY RESPONSE PROTOCOL

** more than 4 hr have elapsed since power outage*

1. Observe current time (24:00) and record
2. Check diesel tank for level (look inside with a flashlight or tap the outside listening for differences). Contact Farm Manager and make preparations as necessary to fill the diesel tank (located outside the barn adjacent to the mechanical room).
3. Before proceeding call Manitoba Hydro to get a timeframe for the power to return (XXX.XXX.XXXX)
   a. Based upon the call to Manitoba Hydro: If power is likely to come back on within the next 2-4 hr DO NOT PROCEED any further with Secondary Response
   b. Oxygen packs have enough O_2 for 24hr (i.e., 16 packs, 99 % pure, from starting point at 2100 psi), but it may be necessary to switch between packs if the current online pack has depleted levels
   c. If bottle pack O2 pressure is below 300 psi begin to make preparations to switch the regulator from one pack to the other.

How to Switch Bottle Packs (moving the regulator):

1. Note: oxygen can be turned off to the delivery system for a short amount of time without affecting oxygen levels too seriously (~ 7 minute window).
2. Observe regulator delivery pressure (left hand dial)

- Should be approximately 8 psi if running on backup oxygen; if lower it is time to move quickly

3. Gather appropriately sized wrench for the brass regulator nut.
4. Tighten each individual oxygen bottle using the mantra "righty-tighty (clockwise motion), lefty loosy (counter clockwise motion)".
5. Tighten the main line valve for the entire bottle pack, located on the top of the bottle pack frame near the regulator.
6. Close the regulator valve.

   Note: the regulator closes via a spring loaded mechanism which is typical of many high pressure regulators; "left loosy" (counter clockwise) is how to effectively close/tighten the regulator valve.

7. Using the appropriate wrench and a counter-clockwise motion (lefty loosy applies here) remove the regulator.
8. Position the regulator on the new bottle pack in the same orientation as previously observed.
   a. Using considerable force tighten the regulator using the wrench (righty tighty) within reason and without stripping the threads.
   b. Ensure that the regulator reads zero on both dials.
9. Begin opening each individual bottle in the new bottle pack by slowing turning the valves in a counter-clockwise motion.
   - Double check that each bottle is opened fully.
10. Very slowly, open the main line bottle pack valve.

    Note: if oxygen is observed to be leaving the regulator (will be easy to notice) the regulator valve is not fully closed.

11. You should now read ≥ 2100 psi on the right-hand dial of the regulator for a fully charged bottle pack.
12. Slowly turn the regulator valve in a clockwise motion to open it.
13. Stabilize delivery pressure at ~ 8 psi on the left hand regulator dial.

4. Follow **3-2 Pump Protocol** (provided by Water Management Technologies Inc.) to shut down to two pump operation if not already at 2 pump operation.

- Add in LHO blanking plates to maintain normal biofilter operating levels (i.e., raise water level in biomedia cells to optimize cell performance) at the downstream side of the LHO.

5. Turn off one blower
    a. Observe biomedia cells to ensure there is no excessive rafting/wall bowing
    b. Take note of the air pressure within the blower line (in of H_2O)
6. If biomedia cells remain functional and intact, turn on the Air Compressor using the GREEN BUTTON
    a. Using the main transfer switch override, turn on the Air Compressor.
        i. It looks like a normal commercial light switch located on the inside of the Air Compressor Panel), transfer power to the air compressor.
        ii. Should be followed by a change in the sound of the Diesel Generator.
    b. If startup is not initiated hold down the green button on the front of the display. If it still does not start but appears to have power hold down the red button until the display changes and then hold down the green button
    c. You should hear the compressor start and begin to pressurize it's storage tank (max psi ~ 125).
    d. If it does not appear to have power, proceed to the appropriate breaker panel (north wall of the mechanical room) and ensure that the breaker switches (combined series of 3) are not tripped.
        - Reset the switches if necessary to the ON position and repeat above steps 6a to 6c.
7. Turn ON the oxygen generator if it is not on.
    a. Observe the oxygen generator for strange noises/normal operating procedure
    b. The Oxygen generator should now be filling the reserve tank (beside ozone generator) and oxygen should be flowing to the LHO via the Ozone feed line.
    c. If Oxygen levels drop, the monitoring system will add oxygen to the system through the oxygen diffusers or the 'booster' lines
    d. Observe diffusers should only be operating as required by the monitoring system
    e. Note: oxygen pressure on the left handed back up oxygen dial should now match delivery pressure from the oxygen generator (~ 32 psi at stable pressure) and not the 8 psi that the bottle packs are set to deliver at.
    f. If the power is not being delivered to the oxygen generator check the breaker (see *6 d*).
8. Ensure adequate diesel fuel is available for the generator
9. IF MORE THAN 12 HOURS ELAPSE ENSURE THAT ADDITIONAL OXYGEN IS ENROUTE
    a. Call Farm Manager
    b. Oxygen Supply Company Phone Number (XXX.XXX.XXXX)
        - *Name* of the best person to talk at the supply company.
    c. Account Number: **XXXX**
    d. Ask for Delivery if Necessary via a low bed truck if possible.

Licenses and Permitting

Activity	***License / Permit***	***Governing Body***
Farming Fish	Fish Farming Licence	Manitoba Water Stewardship (Fisheries Branch)
Constructing a new well and withdrawing groundwater for testing	Groundwater Exploration Permit	Manitoba Water Stewardship (Water Use Licensing Section)
Discharging retained water and constructing drainage or other works including culverts and retention ponds	Water Rights Licence	Manitoba Water Stewardship (Water Use Licensing Section)
Exporting whole fish product across Provincial/National borders to a non-CFIA *Registered* processing facility	Fish Export License	Food Safety Division of the Canadian Food Inspection Agency
Processing of fish or fish products intended for export across Provincial/National borders	Processing Facility *Registration*	Food Safety Division of the Canadian Food Inspection Agency
Importing a Species Listed under Schedule III of the *Health of Animals Regulations* across National borders	Import Permit	Aquatic Animal Health Division of the Canadian Food Inspection Agency

Disclaimer: The licence and permitting requirements for new fish farm entrants and currently operating fish farms are continually being updated at the national and provincial levels. It is highly recommended that anyone seriously considering fish farming not rely solely on the table provided and that they exercise their own due diligence to ensure that they are meeting or exceeding all regulatory, permitting and licensing requirements.

Harvesting Fish

The following documents were developed for the M-CMAF to obtain an Export License via the Canadian Food Inspection Agency (CFIA) for shipping of whole fish across Provincial borders from early February 2012 to January 2013. The regulations regarding License requirements have since changed and an *Export License* is now only required when shipping whole fish to processing facilities outside of the Province that are not CFIA *Registered*.

The below *Action Items* and *Standard Operating Procedures* are, however, useful for demonstration of how the M-CMAF was harvesting fish, working within established legislation (i.e., *Fish Inspection Regulations*) and meeting industry standard quality assurance principles.

M-CMAF Canadian Food Inspection Agency Issued Export License Action Items

Re: Compliance Items Pertaining to Section 15.1 of the *Fish Inspection Regulations* [as written and delivered to the CFIA]

15.1

(a)

(i) Should be filled appropriately on the *Fish Export Application* form which was delivered.

(ii) Diagram has been submitted, including product process flow.

(iii) **a description of the activities to be carried out at the establishment:**

We will be shipping 3500-5000 kg of 1.0 – 1.4 kg Rainbow trout (*Oncorhynchus mykiss*) to a CFIA registered facility preferably on a bi-weekly basis. Fish may be gilled prior to transport in accordance with our SOPs and at our discretion pending client preference and/or conditions and/or our own product quality concerns.

(iv) **a description of the controls to be implemented to ensure complicance with the Act and these regulations:**

The fish will be removed from the depuration tank into 1 m^3 insulated blue polyethylene totes (supplied by Barr Plastics, model DX335). The fish will be shipped in a slurry utilizing water produced onsite. The ice for the slurry will be shipped in totes supplied by the CFIA registered facility. The truck to be utilized year round will be refrigerated and will meet the CFIA registered facility's requirements for trucking (i.e., any additional

items being transported pose no risk of contaminating our whole fish product).

Total and faecal coliform samples from the M-CMAF onsite ice machine and the well water from the secondary well will be submitted to an accredited analytical laboratory (ALS Environmental) on a semi-annual basis. All coliform testing results will be disclosed with CFIA inspectors and the CFIA registered facility as requested. The Primary well is dedicated for use as 'make-up' water for the main rearing area of the facility (i.e., there is no risk of 'accidental' use of the primary well for any activities). Any water to be used for net baths, tote cleaning, slurry creation etc will be via the Secondary Well.

Any sterilization of nets, totes and tote lids that may come into contact with the fish during the loading phase of transport (i.e., at our facility) will be done so using dilute bleach and water prior to fish handling. Virkon Aquatic® will also be used in accordance with our biosecurity protocol for use in foot baths and to sterilize the walls and floors of the *Loading Area*. After all fish have been loaded into totes, the loading area will be cleaned and sterilized in accordance with *Company Name Loading Area Cleaning and Sterilization SOP*.

Refer to the following documents as required:

M-CMAF Fish Export Operations SOP – Ungilled, Whole fish
M-CMAF Fish Export Operations SOP –Gilled, Whole fish
M-CMAF Gilling Station and Sterilization SOP
M-CMAF Loading Area Cleaning and Sterilization SOP
M-CMAF Tote Cleaning and Sterilization SOP
M-CMAF Water and Ice Quality Assurance SOP

Statement of Therapeutic & Antibiotic Use/Future Use:
Therapeutics and Antobiotics have not been used at this facility to date. *Parasite-S* was used with veterinary oversight to control a disease issue related to animal health. Parasite-S is an approved parasiticide for use with food fish and has zero withdrawal time.

If a therapeutic or antibiotic is to be used in the future because of veterinary recommendation it will only be used if the therapeutic/antibiotic meets industry standard for use with fish meant for human consumption. Withdrawal time for the therapeutic/antibiotic will also be taken into consideration prior to exporting fish.

Fish samples were submitted to a *Specialized Commercial Lab* in accordance with the CFIA *Registered* Facility`s QMP. Future fish samples

will be submitted at a frequency defined by any associated CFIA registered facility in accordance with their QMP.

Statement of Facility Construction:
The rearing system, filtration system, and depuration system were designed by *Designer's Name* and meet industry standards for concrete tanks. All other materials used that could have contact with our water have to be approved for use by M-CMAF management and the only materials approved include: plastics (primarily polyvinylchloride and nylon mesh), fibre glass, aluminum, and stainless steel. The drum filter, which is a component of the filtration system, sits in the water and is constructed of aluminum components with nylon mesh. The drum filter requires greasing every 3 weeks and the grease used is food grade (i.e., *Name of Food Grade Grease Used*). All other components of the overall system meet M-CMAF management's approved materials requirements mentioned above (i.e., plastic, fibre glass, aluminum or stainless steel). **drum filter keyed on in above statement because of the necessity for greasing; all other components/equipment that requires greasing or similar maintenance is done so with *no risk of contact with tank water***

Statement of Loading Area Construction:
Most of the walls and all of the ceilings of the facility have been sheeted with a commercially available product called P2000. P2000 is made of Styrofoam with an aluminum foil coating which can be sterilised. Plywood coated with an epoxy paint has also been used to sheet over the insulation up to the 10 ft wall mark. The loading door which represents part of the west wall (i.e., the only wall in the loading area other than the fish tank walls) in the loading area is a standard garage door constructed of metal with a plastic coating which can be sterilised. The rest of the wall (~ 18 ft) in the loading area is under construction: it currently consists of plywood with no coating, however fastened to the plywood is metal which will extend from the floor up to 8 ft to allow for sterilisation. We currently have the means to sterilise ALL the walls in this critical area.

* *Loading Area* is defined in *M-CMAF Loading Area Cleaning and Sterilization SOP*

M-CMAF Fish Export Operations S.O.P. – Gilled, Whole Fish

Fish Export Operations, Loading Area Cleaning and Sterilization, Tote Cleaning and Sterilization, and *Water and Ice Quality Assurance* SOPs will be read and understood prior to enacting this SOP.

Fish Gilling Definition:
Fish gilling is the act of severing the major artery and vein located below the gill arches which supplies oxygen flow to and from the heart and/or severing of a gill arch itself.

Gilling fish prior to transport is not required if transport and processing times can be kept low enough to avoid off flavours and/or other TDU (Tainted, Decomposed, Unwholesome) issues. Gilling of fish may be deemed necessary according to the M-CMAF's desired product quality and/or client recommendations/conditions. The following sub-sections will be specific to inter-provincial movements (i.e., whole fish moving across provincial borders) of gilled fish or intra-provincial (i.e., whole fish moving to a CFIA registered facility within Manitoba) movements of gilled fish from the M-CMAF which is a CFIA licensed facility.

A. Shipping of Gilled, Whole Fish Across Provincial Borders

1. Ensure that all trucking arrangements have been made and meet the CFIA registered facility's standards/requirements.
    - Make sure the truck is not transporting anything that could impart an odour, flavour, or otherwise deleterious substance into the whole fish product which is to be transported.
        - This includes the transport of totes containing ice from the CFIA registered facility free of contamination.
2. Enact the *Loading Area Cleaning and Sterilization SOP* 24 hours prior to moving totes into the building to ensure that it is free of contamination.
3. Enact the *Gilling Station Setup and Sterilization SOP* at least 24 hours prior to moving totes into the building to ensure that there is no risk of contamination.
4. Totes *may* be received from a CFIA registered facility containing the desired proportion of ice to be used in a slurry, as defined by that registered facility.
    a. If totes are not received clean and free of potential contamination review and enact the following SOPs where applicable:
        i. *Tote Cleaning and Sterilization*
        ii. *Water and Ice Quality Assurance*
    b. If totes are not received from a CFIA registered facility containing a enough ice it is important to note the following:
        i. The onsite ice machine DOES NOT have the capacity to produce ALL of the ice for the typical total mass of fish (i.e., 3500-5000 kg) we intend to export within a 24 hr period.
        ii. The process of filling totes with ice will have to be started several days prior to loading of fish into totes during which

time totes will be stored in a designated area free of potential contamination with lids firmly in place.

- Enact *Tote Cleaning and Sterilization SOP* prior to filling the tote with ice.

iii. Utilizing the Secondary Well (i.e., hose connection at sink) fill the tote containing ice partially up (1/4 - 3/8) with water.

- Review *Water and Ice Quality Assurance SOP* prior to filling the tote.

5. Go to the *Company Name* Inc *other food products* processing facility: Prepare a bleach bath in the 375 L black Rubbermaid® Tote within the *Company Name* Inc *other food products* processing facility.
    a. Utilize 2 L of Sodium Hypochlorite and fill the tote to the top.
    b. The following items are now to be placed in the bleach bath for sterilization and/or scrubbed with bleach bath water:
        i. Dedicated loading-only dip nets
        ii. Food safe ice chisel (i.e., dedicated and labeled)
        iii. Food safe polypropylene ice shovel (i.e., dedicated and labeled)
        iv. Rain gear
            1. Personnel responsible for loading of totes will wear designated rain gear.
            2. Rain gear will be scrubbed with water from the bleach bath prior to commencing of operations.
            3. Rain gear will be rinsed utilizing water from an approved water source (i.e., secondary well) until there is no bleach present.
        v. Tote lids prior to securing the lid onto the fish-slurry filled tote.
6. Fill the stainless steel bleed out tank.
7. Ensure slurry filled totes are ready for use in the *Company Name* Inc *other food products* processing facility prior to commencing further activites.
    a. Is the ice in the totes chipped and moving freely (i.e., no ice blocks on the bottom)?
    b. Have the lids been maintained in place during the filling of ice and or storage of ice received from a CFIA registered facility?
8. Totes that need to be moved from the outside to the inside will be placed on the inside of the door utilizing the Bobcat® skid steer without placing the tires of the Bobcat® on the concrete of the *Company Name* Inc *other food products* processing facility loading area (i.e., avoid contaminating the floor of the *Company Name* Inc *other food products* processing facility loading area).
    - Once in the facility, slurry filled totes will only be moved around within the facility utilizing the dedicated pallet jack (this includes the dedicated ‘temperature shock’ tote).
9. Ensure the temperature shock tote (significantly smaller and not intended for use in transport off-property) is filled with an adequate amount of ice. Move the temperature shock tote from the *Company Name* Inc *other food products* processing facility loading area utilizing the Bobcat® skid steer to the M-

CMAF loading area garage door and place the temperature shock tote within the facility without contaminating the Loading Area.

10. Begin crowding the fish utilizing the dedicated purge tank crowder to increase the density at the end of the purge tank closest to the Loading Area to facilitate loading of fish into designated totes.
    - The crowder position will be adjusted as fish are removed from the purge tank.
11. Utilizing hand dip nets load a maximum of a 100 fish into the temperature shock tote and add water from the secondary well (i.e., an approved water source; see *Water and Ice Quality Assurance SOP*).
12. Move the fish containing temperature shock tote to the *Company Name* Inc *other food products* processing facility and place the tote without contaminating the *Company Name* Inc *other food products* processing facility loading area.
13. Move the temperature shock tote to a convenient position close to the Gilling Station (i.e., as defined within *Gilling Station Setup and Sterilization SOP*) utilizing the dedicated *Company Name* Inc *other food products* processing facility pallet jack.
14. Wait for the fish movement within the temperature shock tote to cease completely
    - This could take 5-10 min
15. Begin fish gilling
    a. Remove fish from the temperature shock tote by hand, stunning any fish utilizing a fish bonker (i.e., looks like a small baseball bat) so that fish gilling is precise and performed in a humane way.
    b. Utilizing a filleting knife (i.e., sterilized in accordance *Gilling Station Setup and Sterilization SOP*) insert the knife into the lower portion of the gill arch and severe the main artery/vein by running the knife forward towards the lower jaw with the cut coming out just below the tip of the jaw on the ventral side of the fish (i.e., the bottom).
        i. Alternatively try severing one gill arch with the knife. This will also have the intended effect and might prove to be much easier to accomplish.
        ii. Try to maintain as much consistency from fish to fish as possible as any irregularities could create problems for further processing by clients and/or custom processing operations.
16. Place the fish into the designated stainless steel bleed-out tank and wait an additional 5-10 min. *** *This Step Represents the most significant difference between Inter and Intra Provincial Shipping Operations****
17. Prior to adding bled fish to a desired tote the tote must be prepared.
    a. Tote lids are to be placed on a stand comprised of concrete or plastic (i.e., sterilizable surface) to prevent contact of the tote lid with the floor.
    b. Utilizing the now sterilized food safe ice chisel break up the ice in the tote.

c. If there is too much ice, remove it utilizing the now sterilized food safe ice shovel.

18. Utilizing a dedicated hand dip net place fish from the bleed-out tank into the desired tote maintaining appropriate counts as defined by the to be accompanied SQA.
    a. Add water from the approved water source (i.e., the secondary well; see *Water and Ice Quality Assurance SOP*) until the desired amount of water is present in the tote.
    b. Loading of totes with whole fish is to be carried out utilizing designated loading-only dip nets.
        i. Harvesting/loading specific dip nets onsite are comprised of an aluminum/fibre glass frame with a nylon mesh.
        ii. Dip nets will be sterilized and ready for use in the dedicated bleach water baths found ONLY in the loading area.
        iii. DO NOT place the bleached net on the side walls of the main tank or in the main rearing area without rinsing until no bleach is present.
        iv. Rinse the dip net until no bleach is present prior to utilizing the net for loading.
        v. Re-sterilize the dip nets as required during loading. Keep the net end of the dip nets free of contamination.
        vi. Hang the dip nets at the designated harvest dip net location if they are not in use or place the net in the dilute bleach water net bath.
19. Designate one person to count fish as they are placed into the totes
    a. Utilize a 'clicker-counter' (i.e., do not rely on your own ability to keep track)
    b. Utilize designated *Product Export Inventory Sheet*
        i. Calculate total mass in each tote as a product of average weight x total number added to the tote and record
            - e.g. fish are 1200 g on average x 500 fish in the tote = 600,000 g or 600 kg
        ii. Keep all product inventory paperwork related to fish export in a designated area (i.e., file cabinet in office).
    c. All final calculations should be re-recorded onto the shipment's accompanied SQA.
20. Begin moving fish into a designated tote until the tote is deemed to be full
    a. Fish slurry will be within a few inches of the top of the tote to prevent the fish-slurry from gaining momentum during transport and potentially forcing the lid of the tote to open jeopardizing the integrity of the tote.
    b. Random temperatures (^{o}C) will be taken from each tote prior to putting tote lids on (i.e., one temp during loading and one temp prior to moving the tote onto the truck for example).
        - Record the temperatures on the SQA provided with each shipment

21. Brush the tote lid with water from the bleach water bath once the tote lid is required (i.e., the tote is full of fish, ice, and water).
    a. Rinse the tote lid with water from an approved source (i.e., the secondary well) until no bleach is present.
    b. Securely fasten the lid of the tote into place.
22. Move the tote utilizing the pallet jack to the overhead garage door.
23. Once several totes have been properly loaded designate a Bobcat® driver to load the totes onto the transport truck if the truck does not have a hydraulically lower able loading deck and truck-dedicated pallet jack.
24. A *Statement of Quality Assurance* will be provided with each shipment containing the following pieces of information:
    a. Current Date
    b. Harvest Time Start (24 hr)
    c. Harvest Time End (24 hr)
    d. Total Number of Totes
    e. Trucking Seal #
    f. Treatment Name(s) (i.e., if applicable)
    g. Last Treatment Date (s) (i.e., if applicable)
    h. Withdrawal Time (s) (i.e., if applicable)
    i. Total Biomass of Shipment
    j. Lot Coded Number (yyyymmdd [date of last sample] – mmdd [date of shipment] S/R [S – meaning shipment, R – meaning Reception])
       E.g., 20120127-0131S
    k. Tote ID number
    l. Average weight of the fish at last sample ± SD (standard deviation)
    m. Number of fish (per tote)
    n. Biomass Calculated (i.e., based on average weight x fish counted per tote)
    o. A temperature (^{o}C) of each tote during loading
    p. Temperature (^{o}C) prior to movement of the fish-slurry containing tote onto the refrigerated truck (i.e., two temperatures will be recorded for each tote).
    q. A statement with a check box that water quality testing (i.e., E. coli and total coliforms) have been recently tested in accordance with the frequency defined within *Company Name*'s *Water and Ice Quality Assurance SOP*.
    r. A statement with a check box that the truck responsible for delivery was inspected and appeared to be free of odors and/or anything that might render our fish product TDU
25. Once all totes have been loaded enact the *Loading Area Cleaning and Sterilization SOP*.

B. Shipping of Gilled, Whole Fish Within Provincial Borders

1. Ensure that all trucking arrangements have been made and meet the CFIA registered facility's standards/requirements.
    a. Make sure the truck is not transporting anything that could impart an odour, flavour, or otherwise deleterious substance into the whole fish product which is to be transported.
        - This includes the transport of totes containing ice from the CFIA registered facility free of contamination.
    b. If *Company Name* truck and trailor are to be used, ensure that they are in good working order and that weather conditions will not render fish product shipments TDU (i.e., due to it being too hot).
2. Enact the *Loading Area Cleaning and Sterilization SOP* 24 hours prior to moving totes into the building to ensure that it is free of contamination.
3. Enact the *Gilling Station Setup and Sterilization SOP* at least 24 hours prior to moving totes into the building to ensure that there is no risk of contamination.
4. For fulfilling large volume orders/shipments: totes *may* be received from a CFIA registered facility containing the desired proportion of ice to be used in a slurry, as defined by that registered facility.
    a. If totes are not received clean and free of potential contamination review and enact the following SOPs where applicable:
        i. *Tote Cleaning and Sterilization*
        ii. *Water and Ice Quality Assurance*
    b. If totes are not received from a CFIA registered facility containing a enough ice it is important to note the following:
        i. The onsite ice machine DOES NOT have the capacity to produce ALL of the ice for the typical total mass of fish (i.e., 3500-5000 kg) we intend to export within a 24 hr period.
        ii. The process of filling totes with ice will have to be started several days prior to loading of fish into totes during which time totes will be stored in a designated area free of potential contamination with lids firmly in place.
            - Enact *Tote Cleaning and Sterilization SOP* prior to filling the tote with ice.
        iii. Utilizing the Secondary Well (i.e., hose connection at sink) fill the tote containing ice partially up (1/4 - 3/8) with water.
            - Review *Water and Ice Quality Assurance SOP* prior to filling the tote.
5. For small volume orders/shipments: Smaller containers, such as Rubbermaid totes, for ease of transport may be used. Any transport container will be cleaned in accordance with *Tote Cleaning and Sterilisation* and *Water and Ice Quality Assurance SOPs*.
    - All ice and water used for transport will meet criteria defined within the *Water and Ice Quality Assurance* SOP.

6. Go to the *Company Name* Inc *other food products* processing facility: Prepare a bleach bath in the 375 L black Rubbermaid® Tote within the *Company Name* Inc *other food products* processing facility.
    a. Utilize 2 L of Sodium Hypochlorite and fill the tote to the top.
    b. The following items are now to be placed in the bleach bath for sterilization and/or scrubbed with bleach bath water:
        i. Dedicated loading-only dip nets
        ii. Food safe ice chisel (i.e., dedicated and labeled)
        iii. Food safe polypropylene ice shovel (i.e., dedicated and labeled)
        iv. Rain gear
            1. Personnel responsible for loading of totes will wear designated rain gear.
            2. Rain gear will be scrubbed with water from the bleach bath prior to commencing of operations.
            3. Rain gear will be rinsed utilizing water from an approved water source (i.e., secondary well) until there is no bleach present.
        v. Tote lids prior to securing the lid onto the fish-slurry filled tote.
7. Fill the stainless steel bleed out tank if is to be used (see *Step 17*).
8. Ensure slurry filled totes/smaller containers are ready for use in the *Company Name* Inc *other food products* processing facility prior to commencing further activites.
    a. Is the ice in the totes chipped and moving freely (i.e., no ice blocks on the bottom)?
    b. Have the lids been maintained in place during the filling of ice and or storage of ice received from a CFIA registered facility?
9. Totes that need to be moved from the outside to the inside will be placed on the inside of the door utilizing the Bobcat® skid steer without placing the tires of the Bobcat® on the concrete of the *Company Name* Inc *other food products* processing facility loading area (i.e., avoid contaminating the floor of the *Company Name* Inc *other food products* processing facility loading area).
    - Once in the facility, slurry filled totes will only be moved around within the facility utilizing the dedicated pallet jack (this includes the dedicated ‘temperature shock’ tote).
10. Ensure the temperature shock tote (significantly smaller and not intended for use in transport off-property) is filled with an adequate amount of ice. Move the temperature shock tote from the *Company Name* Inc *other food products* processing facility loading area utilizing the Bobcat® skid steer to the M-CMAF loading area garage door and place the temperature shock tote within the facility without contaminating the Loading Area.
11. Begin crowding the fish utilizing the dedicated purge tank crowder to increase the density at the end of the purge tank closest to the *Loading Area* to facilitate loading of fish into designated totes.
    - The crowder position will be adjusted as fish are removed from the purge tank.

12. Utilizing hand dip nets load a maximum of a 100 fish into the temperature shock tote and add water from the secondary well (i.e., an approved water source; see *Water and Ice Quality Assurance SOP*).
13. Move the temperature shock tote to a convenient position close to the Gilling Station (i.e., as defined within *Gilling Station Setup and Sterilization SOP*) utilizing the dedicated *Company Name* Inc *other food products* processing facility pallet jack.
14. Wait for the fish movement within the temperature shock tote to cease completely
    - This could take 5-10 min
15. Begin fish gilling
    a. Remove fish from the temperature shock tote by hand, stunning any fish utilizing a fish bonker (i.e., looks like a small baseball bat) so that fish gilling is precise and performed in a humane way.
    b. Utilizing a filleting knife (i.e., sterilized in accordance *Gilling Station Setup and Sterilization SOP*) insert the knife into the lower portion of the gill arch and severe the main artery/vein by running the knife forward towards the lower jaw with the cut coming out just below the tip of the jaw on the ventral side of the fish (i.e., the bottom).
    c. Alternatively try severing one gill arch with the knife. This will also have the intended effect and might prove to be much easier to accomplish.
        - Try to maintain as much consistency from fish to fish as possible as any irregularities could create problems for further processing by clients and/or custom processing operations.
16. Place the fish into the designated stainless steel bleed-out tank and wait an additional 5-10 min if desired. Utilizing the bleed-out tank may not be necessary for short transport timelines (i.e., less than 2 hours)

*** *This step represents the <u>most significant difference</u> between inter and intra Provincial shipping operations****

17. Prior to adding fish to a desired tote/container, the tote/container must be prepared.
    a. Tote lids are to be placed on a stand comprised of concrete or plastic (i.e., sterilizable surface) to prevent contact of the tote lid with the floor.
    b. Utilizing the now sterilized food safe ice chisel break up the ice in the tote.
    c. If there is too much ice, remove it utilizing the now sterilized food safe ice shovel.
18. For large volume orders/shipments: utilizing a dedicated hand dip net place fish from the bleed-out tank (i.e, if fish were bled) into the desired tote maintaining appropriate counts as defined by the to-be-accompanied SQA.

a. Add water from the approved water source (i.e., the secondary well; see *Water and Ice Quality Assurance SOP*) until the desired amount of water is present in the tote.
b. Loading of totes with whole fish is to be carried out utilizing designated loading-only dip nets.
    i. Harvesting/loading specific dip nets onsite are comprised of an aluminum/fibre glass frame with a nylon mesh.
    ii. Dip nets will be sterilized and ready for use in the dedicated bleach water baths found ONLY in the loading area.
    iii. DO NOT place the bleached net on the side walls of the main tank or in the main rearing area without rinsing until no bleach is present.
    iv. Rinse the dip net until no bleach is present prior to utilizing the net for loading.
    v. Re-sterilize the dip nets as required during loading. Keep the net end of the dip nets free of contamination.
    vi. Hang the dip nets at the designated harvest dip net location if they are not in use or place the net in the dilute bleach water net bath.

19. For small volume orders/shipments: placing fish one-by-one into desired containers is allowed. If fish have been bled and are to be removed from the bleed-out tank utilize a dedicated loading only dip net (see previous *Step 19, b*)
20. Designate one person to count fish as they are placed into the totes/containers
    a. Utilize a 'clicker-counter' (i.e., do not rely on your own ability to keep track)
    b. Utilize designated *Product Export Inventory Sheet*
        i. Calculate total mass in each tote as a product of average weight x total number added to the tote and record
            - e.g. fish are 1200 g on average x 500 fish in the tote = 600,000 g or 600 kg
        ii. Keep all product inventory paperwork related to fish export in a designated area (i.e., file cabinet in office).
    c. All final calculations should be re-recorded onto the shipment's accompanied SQA.
21. Begin moving fish into a designated tote/container until the tote/container is deemed to be full
    a. Fish slurry will be within a few inches of the top of the tote to prevent the fish-slurry from gaining momentum during transport and potentially forcing the lid of the tote to open jeopardizing the integrity of the tote.
    b. Random temperatures (^{o}C) will be taken from each tote prior to putting tote lids on (i.e., one temp during loading and one temp prior to moving the tote onto the truck for example).
        - Record the temperatures on the SQA provided with each shipment

22. Brush the tote lid with water from the bleach water bath once the tote lid is required (i.e., the tote is full of fish, ice, and water).
    a. Rinse the tote lid with water from an approved source (i.e., the secondary well) until no bleach is present.
    b. Securely fasten the lid of the tote into place.
23. Move the tote utilizing the pallet jack to the overhead garage door.
24. Once several totes have been properly loaded designate a Bobcat® driver to load the totes onto the transport truck if the truck does not have a hydraulically lower able loading deck and truck-dedicated pallet jack.
25. A *Statement of Quality Assurance* will be provided with each shipment containing the following pieces of information:
    a. Current Date
    b. Harvest Time Start (24 hr)
    c. Harvest Time End (24 hr)
    d. Total Number of Totes
    e. Trucking Seal #
    f. Treatment Name(s) (i.e., if applicable)
    g. Last Treatment Date (s) (i.e., if applicable)
    h. Withdrawal Time (s) (i.e., if applicable)
    i. Total Biomass of Shipment
    j. Lot Coded Number (yyyymmdd [date of last sample] – mmdd [date of shipment] S/R [S – meaning shipment, R – meaning Reception])
       E.g., 20120127-0131S
    k. Tote ID number
    l. Average weight of the fish at last sample ± SD (standard deviation)
    m. Number of fish (per tote)
    n. Biomass Calculated (i.e., based on average weight x fish counted per tote)
    o. A temperature (^{o}C) of each tote during loading
    p. Temperature (^{o}C) prior to movement of the fish-slurry containing tote onto the refrigerated truck (i.e., two temperatures will be recorded for each tote).
    q. A statement with a check box that water quality testing (i.e., E. coli and total coliforms) have been recently tested in accordance with the frequency defined within *Company Name*'s *Water and Ice Quality Assurance SOP*.
    r. A statement with a check box that the truck responsible for delivery was inspected and appeared to be free of odors and/or anything that might render our fish product TDU
26. Once all totes have been loaded enact the *Loading Area Cleaning and Sterilization SOP*.

M-CMAF Fish Export Operations S.O.P. – Ungilled, Whole Fish

**Loading Area Cleaning and Sterilization*, *Tote Cleaning and Sterilization*, and *Water and Ice Quality Assurance* SOPs will be read and understood prior to enacting this SOP.

Fish Export Definition:
Fish Export for the purposes of this document refers only to the intended movement of whole fish across provincial boundaries within designated containers for processing at a CFIA registered facility.

1. Ensure that all trucking arrangements have been made and meet the CFIA registered facility's standards/requirements.
    - Make sure the truck is not transporting anything that could impart an odour, flavour, or otherwise deleterious substance into the whole fish product which is to be transported.
        - This includes the transport of totes containing ice from the CFIA registered facility free of contamination.
2. Enact the *Loading Area Cleaning and Sterilization SOP* 24 hours prior to moving totes into the building to ensure that it is free of contamination.
3. Totes *may* be received from a CFIA registered facility containing the desired proportion of ice to be used in a slurry, as defined by that registered facility.
    a. If totes are not received clean and free of potential contamination review and enact the following SOPs where applicable:
        i. *Tote Cleaning and Sterilization*
        ii. *Water and Ice Quality Assurance*
    b. If totes are not received from a CFIA registered facility containing a enough ice it is important to note the following:
        i. The onsite ice machine DOES NOT have the capacity to produce ALL of the ice for the typical total mass of fish (i.e., 3500-5000 kg) we intend to export within a 24 hr period.
        ii. The process of filling totes with ice will have to be started several days prior to loading of fish into totes during which time totes will be stored in a designated area free of potential contamination with lids firmly in place.
            - Enact *Tote Cleaning and Sterilization SOP* prior to filling the tote with ice.
        iii. Utilizing the Secondary Well (i.e., hose connection at sink) fill the tote containing ice partially up (1/4 - 3/8) with water.
            - Review *Water and Ice Quality Assurance SOP* prior to filling the tote.
4. Move slurry filled totes into the facility via the West overhead garage door.
    a. Totes will be placed on the inside of the door utilizing the Bobcat® skid steer without placing the tires of the Bobcat® on the concrete of the loading area (i.e., avoid contaminating the floor of the Loading Area).

b. Once in the facility, slurry filled totes will only be moved around within the facility utilizing the dedicated pallet jack.

5. Prepare a bleach bath in the 375 L black Rubbermaid® Tote.
    a. Utilize 2 L of Sodium Hypochlorite and fill the tote to the top.
    b. The following items are now to be placed in the bleach bath for sterilization and/or scrubbed with bleach bath water:
        i. Dedicated loading-only dip nets
        ii. Food safe ice chisel (i.e., dedicated and labeled)
        iii. Food safe polypropylene ice shovel (i.e., dedicated and labeled)
        iv. Rain gear
            1. Personnel responsible for loading of totes will wear designated rain gear.
            2. Rain gear will be scrubbed with water from the bleach bath prior to commencing of operations.
            3. Rain gear will be rinsed utilizing water from an approved water source (i.e., secondary well) until there is no bleach present.
        v. Tote lids prior to securing the lid onto the fish-slurry filled tote. (see *Step 11*)
    c. It is VERY important that bleach does NOT contact the rearing system and/or the purge tank (i.e., extra rinsing is encouraged)
6. Begin crowding the fish utilizing the dedicated purge tank crowder to increase the density at the end of the purge tank closest to the Loading Area to facilitate loading of fish into designated totes.
    - The crowder position will be adjusted as fish are removed from the purge tank.
7. Prior to adding fish to a desired tote the tote must be prepared.
    a. Tote lids are to be placed on a stand comprised of concrete or plastic (i.e., sterilizable surface) to prevent contact of the tote lid with the floor.
    b. Utilizing the now sterilized food safe ice chisel break up the ice in the tote.
    c. If there is too much ice, remove it utilizing the now sterilized food safe ice shovel.
    d. Add water from the approved water source (i.e., the secondary well) until the desired amount of water is present in the tote.
8. Loading of totes with whole fish is to be carried out utilizing designated loading-only dip nets.
    a. Harvesting/loading specific dip nets onsite are comprised of an aluminum frame with a nylon mesh.
    b. Dip nets will be sterilized and ready for use in the dedicated bleach water baths found ONLY in the loading area.
        - DO NOT place the bleached net on the side walls of the main tank or in the main rearing area without rinsing until no bleach is present.

c. Rinse the dip net until no bleach is present prior to utilizing the net for loading.
d. Re-sterilize the dip nets as required during loading. Keep the net end of the dip nets free of contamination.
    - Hang the dip nets at the designated harvest dip net location if they are not in use or place the net in the dilute bleach water net bath.

9. Designate one person to count fish as they are offloaded into the totes
    a. Utilize a 'clicker-counter' (i.e., do not rely on your own ability to keep track)
    b. Utilize designated *Product Export Inventory Sheet*
        i. Calculate total mass in each tote as a product of average weight x total number added to the tote and record
            - e.g. fish are 1200 g on average x 500 fish in the tote = 600,000 g or 600 kg
        ii. Keep all product inventory paperwork related to fish export in a designated area (i.e., file cabinet in office).
    c. All final calculations should be re-recorded onto the shipment's accompanied SQA.
10. Begin moving fish into a designated tote until the tote is deemed to be full
    a. Fish slurry will be within a few inches of the top of the tote to prevent the fish-slurry from gaining momentum during transport and potentially forcing the lid of the tote to open jeopardizing the integrity of the tote.
    b. Random temperatures (^{o}C) will be taken from each tote prior to putting tote lids on (i.e., one temp during loading and one temp prior to moving the tote onto the truck for example).
        - Record the temperatures on the SQA provided with each shipment
11. Brush the tote lid with water from the bleach water bath once the tote lid is required (i.e., the tote is full of fish, ice, and water).
    a. Rinse the tote lid with water from an approved source (i.e., the secondary well) until no bleach is present.
    b. Securely fasten the lid of the tote into place.
12. Move the tote utilizing the pallet jack to the overhead garage door.
13. Once several totes have been properly loaded designate a Bobcat® driver to load the totes onto the transport truck if the truck does not have a hydraulically lower able loading deck and truck-dedicated pallet jack.
14. A *Statement of Quality Assurance* will be provided with each shipment containing the following pieces of information:
    a. Current Date
    b. Harvest Time Start (24 hr)
    c. Harvest Time End (24 hr)
    d. Total Number of Totes
    e. Trucking Seal #
    f. Treatment Name(s) (i.e., if applicable)

g. Last Treatment Date (s) (i.e., if applicable)
h. Withdrawal Time (s) (i.e., if applicable)
i. Total Biomass of Shipment
j. Lot Coded Number (yyyymmdd [date of last sample] – mmdd [date of shipment] S/R [S – meaning shipment, R – meaning Reception])
E.g., 20120127-0131S
k. Tote ID number
l. Average weight of the fish at last sample ± SD (standard deviation)
m. Number of fish (per tote)
n. Biomass Calculated (i.e., based on average weight x fish counted per tote)
o. A temperature (^{o}C) of each tote during loading
p. Temperature (^{o}C) prior to movement of the fish-slurry containing tote onto the refrigerated truck (i.e., two temperatures will be recorded for each tote).
q. A statement with a check box that water quality testing (i.e., E. coli and total coliforms) have been recently tested in accordance with the frequency defined within *Company Name*'s *Water and Ice Quality Assurance SOP*.
r. A statement with a check box that the truck responsible for delivery was inspected and appeared to be free of odors and/or anything that might render our fish product TDU

15. Once all totes have been loaded enact the *Loading Area Cleaning and Sterilization SOP*.

M-CMAF Loading Area Cleaning and Sterilization S.O.P.

Loading Area Definition:
The Loading Area is physically defined within the M-CMAF as the concrete pad located adjacent to the large overhead door on the West side of the building. The Loading Area is the ONLY designated area within M-CMAF authorized for operations related to Fish Export (i.e., export across provincial borders). The definition of the Loading Area includes all wall and floor surfaces which may potentially become contaminated due to fish export loading activities.

Loading Area Function:
The function of the Loading Area is to provide a clean and sterilized working environment to facilitate movement of whole fish from the depuration tank (aka purge tank) to a designated tote while preventing contamination of the fish product intended for later processing at a CFIA approved facility. **The Loading Area is to be cleaned after any activity which may contaminate it to prevent the unwanted spread of potential pathogens throughout the facility.**

Contact Time Definition:
Used in association with an approved sterilizing agent (i.e., Virkon Aquatic ®) and is the amount of time the sterilizing agent is allowed to neutralize potential pathogens after the sterilizing agent is applied to a surface prior to rinsing. Contact time affects the efficacy of sterilizing agents.

1. The Loading Area is to be cleaned prior to and after:
    a. enacting the *Tote Cleaning and Sterilization SOP*
    b. enacting the *Fish Export Operations SOP*
2. Loading Area cleaning and Sterilization will be performed as follows:
    a. If the Loading Area is dry, the floor is to be swept utilizing a broom prior to the use of water
        - The ONLY broom approved for use in the loading area is the RED HANDLED broom
    b. The Loading Area is to be **rinsed** utilizing water from an approved water source (i.e, the Secondary Well)
        i. see *Water and Ice Quality Assurance SOP*
        ii. This step is intended to facilitate removal of all coarse material and to provide.
        iii. Use **soap** if necessary.
            - After using soap, apply a second rinse until there is no soap present.
    c. **Virkon Aquatic** ® will then be applied to all surfaces within the loading area utilizing the backpack/hand pump sprayer

i. Refer to MSDS and directions for use before handling Virkon Aquatic®
ii. DO NOT immediately rinse Virkon Aquatic ® from intended surfaces (i.e, contact time of Virkon Aquatic ® affects efficacy)
    1. Pre Fish Export Operations Virkon Aquatic® allowed contact time = 24 hr
    2. Post Fish Export Operations Virkon Aquatic® allowed contact time = 24 hr
    3. Post Tote cleaning Virkon Aquatic® allowed contact time = 1 hr
    4. Use reasonable judgment to gauge contact time in all other instances utilizing 1 hr as the minimum

d. **Rinse** utilizing water from an approved water source (i.e, the Secondary Well) all surfaces within the Loading Area after prescribed amount of contact time has expired

M-CMAF Gilling Station Setup and Sterilization S.O.P.

Gilling Station Definition:
For the purposes of this document, gilling station refers specifically to a stainless steel table, plastic filleting table, filleting knives, fish bonker, and stainless steel bleed-out tank all located within the *Company Name* Inc.

Company Name Inc processing facility *Statement of Intended use*:
The processing facility is primarily used to process *other food products* intended for farm gate sales every 6 months (on average there are 24 days of processing annually). Fish processing (i.e., bleeding, heading, gutting, filleting, etc) will only occur when the facility is not being used to process *other food products* and there is limited risk of cross contamination. Prior to fish processing the working area/relevant area within the facility will be cleaned and sterilized in addition to previous post processing of *other food products* cleaning operations.

Company Name Inc *other food products* processing facility *background information*:
The *Company Name* Inc *other food products* processing facility is pre-rinsed (utilizing a pressure washer), sterilized (utilizing Neogen's Biosentry® 904 or Sodium Hypochlorite), and rinsed (via pressure washer again) all utilizing heated water from the secondary well (i.e., an approved water source) at the end of every *other food products* processing day. Typical washing and sterilization regimes include all surfaces within the facility (i.e., ceilings, floors, walls, light fixtures, etc.), floor drains, and *other food products* processing equipment (e.g., stainless steel tables. vacuums, scalding tank). All offal from processing is kept at a pile located roughly 30 ft from the North side door of the *Company Name* Inc *other food products* rearing facility (i.e., ~ 350 ft from the *Company Name* Inc *other food products* processing facility).

Company Name Inc *other food products* processing facility *statement of construction materials*:
The *Company Name* Inc *other food products* processing facility has concrete flooring with one central trough-style drain which runs the full length of the processing area. Ceiling and wall construction consists of corrugated galvanized sheeting and is well sealed to prevent the unwanted growth of bacteria between the walls and studs. Floor drains are well sloped and drains dry after only a few hours. All run off from drains runs via PVC piping to a wooded ditch located at the north side of the building roughly 40 ft from the rear door. Tables, tanks, holding areas are stainless steel and vacuums, hooks, and wall fixtures are galvanized.

1. Utilizing a pressure washer hook-up, pre-rinse the gilling station area with heated water prior to enacting *Gilled, Whole Fish Fish Export Operations SOP*.
    a. If you don't know where the gilling station is normally setup, ask.

   b. Ensure that all surfaces within 10 ft of the gilling station area are pre-rinsed and properly prepared for sterilization (i.e., includes moving equipment out of the area gilling station area which will not be in use, if possible)
   c. Include the *Company Name* Inc *other food products* processing facility loading area in your rinsing regime.
2. Apply Biosentry® 904 disinfectant or Sodium Hypchlorite solution utilizing the pressure washer application injection tube.
   a. Apply the disinfectant and/or Sodium Hypochlorite liberally on all surfaces within the gilling station area.
      - Includes: walls, ceiling, floors, bleed-out tank, stainless steel tables.
   b. Allow some contact time
      - E.g., 15 min is ideal
   c. Include the *Company Name* Inc *other food products* processing facility loading area in your disinfection regime.
3. Rinse the disinfectant or sodium hypochlorite from all surfaces where it was applied.
   a. Run the pressure washer prior to rinsing to remove any disinfecting solution from the line.
   b. Do not rinse the disinfectant from the *Company Name* Inc *other food products* processing facility loading area to allow for continuous contact time at the loading area during fish bleeding operations.
4. If gilling station is to be setup immediately:
   a. Start filling the bleed-out tank (i.e., if it's to be used).
   b. Prepare the bleach bath 375 L bleach bath and put all relevant equipment into the bath including:
      i. Knives
      ii. Brush (for scrubbing of rain gear, tote lids, polyethylene/polypropylene gloves)
      iii. Designated food safe ice chisel
      iv. Designated food safe ice shovel
      v. Fish bonker
      vi. Designated hand dip net (for movement of fish out of the bleed out tank)
      vii. Plastic filleting table (if it's to be used)

M-CMAF Tote Cleaning and Sterilization S.O.P.

** This SOP is to be enacted if totes are new or have been received from a CFIA approved facility and the risk of potential contamination is apparent.*

1. All totes onsite MUST be cleaned and sterilized prior to them being used for fish transport.
2. There is only ONE designated location onsite where totes can be washed:
    - In the *Loading Area* (as defined in *Loading Area Cleaning and Sterilization SOP*)
3. All washing is to be done utilizing the Secondary Well
    - Assumed that Secondary Well has been recently tested for Coliforms including faecal coliforms in accordance with *M-CMAF Water and Ice Quality Assurance SOP*
4. Totes are to be washed in accordance with the following:
    a. Setup washing station for tote near the central drain (drain closest to the sink) utilizing hose connections for the Secondary Well
    b. Ensure that the drains for the tote are open and that water can pass freely through the drain
        - Elevate edges of tote to aid draining as necessary utilizing a cinder block or other plastic materials for example
    c. Apply soap to all surfaces of the tote (i.e., with the exception of the bottom) utilizing a mop or other similar cleaning utensil, including the tote lid
    d. Rinse the outside of the tote and the inside until no soap is present
    e. Apply **Bleach** as a sterilizing agent utilizing the bottle sprayer to all surfaces (i.e., with the exception of the bottom), including the tote lid
        - Refer to MSDS and directions for use before handling Bleach
    f. Rinse the outside of the tote and the inside until no Bleach is present
    g. Once all rinsing is complete and no Bleach is present, place the lid on the tote and move the tote to a designated holding area.
5. Refer *to M-CMAF Loading Area Cleaning and Sterilization SOP* once all totes are ready for use.

M-CMAF Water and Ice Quality Assurance S.O.P.

** This SOP ONLY applies if ice and water for slurry are not obtained from CFIA approved facility and we are required to create the slurry onsite.*

1. Water and Ice samples are to be obtained from each source which will be used to create a slurry for the transport of fish
    a. The Secondary Well is the ONLY designated water source at this facility to be used for fish transport and cleaning of all equipment to be used in fish transport.
    b. Ice samples are to be obtained from ice recently (i.e., within 24 hr) generated by the ice machine.
2. Coliform sampling/testing will be performed semi annually (i.e., twice per year) or earlier as directed by CFIA Inspectors and/or an associated CFIA registered facility.
3. Coliform sampling will be conducted in accordance with M-CMAF monitoring guidelines:
    a. Consult analytical lab contact (currently is *Lab Company Name*, *Lab Contact Name*, XXX.XXX.XXXX) prior to sampling for clarification of sampling protocol if required
    b. Current *Certified Lab Name* Analysis Code for coliform testing = *CODED NAME*
    c. Method Description:

> "The analysis of Total Coliform (TC) & Escherichia coli (EC) is processed by Quanti-tray (QT): Two substrates, ONPG for TC detection and MUG for EC detection are used. The substrates are added to the 100 ml sample dispensed into the 51 well tray. The tray is incubated at 35 Celsius for 24 hours. A colour reaction develops to indicate a positive reaction (presence of TC, EC). The number of positive wells are counted and converted to Most Probable Number Units (MPNU) per 100 ml. This test is also called 'rapid MPN method', therefore, the MPN results are derived from a statistical table with a 95 % confidence and report as MPN units. The QT detection limit for a negative result is reported as zero."
>
> Provided in Certificate of Analysis from ALS Environmental located in Winnipeg MB

4. Certificate of Analysis provided by the accredited lab will be supplied to CFIA inspectors upon request and/or the associated CFIA registered facility.
5. If any samples test positive for coliforms/faecal coliforms all operations related to fish export shall cease until such time that the positive result can be verified in duplicate (i.e., two samples will taken from the same source).
6. CFIA and/or an associated CFIA registered facility will be notified immediately upon suspicion of contamination (i.e., initial results from the accredited lab test positive).

7. Any corrective actions taken to remove the source of contamination will be fully disclosed with CFIA inspectors and/or an associated CFIA registered facility.
8. Fish Export Operations (i.e., including inter provincial and intra provincial movements of fish) will not continue until ice and water coliform testing yields duplicate negative results and approval from CFIA inspectors is granted and/or an associated CFIA registered facility.

M-CMAF Statement of Quality Assurance

In accordance with typical CFIA registered facilities' Quality Management Programs and Hazard Analysis and Critical Control Points procedures this Statement of Quality Assurance is to notify the receiver that the fish product listed below conforms to all Canadian Federal Government Regulations applied by the Canadian Food Inspection Agency for receipt into their registered facility for processing. All fish products listed below are guaranteed non-TDU with respect to all potential physical, chemical, and biological contaminants. All documentation related to this statement is on file at *Company Name.*

A quality assurance statement from *Company Name*'s feed supplier is available upon request. This document is meant to accompany every shipment from *Company Name* to a CFIA registered facility.

Current Date:_____ Last Treatment Date (s):_____
Harvest time start (24 hr):_____ Treatment Name (s):_____
Harvest time end (24 hr):_____ Withdrawal Time (s):_____
Total Number of totes in shipment:_____ Total Biomass of Shipment:_____
Trucking Seal #:_____

Coded Lot #	Tote ID #	Average Weight of Fish (g)	Number of Fish	Biomass (calculated; kg)	T°C during loading	T°C after loading

Notes:

☐ Statement of water and ice quality testing (i.e., *E. coli* and total coliforms):
All ice and water provided by *Company Name* to create the slurry have been recently tested in accordance with the frequency defined within *Company Name*'s *Water and Ice Quality Assurance SOP*.

☐ Statement of truck inspection:
Truck was inspected and appeared to be free of odors and/or anything that might render our whole fish product TDU

*** Indicate compliance with statement by checking or marking with an 'X'***