SECTION 4
BMPS FOR CAAP FACILITIES

4.1 Introduction

The following section describes BMPs for the CAAP industry. Practices for the following CAAP activities are provided:

Each section describes the practice and guidance for its implementation. Each practice also includes a summary of systems for which the practices are applicable.

4.2 Feed Management

Systems: Pond, flow-through, recirculating, net pens, and alligators

Feed is the primary input of pollutants to CAAP systems. Feed management recognizes the importance of effective, environmentally sound use of feed. Facility operators should continually evaluate their feeding practices to ensure that feed placed in the system is consumed at the highest rate possible. For all systems, observing feeding behavior and noting the presence of excess feed can be used to adjust feeding rates to ensure maximum feed consumption and minimal excess.

The primary operational factors associated with proper feed management are development of precise feeding regimes based on the weight of the cultured species and regular observation of feeding activities to ensure that the feed offered is consumed. An advantage of this practice is that proper feed management decreases the costs associated with the use of excess feed that is never consumed by the cultured species. Excess feed distributed to systems breaks down, and some of the resulting products remain dissolved in the system water.

Guidance for Flow-through and Recirculating Systems

1. Avoid overfeeding fish. Regardless of the delivery system, focus on directing feed to the fish.

2. Store feed properly to reserve the nutrient quality. Minimize humidity to prevent growth of molds or bacteria on feed. Follow manufacturers' recommendations for feed shelf life.

3. Handle feed with care to prevent fines. If fines are present, remove and dispose of them properly.

4. Know the feed requirements of the cultured species to determine the percentage of body weight per day. Use size of fish, water temperature, projected growth rates, and biomass in the system to determine appropriate feeding rates (Westers, 1995).

5. Use high-quality feeds to improve feed conversion and efficient use of nutrients.

6. Observe feeding behavior to monitor feed utilization.

Implementation Notes

- Feed only the amount that will be consumed in 20 minutes. (US Trout Farmers Association, 1994).
- Use feed delivery systems that have devices for the removal of fine particles from feed.
- Generally, frequent feedings of smaller amounts are better than giving the day's ration in a few feedings (IDEQ, n.d.)
- Oxygen levels drop dramatically where large amounts of feed are fed at one time.
- Fish should be fed during the coolest parts of the day in hot weather; reduce feeding when water temperatures reach 65–70 °F for trout. Feeding

in low-oxygen environments reduces dietary efficiency and can result in fish health problems.

- Use of demand feeders allows fish to set the frequency and duration of feeding.
- Blowers, as well as automated delivery systems that supply discrete amounts of feed frequently over a long period of time, may also be used to distribute feed in raceways or tanks.
- Regardless of the method of feed distribution, it is important to observe feeding behavior and prevent overfeeding.
- Overfeeding can affect the health of the fish by contributing to liver and kidney problems.
- Excess feed results in economic losses and degrades water quality, which can adversely affect the health of the aquatic animals.

Guidance for Pond Systems

The following is based on guidance from Alabama aquaculture BMP fact sheet BMP No. 7, "Feed Management" (Auburn University and USDA, 2002g).

1. Use high-quality feed that contains adequate, but not excessive, nitrogen and phosphorus.

2. Protect feed quality by storing feed in well-ventilated, dry bins or, if bagged, in a well-ventilated, dry room. Always use fresh feed to maximize the efficiency with which fish can use it.

3. Apply feed uniformly across the surface of the pond using a mechanical feeder.

4. Do not overfeed fish. Avoid overfeeding by observing fish feeding behaviors. Do not apply more feed than the fish will eat.

5. Maintain adequate levels of dissolved oxygen. Fish stressed by poor water quality conditions will be less efficient in their ability to convert feed to flesh.

6. For daily feed applications in catfish ponds, do not exceed 30 lb/ac in unaerated ponds. In ponds with 2 hp of aeration per acre, daily feed applications can be increased to 100 to 120 lb/ac. These feed amounts are maximum amounts to be applied on a given day, not annual averages.

Implementation Notes

- Because feed management is the main source of nutrients in the pond systems, good feed management, reasonable stocking rates, and adequate aeration are effective tools for enhancing effluent quality.
- Percentages of 4.5% to 5.1% (28% to 32% crude protein) for nitrogen and 0.75% to 1.0% phosphorus are acceptable levels of these elements in feeds for growout.
- Mechanical feeders dispense feed evenly around the edges of the pond to ensure that fish have an opportunity to eat an adequate amount of feed.
- One sign of overfeeding is the accumulation of feed in the corners of the pond.
- Overfeeding is costly and results in unnecessary nutrient inputs into the pond.
- Several factors influence feed consumption, including water temperature, poor environmental conditions like low levels of dissolved oxygen or high concentrations of ammonia, and disease or parasite problems.
- Mechanical aeration prevents low dissolved oxygen concentrations, thereby avoiding fish stress and improving the effectiveness of the pond to assimilate wastes from feeding, ensuring the water quality of the pond and the effluent.

Guidance for Net Pen Systems

In addition to the above practices, feed management practices for net pen facilities should a real-time monitoring system to monitor the rate of feed comsumption. Excess feed is the primary source of sediment accumulation beneath net pens, which can have an adverse effect on the benthic community. Refer to section 4.9 for more detail.

4.3 Designing and Maintaining Quiescent Zones

Systems: Flow-through

Quiescent zones are used in raceway flow-through systems (typically concrete raceways) in which the last approximately 10% of the raceway serves as a settling area for solids.

Quiescent zones usually are constructed with a wire mesh screen that extends from the bottom of the raceway to above the maximum water height to prevent the cultured species from entering the quiescent zone. Reducing the turbulence usually caused by the swimming action of the cultured species allows the solids to settle in the quiescent zone. The collected solids are then available to be efficiently removed from the system.

Guidance

The following design guidance is based on the *Idaho Waste Management Guidelines for Aquaculture Facilities* (IDEQ, n.d.).

1. A quiescent zone (QZ) is a settling zone; therefore, the dimensions of the QZ must be adequate to ensure that the overflow rate (V_o) is smaller than the settling velocity (V_s):

   $V_o = ft^3/s/ft^2$ or cubic feet per second of flow per square foot of settling area = ft/s (velocity)

   V_s = settling velocity of biosolids in feet per seconds

2. The accepted range of V_s values for biosolids in raceways is 0.031 ft/s to 0.164 ft/s, so the dimensions for QZs should provide a V_o value smaller than 0.031 ft/s.

3. Widths of troughs or raceways and their QZs are usually proportional to flow rate, which is directly related to the amount of fish that the rearing area will support.

4. Example: A QZ with a width of 18 feet, a length of 20 feet, and a flow of 6cfs has an overflow rate (V_o) of 0.017 ft/s. This value is just over half of the lower range for V_s values of QZs, meeting the criteria for QZ dimensions.

5. Other design options: sloped, recessed floors of QZ. (See *Idaho Wastewater Management Guidelines* for more detail.)

6. The most common method of solids removal from QZs is by suction through a vacuum head. Facilities may use standpipes in each QZ to connect to a common 4-to 8-in. PVC pipe that carries the slurry of water and solids to the off-line settling basin. Suction is provided by head pressure from the raceway water depth and by gravity, or by pumps.

7. Slurry transport pipes and pumps should be properly sized to carry the required flow and provide adequate suction. Without adequate suction, the vacuum head will resuspend the particles before they can be vacuumed. To operate a 12- to 18-in. wide vacuum head, 100 gpm is ideal.

8. Pumps should be designed to handle 12% solids, moss, leaves, and other debris, which might collect in the QZ.

9. Where lift is needed, it is more efficient and cost-effective to connect pipes from several QZs by gravity flow to a sump or lift station with a

stationary pump than it is to move a portable pump from one QZ to another.

10. Design piping systems to minimize settling of solids within the pipes. Consider clean-outs throughout the piping system. Long-radius bends are better than short radius bends. Pipes should be sloped to provide adequate cleaning velocities.

11. Design system hydraulics to prevent system components from freezing.

12. Consider spare parts for key equipment and a contingency plan for maintaining compliance in the event of equipment failures.

13. Consider the use of baffles in the raceway or trough to direct water flow. Water flows underneath the baffles, increasing flow velocity along the bottom of the pond or raceway and moving solids downstream where they can be collected in QZs. Placement of baffles varies with raceway or pond dimensions, flow, and fish size.

Implementation Notes

- The settled solids should be removed regularly so they cannot become entrained in the wastewater flow and contribute to the pollutant loadings of the facility. Two operational factors associated with operating QZs are (1) the necessity to clean the screens, and (2) the regular removal of collected solids from the QZs.
- QZs should be cleaned as frequently as possible, at least once every 2 weeks (IDEQ, n.d.)
- Screens separating the rearing area from the QZ should be cleaned daily to promote laminar flow.
- System designs that provide gentler handling of solids are better preferred because systems where more turbulence occurs need larger settling areas to compensate for the settling requirement of small particles.
- System designs that allow for frequent or continuous harvest of solids are preferable and should require smaller settling zones.
- Rectangular settling zones or quiescent zones promote flow that is evenly distributed over the entire surface area (laminar flow).
- Cleaning of the QZs also creates a highly concentrated waste stream that should be treated before it is discharged into a receiving water body.

4.4 Designing and Maintaining Sedimentation Basins (Primary Settling)

Systems: Ponds, flow-through, and recirculating

Sedimentation basins separate solids from water using gravity settling of the heavier solid particles (Metcalf and Eddy, 1991). In the simplest form of sedimentation, particles that are heavier than water settle to the bottom of a tank or basin. Periodically, the basin is cleaned of the accumulated solids. Sedimentation basins (also called settling basins, settling ponds, sedimentation ponds, or sedimentation lagoons) are used extensively in the wastewater treatment industry and are commonly found in many flow-through AAP facilities. Most sedimentation basins are used to produce a clarified effluent (for solids removal), but some sedimentation basins remove water from solids to produce a more concentrated sludge.

How Sedimentation Basins Work

Settling in sedimentation basins occurs when the horizontal velocity of a particle entering the basin is less than the vertical (settling) velocity in the tank. The settling properties of an effluent, particularly the settling velocities, are determined and sedimentation basins are sized to accommodate the expected flow through the basin. The length of the sedimentation basin and the detention time can be calculated so that particles with a particular settling velocity will settle to the bottom of the basin (Metcalf and Eddy, 1991).

Other design factors include the effects of inlet and outlet turbulence, short-circuiting of flows within the basin, solids accumulation in the basin, and velocity gradients caused by disturbances within the basin (such as those from solids removal equipment).

Guidance for Flow-Through Systems

For flow-through systems, there are two types of settling basins: off-line settling (OLS) basins and full-flow settling (FFS) basins. Off-line settling basins are settling zones that receive water and solids slurry removed from QZs and rearing areas. These basins are the second settling area in the solids collection system after QZs. QZs in combination with OLS basins are the most commonly used solids collection system (IDEQ, n.d). A full-flow settling basin may not include QZs; instead, this system has one or two large settling areas that collect solids from the water flow from the entire facility. Solids might not be removed from individual rearing units.

OLS basins

1. Solid entering OLS basins are usually smaller because of the turbulence associated with the pumps and pipes that carry solids from the QZs. The range of accepted V_s value range for these smaller particles is 0.00151 ft/s

to 0.00302 ft/s. The V_o value for OLS should be less than 0.00151 ft/s (IDEQ, n.d.)

2. OLS basins are usually 3.5 ft deep but may be deeper. Depth is not required for settling efficiency, but it is required for solids storage. (A depth of 3.5 ft provides adequate storage if solids are removed monthly (IDEQ, n.d.).

3. Facilities may also use several OLS basins to improve solids removal efficiency. When one basin is undergoing solids harvesting, flow can be redirected to another basin (IDEQ, n.d.). Multiple OLS basins may be operated in a series or in parallel. Basins linked in a series generally have a V_o value smaller than 0.00151 ft/s. Basins linked in parallel divide the flow and reduce the water velocity, which improves the V_o and weir rate.

FFS basins

1. Solids particles flowing to FFS basin systems are larger than solids in OLS basins because they are exposed to less turbulence, but they are smaller than solids from QZs. The recommended V_o value for FFS basins is 0.013 ft/s or less (IDEQ, n.d.).

2. The design should include a bypass channel for the FFS basin so solids can be removed (IDEQ, n.d.).

3. FFS systems should include two basins operated in parallel so that one basin remains operational when solids are being harvested from the other basin (IDEQ, n.d.).

Implementation Notes

- System operators should attempt to minimize the breakdown of particles (into smaller sizes) to maintain or increase the efficiency of sedimentation basins (IDEQ, n.d.).
- Proper design, construction, and operation of the sedimentation basin are essential for the efficient removal of solids (IDEQ, n.d.).
- Solids must be removed at proper intervals to ensure the designed removal efficiencies of the sedimentation basin. For both OLS and FFS basins, IDEQ recommends a minimum harvest frequency of every 6 months. Infrequent harvests could result in the breakdown of solids and the release of dissolved nutrients into the receiving waters.
- FFS basins are most commonly used at smaller facilities with low flow volumes.

- For FFS basins, some facilities might batch crop their fish so that they can all be harvested at the same time. Then solids can be harvested from the FFS basins when the facility is empty (IDEQ, n.d.).

4.5 Secondary Settling with Microscreen Filters

Systems: Flow-through and recirculating

Solids polishing is the use of a secondary wastewater treatment technology to further reduce solids discharged from flow-through systems. Several technologies are available, including microscreen filters, vegetated ditches, and constructed wetlands. Microscreen filters are fine mesh filters with automatic backwash that collect solids. Polishing ponds are secondary sedimentation basins used to settle solids from the discharge of the primary sedimentation basin.

Microscreen filters are commonly used filtration systems that consist of a synthetic screen of specific pore size that is used to remove solids from the effluent stream. Pore sizes for microscreen filters vary from 15 to 60 micrometers(μm)(Metcalf and Eddy, 1991). Most microscreen filters operate by pumping the wastewater stream into a space inside the filter. The water passes through the screen and solids are trapped inside the screen. The solids can be discharged to further treatment or to a solids holding unit.

Guidance

1. Microscreening involves the use of variable low-speed (up to 4 revolutions/min), continuously backwashed, rotating drum filters operating under gravity conditions. The wastewater enters the open end of the drum and flows outward through the rotating screening cloth. The solids are backwashed by high-pressure jets into a trough located within the drum (Metcalf and Eddy, 1991).

2. Typical values for design parameters:

a. Screen size:	15 to 60 μm Stainless steel or polyester screen cloths are available in sizes ranging from 15 to 60 μm
c. Hydraulic loading:	75 to 150 gal/ft^2/min
d. Drum diameter:	8 to 16 ft
d. Drum submergence:	70% to 75% of height; 60% to 70% of area
e. Drum speed:	15 ft/min at 3-in. headloss; 115 to 150 ft/min at 6-in headloss.

Implementation Notes

- Pilot plant studies are recommended, especially if units are to be used to remove solids from stabilization pond effluents.
- When installing this technology in a facility, consider the characterization of the suspended solids; the selection of unit design parameter values that will provide adequate capacity to meet maximum hydraulic loadings with critical solids characteristics; design parameters that also will provide desired performance over the expected range of hydraulic and solids loadings; and provision of backwash and cleaning facilities to maintain the screen.
- Filters require cleaning to remove trapped particles. Sprayers are used to remove collected particles and to provide additional filter cleaning. Filters may also be cleaned using a periodic rinse cycle with a heated solution.

4.6 Secondary Settling with Vegetated Ditches

Systems: Ponds, flow-through, and recirculating

Vegetated ditches are another effective means of removing solids from effluent. A vegetated ditch is an excavated ditch that serves as a discharge conveyance, treatment, and storage system. The walls of the ditch are excavated at an angle that supports the growth of a dense vegetation layer. The vegetation layer aids in treating the discharge and reduces the susceptibility of the ditch banks and bottom to erosion. The length and width of the ditch are designed to allow for the slowing and temporary storage of the discharge as it flows toward the receiving water body. The vegetation layer increases the ability of the ditch to remove both coarse and fine particulate matter and the associated pollutants, such as BOD, settleable solids, and suspended solids.

Vegetated ditches are channels lined with grass or other plants that can convey or move water, treat discharges by removing sediment and solids, and store water prior to discharge. The walls of a vegetated ditch are excavated at a slope that allows for the growth of a dense vegetation layer, and the length and width of the ditch are designed to slow the flow of the discharge.

Guidance

1. Ditches should be designed to convey the volume of wastewater discharged with appropriate length and slope of ditch as well as suitable vegetation to maximize pollutant removal.

2. Install riprap in bottoms of ditches in places that are susceptible to erosion.

Implementation Notes

Vegetated ditches require regular maintenance. Maintenance practices include the following:

- Repairs to ditch as needed.
- Weed and brush control to prevent competition with desirable species. (mowing and herbicides)
- Irrigation during dry season to maintain vegetation.
- Routine inspection for repairs and after heavy rains.

4.7 Solids Polishing with Constructed Wetlands

Systems: Ponds, flow-through, and recirculating

Constructed wetland treatment systems also promote secondary solids removal from effluent discharges. These systems consist of shallow pools constructed on non-wetland sites. Constructed wetlands provide substrate for specific emergent vegetation types such as cattail, bulrush, and reeds. Constructed wetlands are designed to treat discharges through physical, chemical, and biological processes. The vegetation causes the discharge to slow and flow in a more serpentine manner, increasing the likelihood of solids settling. The vegetation also aids in the adsorption of potential pollutants through plant and bacterial uptake, and it increases the oxygen level in the discharge flowing through it.

Constructed wetland treatment systems consist of shallow pools constructed on non-wetland sites with water at depths of usually less than 2 ft. They have varying success in aquaculture operations. Constructed wetlands can be designed to provide several different benefits, including treatment of the discharge through biological and chemical processes, temporary storage of discharges, recharge of aquifers, and reduction in discharge volume to receiving water bodies.

Guidance

1. Site evaluation and selection. Consider site characteristics such as topography, soil characteristics, existing land use, flood hazard, and climate (Metcalf and Eddy, 1991).

2. Determination of pretreatment level. The minimum pretreatment for a wetland system should be primary treatment or aerated ponds with a short detention time. Use of oxidation ponds that generate high concentrations of algae should be avoided prior to wetland treatment because algae removal through wetlands is inconsistent. Phosphorus

removal prior to application to wetlands is recommended because wetlands remove minimal phosphorus (Metcalf and Eddy, 1991).

3. Vegetation selection and management. Emergent plants, plants rooted in the soil that penetrate the surface of the water, are used in constructed wetlands. Constructed wetlands provide substrate for specific emergent vegetation types such as cattail, bulrush, and sedges (Metcalf and Eddy, 1991).

4. Determination of design parameters. The primary design parameters for constructed wetland systems are hydraulic detention time, basin depth, basin geometry (width and length), 5-day biochemical oxygen demand (BOD_5), loading rate, and hydraulic loading rate (Metcalf and Eddy, 1991).

5. Vector control measures. Wetlands can provide breeding habitat for mosquitoes; design plans might need to include measures for controlling mosquitoes with mosquito fish or chemical control agents (Metcalf and Eddy, 1991).

6. Detailed design of system components (Metcalf and Eddy, 1991).

7. Determination of monitoring requirements (Metcalf and Eddy, 1991).

Implementation Notes

- Once the system is operating properly, it should be inspected regularly to remove dead or fallen vegetation, check for erosion and channelization, and monitor sedimentation levels.
- Periodic harvest and proper disposal of the vegetation can also increase nutrient removal.
- The wetlands require large areas for treatment of relatively small volumes of water; therefore, facilities with limited available land for expansion are not able to use constructed wetlands.
- In many parts of the United States, constructed wetlands have seasonal differences in pollutant removal efficiencies. For example, in colder climates, constructed wetlands might discharge some dissolved nutrients during the colder season and become a sink for these pollutants during warmer months.

4.8 Solids Disposal

Systems: Ponds, flow-through, recirculating, and alligators

4.8.1 Dewatering

Dewatering is the physical process used to reduce the moisture content of sludge to make the sludge easier to handle before it is transported or composted. Several techniques are used to dewater sludge. Some rely on natural evaporation, whereas others use mechanically assisted physical means like filtration, squeezing, capillary action, vacuum withdrawal, and centrifugal separation (Metcalf and Eddy, 1991). Chemicals can be added to assist with the dewatering process.

Guidance

1. The selection of dewatering devices should be determined by the type of sludge to be dewatered and the availability of space. Drying beds or lagoons can be used where land availability is not an issue. Mechanical devices are more likely to be used on sites where space is restricted.

2. Some sludges, such as aerobically digested sludges, do not respond well to mechanical dewatering.

4.8.2 Composting

Composting is a process in which organic material undergoes biological degradation to a stable end product (Metcalf and Eddy, 1991). Approximately 20% to 30% of the volatile solids are converted to carbon dioxide and water. As the organic material in the sludge decomposes, the compost heats to temperatures in the range of 120 to 160 ^{o}F, and pathogenic organisms are destroyed.

Guidance

Composting generally involves the following steps:

1. Mixing dewatered sludge with an amendment or bulking agent. Fish manure is usually dense, wet, and nitrogen-rich; therefore, it is necessary to mix the manure with materials like straw, corn stalks, yard trimmings, or wood chips to add carbon and absorb excess moisture.

2. Aerating the compost pile by adding air or mechanically turning the compost.

3. Recovery of the bulking agent.

4. Further curing and storage.

5. Final disposal.

4.8.3 Land Application

Land application is the most common sludge disposal process in the aquaculture industry (Chen, 2002). Land application of sludge is defined as the spreading of sludge on or just below the soil surface (Metcalf and Eddy, 1991). Application methods include using sprinklers and tank trucks to apply the sludge directly to the land. Sludge may be applied to agricultural land, forest land, disturbed land, and dedicated land disposal sites. In all of these cases, the land application is designed with the objective of further providing sludge treatment (Metcalf and Eddy, 1991). Sunlight, soil microorganisms, and dryness combine to destroy pathogens and other toxic organic substances found in sludge.

Guidance

Sprinkler application

1. When agricultural land is adjacent to an AAP facility, solids can be vacuumed directly from quiescent zones and into a sprinkler system that applies solids and water.

2. Application rates should not cause surface runoff or contaminate groundwater.

3. The sprinkler line should have a small settling pond at the end of the line to allow for emergency cleaning during freezing weather.

Field application

1. For use of slurry on fields, consider site conditions (weather), timing of application, application rates, crop type, crop uptake capacity, and land availability (IDEQ, n.d.)

2. Consider the slope of the field and the location of surface water to prevent slurry from entering surface waters during or after application.

3. Avoid field areas with exposed bedrock or shallow soil because nutrients might leach into the groundwater.

4. Plan ahead and maintain good working relationships with nearby farmers to find fallow fields during the growing season and accessible fields during the winter months.

4.8.4 Publicly Owned Treatment Works

Publicly owned treatment works (POTWs) are wastewater treatment plants that are constructed and owned by a municipal government for the purpose of treating municipal and industrial wastewater from homes and businesses within its borders and/or surrounding areas. Facilities that discharge to POTWs are considered to be indirect dischargers because their wastewater is directed to a POTW for treatment before being discharged to surface water. Some aquaculture facilities are indirect discharges.

4.8.5 Storage Tanks and Lagoons

Manure, or sludge, from aquaculture facilities has to be properly treated and disposed. Storage tanks or storage lagoons are used to store either untreated or treated wastewater until the water can be treated, or until the treated wastewater can be reused by the production system. Holding tanks, storage tanks, and surge tanks are used through the aquaculture industry to hold wastewater and treated wastewater before they are returned to the culture system.

Guidance

1. Storage lagoons are usually shallow, bermed earthen ponds with a high surface area-to-volume ratio to facilitate rapid drying of slurry. For example, a lagoon with dimensions of 300 ft by 50 ft and a depth of 1 ft is needed to store 120,000 gal (IDEQ, n.d.)

2. To avoid nutrient leaching, facilities should avoid building storage lagoons on or near exposed bedrock, on thin or sandy soil, or in locations with high groundwater.

3. Storage lagoons should be sited away from natural drainage areas prone to flooding.

4.9 Active Feed Monitoring

System: Net pens

In addition to general feed management, feed management practices for net pen facilities should include a real-time monitoring system to monitor the rate of feed consumption. Excess feed is the primary source of sediment accumulation beneath net pens, which can have an adverse effect on the benthic community.

Active feed monitoring is considered a management practice for all net pen facilities. This relatively new but proven technology is used by some facility operators in the salmon industry. Some type of remote monitoring equipment, such as an underwater video camera, is lowered from the surface to the bottom of a net pen during feeding to monitor for uneaten feed pellets as they pass by the camera.

The goal of active feed monitoring is to further reduce pollutant loads associated with feeding activities. Various technologies have been reported, including video cameras with human or computer interfaces to detect passing feed pellets. A new

NPDES permit issued in Maine (USEPA, 2002) also suggests that ultrasonic equipment might be available. Most facilities that use this technology use a video monitor at the surface that is connected to the video camera. An employee watches the monitor for feed pellets passing by the video camera and then stops feeding activity when a predetermined number of pellets (typically only two or three) pass the camera.

4.10 Practices to Minimize the Potential Escape of Nonnative Species

Systems: Ponds, flow-through, recirculating, and net pens

Practices to minimize the potential escape of nonnative species are designed to prevent nonnative aquatic organisms from escaping and adversely affecting local wild populations. These practices might include precautions such as double netting for net pen systems or screens over influent and effluent drains for flow-through systems. Practices might also include protocols for escape recovery and steps taken to prevent fish from escaping during stocking and grading activities.

Guidance

1. Describe the precautions the facility will take to prevent nonnative aquatic organisms from escaping and adversely affecting local wild populations.

    a. Describe in detail the precautions the facility will take to minimize the potential escape of nonnative species.

    b. Include a description of a schedule for preventative maintenance and inspection of the containment system, methods of escape recovery protocols, and fish transfer procedures during stocking and grading.

2. For net pen systems, describe secondary containment equipment. Secondary containment involves the use of a second set of containment netting around a net pen system. The secondary containment netting should be positioned to capture any fish that might escape the primary containment netting because of damage to the net pen system that could occur during a storm event or other structural failure.

4.11 Mortality Removal

Systems: Ponds, flow-through, recirculating, and net pens

Mortality of the cultured species in small numbers is a common occurrence in aquaculture systems. The timely removal of mortalities ensures against the spread of disease and the introduction of excess nutrients into the system. There are no known disadvantages to the timely removal of mortalities; however, when ponds have large numbers of mortalities, removal might be costly and require seines and crews similar to those used during harvest.

Guidance

1. Maintain good water quality to prevent disease outbreaks.
2. Avoid overstocking rearing units to reduce stress and promote optimal culture water quality.
3. Inspect culture units daily to check for the presence of mortalities.
4. Many of the mortalities float to the surface of the culture water and can be collected by hand or with nets.

4.12 Net pen siting

System: Net pens

Siting involves the preimplementation planning that should take place to ensure that the net pen system is located in an area of adequate flow. Net pens located in areas without sufficient tidal flow have an increased probability of solids buildup below the pens. The net pens should also be located in areas that are protected from storm events so they do not become a hazard to navigation.

Guidance

1. Evaluate prospective sites to determine flushing rates, as well as the direction in which waste products will be carried as a function of tidal flow and wind generation (Stickney, 2002).
2. Identify any physical conditions, such as water depth, that may affect dispersal of nutrients
3. Consider establishing operations in suitable offshore environments to reduce nearshore environmental impacts.
4. Consider sites that can be used for polyculture as a means of reducing nutrient accumulations beneath the net pens (Stickney, 2002).
5. Consider rotating pen locations, if possible, to minimize impacts on benthic communities.

4.13 Net cleaning

System: Net pens

The regular cleaning of the production nets helps to ensure a constant flow of water through the production area of the net pen. As the net pen sits in the culture area, marine organisms attach and grow on the nets. These organisms reduce the area of the openings. The reduction in area reduces the water flow through the net pen and the amount of dissolved oxygen available, and it increases the buildup of metabolic waste.

Guidance

1. Minimize the concentration of net-fouling organisms that are discharged during events such as changing and cleaning nets.

2. Remove fouled nets, transport ashore, air dry, and clean with pressure washers, if necessary. Avoid discharges of cleaning water or net-fouling organisms to open waters.

3. Avoid discharges of chemicals used to clean nets or other gear in open waters.

4. Do not use materials containing or treated with tributylin.

4.14 Discharge Management

System: Ponds

Ponds can release effluents through overflow from rain events and intentional draining. Effluent volume can be reduced by operating ponds to maximize storage capacity to reduce overflow and by draining ponds only when necessary. Discharge management applies practices to *reduce the volume* of water discharged and to improve the quality of the effluent discharged.

Water might be intentionally discharged from ponds to facilitate harvests or to improve the quality of the water in the pond by flushing or exchanging the water with new water additions. For catfish ponds, draining might occur any time during the year. Scheduling drainings, when possible, to minimize the release of sediment and nutrients can reduce the potential pollutants in pond effluent. The following summary is based on guidance from Alabama Aquaculture BMP Practice No. 10, "Managing Ponds to Improve Quality of Draining Effluent" (Auburn University and USDA, 2002j).

Guidance

1. When possible, construct seine-through ponds that do not have to be drained for harvest.

2. Harvest fish by seining and without partially or completely draining the pond unless it is necessary to harvest in deep ponds, restock, or repair pond earthwork. Where possible, avoid discharge when harvesting fish.

3. Avoid flushing new supplies of water into the pond by discharging a portion of the production water. Research has proven that mechanical

aeration is a more effective mean of preventing low dissolved oxygen levels than the practice of water exchange.

4. Discharge due to rainfall events can be prevented by maintaining the water level below the tops of the overflow pipes. When makeup water is added, it should be kept 3 to 4 in. below the tops of overflow pipes, preventing storm overflow. Pond edges can be deepened if water becomes shallow around the edges.

5. Design new ponds with structures that allow the ponds to be drained near the surface instead of from the bottom. Where practical, alter drain structures for surface discharge when old ponds are drained for harvest or renovation.

6. Typically ponds must be drained completely to repair the pond and the surrounding area. The frequency of draining varies from every few years up to every 20 years. When ponds must be drained completely, it is recommended that the final 20% to 25% of the pond volume be discharged into a settling basin or held for 2 or 3 days to minimize suspended solids and then discharged slowly.

7. When draining ponds, drain from the surface to the bottom. If necessary, swivel-type drains can be installed to take in water from the surface and be lowered to completely drain the pond. Most catfish pond drains usually have the discharge pipe inlet at the pond bottom.

8. Use riprap at discharge points to protect against erosion.

Implementation Notes

- During final draining the valve should be opened to one-fourth its maximum capacity. At the beginning of rainfall the valve should be closed and not reopened until the water has cleared.
- Where ponds are located in close proximity, water from the pond being drained for harvest can be transferred to adjacent ponds for reuse.

4.15 Erosion Control

System: Ponds

Erosion occurs in ponds as a result of wave action, water currents from aerators, inadvertent damage from vehicles and other farm equipment, and rain affecting bottoms, dams and embankments of empty ponds (Auburn University and USDA, 2002d; Auburn University and USDA, 2002e). Soil particles suspended by erosion increase TSS concentrations in pond waters and effluents, and clay particles increase turbidity. Sediment that has been removed from ponds but improperly disposed of can erode and cause contamination of surface water with suspended solids.

Erosion can also occur within the pond watershed, on the sides and tops of pond embankments, in emergency spillways, and from farm roads around the pond, access roads to the farm, and stream crossings. These sources of sediment increase suspended solids concentrations and turbidity in pond waters. Erosion control minimizes the input of solids added to pond waters and also reduces the levels of suspended solids in pond effluents.

In the pond, wave action against embankments causes soil particles to detach. Grass cover above the normal water level on the wet side of embankments provides protection from wave action. Erosion is most severe when water levels are low and bare soil is exposed to waves and rain. Aerators can also increase erosion by generating strong water currents that can suspend soil particles from the pond bottoms and detach soil particles from pond banks. Sediment accumulates in ponds over time and eventually needs to be removed. If sediment is placed in unvegetated piles, rain falling on the piles causes erosion and the runoff has high concentrations of suspended solids.

In the pond watershed, erosion from soil surfaces can result from rain events that loosen soil particles. Runoff flowing downslope can suspend and transport the loose particles. The energy of flowing water can result in gullies. Bare soil exposed on farm roads or the tops of embankments erodes easily; erosion potential also increases with a steeper slope. In addition, livestock traffic can also expose bare soil or create paths that are highly erodible. If cattle wade in ponds, they suspend sediment and increase turbidity.

The following guidance is based on Alabama Aquaculture BMP No. 3, “Erosion Control on Watershed and Pond Embankments;” No. 4, “Pond Management to Minimize Erosion,” and No. 5, “Control of Erosion by Effluents” (Auburn University and USDA, 2002c; Auburn University and USDA, 2002d; Auburn University and USDA, 2002e).

Guidance

1. Close drains as soon as the maintenance or other activities for which the pond was drained are completed.

2. If possible, prevent damage to levees or embankments caused by equipment or vehicles. If damage does occur, make repairs immediately to prevent erosion.

3. Install stationary mechanical aerators such that water currents caused by these devices do not cause erosion of pond banks or bottoms.

4. Position tractor-powered emergency aerators to avoid erosion.
5. Sediment should be used where possible to repair pond earthwork. If sediment is removed from ponds, it should be stabilized to prevent erosion.
6. Use earthen berms, riprap, or vegetation to minimize erosion from wave action in the pond.
7. Control erosion in watersheds by providing vegetative cover, eliminating gully erosion, and using diversions to route water away from areas of high erosion potential.
8. Eliminate steep slopes on farm roads and cover these roads with gravel, especially roads built on soil with high clay content.
9. Use a 3:1 (horizontal:vertical) ratio or flatter side slopes for pond embankments in new construction.
10. Provide grass cover on the sides of pond dams or embankments and grass or gravel on the tops of dams or embankments.
11. NRCS recommends that new ponds or extensions of existing ponds should be constructed to maintain 40% to 50% of the owner's 100-year floodplain area near the channel.

Implementation Notes

- For watershed ponds, enough watershed area to supply water to fill ponds during the winter and spring is desirable; however, excessive overflow from ponds could cause erosion of pond outlet structures and increase TSS in effluents.
- Diversions can be useful for controlling water in the watershed. A diversion is a channel constructed across the slope with a supporting ridge on the lower side.
- Maintain storage between the top of the overflow pipe (approximately 3 to 4 in.) and the surface of the water.
- Water overflowing out of ponds also flushes out products added to ponds to enhance water quality and fish production (e.g., fertilizer, lime, salt); therefore, overflow discharges can waste resources and affect fish production.

4.16 Managing Rainwater and Reducing Overflow

System: Ponds

Rainwater management includes practices that minimize overflows from ponds during rain events. Storm runoff or overland runoff is the water that flows over the land surface following rainfall events. The amount of water entering ponds depends on the size and characteristics of the watershed and the intensity of the storm event. Rainwater management practices are influenced by the pond type, levee or watershed. Moreover, the volume of effluent from ponds in response to heavy rains depends on the watershed area-to-pond surface ratio.

There are two common types of pond discharge: release of effluents following rainfall events and intentional draining for harvest or repair of the ponds. Effluent volume can be reduced by operating ponds to maximize storage capacity and draining them only when necessary.

Discharge from a pond due to overflow after a rain or storm event occurs when the amount of water entering the pond exceeds the capacity of the pond to store water. Discharge due to overflow can be mostly avoided if the pond is not full to the top of the overflow pipes when rain occurs. When overflows do occur, the impact of potential effluents can be minimized by maintaining good water quality in the pond system by using aeration. The following guidance is based on Alabama Aquaculture BMP No. 9, "Managing Ponds to Improve Quality of Overflow Effluent," and BMP No. 2, "Managing Ponds to Reduce Effluent Volume"(Auburn University and USDA, 2002b; Auburn University and USDA, 2002i).

Guidance

1. Maintain adequate storage capacity to capture rain falling or running into ponds during summer and early fall by maintaining the water level below the top of the stand pipe drain.

2. Use diversions or grade stabilization structures to divert excess runoff around ponds, or, if possible, build an additional pond to increase water storage capacity.

3. Maintain good vegetative cover on all parts of the watershed. Where possible, replace short or sparse vegetation with taller, denser vegetation.

4. Improve the quality of the overflow by maintaining adequate dissolved oxygen levels using mechanical aeration.

5. Avoid the practice of rearing livestock on farm watershed and allowing livestock to walk on pond embankments and near ponds. Livestock

produce manure that may wash into the ponds and degrade the quality of the water by adding additional nutrients.

Implementation Notes

- For watershed ponds, enough watershed area to supply water to fill ponds during the winter and spring is desirable; however, excessive overflow from ponds can cause erosion of pond outlet structures and increase total suspended solids in effluents.
- Diversions can be useful for controlling water in the watershed. A diversion is a channel constructed across the sloping landscape with a supporting ridge on the lower side.
- Maintain storage between the top of the overflow pipe (approximately 3 to 4 in) and the surface of the water.
- Water overflowing out of ponds also flushes out products added to ponds to enhance water quality and fish production (e.g., fertilizer, lime, salt); therefore, overflow discharges can waste resources and affect fish production.

4.17 Using Drugs and Chemicals: Fertilizers, Therapeutic Agents, and Water Quality Enhancers for Ponds

System: Ponds

Guidance for pond systems

1. For pond systems, apply fertilizers only when necessary to promote phytoplankton blooms (Auburn University and USDA, 2002h).
2. Use Secchi disk visibility to determine if fertilizer is necessary (Auburn University and USDA, 2002h).
3. Manage pond water levels to prevent or minimize effluent release if possible (Auburn University and USDA, 2002h).
4. Apply agricultural limestone to ponds with a total alkalinity below 20 ppm (Auburn University and USDA, 2002h).
5. Only use water quality enhancers that have been approved by FDA and EPA, and follow the label instructions carefully (Auburn University and USDA, 2002l).

4.18 Oxidation Lagoons

Systems: Flow-through, recirculating, and alligator

Oxidation lagoons, also know as stabilization ponds, are usually earthen, relatively shallow wastewater treatment units used to separate solids and treat soluble organic wastes (Metcalf and Eddy, 1991). The basins are cleaned of solids as needed, which might be as long as once every 20 years. Oxidation ponds are used extensively in the wastewater treatment industry and are commonly used by the alligator industry for the treatment of wastewater generated during alligator pen cleaning.

Oxidation lagoons are usually classified as aerobic, anaerobic, or aerobic-anaerobic (facultative) according to the nature of the biological activity in the pond. Aerobic and facultative lagoons require that oxygen be added to all or parts of the lagoon constantly; therefore, in order to reduce costs, most lagoons in the alligator industry are operated as anaerobic lagoons.

4.19 References

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