APPENDIX A
ADDITIONAL RESOURCES

Pond systems

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Appendix B
Example BMP Plan

Example BMP Plan[1]

FantaSea Fish Farm
Prepared October 6, 2000
for EPA NPDES Workshop
held November 8, 2000

Goal: To describe the standard operating procedures and best management practices used to minimize, collect, and dispose of pollutants generated during facility operations.

Description: FantaSea Fish Farm is a Class 3 aquaculture facility that produces approximately 250,000 lbs of rainbow trout annually. The facility was initially constructed in 1962. The facility expanded to include a third use of raceways and an off-line settling pond system in 1987. The facility presently has 12 100 fit long raceways, a small hatchery building, an office/shop, and an OLS pond for waste treatment (see attached diagram). The fish farm is located near Jerome, Idaho (T_, R_, Sec_). The facility has a non-consumptive water right for 14 cfs of water from Ideal Springs. The facility has two discharge points, both of which go into Ideal Creek. FantaSea Fish Farm's NPDES permit number is IDG130000. The facility was covered under the Idaho General Permit for Aquaculture Facilities March 1, 2000. FantaSea Fish Farm's previous NPDES permit number was ID000000-0.

Source: The FantaSea Farm uses water that comes from Ideal Spring. Ideal Spring is a pure spring source with TSS levels generally measured at less than 2.0 mg/L (see historic DMRs). Aquatic vegetation grows in the spring and the ditch leading to the raceways. An inflow trash rack screen is used to catch vegetation from the springs and ditch prior to entering the facility. The trash rack screen is cleaned at least daily to prevent vegetation from affecting the water flow to the facility. The spring and head ditch is manually cleaned twice a year to prevent build up of aquatic vegetation. The ditch has an adjustable head gate that controls the water flow to the facility from the spring area.

Influent weir: FantaSea Farm uses an influent weir to measure flow for the facility. Their weir is a calibrated suppressed rectangular weir. The weir is located below the trash rack screen to prevent debris from interfering with weir measurements. The weir is checked for level annually. The weir face and box area is swept clean prior to any measurements being taken. The staff gauge is placed along the weir box wall six times the head distance upstream of the weir crest. The weir has a 3/16 in. blade crest that falls off to a 45° angle to allow

[1] Prepared by Rob Sharpnack, DEQ and Carla Fromm, USEPA

water to spring free of the blade. If the blade is nicked, bent, or rounded it is to be replaced. Weir calibration and testing curve validation is conducted annually.

Immediately below the catch pool for the weir is the influent fish screen used to prevent fish from swimming out of the rearing areas and into the springs.

Raceways: At the bottom of each raceway is a 20 ft. long quiescent zone (QZ). The QZ distance meets the minimum desing criteria set forth by the State of Idaho in the *Idaho Waste Management Guidelines for Aquaculture Operations* for QZ length. Each QZ has a wastewater drain line connection that allows each QZ to be vacuumed individually. The vacuum hose is attached to slotted pipe that is 2 ft. long that serves a vacuum head. Floats are attached to the vacuum hose to prevent the hose from stirring up solids during cleaning events. Gravity transports the wastewater from the QZ to the OLS pond for treatment and storage.

The delivery rate of wastewater to the OLS pond for raceway or QZ cleaning is 200 gpm. The delivery rate for the OLS system is the average time it takes to fill a known volume (the empty OLS pond). QZ cleaning is done sporadically throughout the work week.

Quiescent zones are vacuumed every two weeks and prior to fish grading or harvesting events. The screens in front of the QZ are cleaned daily to removr moss and dead fish. Screens are cleaned to facilitate settling of biosolids from the raceway and to prevent blowouts.

The purpose of the QZ area is to settle out biosolids for easy collection and rapid removal from the rearing environment to prevent their discharge from the facility. Fish that get into the QZs are removed promptly when discovered.

The raceways are screened to prevent avian predators from eating the fish. This benefits the waste management on the farm by reducing direct mortality from injured fish. The netting reduces indirect mortality by reducing the incidence of disease on the facility. Healthy fish consume feed better, which prevents uneaten feed from going to waste. Also, healthy fish are more active in the raceway which allows accumulated biosolids to be moved more readily down the raceway to the QZs, facilitating cleaning and faster removal of biosolids.

Raceways above the QZ are vacuumed before any scheduled fish grading or harvesting events to prevent unnecessary disturbance and subsequent discharge of biosolids from the raceways.

The level of the roadways around the raceways has been graded down to be approximately 1 ft below the level of the raceway walls. This prevents stormwater and windblown dirt from entering the raceways and adding to the waste management load for the facility.

There is approximately 2.5 ft of drop between the first and second use of raceways to allow for passive oxygen recharge of the raceway water. There is 3.5 ft of drop between the second and third raceway use. Between raceway sections the waterfalls onto a splashboard before entering the next lower section. The purpose of this splashboard is to break up the water stream leaving the upper raceway and expose as much surface area of the water to open air as possible to maximize the replenishment of dissolved oxygen levels in the raceway waters. After the third and final use, water falls 3.5 ft to a concrete pad before flowing into the tail ditch and off of the facility. We feel that the accomplishes the same goal as the splashboards between raceway sets (i.e. it maximizes DO levels for wastewater entering Ideal Creek).

Influent and effluent settleable solids from the raceways has always been < 0.1 ml/L. Net TSS results have been between 1.0 mg/L and 4.0 mg/L. Facility flow fluctuates through the year and ranges form 12 to 14 cfs. In 1990-91, six phosphorus and nitrogen samples were taken from the raceway influent and effluent. Net phosphorus results for the raceways averaged 0.07 mg/L. Net nitrite + nitrate results were 0.02 mg/L. Net TKN results were 0.3 mg/L. Net ammonia results were 0.2 mg/L.

OLS Pond: The OLS pond is set up to handle a design flow of 300 gpm. The dimensions of the OLS pond are 30 ft by 30 ft (surface area of 900 sq ft). The pond slopes to a maximum depth of 3.5 ft. Wastewater comes into the OLS pond from the gravity flow system pipe that spills onto the access ramp. This helps to distribute the flow across the width of the settling pond. Water leaves the pond through an 8 in. standpipe. The standpipe is attached to a 90° elbow that can swivel inside the pond. There is a collar around the standpipe that causes the water that is discharged to be pulled from 20 in. below the pond surface. The collar prevents floating materials from washing out of the pond. The water leaving the pond goes back to a box with a calibrated v-notched weir. The weir is used to verify flow rates through the OLS pond during cleaning events.

When the OLS pond is harvested, the water in the pond is slowly decanted by removing the collar from around the standpipe and slowing rotating the standpipe on the 90° elbow to gradually lower the water level in the pond. Once the pond is decanted, a tractor is driven into the pond and the slurry is stirred to a uniform consistency to allow for pumping. The sludge is pumped from the OLS pond into a “honey wagon” which takes it a field for land application. Solids content of the slurry varies between 6 % and 12 %.

The OLS pond is harvested twice annually. (Spring and Fall)

Effluent settleable solids results for the OLS pond has always been <1.0 ml/L. Gross TSS results have ranged from 20 mg/L to 87 mg/L. Monthly average flows for the OLS pond have historically ranged from 0.01 mgd to 0.03 mgd. In 1990-1991, six phosphorus and nitrogen samples were taken from the OLS pond influent and effluent. Gross phosphorus results for the OLS pond averaged 3.2 mg/L. Net nitrite + nitrate results were 0.62 mg/L. Net TKN results were 5.3 mg/L. Net ammonia results were 1.8 mg/L.

Feeding: FantaSea Fish Farm recognizes that the fish feed management is critical in operating an environmentally friendly and profitable fish farm. Approximately 250,000 lb of trout are produced per year on about 300,000 lb of feed, at a conversion rate of 1.2. Feed used is produced from Best Feed for Fish and generally is composed of __% ash, ___% phosphorus, and 30% fat. Feed contents do change based on availability of constituents to the feed manufacturer. FantaSea uses commercially available sinking extruded diets to feed our fish. We fee that using extruded diets leads to the best feed conversion ratios and this minimizes the amount of waste generated by the facility. Specific quantities of feed are fed through demand feeders on each outdoor raceway depending on the quantity, size, and condition of the fish in that raceway. There are two demand feeders on each raceway. Demand feeders allow the fish to decide how much food they need and when they want to feed. This maximizes feeding opportunity and lowers feed conversions by providing a steady, stress free, feeding environment with little wastage. Demand feeders are filled daily or as necessary. Fish in the hatchery building are fed by hand several times per day.

Bagged feeds are stored in the shop area and are used on a “first in, first out” basis to prevent lengthy storage of feed. Use of fresh diets improves dietary efficiency. No feed is used if it has exceeded the storage period recommended by the manufacturer. The largest diets are purchased in bulk and stored in feed bins. Feed can be poured from the bins and fines screened off before the feed is put in the demand feeders.

Demand feeders need to be constantly adjusted to the conditions on the facility to maximize feeding efficacy. Any feeder discovered to be out of adjustment (feeding too freely or jammed up) is immediately corrected by an employee.

Employees are to observe the feeding behavior of the fish at all times. Fish that are not feeding well should have their feed restricted until they are again feeding normally to prevent feed from being wasted and discharged.

All the demand feeders are set up with a windshield to prevent the undesired release of feed on windy days.

Fish are taken off feed prior to harvest, movement or grading to minimize mortality that can occur from those activities.

Hatchery Building: The hatchery building is where trout eggs are hatched and the fish raised up to a size where they can be moved outdoors to the production raceways to finish growing to market size. The troughs and small raceways in the hatchery building all have screened QZs at their bottom ends. The troughs, small raceways, and their corresponding QZs all are cleaned daily. The troughs and raceways all have a separate drain line that allows the cleaning wastewater to be diverted to the OLS pond. Water flow has been measured for the trough and small raceway QZ drains and is 30 gpm and 75 gpm, respectively. Quiescent zone cleaning flows are recorded and used in the calculations for the discharge from the OLS pond. Water used in the hatchery building is diverted from the influent ditch below the weir and is discharged to the head ditch above the first raceways near pond #1a. Mortality from the hatch house is disposed of with mortality collected from the raceways.

Mortality: Mortalities generally range from 1% to 7% of fish on hand, now that the raceways are screened, and depending on the disease and timing of the disease outbreak. Normal operational mortality is disposed of in a "mort pit," dug for this purpose. The mort pits are dug at least 100 ft from any surface water. None of the mort pits previously used are closer than ¼ mile from the nearest well. Soil depth in the area is generally 10 ft. Below the soil is fractured basalt. Depth to ground water is about 45 ft. Mort pits are dug not deeper than 6 ft in depth to allow for 4 ft of soil above the basalt. As the mort pit is used, soil and lime are applied in layers to prevent odors and vector attraction, and aid in the decomposition of the material. The mort pit is full when it gets with 2 ft of the surface and then is covered with soil from the initial excavation.

Therapeutants: All drugs, disinfectants, and chemicals used at this facility are used in a manner consistent with label directions. Therapeutants are only used as needed. Therapeutant use at this facility has been infrequent in the past. All drugs, disinfectants, and chemicals are stored in a cabinet in the office building in their original containers. The chemical cabinet is in a dry well-ventilated place, away from water, and with no floor drains. Material Safety data sheets for all chemicals used at the facility are kept within a binder in the chemical cabinet. Treatments are only made up for the amount necessary for immediate use. Water from disinfection treatments is neutralized prior to discharge. Records are kept as required by the NPDES permit for all drug and chemical usage, including the use of medicated diets. Medicated diets are stored away from normal diets and used as recommended.

Disposal of Biosolids: Sludge and slurry that have been collected in the OLS pond are recycled by land application to nearby cropped fields. Farmers that accept the slurry must agree to disc it under within 24 hours of application and prior to any irrigation water being applied to the field. All land application must be done in such a manner as to prevent the materials from entering surface or ground waters. The dates, locations, concentration, and amounts of land application are kept in a record. Fields used for land application are approved by IDEQ prior to application. FantaSea Farm works with local farmers to insure that the land applied biosolids are applied at agronomic rates appropriate for crop and soils conditions.

Endorsement: This BMP plan has been written and endorsed by FantaSea management and staff responsible for the day-to-day operations and maintenance of the facility.

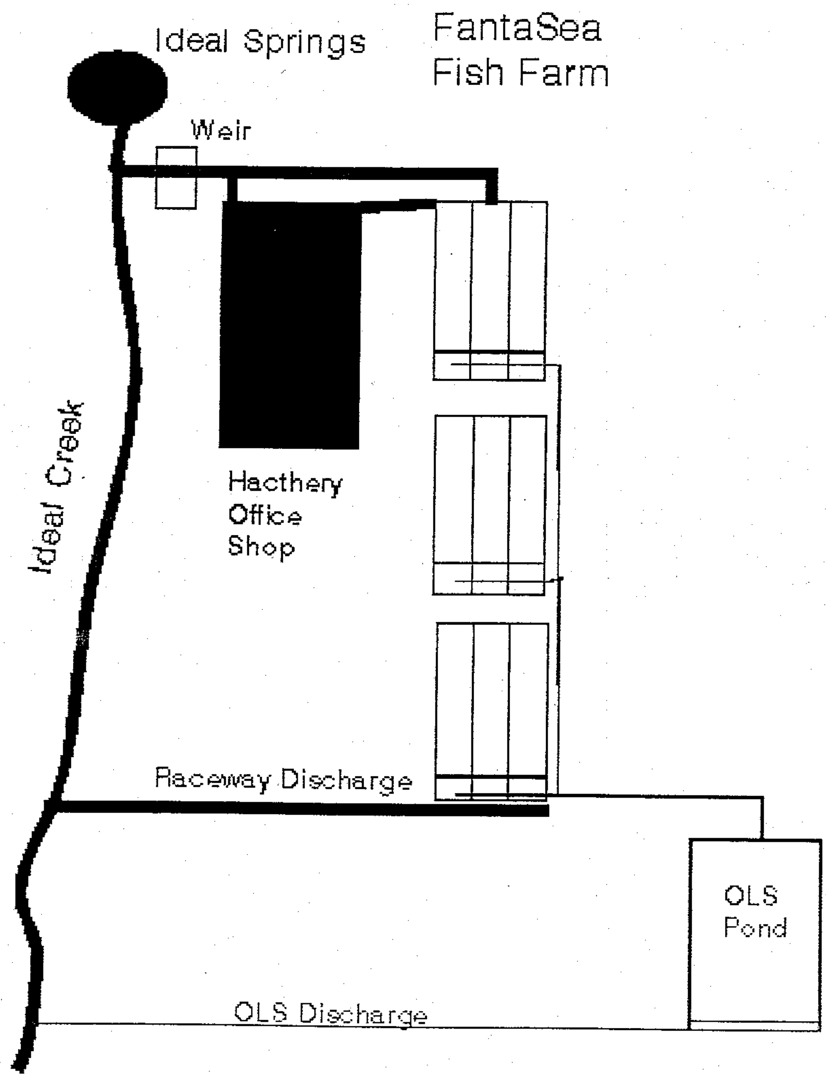

Figure 1: Facility Diagram

CERTIFICATION OF COMPLETION AND IMPLEMENTATION OF THE BEST MANAGEMENT PRACTICES PLAN

FantaSea Fish Farm
ID-G13-0000

This BMP plan has been written, reviewed and is being implemented at FantaSea Fish Farm. The BMP plan is available to employees and IDEQ, EPA, and IDA upon request.

____
Facility Owner/Operator

Submitted ___(date)_________, which is within 9 months of receiving authorization to discharge.

APPENDIX C
BMP FACT SHEETS

Fact Sheet #1: Feed management in flow-through and recirculating systems

What is feed management?

Good feed management minimizes nutrient inputs into pond water. The primary operational factors associated with proper feed management include 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.

How does it work?

Fish do not convert all of the applied feed to flesh. The difference between the input of a substance in feed and the amount of a substance in the harvested fish represents the amount of the substance that enters the pond ecosystem as uneaten feed and in fish feces and metabolites. Uneaten feed and feces are decomposed to metabolites, like carbon dioxide, ammonia, and phosphate, by pond bacteria. These substances are nutrients for the production of phytoplankton, and they also represent potential pollutants in pond effluent. Nutrient inputs and phytoplankton abundance increase as feeding rates increase. Mechanical aeration is used to maintain adequate levels of dissolved oxygen and encourage the oxidation of ammonia to nitrate by nitrifying bacteria. Deterioration of water quality from increased nutrient inputs stresses fish, and causes them to eat less, grow slowly, and be more susceptible to disease. Lowered water quality in ponds also increases the pollution potential of pond effluents.

Practices

1. Uneaten food should be avoided. Feed waste should not exceed 3% to 5%.
2. Do not overfeed fish.
3. 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.
4. Handle feed with care to prevent fines. If fines are present, remove and dispose of them properly.
5. Know the feed requirements of the cultured species to determine percent 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).
6. Use high quality feeds to improve feed conversions and efficient use of nutrients.

Implementation Notes

- Feeding by hand ensures observation of fish feeding behavior.
- Feed only the amount that will be consumed in 20 minutes. (US Trout Farmers Association, 1994)
- 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 allow fish to set the frequency and duration of feeding.
- Blowers may also be used to distribute feed in raceways or tanks, or automated delivery systems that supply discrete amounts of feed frequently over a long period of time.
- Regardless of method of feed distribution, it is important to observe feeding behavior and prevent overfeeding.
- Overfeeding can affect the health of the fish by leading to liver and kidney problems.
- Excess feed results in economic losses and degrades the water quality, which can impact the health of the fish.

Additional Resources

Westers, H. 1991. Operational waste management in aquaculture effluents. In *Nutritional Strategies and Aquaculture Waste*. C.B. Cowey and C.Y. Cho, eds. University of Guelph, Ontario, Canada. Pp. 231-238.

Cho, C.Y., J.D. Hynes, K.R. Wood, and H.K. Yoshida, 1991. Quantitation of fish culture wastes by biological (nutritional) nutrient dense (HND) diets. In Nutritional Strategies and Aquaculture Waste. C.B. Cowey and C.Y. Cho (Eds)., University of Guelph, Ontario, Canada. Pp. 37-50.

Fact Sheet #2: Feed management in pond systems

Channel Catfish feeding at the surface of the water. Source: www.aquanic.org, 2002.

The following is based on Alabama Aquaculture BMP no. 7, "Feed Management," by Auburn University and U.S Department of Agriculture.

What is feed management?

Good feed management minimizes nutrient inputs into pond water.

How does it work?

Fish do not convert all of the applied feed to flesh. The difference between the input of a substance in feed and the amount of a substance in the harvested fish represents the amount of the substance that enters the pond ecosystem as uneaten feed and in fish feces and metabolites. Uneaten feed and feces are decomposed to metabolites, like carbon dioxide, ammonia, and phosphate, by pond bacteria. These substances are nutrients for the production of phytoplankton, and they also represent potential pollutants in pond effluent. Nutrient inputs and phytoplankton abundance increase as feeding rates increase. Mechanical aeration is used to maintain adequate levels of dissolved oxygen and encourage the oxidation of ammonia to nitrate by nitrifying bacteria. Deterioration of water quality from increased nutrient inputs stresses fish, and causes them to eat less, grow slowly, and be more susceptible to disease. Lowered water quality in ponds also increases the pollution potential of pond effluents.

Practices

1. Select high quality feed that contains adequate, but not excessive, nitrogen and phosphorus.
2. Apply feed uniformly across the surface of the pond using a mechanical feeder.
3. Avoid over feeding by observing fish feeding behaviors. Do not apply more feed than the fish will eat.
4. 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.
5. For catfish ponds, daily feed application should not exceed 30 lb/ac in unaerated ponds. In ponds with 2 hp of aeration per acre, daily feed application usually 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 pond systems, good feed management, reasonable stocking rates, and adequate aeration are effective tools for enhancing effluent quality
- Mechanical feeders spread 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 corner 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.
- Managers need to observe the feeing behavior of fish to avoid overfeeding.

Additional Resources

Auburn University and U.S. Department of Agriculture (USDA). 2002. Alabama Aquaculture BMP fact sheets, No. 7: Feed Management. <www.al.nrcs.usda.gov/ Sosections/Engineering/BMP index.html>. Accessed May 23, 2002.

Boyd, C.E. and C.S. Tucker. 1998. *Pond Aquaculture Water Quality Management*. Kluwer Academic Publishers, Boston, MA.

Gross, A., C.E. Boyd, and R.T. Lovell. 1998. Phosphorus budgets for channel catfish ponds receiving diets with different phosphorus concentrations. *Journal of the World Aquaculture Society*, 29:31-39.

Lovell, R.T. 1998. *Nutrition and feeding of fish*. Van Nostrand Reinhold, New York, New York.

Fact Sheet #3: Erosion Control for Pond systems

The following is based on Alabama Aquaculture BMP No. 4, "Pond Management to Minimize Erosion."

What is erosion control?

Erosion occurs in ponds as a result of wave action, water currents from aerators, inadvertent damage from vehicles and other farm equipment, and rain impacting bottoms, dams and embankments of empty ponds. Soil particles suspended by erosion increase total suspended solids (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.

How does it work?

Within the pond, wave action causes water to impact on embankments and detach soil particles. Grass cover above the normal water level on the wet side of embankments provides protection from wave action. Erosion will be 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 the sediment will need to be removed. If sediment is placed in unvegetated piles, rain falling on the piles will cause erosion and the runoff will have high concentrations of suspended solids.

Within the pond watershed, erosion form 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. Livestock traffic can also expose bare soil or create paths that erode. If cattle wade in ponds, they will suspend sediment and increase turbidity.

Erosion control within watershed for roads, dams, and embankments involves protecting the land surface from the impacts of rain events.

Protecting all soil surfaces with vegetation or gravel

Practices

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. Stationary mechanical aerators should be installed so that water currents caused by these devices do not cause erosion of pond banks or bottoms.

4. Tractor-powered emergency aerators should be positioned 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. Earthen berms, rip rap, or vegetation can be used 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 build of soil with a 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 sides of pond dams or embankments and grass or gravel on 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 flood plan 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 total suspended solids in effluents.
- Diversions can be useful for controlling water within 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. (See diagram)

Fact Sheet # 4: Discharge management for ponds

The following is based on Alabama Aquaculture BMP No. 2, "Managing Ponds to Reduce Effluent," and Alabama Aquaculture BMP No. 10, "Managing Ponds to Improve Quality of Draining Effluent."

What is discharge management?

Ponds can release effluents due to overflow from rain events and when they are intentionally drained. 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.

How does it work?

Water may 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 may 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.

Practices

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, to restock, or to repair pond earthwork.

3. Avoid flushing new supplies of water into the pond by discharging a portion of the production water. Research has proven mechanical aeration to be a more effective method of preventing low dissolved oxygen levels than the practice of water exchange.

4. Maintain the water level below the tops of the overflow pipes. When make-up water is added it should be kept 3 to 4 in below the tops of overflow pipes, preventing storm overflow.

5. Design new ponds with structures that allow 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 after about 15 to 20 years to repair earthwork. When ponds must be drained completely, it is recommended that the final 20% to 25% of the pond volume be discharged into a settling or held for 2 to 3 days to minimize suspended solids and then discharged slowly.

7. If possible, install a swivel-type drain that can take in water from the surface and 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.

Implementation Notes

- During final draining the valve should be opened to one-quarter 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 of one another water from the pond being drained for harvest can be transferred to adjacent ponds for reuse.

Additional Resources

Auburn University and U.S. Department of Agriculture (USDA). 2002. Alabama Aquaculture BMP fact sheets, No. 2: Managing Ponds to Reduce Effluent Volume. <www.al.nrcs.usda.gov/ Sosections/Engineering/BMP index.html>. Accessed May 23, 2002.

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McGee, M.V. and C.E. Boyd. 1983. Evaluation of the influences of water exchange in channel catfish ponds. *Transactions of the American Fisheries Society* 112:557-560

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