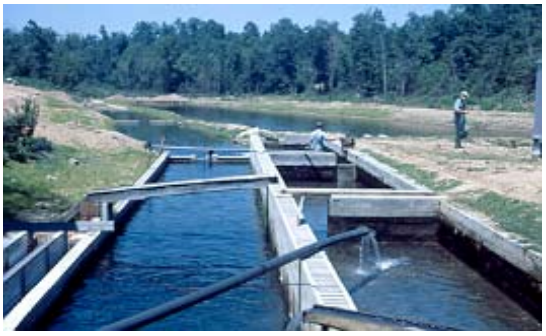
NATURAL RESOURCES CONSERVATION SERVICE
CONSERVATION PRACTICE STANDARD

FISH RACEWAY OR TANK
(Ft. and Ft.^{3})

CODE 398



(Photo courtesy of the Natural Resources Conservation Service)

DEFINITION

A channel or tank with a continuous flow of water constructed or used for high-density fish production.

PURPOSE

- To provide a facility containing flowing water of a suitable temperature and quality for dependable production of fish.
- To manipulate the chemical, physical, and biological factors to enhance fish production.
- To maintain water quality.

CONDITIONS WHERE PRACTICE APPLIES

Where water and land resources are suitable for constructing a raceway or tank that can be used to produce a commercial fish crop.

This standard applies to raceways or tanks that conduct flowing water to produce fish. It applies to earthen channels as well as those channels and tanks constructed of concrete, concrete block, timber, rock, fiberglass, or other materials. It does not apply to hatchery operations that utilize troughs or barrels and are primarily indoors.

CRITERIA

Criteria Applicable to All Purposes

The facility must be designed to provide protection from flooding, sedimentation, and contamination by pollutants from outside sources.

Fish raceways are generally constructed as:

a. Linear channels where water flows in at one end and exits at the other end.

b. Circular, rectangular, or oval tanks where water enters through nozzles or jets in a manner that creates a rotary circulation within the tank and discharge typically is through the tank center by means of a standpipe or bottom drain.

The raceway dimensions shall be designed based on the available water and planned production level.

Water Requirements

Quantity – A water supply of sufficient volume must be available for the species being produced either by gravity or pumping. For linear raceways of 80-100 feet, there shall be a quantity of water sufficient to allow two complete water exchanges per hour.

Quality – Water must be free of harmful gases, minerals, silt, pesticides, and other pollutants. A water analysis shall be made before design and construction, unless previous use or experience indicates the quality is satisfactory. Water quality requirements for trout and catfish are in **Table 1**. Uniquely different water quality parameters may be applicable to other species.

Permits – An Aquatic Resources Alteration Permit (ARAP) for water withdrawal is required from the Tennessee Department of Environment and Conservation for facilities designed to withdraw water from any "water of the state." Water withdrawal from streams within the Tennessee River Watershed will also require a Section 26A permit from the Tennessee Valley Authority.

TABLE 1
WATER QUALITY REQUIREMENTS FOR CHANNEL CATFISH AND RAINBOW TROUT

Quality Parameter		Species	
		Trout	Catfish
Dissolved Oxygen	Desirable	8 ppm or more	6 ppm or more
	Minimum	5 ppm	5 ppm
Temperature	Desirable	(12.8-17.8°C.) 55-64 °F.	(23.9-28.9°C.) 75-84°F.
	Minimum/ Maximum	(7.2/21.1°C.) 45/70°F.	(15.5/32.2°C.) 60/90°F.
pH	Desirable	6.5-9.0	6.5-9.0
	Optimum	6.5-7.5	6.5-7.5
	Minimum/ Maximum	6.0-9.5	6.0-9.5
Carbon Dioxide	Desirable	2 ppm or less	5 ppm or less
	Minimum*/ Maximum	0/3 ppm	0/10 ppm

***Toxicity varies with dissolved oxygen concentration, pH, and temperature.**

Predators

Fences, screens, nets, wires, or other materials shall be provided, as needed, to prevent the loss of fish to predators. Traps or other devices that are potentially harmful for humans, livestock, or pets shall only be placed in secure locations not normally accessible except through special effort. Devices designed to harm predators protected by law (e.g., wading birds) shall not be used without the appropriate authorizing permits (e.g., United States Department of Interior (USDI), Fish and Wildlife Service, Migratory Bird Depredation Permit).

Waste Treatment

Plans for treatment or use of waste generated or caused by the operation of fish raceways or tanks shall be developed and made a part of the design and installation of the practice. The treatments shall include the construction of waste storage ponds, storage structures, treatment lagoons, settling basins, or other facilities.

Waste utilization by the spreading of waste on land through irrigation or hauling is permissible, if soils and land resources are available.

Discharges into streams must meet State standards for the stream based on size of operation and comply with National Pollutant Discharge Elimination Systems (NPDES) regulations.

Levee Protection

A protective cover of vegetation shall be established on all exposed surfaces that have been disturbed. If soil or climatic conditions preclude the use of vegetation, other methods may be used for protection. When re-vegetating the earthen components of this practice, use the same or similar species to those in the surrounding area to help minimize any aesthetic disruption.

Adequate provisions must be made to protect earth surfaces from wave erosion.

Fences shall be installed as necessary to protect levees from being grazed.

Road surfaces along raceways and the outer perimeter of tanks shall be treated, as needed, to provide access and reduce erosion. Dikes and levees shall be crowned to provide drainage.

Cultural Resources

Cultural resources shall be considered when planning this practice. This practice has the potential for adversely affecting cultural resources and compliance with NRCS General Manual 420, Part 401, during the planning process.

Where appropriate, local cultural values shall be incorporated into practice design in a technically sound manner.

Compliance with all applicable Federal, State, and local laws and regulations, including permits, permissions, or notifications, is required.

Criteria Applicable to Linear Channel Raceways

Channel raceways are generally concrete or concrete block construction or earthen channels constructed with a trapezoidal or parabolic cross-section.

a. Concrete or concrete block raceways shall be designed and constructed according to established principles and techniques outlined in the National Engineering Handbook (NEH), American Concrete Institute (ACI) Code, Masonry Handbook, or other approved guides, as appropriate. Where concrete or concrete block raceways are installed, the bulkheads or check-dams must be of the same construction.

b. Earthen channel raceways shall be constructed with a trapezoidal or parabolic cross-section. Bottom widths depend on the volume of water available, but shall be no less than 4 ft. (1.2 meters). Side slopes shall be 1:1 or flatter depending on a saturated soil slope stability analysis. Side slopes and bottoms of raceways must be smooth and uniform to minimize dead water areas and facilitate fish harvest.

Grade

Wherever possible, raceways shall be constructed with a minimum bottom grade

of 0.5 ft. per 100 ft. (0.15 meter per 30 meters). The raceway outlet shall control the water surface grade.

Length

The maximum length of each raceway section is determined by site topography and need for re-aeration of the water, but shall not exceed 100 ft. (30 meters). Depending on water volume and quality, raceway sections may be constructed in series by installing a bulkhead or check-dam at the lower end of each section.

Width

The width of individual raceways shall be selected considering the available water supply, harvesting equipment, and operating and maintenance needs of the system.

Freeboard

The minimum difference in elevation between the water surface in the raceway and the top of the bulkhead, dike, or levee alongside the raceway is 0.5 ft. (0.15 meter).

Dikes and Levees

The minimum top width of an earthen dike or levee shall be 6 ft. (1.8 meters). Side slopes of earthen dikes and levees above the designed water surface shall be 2:1 or flatter. Where the top of the dike or levee is to be used for a road, the minimum top width shall be 14 ft. (4.3 meters).

Bulkheads

Structural or earthen barriers called bulkheads are to be placed across raceway channels to create shorter sections, to establish and maintain the desired water levels, and to provide aeration of the water. In addition to serving as a barrier, they shall have an opening or throat section that allows complete drainage to the bottom of the raceway channel unless other drainage facilities are provided. Bulkheads may be constructed of earth, concrete, concrete block, rock masonry, steel, or other durable metal, treated timber (avoid creosote and pressure-treated lumber containing toxic chemicals), or combinations of these.

Earthen bulkheads are to have a minimum top width of 4 ft. (1.2 meters) and side slopes of 2:1 or flatter. Structural bulkheads used in earthen raceways must extend at least 24 inches (61.0 cm) into the sides and bottom of the channel. Concrete bulkheads shall have a minimum top width of 6 inches (15 cm) and a minimum bottom width of 8 inches (20 cm). Openings and cores in concrete blocks shall be filled with either concrete or mortar mix. The opening or throat section of bulkheads may be constructed of concrete, concrete block, wood, or metal. It shall have slots or grooves along the vertical face that allow flashboards and screens to be installed.

Drains

A pipe drain with a minimum diameter of 6 inches (15-cm) shall be provided at the bottom of the bulkhead unless flashboards used to establish the desired water level can be removed to provide complete drainage. Where possible, each unit in a series should be constructed so that it can be drained independently of the other units.

Screens

Screens shall be provided at the inlet of the system, if necessary, to exclude wild fish. Screens shall also be placed at each bulkhead between sections and at the exit end to prevent loss of fish. They shall be placed at least 6 to 8 inches (15 to 20 cm) upstream from the flash-boards and shall extend at least 6 to 8 inches (15 to 20 cm) above the expected water level to prevent fish from escaping by jumping. Openings for screens shall be designed considering the size range of fish to be separated. The water velocity through screens shall be slow enough to prevent impinging of fish against the screen.

Aeration

Each bulkhead shall be fitted with a weir over-fall. Flashboards in the opening or throat section of the bulkhead may be used for this purpose. The width of the weir or weirs should be equal to the bottom width of the raceway, but shall not be less than 4 ft. (1.2 meters) where flashboards are used to establish the desired water level. Two or more weirs separated by rigid center sections shall be installed where the width of the raceway exceeds 8 ft. (2.4 meters). To increase aeration, a splashboard or series of boards arranged to create successive splashes shall be considered in design. The minimum distance from the weir crest to the water level below should be no less than 1 ft. (0.31 meter).

Maximum Allowable Velocities

Allowable mean velocities to protect against erosion or scour within raceways are outlined in **Table 2**.

TABLE 2.
ALLOWABLE MEAN VELOCITIES IN RACEWAYS OF VARIOUS MATERIALS

Material	V-ft./sec.	V-ft./min.
Very Fine Clay	**0.67**	**40**
Avg. Loam/Alluvium	**3.00**	**180**
Clay Loam	**3.33**	**200**
Heavy Clay	**4.67**	**280**
Coarse Gravel/Cobble	**6.00**	**360**
Cemented Gravel	**6.67**	**400**
Tough Hardpan	**8.33**	**500**
Concrete	**25.33**	**1,520**

Criteria Applicable to Tank Raceways

Tank raceways are circular, rectangular, or oval, and are constructed of concrete, metal, fiberglass, or other suitable material. Fiberglass and a variety of similar materials commonly referred to as “plastic” tanks are generally suitable if construction and support are sufficient to provide strength and durability. Non-circular tanks must have an interior dividing wall to obtain proper circulation. Tank raceways shall be constructed at locations accessible to water supplies, management personnel, and feed and harvest equipment.

Water Supply

Water inlets to the tank may be through jets, nozzles, or similar devices that provide a tangential force to the water in the tank. These nozzles should be located above the water surface to provide aeration. They may be submerged, but should not be near the bottom because of the problem of uplift of waste particles.

The nozzles shall be positioned so that flow in the tank is counterclockwise to take advantage of the natural tendency for water in North America to rotate in this direction.

Waste Removal

Provisions for waste removal shall be incorporated in the design. Bottom troughs, screens, or center-positioned drainpipe shall be provided as part of the tank construction.

CONSIDERATIONS

The cooperator's objective as well as the limitations and potentials of available aquaculture resources (including projected markets) will dictate the level of development and management to be planned. An aquaculture resource assessment must be made to determine the feasibility of the raceway or tank culture system. This should include the estimation of planned carrying capacity, which will dictate the design of the facility.

Carrying capacity will be dependent on oxygen, temperature, water exchange rates and the metabolic requirements of the fish and the effect of fish wastes on the water. As a guide, the carrying capacity for trout may be considered using one of two common methods:

(1) Density Index of 0.5 to 1 times the fish's length in inches at harvest, in pounds per cubic foot. For example, 12-inch fish at harvest would generally mean a carrying capacity of 6-12 pounds per cubic foot of water. NOTE: Exceeding a density index of 1 is possible with increased management and water flow.

(2) Flow Index of 0.5 to 1 times the fish's length in inches at harvest, in pounds per gallon per minute (gpm) of water flow. For example, 12-inch fish at harvest would generally mean a carrying capacity of 6-12 pounds per gpm of flow with an assumed 100 percent oxygen saturation. A 100 gpm flow rate would have a maximum carrying capacity of 1,200 pounds under optimum temperature and 100 percent oxygen saturation. Carrying capacity would be reduced on an equivalent basis to reduced oxygen saturation.

Planning is complete when all practice components essential to reaching the cooperator's management objectives and maintaining the water resource has been identified.

Water Quantity

For trout production, surface water sources should be able to provide a minimum 350-500 gallons per minute for supplemental income production and 1,000 gallons per minute for primary income.

The determination of adequate quantities from surface water sources such as streams and springs can be based on the "ten-year, seven-day average low flow (7Q10)," when available.

Consider the effect on:

- The water budget, especially on volumes and rates of runoff, infiltration, evaporation, transpiration, deep percolation, and ground water recharge.

- Downstream flows and aquifers that would affect other water uses.

- The volume of downstream flow that might cause undesirable environmental, social, or economic effects.

Water Quality

Consider the effect on:

- The visual quality of downstream water resource.
- Short-term and construction-related effects on the quality of the on-site and downstream water.
- The movement of dissolved substances below the root zone and toward the ground water.
- Wetlands and water-related wildlife habitats.

PLANS AND SPECIFICATIONS

Plans and specifications for constructing raceways and tanks and their appurtenances shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose. Plans and specifications are to be prepared for specific field sites and include construction plans, drawings, job sheets, construction specifications, narrative statements in conservation plans, or other similar documents. These documents are to specify the requirements for installing the practice, such as kind, amount, or quality of materials to be used, or the timing or sequence of installation activities.

OPERATION AND MAINTENANCE

An Operation and Maintenance Plan shall be prepared that provides for inspection, operation, and maintenance of vegetation, pipes, valves, raceways, tanks, dikes, levees, bulkheads, and other parts of the system.

REFERENCES

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