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Soil and Water

Operation of a bottom-withdrawal (lake-cleaning) spillway

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This guide describes the operation and maintenance of a unique new principal (pipe) spillway for a pond or lake supplying clean water for municipalities, recreation, domestic use, or trickle irrigation. Operating on the siphon principle, the bottom-withdrawal spillway features an adjustable air-vent tube which allows varying the reservoir water level for weed or wildlife management. This bottom-withdrawal spillway will normally lose fewer fish from the reservoir (compared to a conventional surface-withdrawal spillway). This spillway can also serve extra duty as the withdrawal pipe during the irrigation season (when not required to function as a spillway) by plumbing the discharge end to the intake of a large irrigation system.

An existing hooded or canopy type surface-withdrawal spillway can be converted to a bottom-withdrawal spillway. For design details see, UMC Guide 1531.

When it is desirable to pass more sediment than normal through the reservoir or to improve water quality, the bottom-withdrawal spillway is recommended if: (1) a pond has large inflows or a watershed-to-pond surface area ratio greater than 20 to 1; (2) the inflowing water is usually muddy; (3) the inflow has a high nutrient load (that is, the watershed is well fertilized or contains livestock); or (4) the pond owner does not control the watershed and situations 2 or 3 could occur at any time.

The bottom-withdrawal spillway is not needed when 100 percent of the watershed is in grass, forest, or pavement. This spillway is not to be used for sediment basins or grade-stabilization structures intended to trap sediment.

The quality of water stored in a reservoir improves with time (between runoff events) as algae and aquatic plants use nutrients, and as algae and suspended sediment are deposited. Conventional surface-discharge spillways permit this cleaner water to be discharged during the next runoff event (Figure 1-A) and to be replaced by surface runoff, which is usually lower in quality (Figure 1-C). The water purification process then begins all over again with the additional new sediment and nutrients trapped in the reservoir. This process improves the quality of water discharged from the reservoir at the expense of storing the poorest quality water and shortening the useful life of the reservoir (from sediment buildup).

The bottom-withdrawal spillway is designed for reservoirs that need to store the best possible water from a given watershed. This spillway allows the lower quality storm water to be discharged from the reservoir as soon as it reaches the intake, if the reservoir is full (Figure 2-A). This inflow will go to the bottom of the reservoir with minimum mixing because it has a higher density caused by suspended sediment, dissolved solids or lower temperature. The water quality of the discharge will be more nearly that of the original stream (prior to construction of the dam) except for sand-size or larger particles that are deposited as the runoff water enters the reservoir. The cleanest water remains in the reservoir because it is less dense than the inflow and will float up into the "flood storage area" of the reservoir (Figure 2-B).

After discharge is completed, the clean water will still be in the reservoir (Figure 2-C). Thus, the quality of the stored water is superior when compared to the muddy water stored in a reservoir with a surface-discharge spillway (Figure 2-C versus 1-C). Other benefits include lengthened reservoir life and better conditions for recreational activities such as fishing and swimming.

The normal water level of the reservoir is controlled by the high point in the pipe. However, if the pipe (siphon) primes, the water level can be drawn down to the desired level, controlled by an adjustable

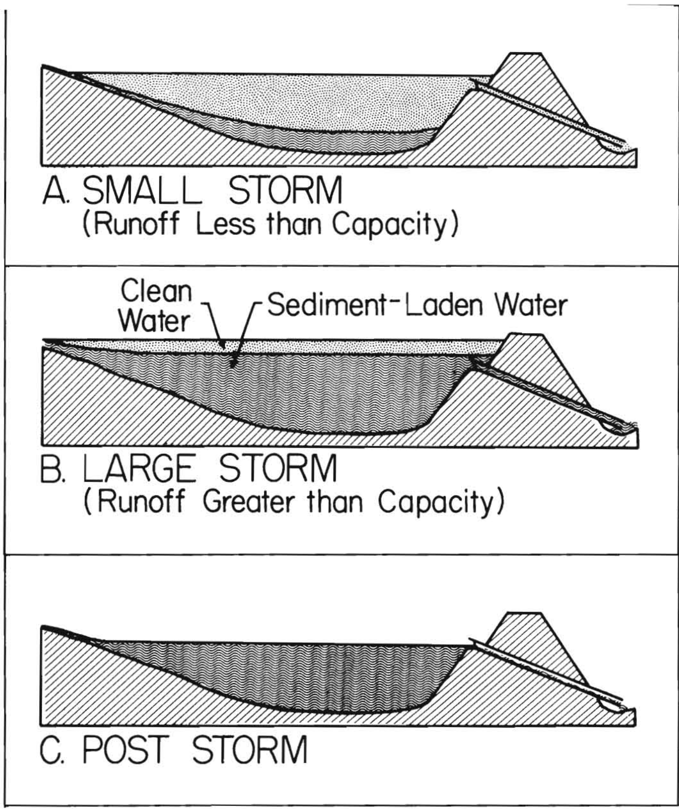

Figure 1. Cross-sectional view of a pond with a surface-withdrawal spillway.

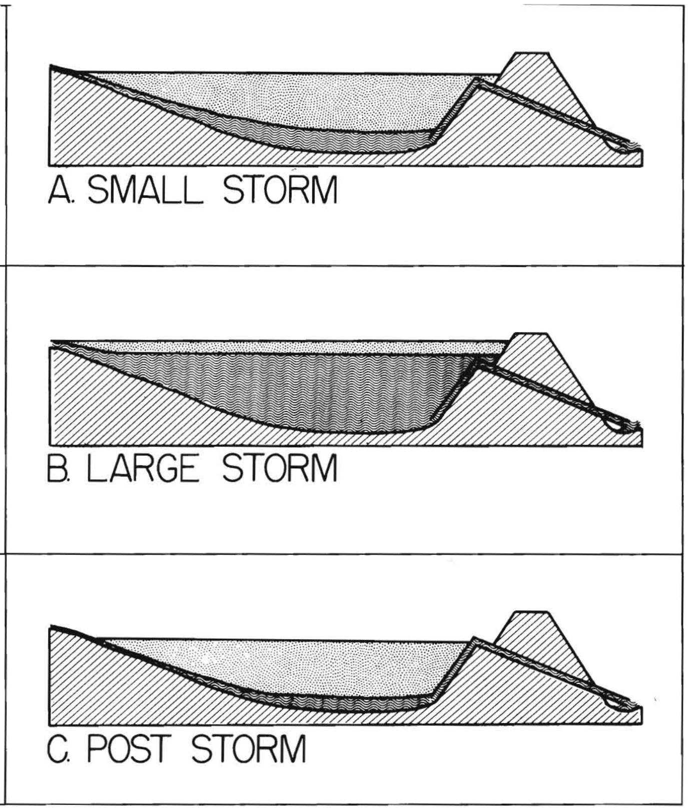

Figure 2. Cross-sectional view of a pond with a bottom-withdrawal spillway.

air vent. The air vent simply allows air to enter the pipe and the siphon is broken. With the ease of controlling the water level, this spillway can be used to lower the water level to control aquatic weeds and improve wildlife habitat. Likewise, stagnant water that accumulates in the bottom of the pond during the summer may be discharged before it mixes with the clean surface water during the "fall overturn" (usually in September).

Sediment control

Most farm ponds trap 85 to 99 percent of entering sediment. If the pond is intended for clean water storage and recreation, sediment deposition defeats its intended purpose. If sediment is not 100 percent controlled in the watershed, a sediment basin or trap immediately upstream of the pond may be necessary.

Ideally, a sediment basin should be a large, shallow pond with a surface-discharge spillway that skims the cleanest water from the surface. Sand, silt, and sand-size aggregates are easily trapped in sediment basins. The remaining suspended clay will flow through the pond downstream and be discharged by the bottom-withdrawal system. Even a deep, narrow sediment basin is better than none at all. The sediment basin can be either an excavation in the stream channel or a small, above-grade structure. The advantage of the excavated type is that it will return to its natural condition when full. The above-grade type will remain a liability and have to be maintained to prevent failure and mass movement downstream. UMC Guide 1528 describes sediment basins.

Bottom-withdrawal spillway features

Depth of intake—A deep intake not only removes more sediment and nutrients, but also prevents loss of fish. Ponds greater than 8 feet deep usually develop an anoxic zone near the bottom during warm weather. Because fish don't inhabit the zone, an intake greater than 8 feet deep will lose very few fish from the pond.

Location of the apex—The elevation of the apex determines the normal pool level. However, the apex may be buried in the fill or left exposed on the upstream side of the dam. Burying the apex may be desirable in northern states, or when using plastic pipes, to prevent ice damage.

Air vent—The air vent is normally set at the elevation of the apex. However, if it is desirable to lower the water level after a storm, or after manual priming, the air vent should be set at the desired elevation. Also, if the spillway is manually primed

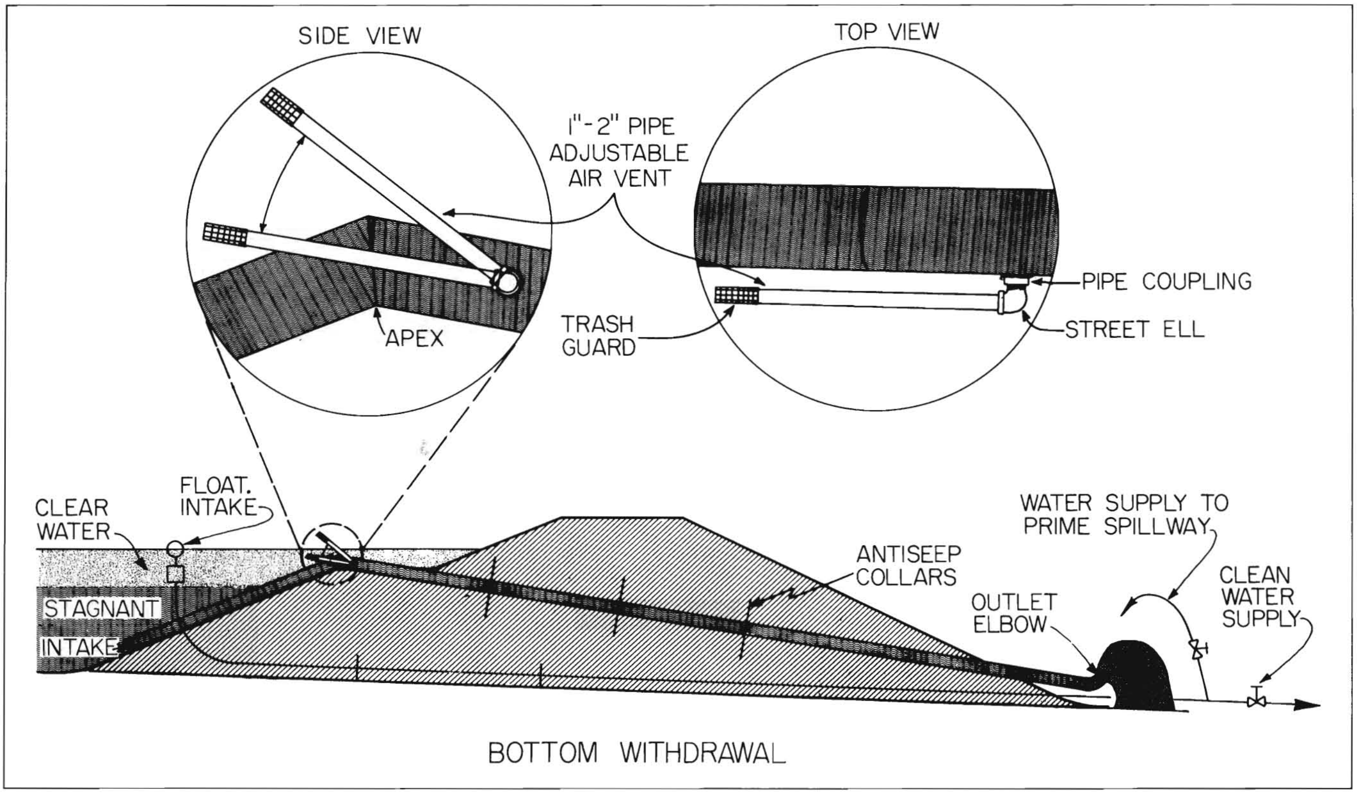

Figure 3. Cross-sectional view of a bottom-withdrawal spillway installation.

(see priming section below), the air vent can be capped and siphoning will continue until the cap is removed.

Outlet elbow—The elbow on the outlet end of the pipe serves three purposes: (1) as an aerator so the anoxic bottom water is aerated before it enters the stream; (2) as an energy dissipator so a deep plunge pool doesn't develop; and (3) as an air lock so siphoning will begin at lower water levels (low flows) and will continue until air enters the upstream air vent.

Anti-seep collars—Anti-seep collars are used to prevent water flow external to the spillway pipe. These collars are usually made of steel, plastic, or heavy butyl rubber. For details, see UMC Guide 1515.

Manually priming the spillway

The spillway will automatically prime (flow full and siphon) when the water level rises a half pipe diameter or less above the apex (if the air vent is submerged). However, there may be times when it is desirable to manually prime the spillway.

The first step is to plug or "stopper" the outlet end. The second step is to fill the pipe with water. This can be done one of three ways: (1) if there is a trickle flow, allow it to fill by itself by leaving the air vent open to the atmosphere; (2) apply a vacuum to the air vent (the vacuum from the manifold of a spark-ignition engine will usually suffice); or (3) attach a hose from the stock water line, or another source, to the downstream end of the pipe, or through the plug, to fill the pipe.

The third step is to cap or plug the air vent or clamp the vacuum line. The fourth and final step is to remove the plug from the outlet end and stand back. It is not necessary to remove all the air from the spillway pipe because as the flow increases, the water will remove it.

The water can be stopped manually by removing the air vent cap. The pond water level can be lowered to any desired level (within bounds) by lowering the air vent to that level. The water flow will stop automatically when the water reaches the air vent level.

Other considerations

Water in the bottom of ponds will not fall below 39 degrees F during winter months. Therefore, if water continues to flow, freezing of the bottom-withdrawal spillway should not occur. However, if the water level of the pond is low when freezing occurs, an ice plug could form upstream of the apex and restrict flow, should a freezing rain produce runoff. This is a rare situation; runoff usually occurs when air temperatures are above freezing.

Plastic pipe may be used for the spillway, but extra care must be exercised during installation. Also, a weep hole should be drilled in the bottom of the outlet elbow to prevent freezing during no-flow conditions in the winter.

The air vent should be protected from floating debris which may plug it and cause prolonged siphoning. A screen may be clamped to the end of the air vent or the air vent may be put into a larger screened-in enclosure.

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