Tide Gate Modifications for Fish Passage and Water Quality Enhancement

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Introduction

What is a tide gate?

A tide gate is a flap gate mounted on a culvert which runs through a dike or levee[1]. Photos of *two* typical tide gates are shown on Plate 1. When the water level outside the dike or levee is higher than inside, tide gates close, preventing flooding of protected land (Figure 1a). When the water level inside the dike or levee is higher, tide gates open, allowing water to flow off the land (Figure 1b). In this way, tide gates maintain low tide conditions within the dike, or prevent floodplain flooding behind a levee.

There are currently two tide gate designs in general use in Oregon. Figure 2 shows a schematic drawing of the most common type. A round, cast iron plate is hung, by means of a double-hinged arm, over the opening of a round culvert. In the other design, shown in Figure 3, a rectangular, wooden door hangs over the opening of a round or rectangular culvert. In both cases, the plate or door is able to swing freely away from the culvert, permitting water to flow off the land. When the water level outside the levee or dike is higher than the water on the inside, the lid or door is pressed against the culvert, preventing water from flowing through the culvert.

What do they do:

Tide gates keep the free standing water level within a dike at or near the low water level of the outside water body. Thus intertidal and low supertidal wetlands can be maintained dry for development.

For levees, tide gates or storm gates permit water to drain through the levee, away from protected development., while maintaining the integrity of the levee during high water events.

What problems do they present?

Tide gates prevent fish and other aquatic wildlife from having free access to the streams and sloughs upland from the dike or levee. In most cases, tide gates are nearly totally impassable to fish,

[1] The terms dike and levee are often used interchangeably, but there is a difference. A dike encloses or encircles a patch of ground, such as former tidal wetland, preventing tidal flooding. A levee is a linear feature, generally placed along a river bank, which prevents flooding of a former floodplain during periods of high water.

preventing the use of any available off-channel holding and rearing areas, and blocking access to upland spawning habitat.

What properties must they have?

Tide gates typically receive little or no regular maintenance, and so must be simple and durable. Floating debris and strong water currents impact many tide gates, so they must be strong, and able to withstand direct impacts.

Quite often, some of the land protected by tide gates is very low in elevation, and hence susceptible to high water table problems. Also, the tidally influenced water outside the dike can be saline during summer months. For these reasons, tide gates must minimize leakage.

Alternate Designs

The following alternate tide gate designs represent a range of possible alternatives for modifying existing tide gate assemblies. Each design provides different benefits, and carries different costs, as compared to a typical tide gate. A discussion of factors to consider when selecting tide gate modification sites follows the descriptions of each design. Table 1 below summarizes each design's performance with respect to tidal flushing, fish passage, durability, drainage, and ease of installation.

1. Pet door, top hinged

A "pet door" is a small hole, cut into the larger tide gate lid, which is covered by a small door mounted on the larger lid (Figure 4). In the case of a top-hinged design, the small door is built to have a low submerged weight. This small, light door will open wide when water flows out through the tide gate, providing a relatively large opening for fish and aquatic wildlife to swim through. Because the small lid has negative buoyancy, it will close when the tide reverses, and water tries to flow back through the culvert.

A tide gate of this design has been built for TBNEP by the *Golden Harvest* company of Burlington, Washington. *Golden Harvest* can be reached at (800) 338-6238. In the Tillamook area, a contractor named Leo Kuntz, (503) 322-0265, has also indicated an interest in building tide gates of this type. This information is provided without any actual or implied endorsement of the *Golden Harvest* company or its products, or of Mr. Kuntz.

2. Pet door, bottom hinged

This design also uses a small "pet door," as in design number one. The small door is attached to the large lid with hinges at the bottom of the small door (Figure 5). A small arm and float are attached to the small door. The arm and float control the position of the small door.

During periods of low water outside the dike, the float allows the small door to open (Figure 6, position 1). During these periods, the opening allows fish and aquatic wildlife to pass through the tide gate, and permit a minimal exchange of water. When the water level rises with the tide (Figure 6, position 2), water will flow through the opening until the float rises to the point where the small door closes (Figure 6, position 3). As water outside the tide gate continues to rise, the large and small doors will remain closed (Figure 6, position 4). When the outside water level falls below that inside the tide gate, the large door will swing open, allowing normal drainage (Figure 6, position 5). As the water level continues to fall, the small door will again open, and the cycle will repeat (Figure 6, positions 6 and 1).

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3. Side hinged doors

The tide gates in Figures 7 and 8 are closely related. In Figure 7, two large, side-by-side rectangular culverts are blocked by large, wooden doors. The doors are hinged at the outside, similar to normal doors. The hinges are angled off the vertical, however, so that the doors have a tendency to swing to their normal resting places over the culverts. Because the angle off the vertical is small, however, little force is required to open the doors, and so given a slight outward flow of water, the doors will open wide. This design is in use on Beaver Creek, off the Tillamook River.

Figure 8 shows a combination of the pet door and side hinged designs. A small door is placed over the pet door hole, as in designs 1 and 2. The door is hinged at the side, slightly off vertical, allowing it to open easily when water flows out through the culvert.

4. Radial (Gator)

A variation on the typical tide gate design uses thin, light, concave lids in place of thick, heavy cast iron or aluminum lids (Figure 9). These lids are considerable lighter than other designs, and hence open wider and permit more drainage.

5. Waterman/Nekton High Water

The *Waterman/Nekton Company* of Exeter, California has developed a "Self-Regulating Tidegate" (SRT) which allows normal tidal fluctuation through a culvert, but closes when water outside the tide gate rises above a tolerable level (Figure 10). The lid is buoyant, and under normal conditions floats on the water (Figure 10, position 1). When water rises above the culvert, the round floats force the gate to shut, limiting the water level behind the gate (Figure 10, position 2).

Waterman/Nekton can be reached at (800) 331-0808. This information is provided without any actual or implied endorsement of the *Waterman/Nekton* company or its products.

6. Aluminum lid

The typical round, cast iron lid can be replaced with a round, aluminum lid. There are subtle differences in how the two lids are mounted to the culvert, but the significant change is in the weight of the lid. The aluminum lid is significantly lighter, allowing greater drainage and possibly increased fish passage potential.

Aluminum tide gates are typically made of the alloy 6061, an alloy commonly used in aircraft, boats, and structures. A sacrificial anode, usually zinc, is attached to the aluminum to reduce corrosion of the aluminum. The lifespan of the anode depends on environmental conditions and the size of the anode. Replacement of the anode is required on a regular basis as part of the maintenance of the tide gate.

7. Combination flap and sluice gate

A sluice gate mechanism can be attached to a standard flap gate, allowing the flap gate to be raised out of the way of the culvert. This allows the tide gate to essentially be removed for certain periods. A rough schematic of this configuration is shown in Figure 11.

Modification Guide

Many factors must be considered when contemplating a modification to an existing, functioning tide gate. Some of these factors are listed below.

Landowner willingness

Given the voluntary nature of Oregon's salmon recovery plan, and the nature of private property rights, nothing can be done with respect to tide gate modifications without the active support of the landowners and drainage district involved.

Maintenance of normal tide gate function

Tide gates are essential to the use of former intertidal and low supertidal land in agriculture and other development. Often this land is only marginally usable, and tide gate performance is a large factor in the continued viability of the agricultural activity. Thus modifications must not reduce the basic effectiveness of the tide gates in preventing tidal flooding and controlling water table elevation.

Size of culvert, depth of culvert

The culvert must be large enough so that fish will pass through if given the chance. The culvert must also be installed low enough relative to low water levels so that it rarely goes dry. In the case of "pet door" designs, the culvert should remain at least 50% filled, even at the lowest water levels. Many in-place culverts will not meet this requirement, so modification may involve a need to replace the culvert as well.

Topography

Some designs, most notably the bottom-hinged pet door (#2), permit more water to flow onto the land than typical tide gates. These designs can only be used where the land behind the tide gate is high enough to not be affected by the raised water level.

Habitat potential

The habitat value or potential value in a water body behind a tide gate is complex. Detailed, site-specific investigations are required. Some factors to consider include: riparian and aquatic vegetation, both current and potential; the volume and depth of the water body; the amount and timing of fresh water inflow; the presence of

upland spawning areas; the salinity of the tidal water body; and the presence of in-water hazards (e.g., in-stream cattle crossings).

Maintenance

Many of the tide gate designs described in this pamphlet involve additional requirements for inspection and maintenance. Traditional cast-iron, double-hinged lids require almost no maintenance or upkeep, and many tide gates operate acceptably for farming with no annual maintenance. Tide gate designs which enhance the productivity of the land, i.e. those which increase fish habitat in addition to maintaining pasture uses, will be more complicated, and hence require more attention, than simpler designs. The requirement for increased attention should be remembered when selecting alternate tide gate designs.

Protection

Many of the tide gate designs presented have more moving parts, and more appendages, than a traditional cast-iron or wooden tide gate lid. They are therefore more vulnerable to damage from strong currents or debris. The selection of a suitable tide gate design should include consideration of the hazards typical for a site.

Design guidance table

The alternate tide gate designs presented above, plus the two typical designs currently in wide use, are compared in the following table. The designs are rated based on their ability to improve tidal flushing, permit fish to pass, improve upland drainage, remain serviceable with little maintenance (durability), and their ease of installation.

	Tidal flushing	Fish passage	Better Drainage?	Durability	Installation ease
Pet door, top	None	High	Yes	Good-Fair	Good
Pet door, bottom	Moderate	Moderate	No change	Fair	Fair
Side hinge, large	None	High	Yes	Good	Poor
Side hinge, small	None	High	Yes	Good	Fair
Radial (Gator)	None	Low-Mod	Yes	Poor	Good
Nekton design	Very high	Very high	N/A	Poor	Good
Aluminum	None	Low	Yes	Good	Good
Sluice/Flap gate	Very high	Very high	Yes	Fair	Fair
Conventional-Cast Iron	None	Low-None	N/A	Good	Fair
Conventional-Wood	None	Low-None	N/A	Good	Fair

Table 1. Comparison of tide gate designs for critical performance considerations.

Comments & Questions

If you have questions or comments on this booklet, you can contact the Tillamook Bay National Estuary Project by phone, fax, US Mail, or email.

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Figures

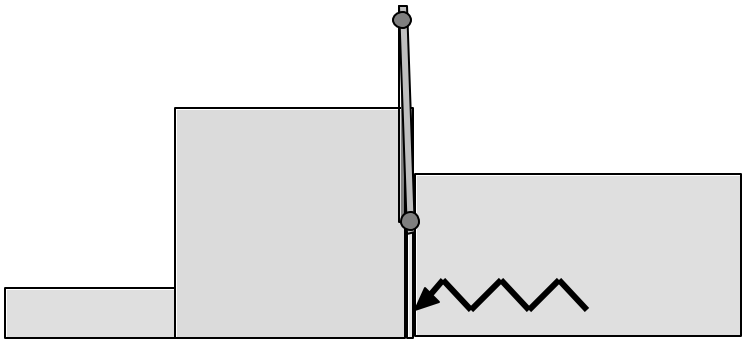

Figure 1a. Tide gates block culverts when the outside water level exceeds that inside the tide gat

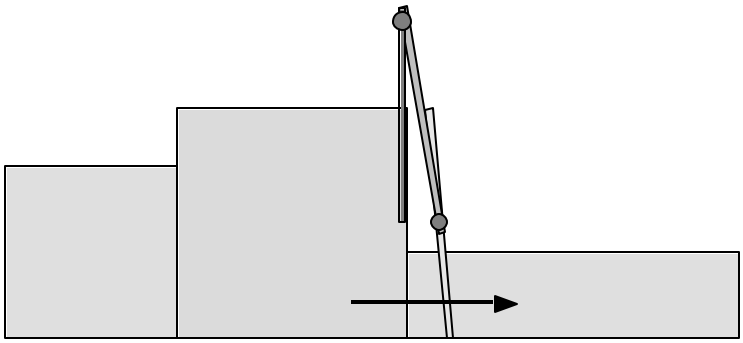

Figure 1b. When the water level outside the tide gate drops, the gate opens, allowing water to d through the culvert.

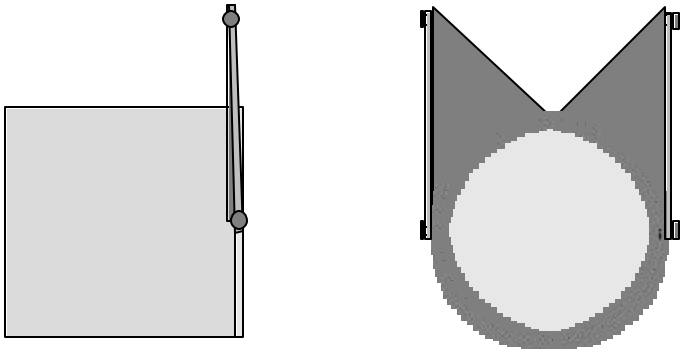

Figure 2. A typical tide gate design in use in Oregon includes a round culvert and a round, flat, cast iron plate hanging in front of the culvert's opening.

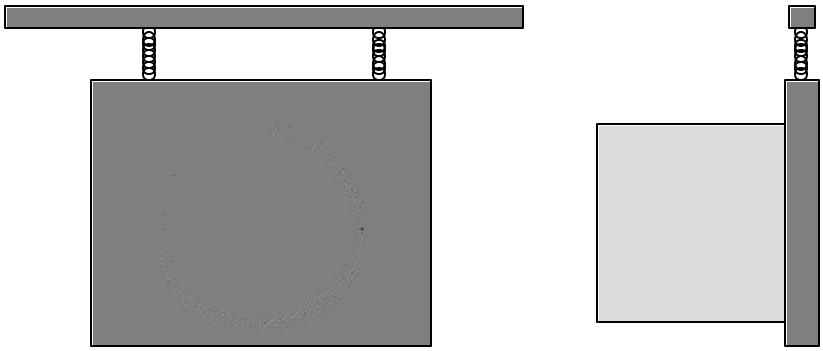

Figure 3. Another typical tide gate design in use in Oregon includes a round or square culvert and a rectangular, flat wooden door hanging in front of the culvert's opening.

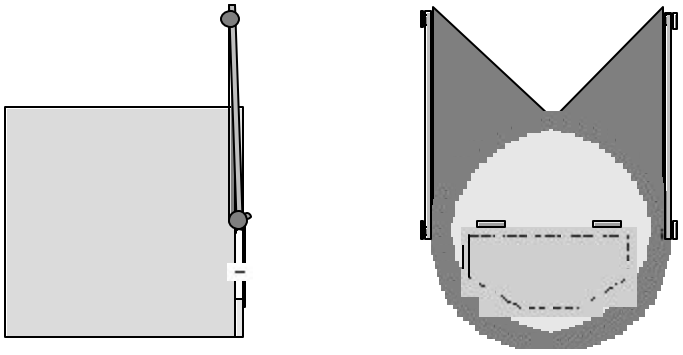

Figure 4. A top hinged pet door design features a small hole in the standard door, with a small door mounted over the hole.

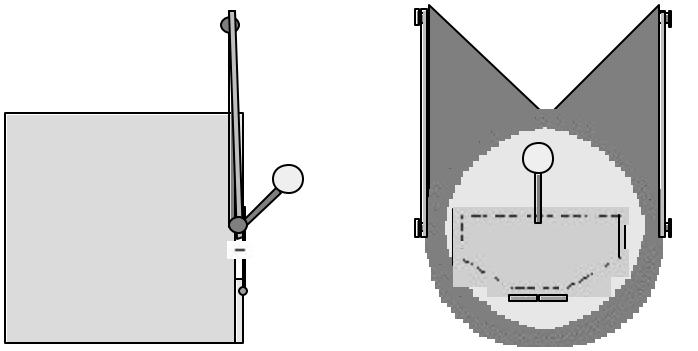

Figure 5. A bottom hinged pet door design features a small hole in the standard door plus a small door mounted over the hole with a float and arm assembly attached.

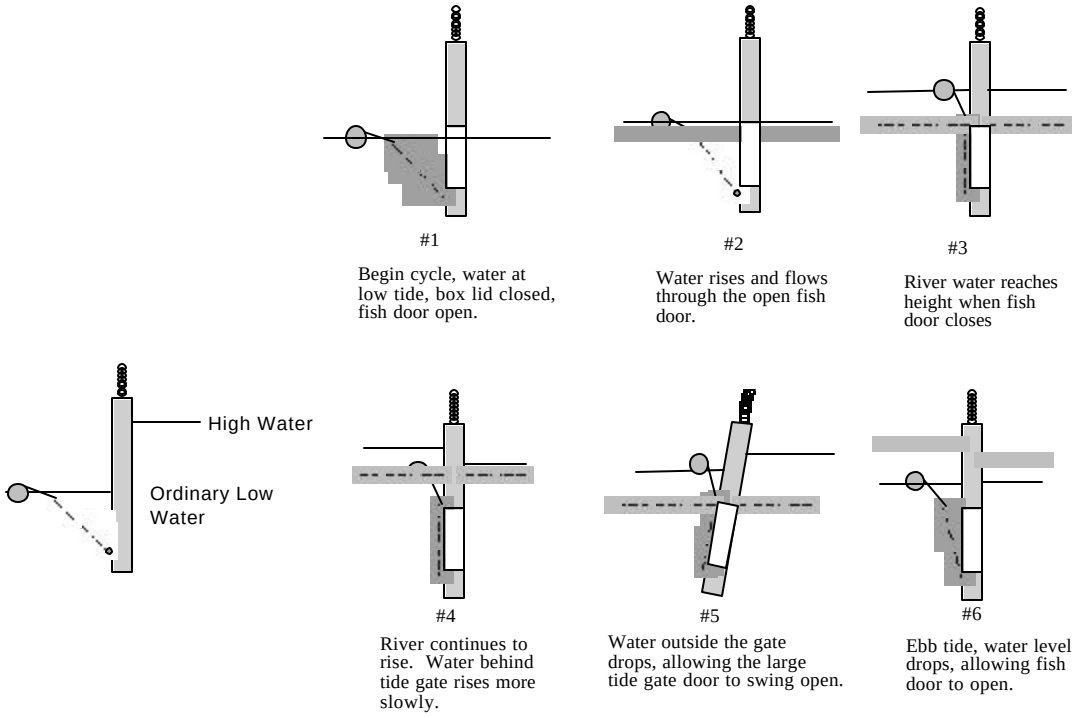

Figure 6. A normal opening and closing cycle for a bottom hinged pet door.

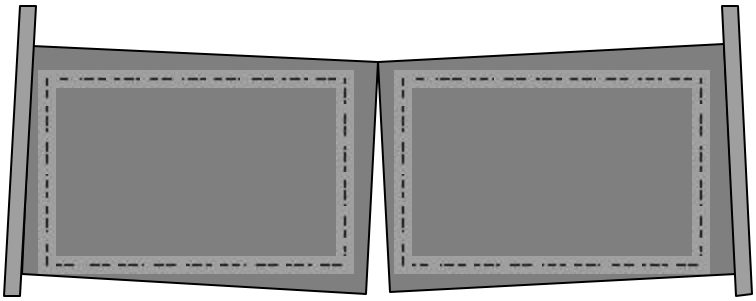

Figure 7. Large, side hinged tide gates are angled inward, providing a small closing force, and are typically mounted over large, rectangular culverts.

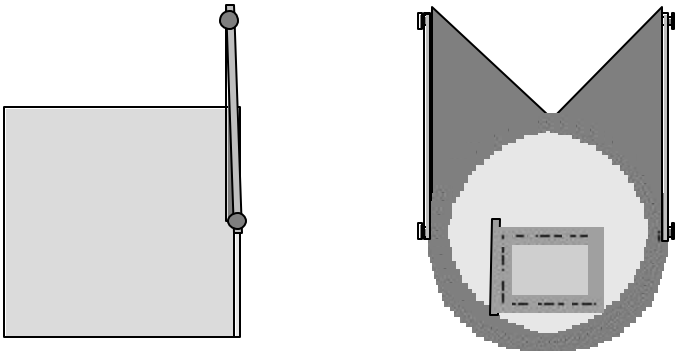

Figure 8. A hybrid of the side hinge and pet door designs uses a small hole in the tide gate lid, plus a small, side hinged door over the hole.

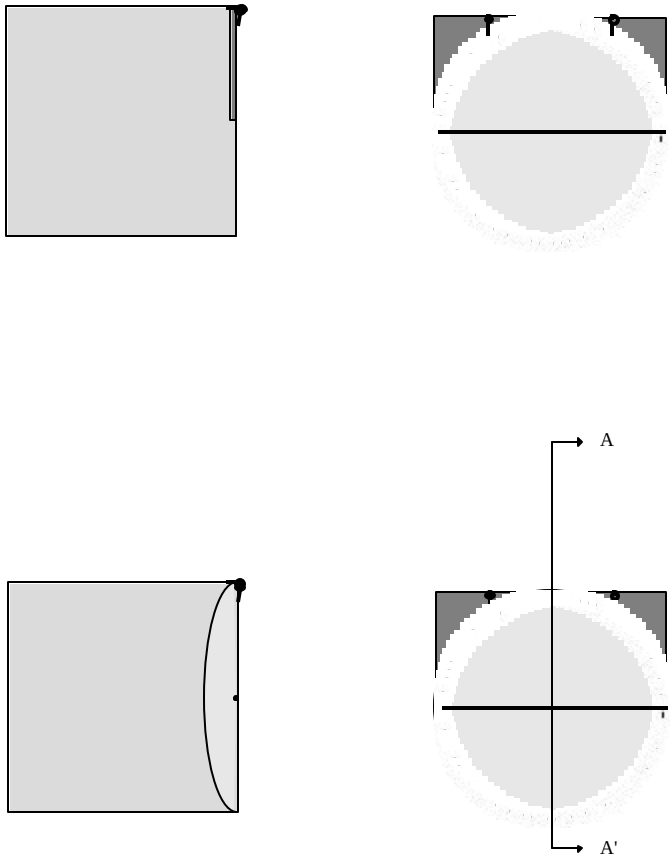

Figure 9. A radial or "Gator" gate uses a thin, concave lid to block the culvert

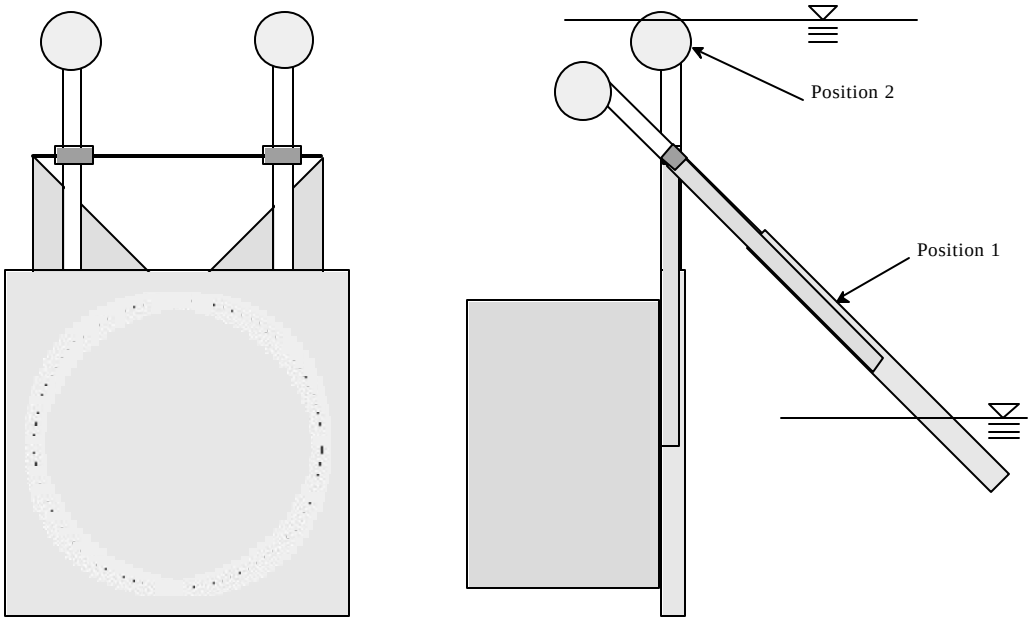

Figure 10. The Nekton gate, made by the so and so company, closes during times of extremely high water .

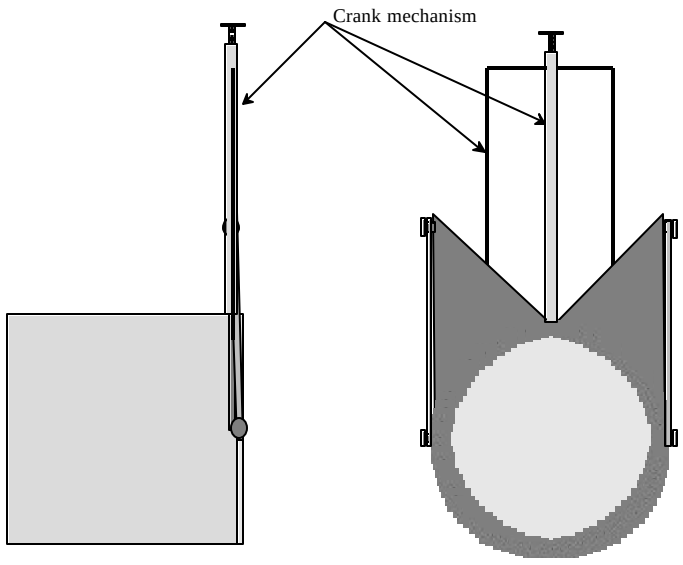

Figure 11. Tide gates can be combined with sluice gates, allowing the tide gate to
opened for extended periods.