A floating intake for irrigation systems being supplied with water from fast-flowing and fluctuating streams

J. A. GILLIES, R. J. FORD, and D. F. WALPER

Department of Agricultural Engineering, University of Saskatchewan, Saskatoon, SK, Canada. *Received 12 June 1989, accepted 23 October 1989.*

Gillies, J. A., Ford, R. J. and Walper, D. F. 1990. **A floating intake for irrigation systems being supplied with water from fast-flowing and fluctuating streams.** Can. Agric. Eng. **32**: 147–149. Many private irrigators are faced with the problem of constructing non-permanent intakes for their irrigation system. Non-permanent intakes on major water courses are required by regulatory agencies to reduce the environmental impact on the river environment of irrigation intakes and pump sites. Intakes must not present a hazard to those who use the water course for recreational purposes. Fluctuating water levels and shifting flow patterns also require the irrigator to have the capability to relocate the intake during the irrigation season. In addition, the intake system must be stable and must accommodate the side thrust on the suction line caused by flowing water. A floating intake system has been developed. The system provides the irrigator the flexibility required to adjust the position of the intake (screen box and foot valve), does not obstruct flow and does not severely impact on the river environment.

INTRODUCTION

Many private irrigators are faced with the problem of constructing non-permanent intake structures for their irrigation systems. These irrigators often do not have the financial resources to design and construct permanent intake structures. In addition, regulatory and conservation agencies require the irrigators to select sites for intakes and pumping plants that minimize the environmental impact on the stream or river and that do not create a hazard to those who use the stream or river for recreational or commercial purposes. Alluvial streams and rivers in the prairies are typically shallow, relatively fast flowing (velocities of 1 m/s or greater) and are characterized by rapid and irregular changes in stage. These streams also tend to meander within the channel or flood plain. In most cases structures placed on or in stream beds are severely affected by scour. During the winter when the streams and rivers are ice covered, irrigation structures must be removed from the channel. These situations impose on the irrigators rather severe limitations on the type of intake structure that can be utilized. A simple and inexpensive floating intake system which provides the irrigator the flexibility required to adjust the position of the intake (screen box and foot valve), does not obstruct flow and does not severely impact on the river environment, has been designed and tested.

DESIGN AND DEVELOPMENT

Design Requirements

After considering several types of support structures (Walper 1987) for intake systems, it was decided that a floating intake support structure with anchoring cables to the shore would be the most suitable.

The following design requirements were established:

- The intake system must be portable.
- The supporting mechanism for the intake must be durable, water proof and easily seen at water level.

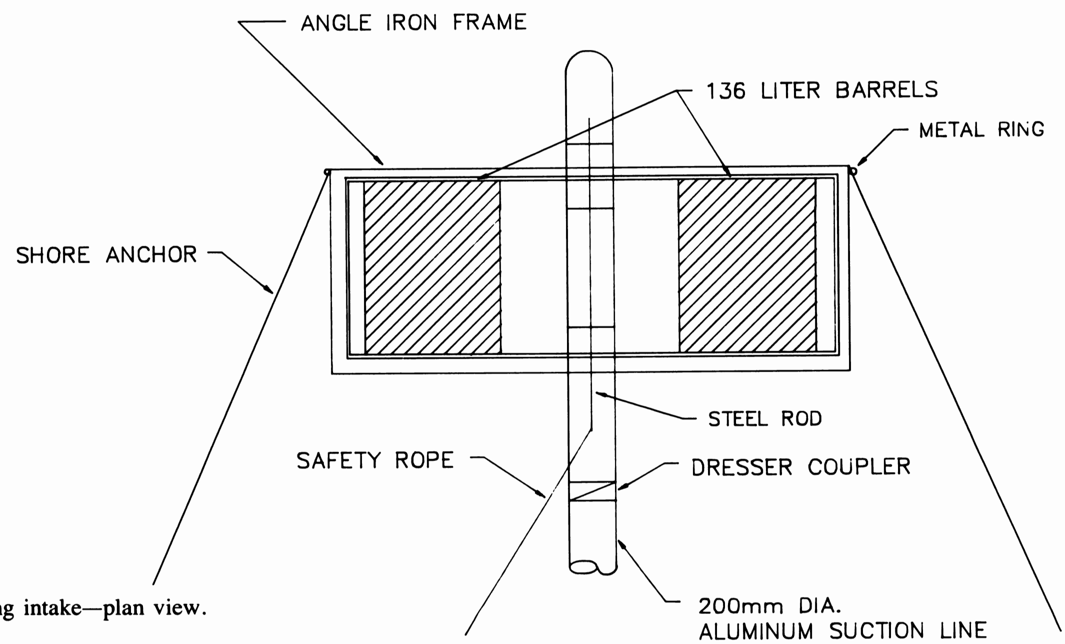

Fig. 1. Floating intake—plan view.

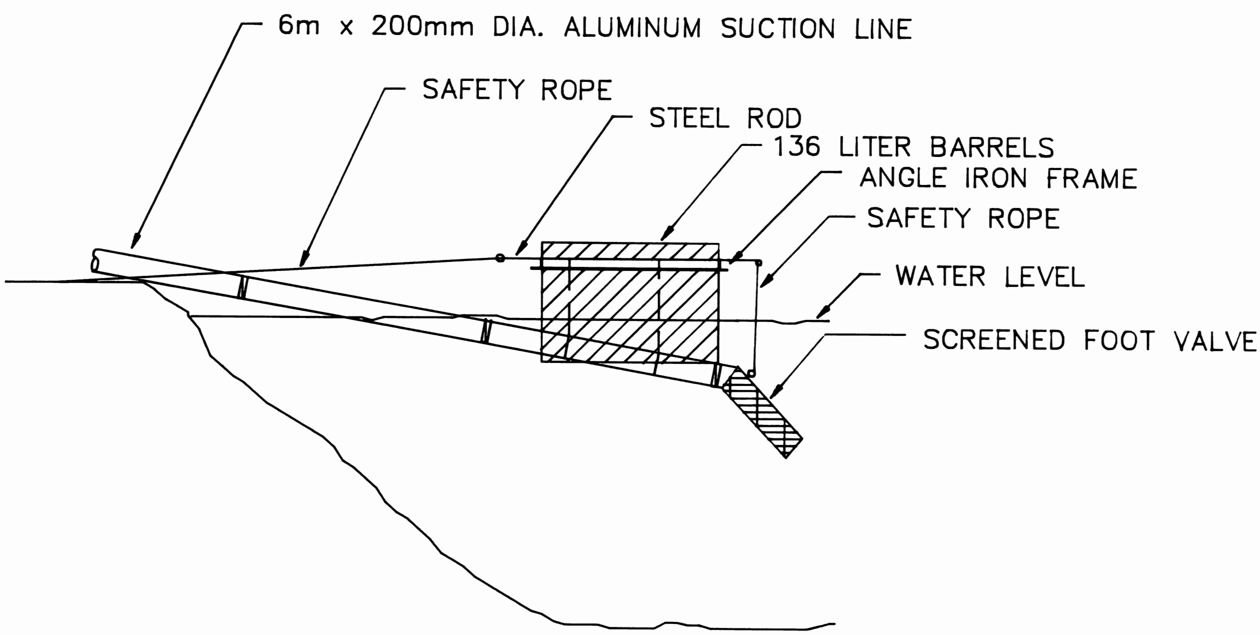

Fig 2. Floating intake—side view.

- The intake structure must not obstruct flow.
- The intake system must not collect floating debris.
- It must be possible to adjust the position of the intake screen and foot valve with respect to the water surface and the stream bed so that adequate depth of water can be maintained above the intake while restricting the possibility of bed material being drawn into the suction line.

The basic components of an irrigation intake system are shown in Fig. 1. This system consists of aluminum suction pipe, Dresser couplers, float mechanism, intake screen and foot valve. As the water level in the stream changes, the couplers provide flexibility in the vertical plane for the pipe. The intake screen prevents trash from entering the suction line and provides a safety cover against possible damage to feet or hands of stream users; the foot valve provides a positive backflow seal at the intake end of the suction line, and thus virtually eliminates the need to prime the irrigation pump.

Design

To support the irrigation intake system (Fig. 1) and to position the intake below the water surface and above the stream bed, a float mechanism was designed. The volume of the float required to support the intake system was calculated, assuming that 10 m of 200-mm-diameter standard irrigation aluminum suction pipe was to be used. The calculations showed that a volume of 65 L would provide sufficient buoyant force to support the intake pipe, screen, foot valve and float.

To provide stability, the float structure consisted of two commercially available 136-L oil barrels welded into a frame as shown in Fig. 2. Angle iron (25 mm × 25 mm × 6 mm) was used to construct the framework of the floating intake structure. As a safety precaution, the barrels were steam-cleaned prior to being welded to the frame. As is illustrated in Fig. 1, the barrels were positioned in the frame so that there was sufficient space between them to accommodate the suction line (380 mm for a 200-mm-diameter suction line). A 4-m-long 12-mm-diameter steel bar was welded to the frame, parallel to the barrels but positioned mid-way between the barrels to provide a point of attachment for the safety ropes.

The float structure was positioned at the end of the suction line. The suction line was supported between the barrels with polyethylene ropes attached to the steel bar. The rope facilitated adjustment of the depth of submergence of the intake end of the suction line. Such adjustment was necessary to prevent the intake from drawing sediment from the stream bed while reducing possibility of occurrence of a vortex during periods of low flow.

The float was anchored to shore by ropes at a 45° angle to the pipe to position the float in the stream and prevent horizontal movement of the intake structure and submerged pipe. Side thrust on the intake system was calculated for conditions noted above. Assuming that the average velocity of flow in the stream was 1 m/s, the resultant tension in the supporting ropes was calculated to be 1.45 kN. Two 12-mm-diameter polyethylene ropes (breaking strength 18 kN) were attached to the metal rings welded to the float frame as illustrated in Fig. 2. The ropes were attached to 2.5-m-long treated wooden posts (100 mm diameter) which were buried to a depth of 1.25 m in firm soil on the shoreline.

FIELD TESTING

The floating intake structure was field tested for 4 yr on the South Saskatchewan River and performed satisfactorily. The floating intake structure supported 10 m of 200-mm-diameter aluminum irrigation pipe and a screened foot valve. Four Dresser couplers were installed in the suction line. The intake supplied 5 m^3/min of water to irrigate 200 ha of specialty seed crops. The reach of the river used for testing is frequented by recreational boaters and canoeists, none of whom found that the structure interfered with their activities. This reach of the river also experiences changes of stage of up to 1 m in a day and significant buildup of dunes due to bed load sediment movement. Under these conditions the intake system had sufficient flexibility to accommodate the changes in stage and could easily be lengthened or shortened (by inserting or removing lengths of suction pipe) to provide sufficient depth of water for proper operation of the intake.

Under low flow conditions, it was necessary to attach a piece of plywood (1.2 m by 2.4 m) to the float structure above the intake end of the suction pipe to prevent a vortex from forming. The plywood was attached to the frame by ropes through the shore anchor attachment rings, and was allowed to float on the water's surface.

As a safety feature, to improve the visibility of the intake structure for boaters, a cyclist's safety flag was attached to the frame of the float mechanism.

COST OF FLOATING INTAKE STRUCTURE

The test version of the floating intake structure and piping system was constructed from materials that are readily available on a farmstead. It was necessary to purchase only the Dresser couplers. Table I lists the costs of materials required to construct the floating intake structure and piping system. The assumption is made that the aluminum tubing would be available as part of the irrigation system. The floating intake structure and couplers will cost approximately $525.00.

Table I. Cost of materials for floating intake structure

Item	Description	Cost
Flotation barrels	Two 136-L oil drums	$ 40.00
Angle iron	Five m 25 mm × 25 mm × 2 mm	$ 30.00
Steel rings	Four 75 mm diameter × 8 mm	$ 8.00
Steel bar	One 1.2 m × 12 mm diameter	$ 15.00
Dresser couplers	Four 200 mm diameter	$400.00
Rope	65 m × 12 mm diameter	$ 30.00
	Total	$523.00

CONCLUSION

A floating intake structure for irrigation systems has been designed, constructed and successfully tested. The structure provides the flexibility required when intakes for irrigation systems are placed in streams or rivers that undergo short-term changes in stage. It does not obstruct flow and has no undue impact on the river environment. In addition, the structure can be constructed from materials that are readily available on the farmstead.

REFERENCES

JAMES, L. G. 1988. Design of farm irrigation systems. John Wiley and Sons, New York, NY.

JENSEN, M. E. (ed.) 1983. Design and operation of farm irrigation systems. ASAE Monograph, Am. Soc. Agr. Engrs. St. Joseph, MI.

VENNARD, J. K. and R. L. STREET. 1982. Elementary fluid mechanics. 6th ed. John Wiley and Sons, New York, NY.

WALPER, D. F. 1987. Floating intake/cable anchor design for irrigation pumping systems. Unpublished report. Department of Agricultural Engineering, University of Saskatchewan, Saskatoon, SK.