

TURBULENT FLOW SELF CLEANING TRASH SCREENS

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Trash and weed seeds are a major problem to irrigators, particularly those using gated pipe or siphon tube irrigation systems. Trash in surface irrigation systems often stops or reduces flow through gates or siphons resulting in inadequate irrigation of the furrows served. Constant surveillance to clean trash out of these orifices is impractical. Weed seeds passing through an irrigation system are distributed throughout the field causing extra tillage operations and reducing yields.

Separation of trash and weed seeds from farm irrigation water, if done at all, has commonly been accomplished by passing water through a removable screen which has sufficiently small openings to retain the undesirable material. The basic problem with screens is accumulation of organic material on the screen which, if not removed as fast as it accumulates, eventually blocks the flow of water through the screen.

Mechanical screening devices have been developed with moving brushes to sweep organic material from an inclined screen. Many of these are reasonably effective. Some are powered by electric motors and others are powered by paddle wheels rotated by the flowing water if sufficient head is available. This allows them to be installed at locations where electric power is not available. However, moving parts and bearings on these devices require considerable maintenance and replacement to keep the device operative.

Dropping the water from a pipe, weir or check structure onto a taut, horizontal screen has been found to be an effective screening technique (reference #1). If the screen is taut and the drop height is sufficient, the screen vibrates and the material moves forward on the screen clearing enough screen area for the water to pass through. Designers of these screens suggest 0.7 m^2 (6 ft^2) of screen area per 28 liters/sec (1 cfs) of flow and a minimum drop of 20 cm (8 in). Problems with maintaining a taut screen or having sufficient drop to obtain the necessary vibratory action resulted in the following studies and suggested design modifications.

Rectangular Horizontal Screens

A horizontal screen is shown in Figure 1.* The material shown on the left was screened from water flowing about 28 liters per second (1 cfs) during an eight hour period, but became partially clogged as indicated by the material collected on the area where the water impacts the screen. The continued pressure of the steady concentrated stream stretched the screen at the point of impact and retained leaves and other flat organic matter. A major portion of the water was deflected by the stationary organic matter and moves over the screen in a manner shown by the froth at the edge of the organic matter. With longer periods of time or higher concentrations of trash in the water, this screen clogged so that most of the water was lost instead of passing through the screen.

The operation of this screen was improved by using a wood deflector to distribute the water more evenly across the screen, as shown in Figure 2. Another and perhaps more important effect of this frame was to create more turbulence in the water. This turbulence is more obvious with higher speed photography as indicated by Figure 3 which was taken at 1/125 second just a few seconds after Figure 2. The relative amounts of organic matter that lodged in the impact area of the screen with and without the deflector are indicated in Figures 4 and 5, respectively. In preparation for each photograph, the screen was scrubbed clean of trash in the impact area and about 1 kg (2 lb) of previously accumulated trash was dropped into the supply ditch above the screen. The photographs were taken about 10 minutes after the trash application. When the deflecting frame was used, the increased turbulence dislodged more of the organic matter and more of the water passed through the screen. When the deflecting frame was used, momentary lodging of leaves did occur. This caused horizontal deflection of the water at the surface of the screen and subsequently pushed the trash away from the impact area. Obviously turbulence plays a large part in causing effective operation of the horizontal weed screens, particularly where the screen was not kept as taut as desired. It is probable that turbulence contributes greatly to the operation of screens that are taut.

A 60-cm (24-in) wide by 90-cm (36-in) long, 8 mesh per cm, horizontal trash screen was installed by a farmer to screen 40 lps (1.4 cfs) of water feeding his "cablegation" system. The screen, placed with a 10-cm (4-in) drop received water from a free discharge, bottom opening gate. The trajectory of the jet of water issuing from this gate impinged on the screen more than half way down the length of the screen. Because there was a large residual horizontal energy component even after impacting the screen, all of the trash and a good part of the water was discharged over the end of the screen. To correct this, a 15-cm (6-in) diameter, 4-spoke paddle wheel was installed in the effluent jet of the turnout (Figure 6) as suggested by Bergstrom (1) for insufficient drop. This paddle wheel was mounted in free running, oiled wood bearings with a bottom clearance

* This screen is manufactured by the Yakima Machine and Foundry Co. Specification of manufacturers' names are for the benefit of the reader and do not imply endorsement by the USDA-ARS.

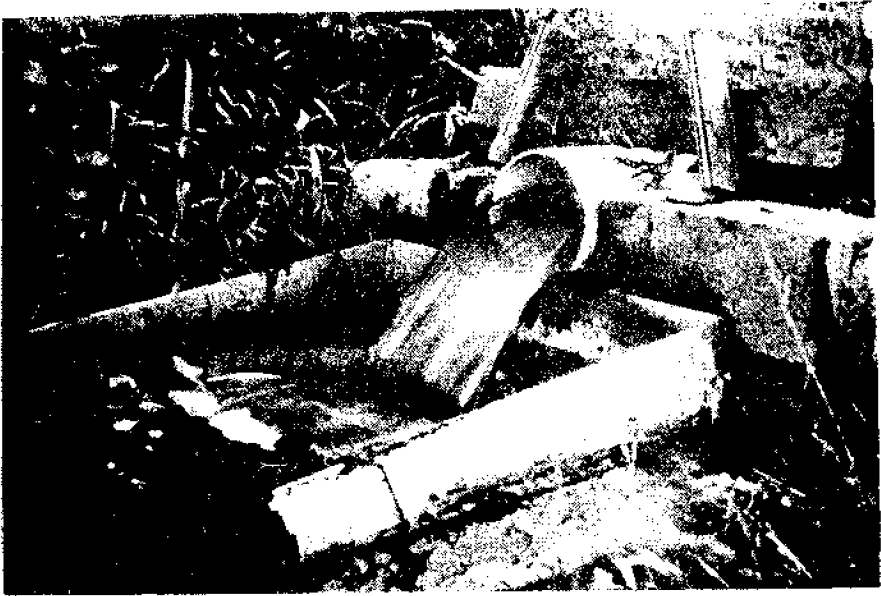


Figure 1. Rectangular horizontal screen with 8 hours collection of trash.

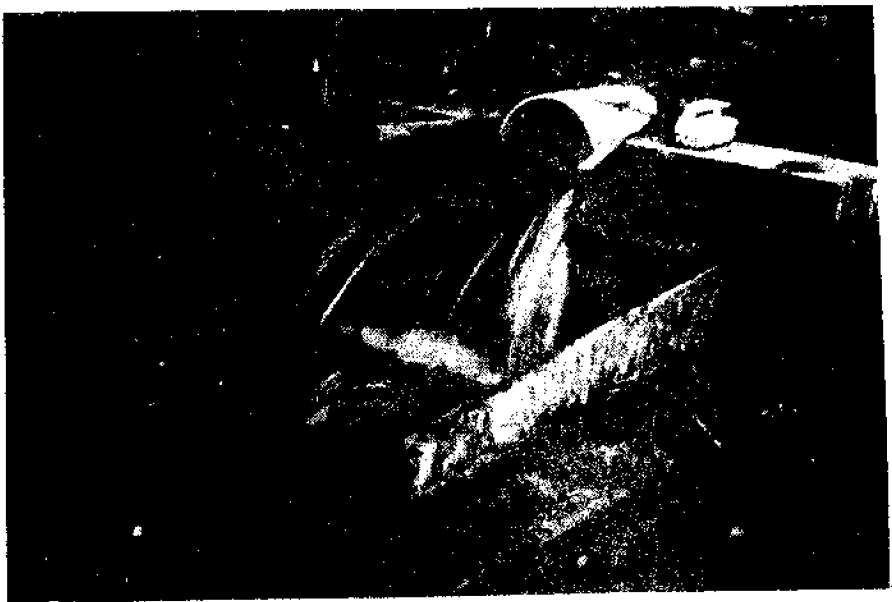


Figure 2. Rectangular horizontal screen with deflector to broaden impact area.



Figure 3. More detail of turbulence shown in higher speed (1/125) photo.



Figure 5. Trash distribution without the deflector

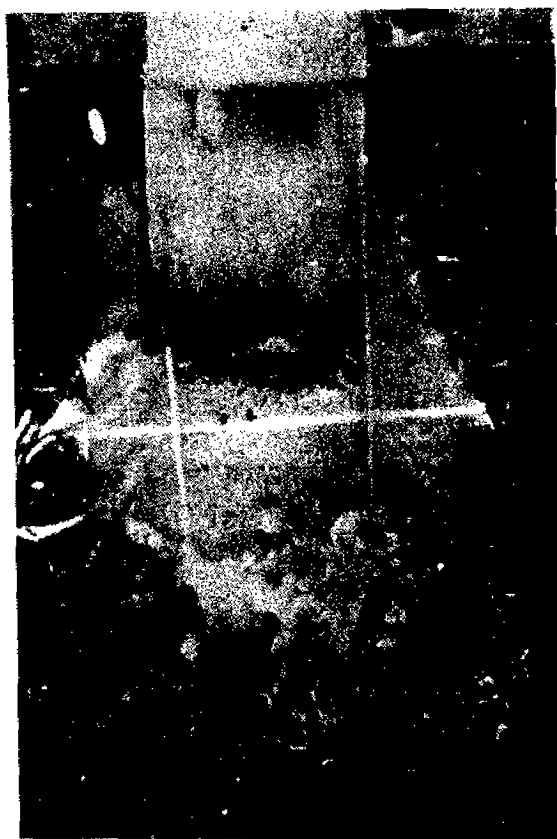


Figure 4. Trash distribution with the deflector.



Figure 6. Paddle wheel used to reduce jet length and induce turbulence.



Figure 7. Horizontal screen adapter to concrete lined ditch (vortex shedding inducer board is just upstream from the check dam).

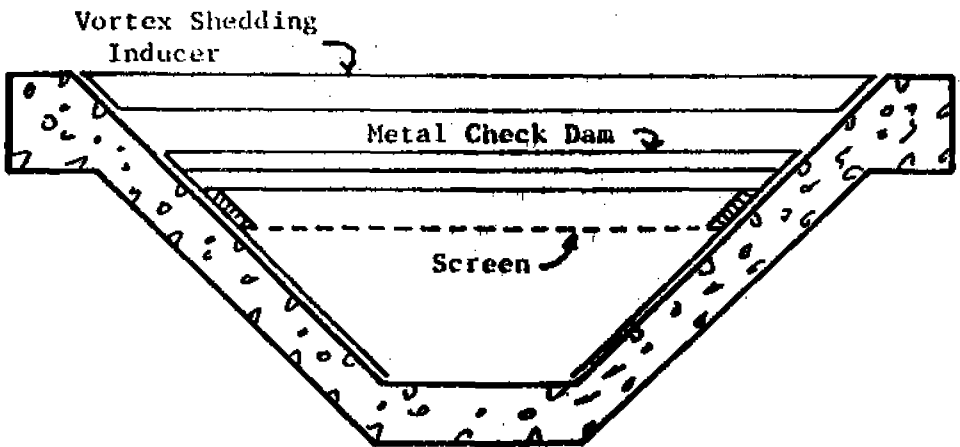
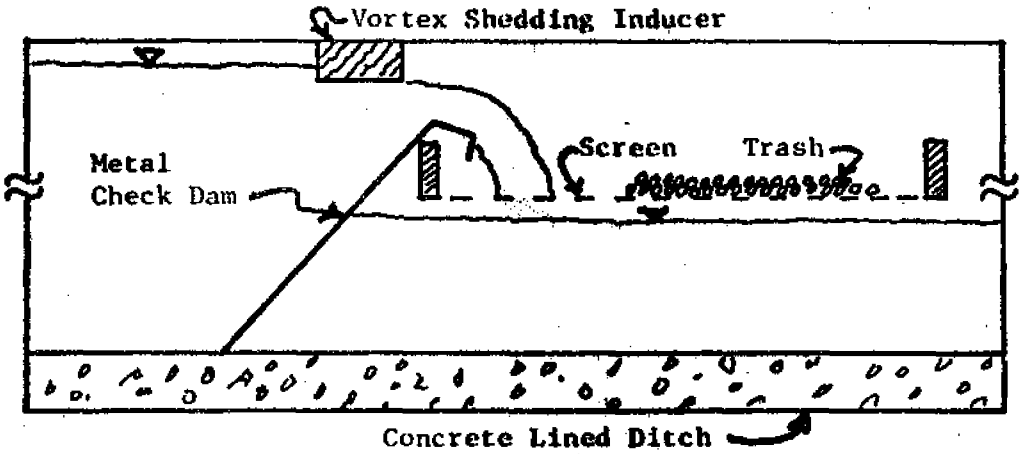


Figure 8. Schematic detail of Figure 7

of approximately 4 mm (1/8 in). The paddle wheel turned at approximately 50 rpm causing about 3 oscillations per second in the flow. The screen operated very satisfactorily thereafter and even removed gelatinous snail eggs from the water.

A 45-cm (1.5-ft) wide by 153-cm (5-ft) long (8 mesh to the cm) horizontal screen was built to fit into a concrete lined, trapezoidal irrigation ditch as shown in Figure 7. The screen was installed just below a 30-cm (12-in) high metal check dam giving a 10-cm (4-in) drop from the folded metal edge of the check dam onto the screen. With a flow of 20 lps (0.7 cfs) this was not enough drop to induce proper cleaning action. To create more oscillation and turbulence in the installation, a vortex-shedding technique was introduced. This was accomplished by placing a length of 5- x 10-cm (2- x 4-in) board immediately above and slightly upstream of the check dam (Figure 8). The location of the board was adjusted to produce oscillations of about 2/sec. The screen prevented all plugging of siphon tubes which had been plugging at a rate of about 25% every 4 hours. The trash was removed from the screen twice each day. A paddle wheel probably could have produced the same result.

Circular Horizontal Screens

Observations on the effect of turbulence on the efficiency of trash screen operation led to the design of a circular, center-fed horizontal trash screen (Figure 9). Water is discharged from a vertical pipe extending through the center of the circular screen and allowed to spill over the screen. Trash caught on the screen was moved to the outside edge of the screen by the action of the water. The screen is supported on the outside edge by a section of 75 cm (30 inch) diameter, concrete pipe which is set vertically in the ground. The water passing through the screen is collected in the large pipe section and flows to the irrigation system via the pipe shown at the right of the figure.

Figure 10, taken at 1/60 sec, shows a flow of 34 lps (1.2 cfs) using a 20-cm (8-in) diameter inlet pipe and a 75-cm (30-in) diameter screen where the underground components are arranged as shown in Figure 9. Since the vertical section of the 20-cm diameter inlet pipe was short, the flow velocity was greater on the outside of the pipe bend and most of the flow spilled over that side of the screen. To obtain a more symmetrical discharge from the outlet pipe, the deflector vane indicated in Figure 9 was installed. This vane induced a more symmetrical flow and increased the turbulence on the screen as indicated in Figure 11 (photo taken at 1/250 sec). The turbulence is more obvious in the photo (Figure 12) taken at 1/500 sec with the vane in the pipe. Several photographs, such as Figure 12, taken at high shutter speed, show the turbulent character of the water with turbulent cells of different velocities and directions which hit the screen at continuously varying angles. This water action results in a rapid migration of organic matter off the screen.

Two of these "turbulent fountain" type screens were field tested during the 1981 irrigation season for a period of about 50 days. These screens operated as designed and did not require cleaning when turbulent flow

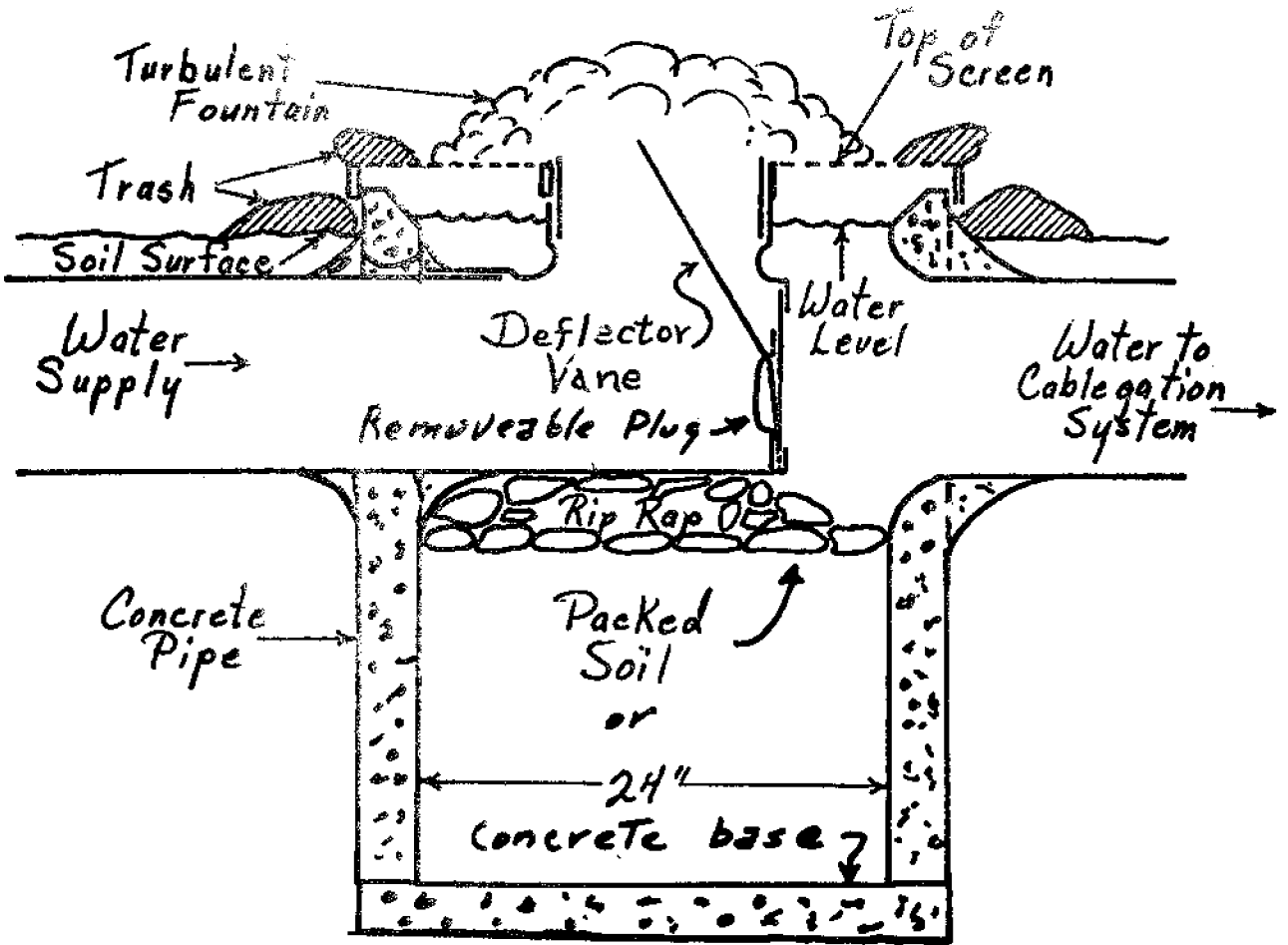


Figure 9. Circular, center fed, horizontal "turbulent fountain" type trash screen.



Figure 10. Moderately turbulent unsymmetric flow with vane out of fountain.

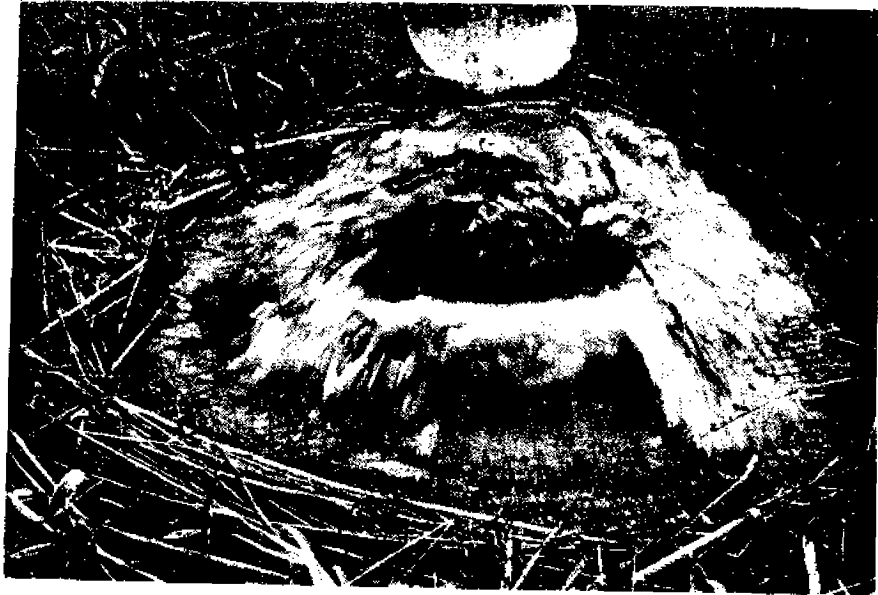


Figure 11. Violently turbulent symmetric flow with vane in fountain.

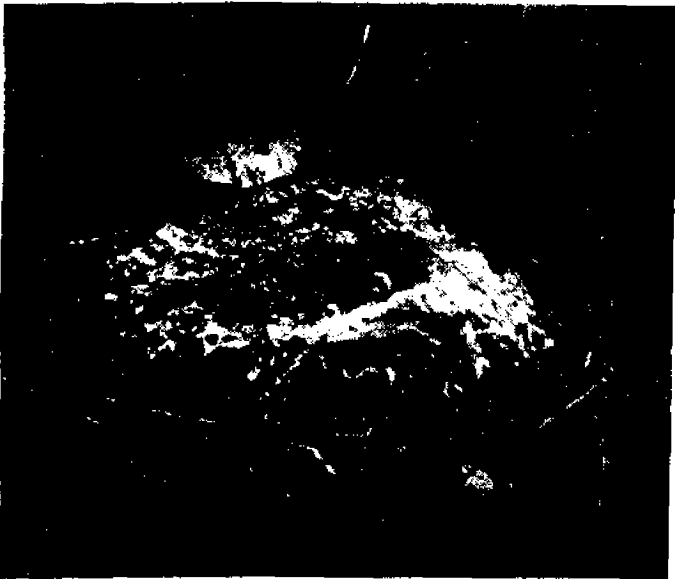


Figure 12. Violently turbulent fountain with photo at 1/500 sec.

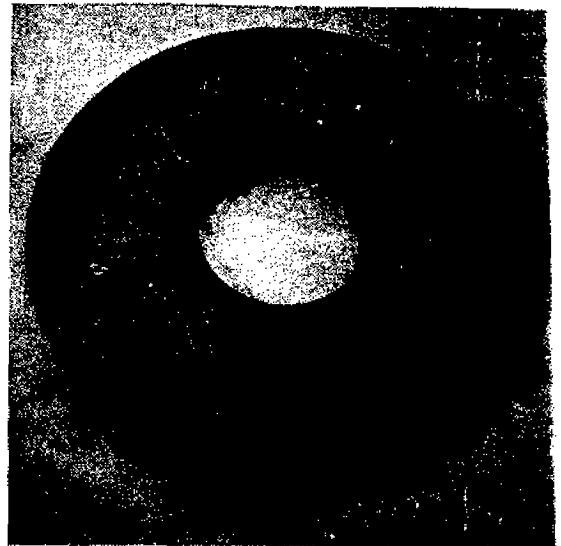


Figure 13. Metal framed screen lying in snow after use for one season.

was maintained. However, when the flow through the screen was reduced from 34 lps (1.2 cfs) to 7 lps (0.25 cfs), the turbulent action of the water was practically eliminated and the screen clogged within 8 hours.

The screen for these "turbulent fountain" type trash screens was 16 mesh/in aluminum window screening supported by 1.25 cm (1/2 in) mesh hail screen. This was supported on a 1- x 3/16-in strap iron spoked frame having 8.1- and 30-inch concentric hoops on the inside and outside (Figure 13).^{*} The outside hoop is supported on the concrete pipe structure.

The performance of the first turbulent fountain screen was evaluated in the field with the inlet pipe extending 1.25 cm (1/2 in), 2.5 cm (1 in) and 5 cm (2 in) above the screen. The amount of trash remaining on the screen was not significantly different under these three conditions when using the 34 lps (1.2 cfs) flow rate. Consequently the inlet pipe was fixed at 1.25 cm (1/2 in) above the screen for the remainder of the season. Under these conditions, a supply head of 12.5 to 15 cm (5 to 6 in) maintained above the screen level created the desired turbulence in the "fountain."

A second "turbulent fountain" screen was installed during the 1981 irrigation season. This screen and supporting vertical pipe were 90 cm (36 in) in diameter rather than the 75 cm (30 in) size. The larger screen resulted in less water spattering outside the vertical supporting stand with less water loss and is recommended for flows of approximately 35 lps (1.25 cfs). However the spill off the 75 cm screen was estimated to be less than 1% of the total flow. The 90-cm diameter screen has nearly 50% more screen area than the 75-cm (30-in) diameter screen. The cost of materials for these installations was about \$170 for the 90-cm diameter screen and \$150 for the screen 75 cm in diameter.

Conclusions

Horizontal screens can be made to operate on a continuously self-cleaning basis. The taut screen concept, augmented by turbulence induced by system design or external means such as flow operated paddle wheels or vortex shedding was used successfully to remove trash and weed seeds from irrigation water. The circular "turbulent fountain" type screen appeared to do a satisfactory job of self-cleaning and worked well in a low head-loss situation. It is well adapted to inlet structures feeding gated pipe systems. Self-cleaning rectangular or circular horizontal screens of the type shown in this paper are relatively inexpensive and are an excellent investment for farmers who have appreciable trash in their irrigation water.

References

1. Bergstrom, W. 1961. Weed seed screens for irrigation systems. PNW Bulletin #43, March.

^{*} These screens were manufactured by Dilworth Welding and Machine Shop. Hansen, Idaho 83334.