Self-Cleaning, Non-Powered Trash Screens for Small Irrigation Flows

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This article is reprinted from the TRANSACTIONS of the ASAE (Vol. 28, No. 1, pp. 113-117, 1985)
Published by the American Society of Agricultural Engineers, St. Joseph, Michigan

ELIMINATION of trash in irrigation water supplies is becoming a more important consideration in surface irrigation systems. When irrigators used earth distribution ditches and sod cutouts they seldom had a problem with trash. With increased use of siphon tubes and gated pipe and their smaller outlets, trash has become a real problem to the irrigator. Resetting siphon tubes or cleaning gate openings can be a major task. Uneven, inefficient irrigation resulting when furrow streams are not kept at the desired flow rate hurts yields. With the development of "cablegation" system automated gated pipe (Kemper et al., 1981) irrigation, trash removal became a priority need.

Many screening devices have been developed over the years. Mechanical self cleaning screening systems generally utilize moving brushes. The brushes may be either water power or use an electric motor. Water driven paddle wheel type screens, designed to fit in concrete ditches have also become available. Humpherys (1983) recently developed a hydraulically cleared and powered, rotating wheel type screening system. Mechanical screens may have problems with wear of bearings, chains, screens, and brushes due to the silt and sand in most irrigation waters. The screens also have been unable to handle some types of trash found in irrigation waters.

Material found in irrigation water which will plug a siphon tube or a gated pipe outlet has been collectively labeled "trash." Included are live and dead plant material, fish, snails, worms, insects, aquatic plants, moss, algae, and miscellaneous materials such as plastics and aluminum cans. Plant materials range from tree limbs to large and small weeds, burned particles, mowed grasses and weed seeds.

At certain times of the season much of the trash in the system will consist of snails and snail eggs. A snail shell is often large enough to plug a gated pipe opening. Fish are also found in most canal systems. In southern Idaho systems may have carp, catfish, trout, and various breeds of minnows. Earthworms and many types of insects are also found.

Aquatic weeds such as sago pondweed and water milfoil as well as moss and algae are present in some waters. The growth of these plants has increased greatly in the past few years in southern Idaho waters apparently due, in part, to the increase of nutrients such as nitrogen and phosphorus in irrigation water supplies. Sago pondweed (*Pomatogeton pectinatus* L.) is a particularly difficult problem for some irrigators. Increasing herbcide costs and environmental considerations have almost prohibited the use of chemicals to control these plants in canal systems.

Some laterals and farm ditches may yield silt, sand or caliche particles. Silt usually appears to be a temporary problem but some laterals discharge sand or caliche particles continuously. Silt is probably more of a problem toward the ends of laterals which also serve as runoff collectors.

Three different screen configurations are described here: (a) the horizontal rectangular screen; (b) the circular, center fed "turbulent fountain" screen (Kemper and Bondurant, 1982); and (c) an instream, submerged screen. The mode of operation to remove trash, screen construction, and field test results are presented.

THEORY OF OPERATION

Bergstrom (1961) described a flat non-powered screen developed for use in the Columbia Basin area. This screen system used a taut screen placed horizontally under an incoming flow at the farmer's turnout. This screen system, used with varying degrees of success, is produced commercially. Tests of these screens, conducted at the Snake River Conservation Research Center, showed that the cleaning ability of a screen was greatly improved by providing a firmer support for the screen and by increasing the amount of turbulence in the water as it hits the screen. In many installations, additional screen support and increased turbulence were found to be the difference between success and failure of screen operation. If the support for the screen is sufficient, the screen does not need to be taut. Firm support can be obtained by using flat, expanded metal mesh to support the screen. The expanded metal mesh is then supported on screen frame members usually not more than 0.61 m (24 in.) apart. Turbulence can be created in a drop structure above a screen by using a turbulence generating bar. The mechanism involved is vortex shedding and is a function the size and placement of the obstruction and the Reynolds number of the flow. It is promoted by having the water flow around fairly sharp edges of flow obstruction. An angle iron with the open face upstream has been found to be the most practical device for turbulence generation. By placing the angle iron above and upstream of the check board vortices having an oscillatory period of about one-half second can be created (Fig. 1). The same effect has been created in concrete ditches using a 2 in. x 4 in. board placed just above and upstream of the check where the water spills onto the screen (Fig. 4).

More turbulence is present in a flow sheared on all sides such as flow issuing from an orifice than is present in flow over a weir where a free surface is present. Flows from an orifice type turnout therefore may not need

Article was submitted for publication in May, 1984; reviewed and approved for publication by the Soil and Water Div. of ASAE in November, 1984.

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Fig. 1—Oscillatory, vortex shedding turbulence caused by an angle iron inserted in the flow.

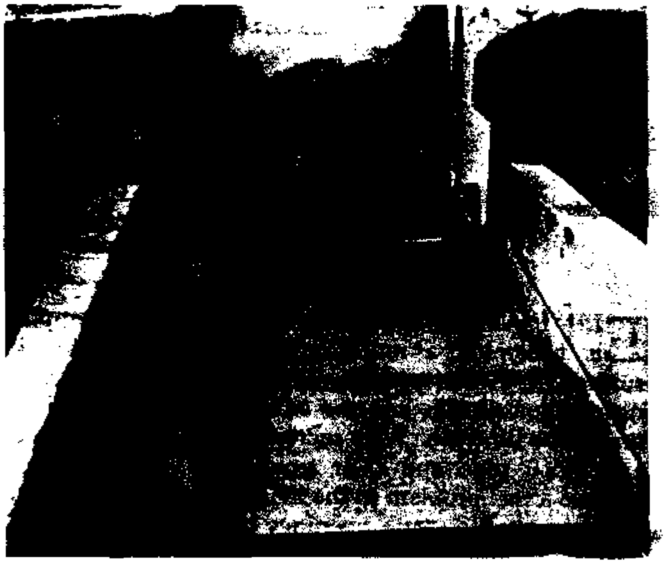


Fig. 3—Paddle wheel placed to interrupt flow from a turnout.

additional turbulence.

In addition to turbulence a certain amount of impact force is necessary to make the flat, horizontal screens operate successfully. The minimum drop onto a screen is about 0.25 m (8 in.) for satisfactory operation. Having less drop onto the screen may require use of a paddle wheel to chop up the flow and create more turbulence.

Screens should be placed horizontally. If the screens are sloped toward the water source, the force of the water will not be able to move the trash. If the screen is sloped away from the source, trash will settle out and the water will flow over it, rather than through the screen.

HORIZONTAL RECTANGULAR SCREENS

Horizontal rectangular screens can be used successfully in many screening situations. A screen area of 4 to 6 $m^2/m^3/s$ (4 to 6 ft^2/cfs) is recommended. The screen is placed horizontally under a drop or check structure preferably so that the water falls at least 20 to 25 cm (8 to 10 in.) onto the screen (Fig. 2). The action of the water on the screen moves the trash forward and keeps an area of the screen open for the water to flow through. The self-cleaning action of these screens has been made more reliable by creating turbulence in the water. Paddle wheels have been used successfully where fall onto the screen is less than about 0.1 m (4 in.) and also to break up excess forward velocity of the water (Fig. 3). Paddle wheels, however, are subject to stopping if the trash material is too large.

The flat, horizontal screen was also adapted to concrete lined ditches (Fig. 4) by placing the screen below a portable check dam. Turbulence was created for improved operation by using a turbulence generating bar (Fig. 5) or by using a second, lower portable dam placed about 0.3 m (1 ft) downstream from the first dam. Enough variation exists in most concrete ditches that screens must be individually sized to the particular location.

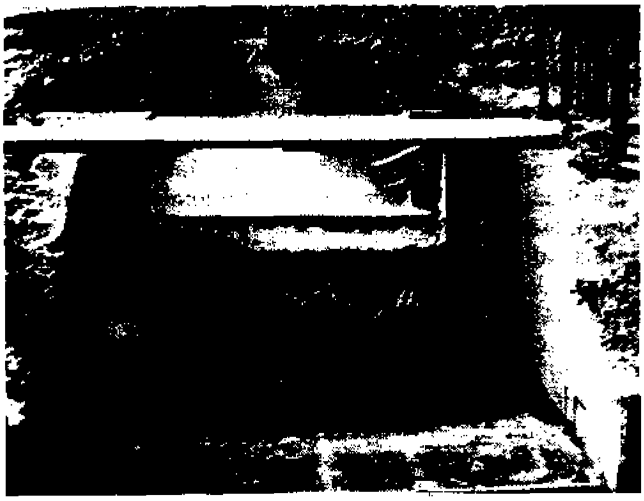


Fig. 2—Horizontal, rectangular trash screen placed in a check structure.

Fig. 4—Rectangular, horizontal screen for concrete ditch.

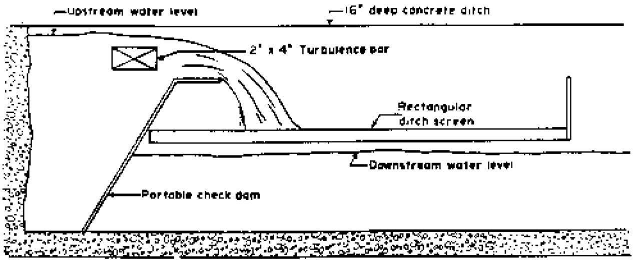


Fig. 5—Side view of trash screen for concrete ditch.

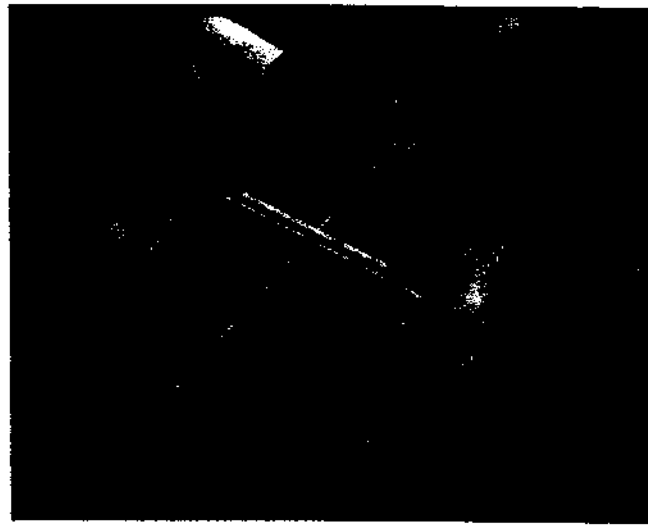


Fig. 7—Galvanized sheet metal base for "turbulent fountain" screen.

TURBULENT FOUNTAIN SCREENS

The turbulent fountain screen format was devised to fit a pipe discharge supply situation (Fig. 6). A pipe tee was fitted onto the end of the pipe and a circular screen was devised to fit around it, thus making a center fed screen. Because the riser was short most of the flow was discharged on one side of the screen. A deflection vane was devised to redistribute the flow evenly and to create turbulence. Adequate turbulence will be generated if an exit velocity of 0.75 m/s (2.5 f/s) is maintained in riser pipe. A head loss of 0.25 to 0.30 m (8 to 12 in.) will create adequate turbulence and allow the screen to clear the downstream water level. It is recommended that a 0.6 m (2 ft) high riser be used. This can be done without sacrifice of head by lowering the incoming pipeline just ahead of the screen. Using a blocked end tee and a 0.6 m (2 ft) riser will help create turbulence and distribute the flow evenly on the screen. Stands for the turbulent fountain screen have been constructed by forming a circular structure out of galvanized sheet metal, large concrete pipe, stock tanks or CMP, and pouring a concrete floor between the riser and the sheet metal (Fig. 7). The trash will accumulate in a circular pattern on the screen and will continue to move to the edge of the screen unless removed by hand. Provision must be made to keep the trash from falling back into the outflow stream. Recommended screen sizes are given in Table 1. The turbulent fountain screen can also be built in a rectangular format (Fig. 8). Screens for larger flows have not been tested although they should work as well.

Turbulence is created in the "turbulent fountain" screen by proper design. An exit velocity of at least 0.75 m/s (2.5 f/s) will create adequate turbulence. Adequate turbulence may be created at low flows in a turbulent fountain type screen by restricting the exit flow area and thus creating a higher exit velocity. This is accomplished at the cost of some additional head loss. A temporary restriction can be made using an orifice fastened over the end of the riser pipe.

TABLE 1. RECOMMENDED "TURBULENT FOUNTAIN" SCREEN SIZES

Flow rate		Screen diameter		Riser pipe diameter for (2.5 f/s) 0.75 m/s velocity	
m^3/s	cfs	m	in.	m	in.
0.03	1	1.06	42	0.20	8
0.09	3	1.52	60	0.30	12
0.12	4	1.83	72	0.38	15
0.15	5	2.13	84	0.46	18

Fig. 6—"Turbulent fountain" screen.

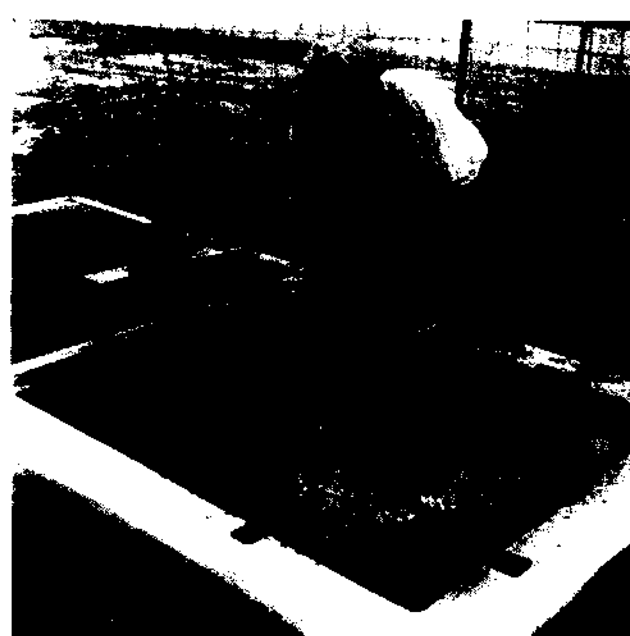


Fig. 8—A rectangular format "turbulent fountain" screen.

Fig. 9—An in-stream trash screen.

INSTREAM SCREENS

An instream trash shedding screen was developed with laboratory flume tests. The tests indicated that it was possible to move trash to the surface of a flow stream by centrifigual force as is used in a cyclone type screen. The water was accelerated up a ramp which had an intake screen shaped to fit the nappe of the water discharging off the end of the ramp. This worked well in the laboratory flume using short term tests with chopped bean straw and plastic baler twine used to simulate trash and pondweed.

Several experimental in-stream screens were placed in the field for the 1983 irrigation season (Fig. 9). These screens were constructed by using a pipe base and a nappe shaped screen attached to the upper downstream quarter of the pipe extending across the flow and discharged through a bulkhead into the turnout. Some screens had all the flow directed over the top of the screen and others had flow over the top and under the screen also.

MATERIALS AND CONSTRUCTION

All of the trash screens consist of three main parts: a frame, a support screen, and a final screen. The flat, rectangular screens have an angle iron frame to which a support screen of 16 ga. flat expanded metal mesh is welded. The final screen was attached with wire or a bolted down strap. The frame and the expanded metal mesh support screen can be protected with a rust proof coating. The expanded metal mesh was supported on a 0.6 m (2 ft) maximum span in one direction. Screens up to three feet wide were made with frames of 2.5 x 0.4 cm (1 x 1/8 in.) angle irons. Larger rectangular screens were made using larger angle iron for frame. The screens for concrete ditch were made with 1.9 x 0.4 cm (3/4 x 1/8 in.) angle iron. The angle iron was placed with the open angle facing out and down so that there was a flat top surface for the support screen and the angle iron also would fit the 45 deg face of the ditch.

The turbulent fountain screens are constructed with a wagon wheel frame format with the inner and outer hoops and six support spokes made of strap iron. The final screen was usually fastened in the center by using a removable inner lock hoop of strap iron which was forced into the center hole, binding the screen in place. The screen can be wired down at the outside, tied on or strapped down with an outer lock hoop.

Instream screens were built using a pipe base. The upper half of the downstream face was removed and the nappe shaped screen attached to this pipe. The screen itself was constructed by attaching the final screen to a roll formed piece of flat, expanded metal mesh support screen. This screen combination was usually bolted to the nappe shaped frame.

Screen materials of various composition and mesh were used. Aluminum, bronze, stainless steel, and plastic woven screenings have been used successfully. Perforated, polished stainless steel screen has also been used. Screen opening sizes from 1.6 to 0.05 mesh (4 to 50 openings/in.) have been used. The recommended screen for the flat rectangular and turbulent fountain screens is 8 openings/cm (20/in.). For the instream screens 1.6 to 2.4 (4 to 5/in.) mesh is recommended.

RESULTS AND DISCUSSION

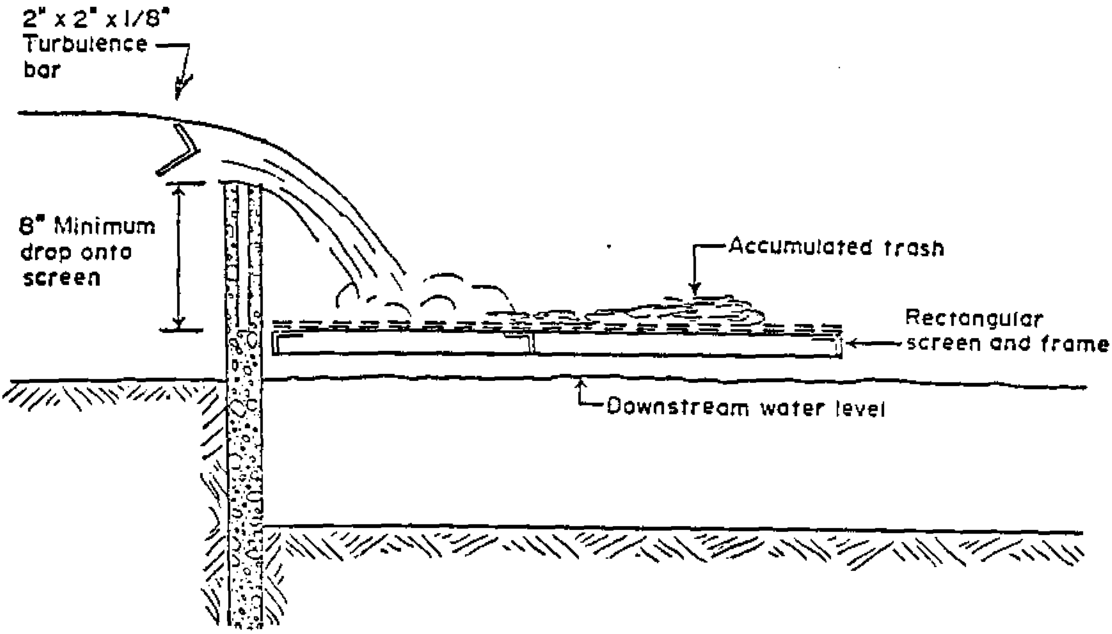
Excellent performance has been obtained in screening trash and weed seeds from irrigation water using horizontal screens. If adequate turbulence is present the screens are self cleaning. If a drop is provided both the rectangular and the turbulent fountain screens will continually push trash off the edge of the screen. If this is not possible, then the screen will have to be cleaned, possible daily, depending on the amount of trash on the screen.

Most functional failures can be traced to insufficient drop and/or turbulence. In some situations a fine moss which grows rapidly on the screen has caused plugging because it catches sediment particles and plugs the screen. In these cases the screen may need to be brushed with a steel wire brush. In general, where enough drop is available, this will not be a problem as the moss will be beat off the screen. In some screens it has been necessary to remove the screen and let it dry thoroughly to remove the moss. A final screen which could easily be removed and scrubbed on both sides would be desirable.

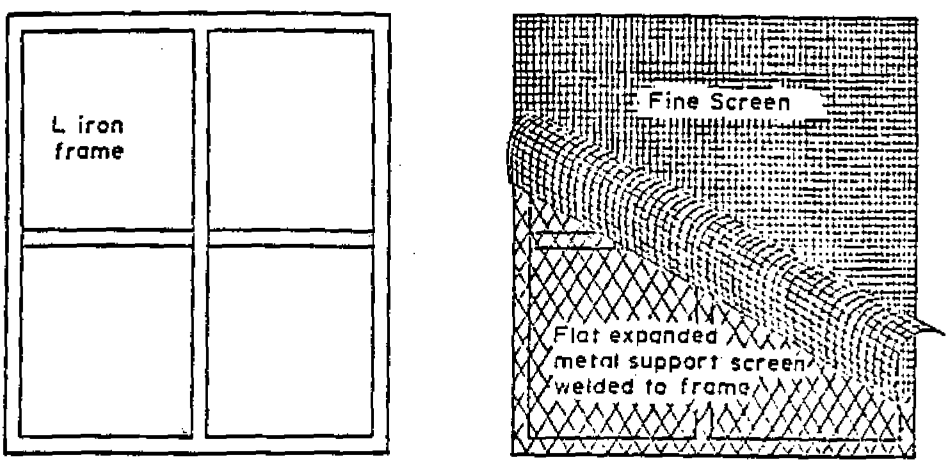
A screen having eight openings/cm (20/in.) was found to be about optimum for most applications. Larger openings allow plant stems to plug the screen while smaller openings can be bridged by calcium deposits or soil particles. If enough energy is available in the water, this material probably will not plug the screen.

Seven in-stream trash screens were built and installed for the 1983 irrigation season. Four of these performed satisfactorily and three did not. A larger screen size, 2/cm (5/in.), was used on those which performed satisfactorily. This still screens out those materials which will plug gated pipe or siphon tubes. Two of the in-stream screens which did not function satisfactorily had 8/cm mesh screens and probably would have operated satisfactorily with 2 or 2.4 openings/cm screens. These two turnouts were in a lateral which had a considerable flow of caliche particles which the farmer wished to screen out. Both caliche and moss were present and caused problems. A turbulence generation bar was used with limited success.

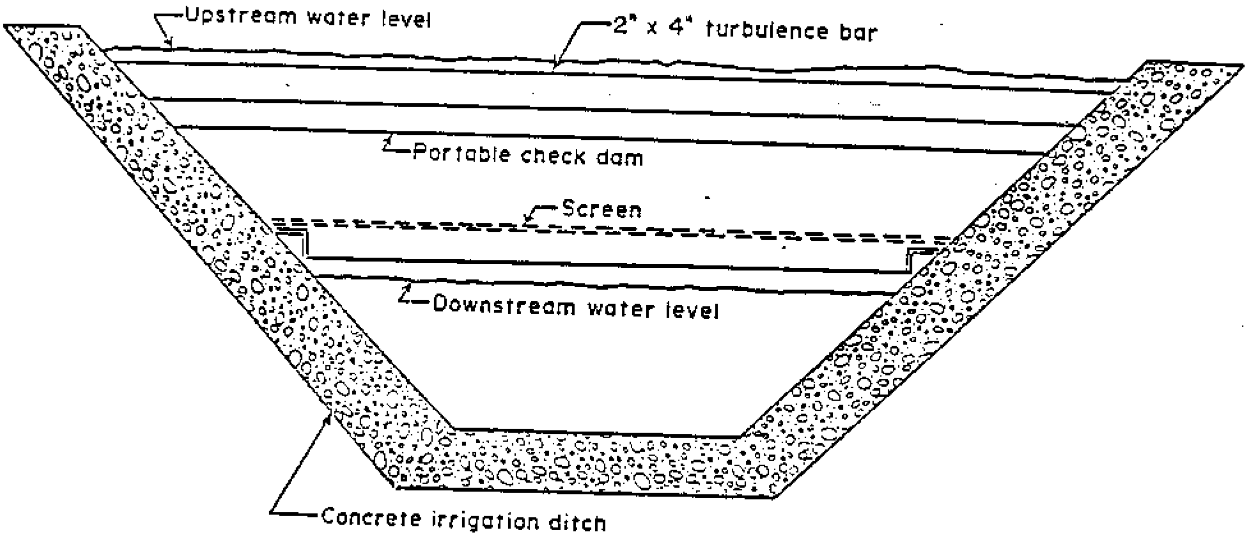
The most successful of the in-stream screens was one which diverted 0.12 to 0.21 m^3 (4 to 7 cfs) from a canal flowing 0.90 to 2.1 m^3/s (30 to 70 cfs) with a head loss of 5 to 15 cm (2 to 6 in.). Four turnouts were placed on the



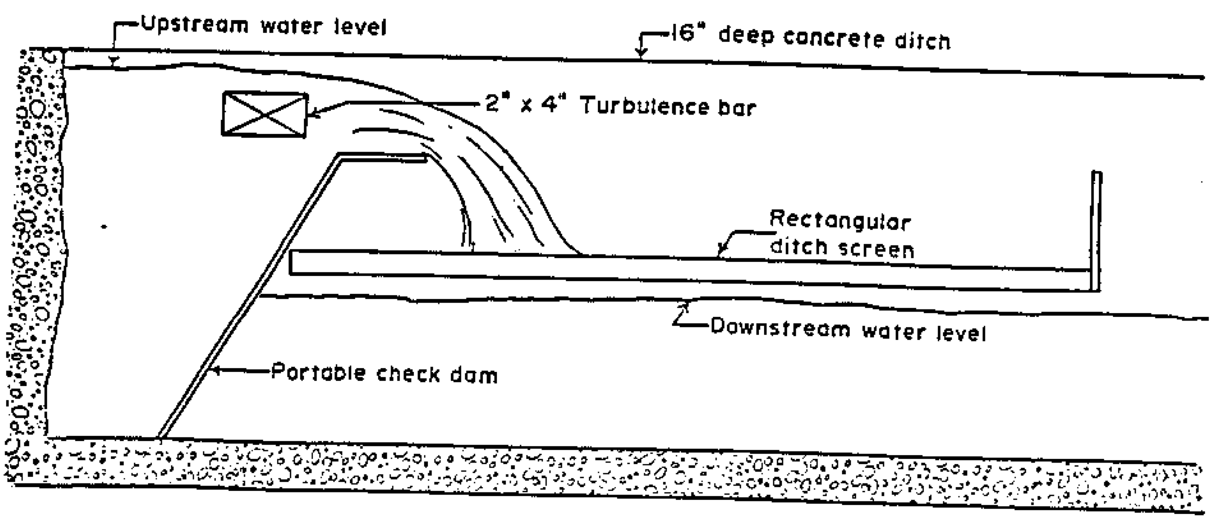
Side view of trash screen below check or drop structure.



Screen details



Cross sectional view of screen in concrete ditch



Side view of screen in concrete ditch