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A Prefabricated Flume for Gaging Ephemeral Streams

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The need for accurate water inventory data is particularly important as multiple use management of wildland resources intensifies. Designing devices to measure water yields from ephemeral streams presents particularly challenging problems for research to solve. Such devices should include, of course, the use of the most economical materials and methods. Fiberglass is one such low-cost material that warranted testing under field conditions. Its use in boats and for automobile body repairs is widely known--as is its durability. This Note outlines the steps taken to reduce costs by fiberglassing plywood panels and prefabricating other components of a trapezoidal flume (fig. 1).

A concrete version of the flume has been in operation for several years, and has worked satisfactorily. Based on the field experiences gained with the concrete flume, it was decided

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Figure 1.--A modified trapezoidal flume made with prefabricated components. Dimensions are 5 feet wide in the approach section (foreground), constricting to 1 foot in the measuring section. Sidewalls are at 30° from the horizontal, and the flume is on a 5-percent slope. Depth is 3 feet, accommodating a maximum discharge of 222 cfs.

to use this model for gaging five streams in New Mexico, but change construction details to reduce costs.

Construction Details for Fiberglassed Flume

Prefabricated Components

Three-quarter-inch exterior grade Douglas-fir plywood was cut and spliced to make the sidewall panels. A coating of polyester resin was applied, and strips of 44-inch-wide, 7-1/2 ounce, Volan chrome finish fiberglass [3] were laid over the wood with a 4-inch overlap (fig. 2). Resin was coated over the fiberglass and squeegeed to work out entrapped air and to insure a solid bond.

Catalyst was added to the resin just before it was applied, to speed the setting. Ideally, room or outdoor temperature should be 70°F. or higher. In lower temperatures, more catalyst should be added. A mixture of 12 cubic centimeters (cc.) of catalyst to 1 quart of resin did not harden before application was completed at shop temperatures around 65°F. (With experimentation, proper combinations can be worked out.) Unskilled men can easily apply the fiberglass and resin. If mistakes are made, the material can be sanded down and the process repeated.

Panels were fiberglassed on both sides and the edges were sealed with resin to prevent decay. When more than one coat of fiberglass was applied, the surface receiving the second coat was allowed to harden, then sanded lightly for the application of new material.

[3] *The mention of trade names or commercial enterprises is solely for necessary information; no endorsement by the U. S. Department of Agriculture is implied.*

Figure 2.--Fiberglass coating being applied to the plywood.

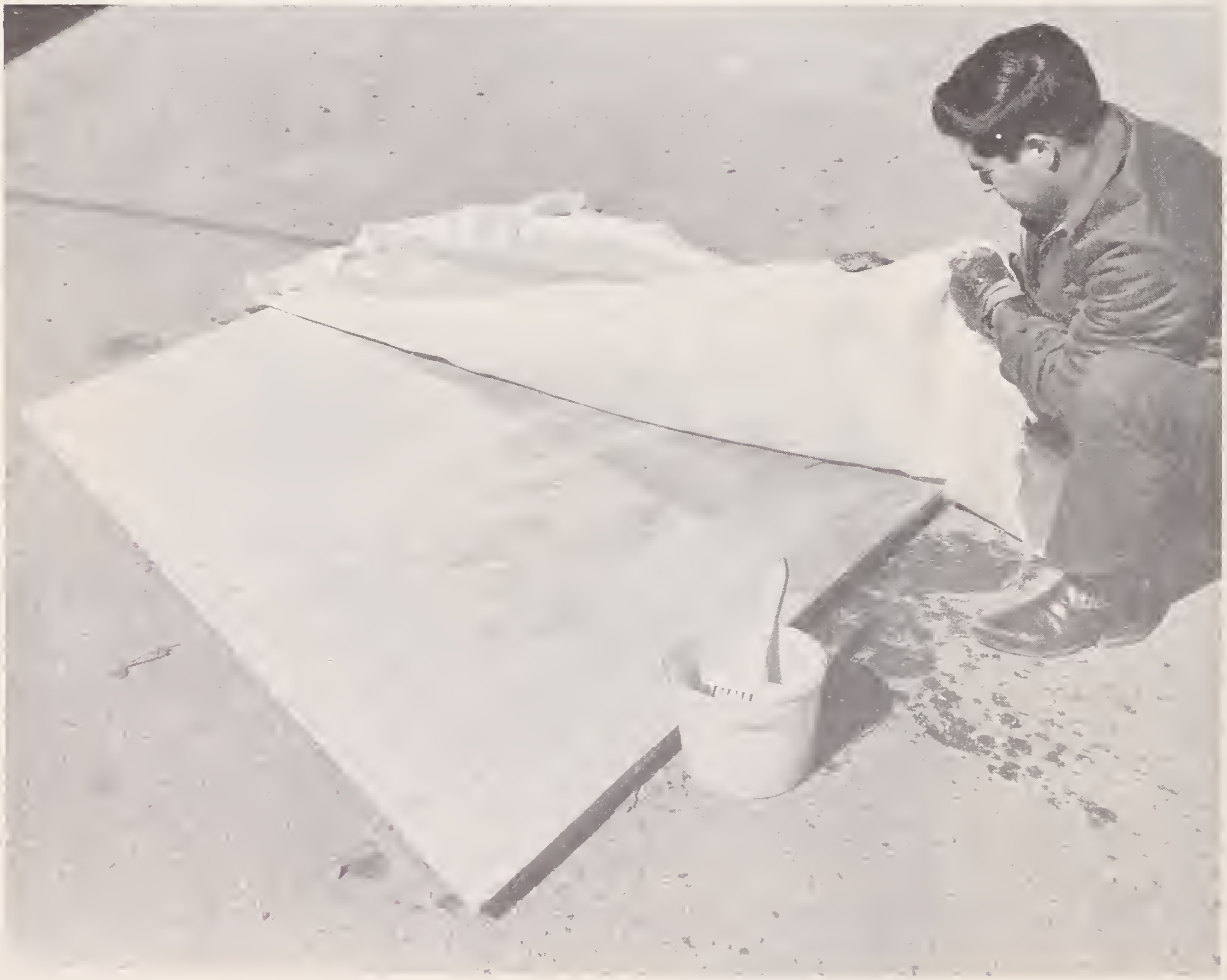
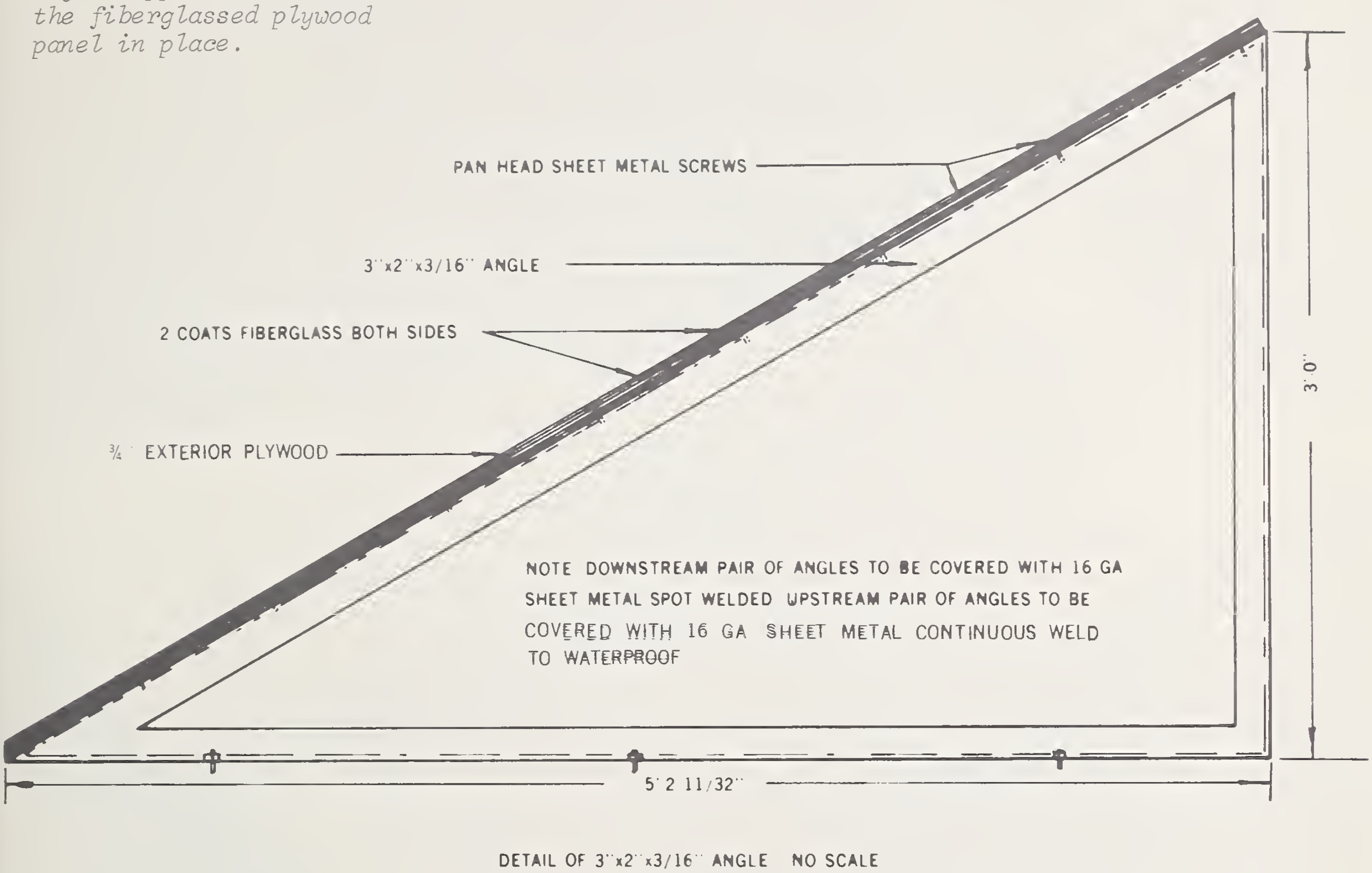


Figure 3.--Detail of steel angle support walls with the fiberglassed plywood panel in place.



The angle iron used for the support walls was cut and welded to a 30° angle (fig. 3). Upstream steel support walls had a continuously welded cover plate of 16 gage steel to insure a watertight seal in the upstream face. The 16 gage steel cover plate on the downstream support walls was spot welded to hold the backfill.

The intake box was made from a steel box beam (fig. 4), 12 by 4 inches, by 3/16 inch thick. The front face, cut at 30° to fit to the flume sidewall, has a 1/4-inch slot running up its full length. The face plate is removable to facilitate cleaning out the inside. A 1-1/4 inch nipple was attached at the back of the box to connect, by pipe, the stilling well and the intake box. The flanges around the intake box which hold the sidewall panel were carefully placed, for it is important that the face of the intake box be set flush with the flume sidewalls. Protuberances or indentations could cause separation near the intake, which would result in miscalculation of water depth as shown in the stilling well.

Field Installation

Since scour and uplift pressures can be serious problems with this flume, field sites should be carefully chosen. If the flume is placed on bedrock, scour should not be troublesome. In several locations where such placement was impossible, a diverging section was constructed (fig. 5). Other methods might be employed to minimize scour, depending on field conditions.

A center line and cutoff walls were surveyed and staked after the site was chosen. The upstream cutoff wall was extended well into the streambanks to prevent water from flowing around the structure. All other walls were made just large enough to hold the steel support walls.

Footings were dug to 3 feet, and concrete was poured into the excavation. Cinder blocks were laid, reinforced, and filled with concrete to bring each wall about up to grade. Weep

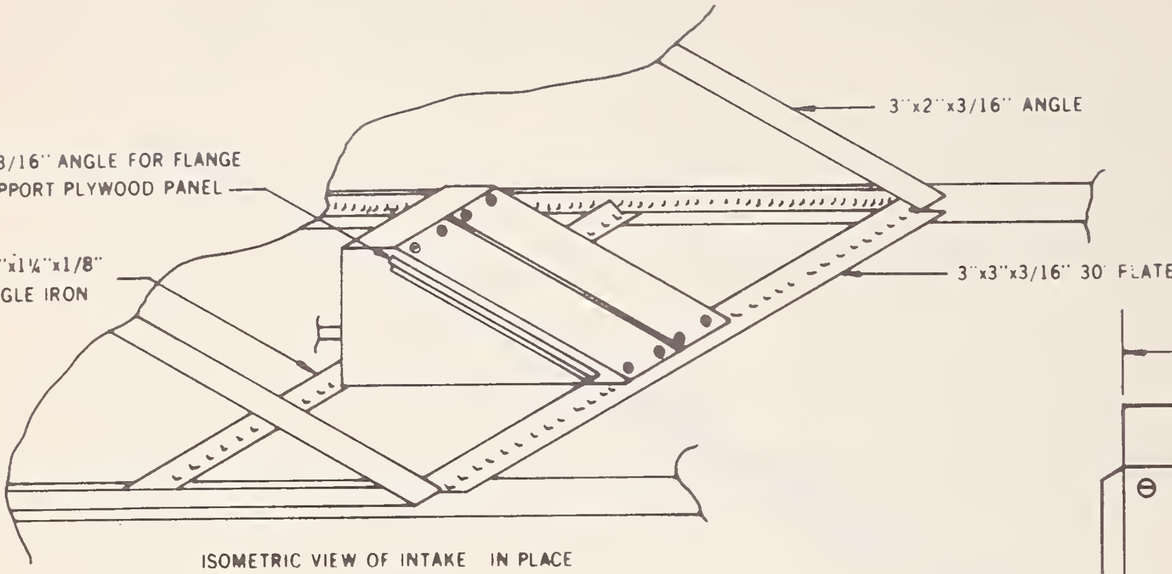


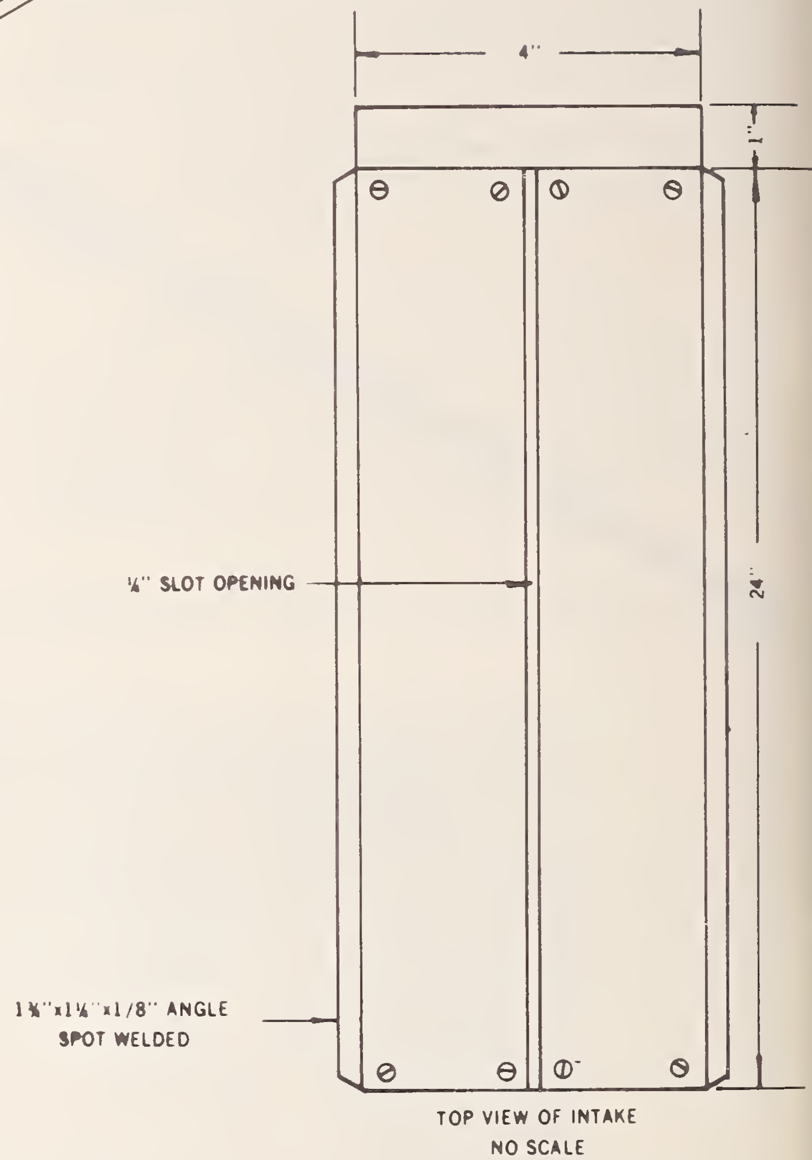
Figure 4.--Detail of intake box.

holes were provided in all but the upstream wall. A 3-inch concrete cap was poured on top of the cinder block to bring the wall to grade (fig. 6). Anchor bolts 1/2 by 6 inches were inserted in the cap to secure the steel support walls and the plywood bottom.

The steel angle support walls were bolted in place. Precut pieces of angle 2 by 1 1/2 by 1/8 inches were welded to connect the tops of the steel angles. Strap iron, 3 by 3/16 inches bent on 30°, was welded to connect the steel angles at the bottom (fig. 7). The intake box was welded to an angle iron support, and the frame formed a monolithic structure that resists uplift pressures.

The upstream cutoff wall was extended into the banks by means of a cinder-block wall. The blocks were reinforced and filled with concrete. Felt coated with roofing plastic on both sides was laid under the steel to insure a watertight seal, and the steel angles were bolted to the block wall. The upstream face of the wall was waterproofed with roofing plastic. The upstream excavation was backfilled with select material and tamped to prevent leakage under the flume.

The fiberglassed plywood panels were attached to the metal frames with 1/4 by 20 by 1-inch self-tapping sheet-metal screws; the joints and screw holes were covered with



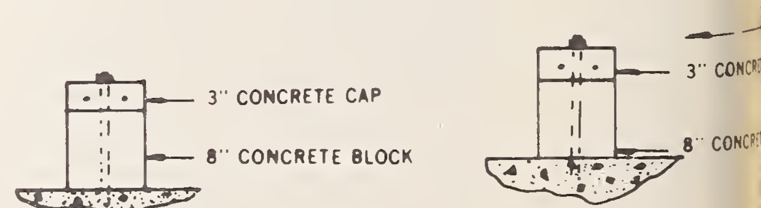
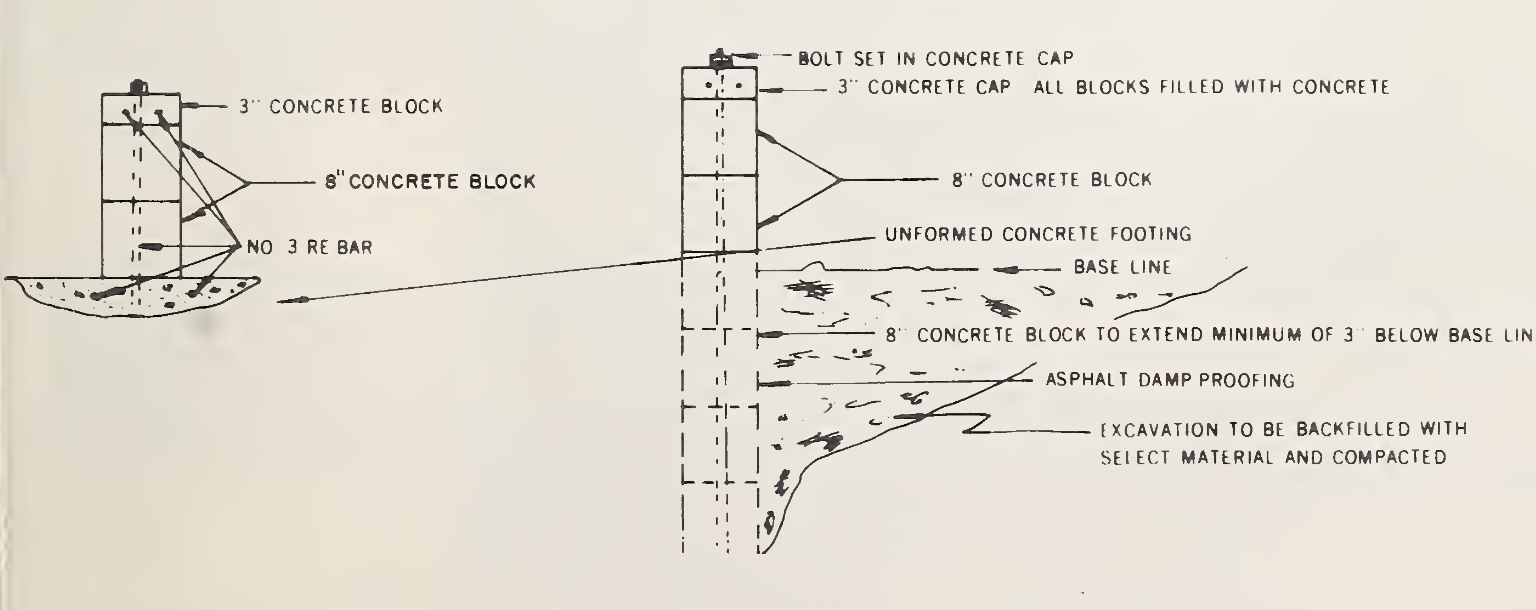


Figure 6.--Cross section of footi
and foundation walls.

Figure 5.--The flume with the diverging section attached to minimize the downstream scour.



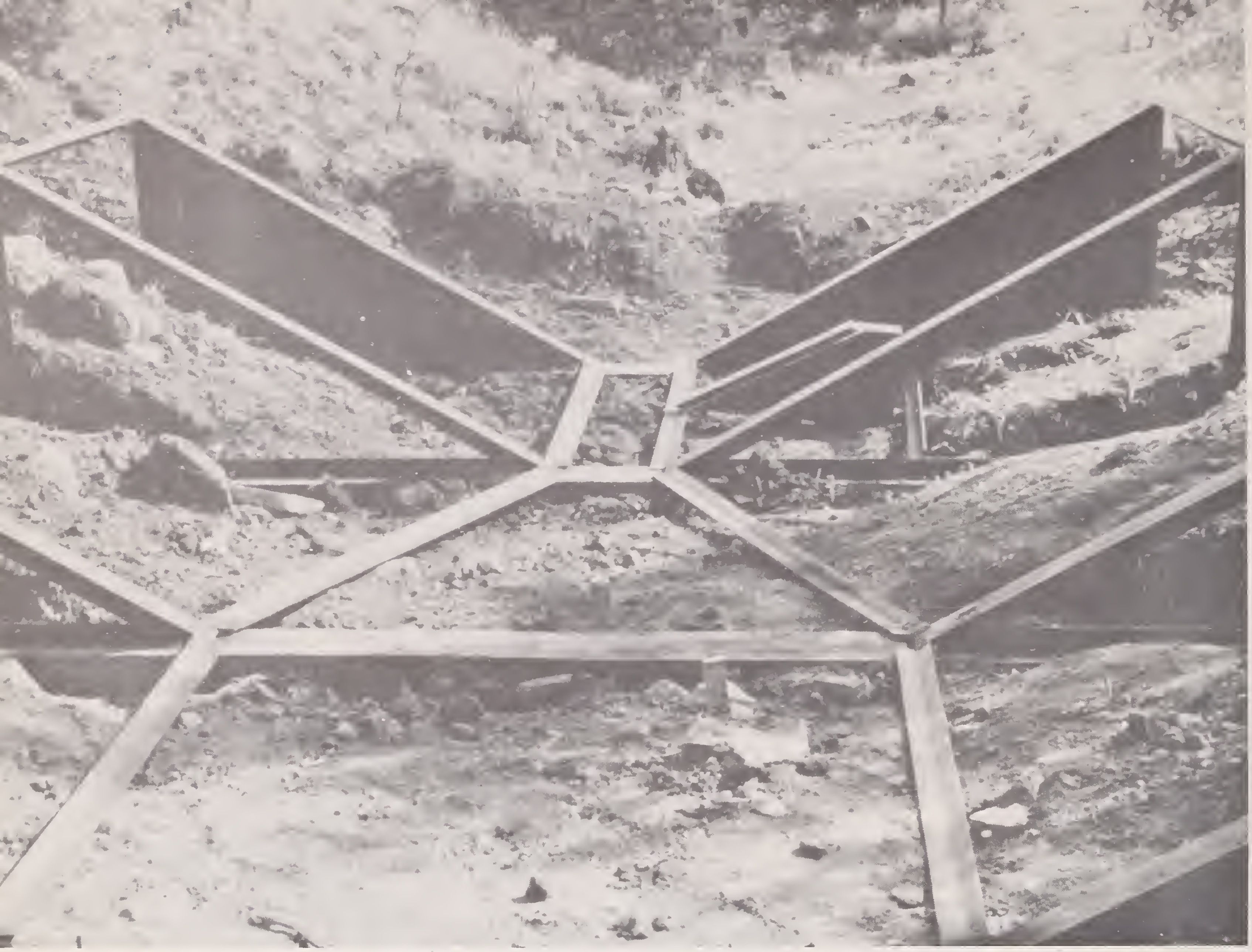


Figure 7.--Angle iron frame prior to attachment of prefabricated fiberglassed panels.

fiberglass in the field. The stilling well was set in concrete, provided with a drain, and connected to the intake box by a 1-1/4-inch pipe set level. The flume should be backfilled with small gravel or other pervious material that will allow any water which gets under the flume to pass through easily. A plywood instrument shelter was then placed on the culvert and the instrument installed.

Maintenance

Should the flume surface erode or should a panel be broken, it is a simple matter to replace the entire panel or to sand the damaged area and fill it with fiberglass. The flumes described here are operated only in summer. If the flume is operated in the winter, freezing problems can arise in the intake pipe, drain, and stilling well unless heat is provided.

Cost

A finished flume, constructed with a 4-man crew in 10 days, cost about $1,500--materials, about $500; labor $800; and the recording instrument, $200 (table 1). When a diverging section was included, material costs were slightly higher, but labor costs were virtually the same.

Table 1.--List of materials for a flume without a diverging section

Item	Quantity	Specifications	Item	Quantity	Specifications
Cement	30 bags	Type I	Re-bars	220 feet 140 feet	No. 3 No. 4
Sand	8 yards	--	Fittings, pipe	--	Nipples, union, couplings--1-1/4 inches
Gravel	12 yards	Small	Lumber for forms		
Roofing plastic	5 gallons	--	Nails for building forms		
Frames, angle iron	8	Prefabricated (15 feet)--3 by 2 by 3/16 inches each	Cinder blocks	150	8 by 8 by 16 inches
Felt	30 feet by 3 inches	90 pound	Bolts, anchor	26	1/2 by 6 inches
Pipe, culvert	1	18 inches by 8 feet, for stilling well	Screws, self tapping	300	1/4 by 1 inch
Pipe, galvanized	8 feet	1-1/4 inches	Plywood	15 sheets	Exterior Douglas-fir, 4 by 8 feet
Strap iron	32 feet	3 by 3/16-inch, bent on 30°	Fiberglass	90 yards	44 inches wide
Angle iron	32 feet	2 by 1-1/2 by 1/8 inch	Resin, polyester	10 gallons	Volan chrome finish, or equivalent
Intake box	1	Prefabricated--12- by 4- by 3/16-inch steel box beam	Catalyst	480 cc.	--
			Acetone	--	Enough for cleanup

Field Experience to Date

Several flumes have received flow since construction. One particular event provided a quick evaluation of the sturdiness and ability of this prefabricated flume to withstand high sediment-carrying flows. The event took place on a 120-acre watershed with highly erosive granitic soils. A high-intensity summer convective storm released 1.57 inches of precipitation in about 20 minutes. The maximum flow was 1-1/2 feet in the flume, with a peak of 38 cubic feet per second (c.f.s.). This flow, and the resulting high sediment load it carried, sheared the downstream sediment basin wall with a resultant loss of some of the sediment in the trap (fig. 8). The 18 tons of sediment that remained, however, were cross sectioned

Figure 8.--A view looking upstream into the sediment basin after at least 18 tons of sediment had passed through the flume in a single flow. (The downstream sediment basin wall failed.) Flume sidewalls were scratched, but there were no dimensional changes.

in the basin after the flow. Boulders, small rock, and sand comprised the bulk of this sediment. No damage to the flume, except for minor scratching of the resin finish, was found. There were no dimensional changes in the flume. The scratched areas were easily re-covered.

Summary

An efficient, low-cost flume can be prefabricated and hauled to the field site for construction. The flume is of a modified trapezoidal design with a capacity of 222 c.f.s. It is accurate over a wide range of flow conditions. Fiberglassed plywood makes up the flume sidewall panels. Other prefabricated components include angle iron support walls and an intake box. Other low-cost materials bring the flume construction costs to about $1500. A four-man crew can construct the flume in about 10 days.

Maintenance costs are low, for the fiberglassed surface can be easily repaired--in much the same manner as automobile fenders and boats are repaired.

Agriculture --- CSU, Ft. Collins