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**DEVELOPMENT OF A FIXED HORIZONTAL SCREEN  
TO PREVENT TRANSBASIN FISH TRANSFER**

**BY**

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# DEVELOPMENT OF A FIXED HORIZONTAL SCREEN TO PREVENT TRANSBASIN FISH TRANSFER

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## ABSTRACT

An irrigation project is being constructed which will result in the transport of water from the Missouri River drainage into the Hudson Bay drainage. To prevent interbasin transport of undesirable fish, a fine-mesh, fixed, horizontal screen is being developed. Laboratory tests are being conducted to evaluate the filtration efficiency of the design using live or preserved fish eggs and larvae; to evaluate hydraulic features of the design, including development of sizing guidelines and optimization of self cleaning features; and to assist in design and development of hardware features, spray cleaning, seal designs, and screen inspection and repair techniques. In addition, operation and maintenance related problems are being evaluated at a field site where fouling and cleaning, corrosion and materials, and accessory equipment are being evaluated. Accessory equipment being tested include traveling screens, vibrating screens, automation devices, and debris handling systems. Maintenance needs, screen wear, and debris type and quantities also are being evaluated. This paper gives a brief overview of some of these activities which will result in a final design.

## INTRODUCTION

The Garrison Diversion Unit of the Missouri River Basin Project of the Bureau of Reclamation is a multibasin irrigation system (Figure 1). Potentially, about 100,000 hectares (250,000 acres) in east-

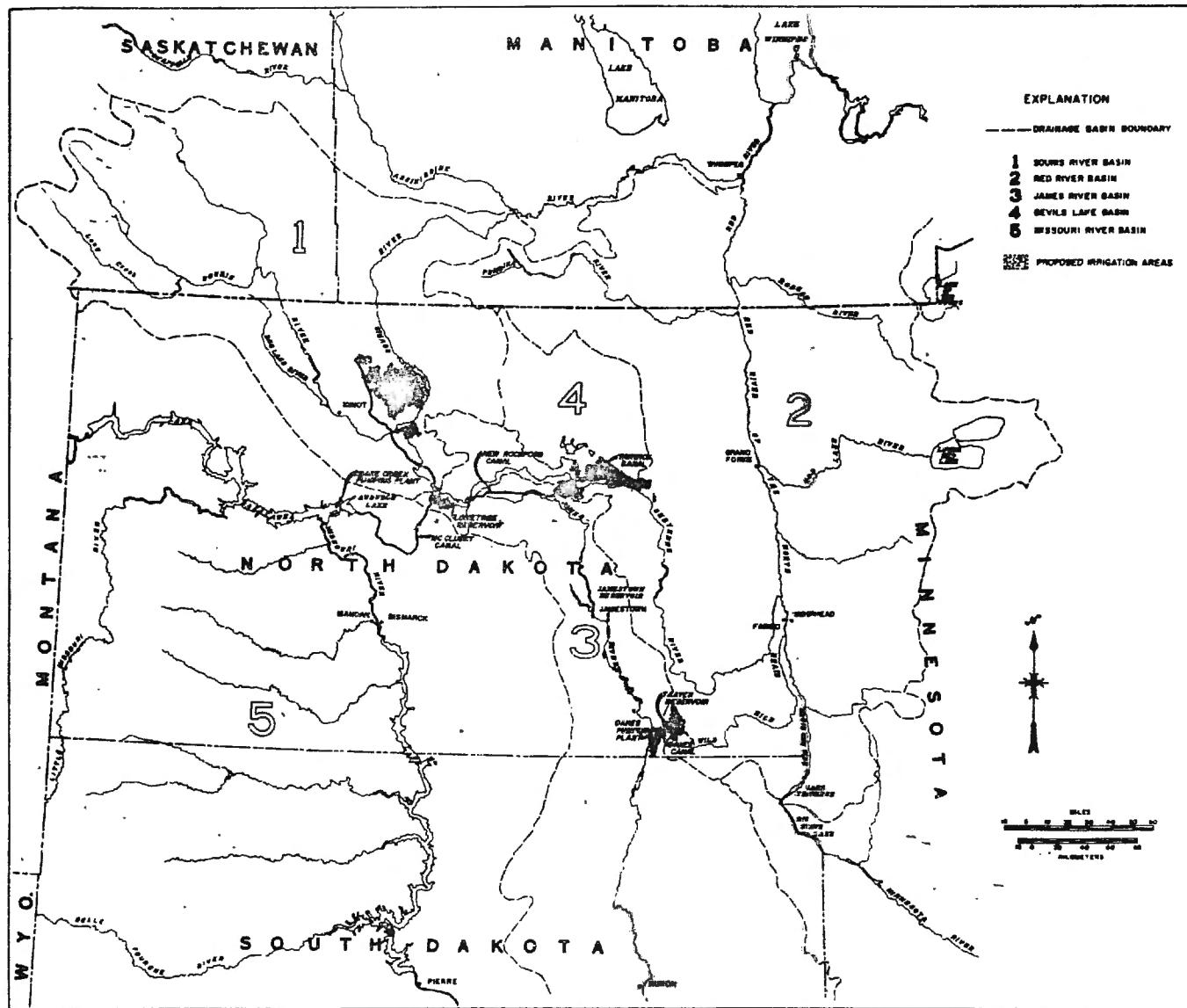
central North Dakota will be served. Up to  $55 \text{ m}^3/\text{sec}$  ( $1950 \text{ ft}^3/\text{sec}$ ) of water will be withdrawn from the Missouri River and delivered to the farmlands through a series of pumping plants, reservoirs, and canals. A portion of irrigation return flows from the project will eventually enter the Hudson Bay drainage.

Canadian officials expressed concern that several undesirable fish species may enter Canadian waters through Garrison Diversion Unit project features and have an adverse impact on sport and commercial fisheries in Manitoba. To address the international concern about introduction of undesirable fish and the problem of preventing or minimizing fish passage, Bureau of Reclamation personnel considered several types of fish barriers. From among the various options available, USBR engineers and scientists selected a fixed fine-mesh screen with a  $5^\circ$  downward slope for intensive laboratory study. Protection or survival of fish were not considerations and were not studied. Fouling, cleaning, corrosion and other operation and maintenance problems are being evaluated at a field test facility in North Dakota.

## MATERIAL AND METHODS

### LABORATORY STUDIES

All laboratory studies were conducted in the Engineering Laboratories of the Bureau of Reclamation's Engineering and Research Center in Denver, Colorado.



**Figure 1. Multibasin irrigation system**

Laboratory efforts concentrated on a sectional model of the proposed McClusky Canal Fish screen (Figure 2). The model simulates a full-scale slice from the final structure. The 0.9- x 3.7-m frame accommodates one full screen panel and allows evaluation of fine-mesh screens, the screen retention system, and the frame seals. Water flows over the screen and drops into the tail box where a large plankton net refilters all water passing through the model. To evaluate design filtration efficiency, about 10,000 eggs and larvae of selected fish species were injected into the flow above the headwall, the model was operated for 45 minutes, and the material collected in the plankton net was examined. A randomized test schedule was followed for studying discharges ranging from 0.085 m<sup>3</sup>/sec to 0.510 m<sup>3</sup>/sec. Tests conducted to date used eggs and larvae of rainbow smelt, Utah chub and carp. Additional tests using eggs and larvae of gizzard shad

will be conducted this spring. Live organisms were preferred for testing; if they were not available, formalin preserved specimens were used. A total of 49 tests have been conducted as of this writing. The model has also been used to investigate hydraulic characteristics of the screen, to test alternative cleaning devices and to study the sealing characteristics of the frame seals.

## FIELD STUDIES

### Test Facility Considerations

A field test facility was constructed at Lake Brecken, near Turtle Lake, North Dakota, in 1979 (Figure 3). The field facility is similar to the laboratory sectional model but is 1.8 m wide and contains two full screen panels. The facility is supplied with water by a feeder canal which branches off the 118 km long McClusky Canal 24 km downstream of the head-

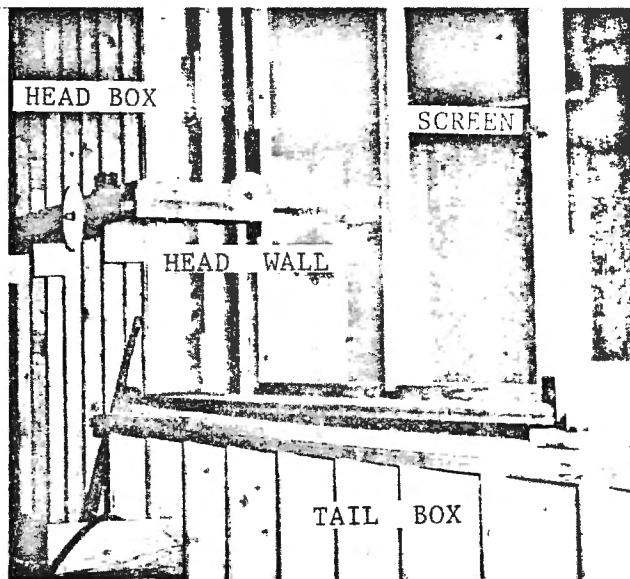
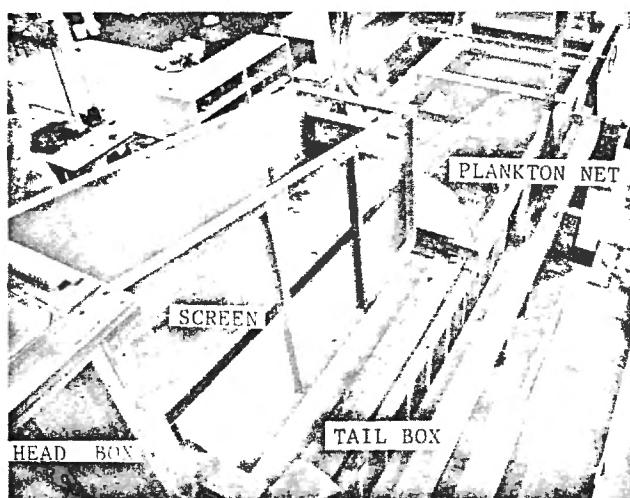


Figure 2. Laboratory sectional model

works. The McClusky Canal is the principal supply works for the Garrison Diversion Unit. The field test facility is primarily being used to study operation and maintenance-related problems, principally fouling and spray cleaning systems, corrosion and materials selection, and accessory equipment evaluation. Accessory equipment being tested includes traveling screens, vibrating screens, automation devices, and debris handling systems. Maintenance needs, screen wear, and debris types and quantities are also being evaluated.

The spray cleaning device tracks upstream and downstream below the screen panels (Figure 4). The spray cleaning device contains a manifold with a series of nozzles that create flat fan-shaped jets positioned to spray up through the bottom sides of the screen panels. Fouling material is disrupted by the spray and swept downstream by the flow over the screens (Figure 5). The spray cleaning system effectively cleaned the screens while the screens

were in operation. Field use allowed testing under more representative debris and fouling conditions than encountered in the laboratory.

Corrosion and materials selection were also studied. Two 70-mesh screen materials were tested in conjunction with the stainless steel frames. Stainless frames were selected to minimize corrosion and maintenance requirements. Phosphor bronze 70-mesh screen with a 90 percent copper content was tested to evaluate its algicide property and antifouling potential. Since the phosphor bronze has poor galvanic characteristics with respect to stainless, tests were conducted both with and without cathodic protection to evaluate this problem. Monel screen (70 percent nickel and 25 percent copper) was also tested in conjunction with the stainless frames.

Wear on the 70-mesh screens is being evaluated using photographs taken before and after operation (Figure 6). Ten specific locations have been selected on each screen panel. Photographs are taken at these locations immediately after screen installation and after intervals of operation. Dimensions of openings are measured from the photographs in a randomized process and analyzed statistically to obtain the size distribution. The size distributions will be compared to the egg and larvae size distributions as measured in the laboratory to evaluate the probability of egg and larvae passage. The opening size distribution data for new and used screen will also be compared to evaluate wear due to abrasion or corrosion.

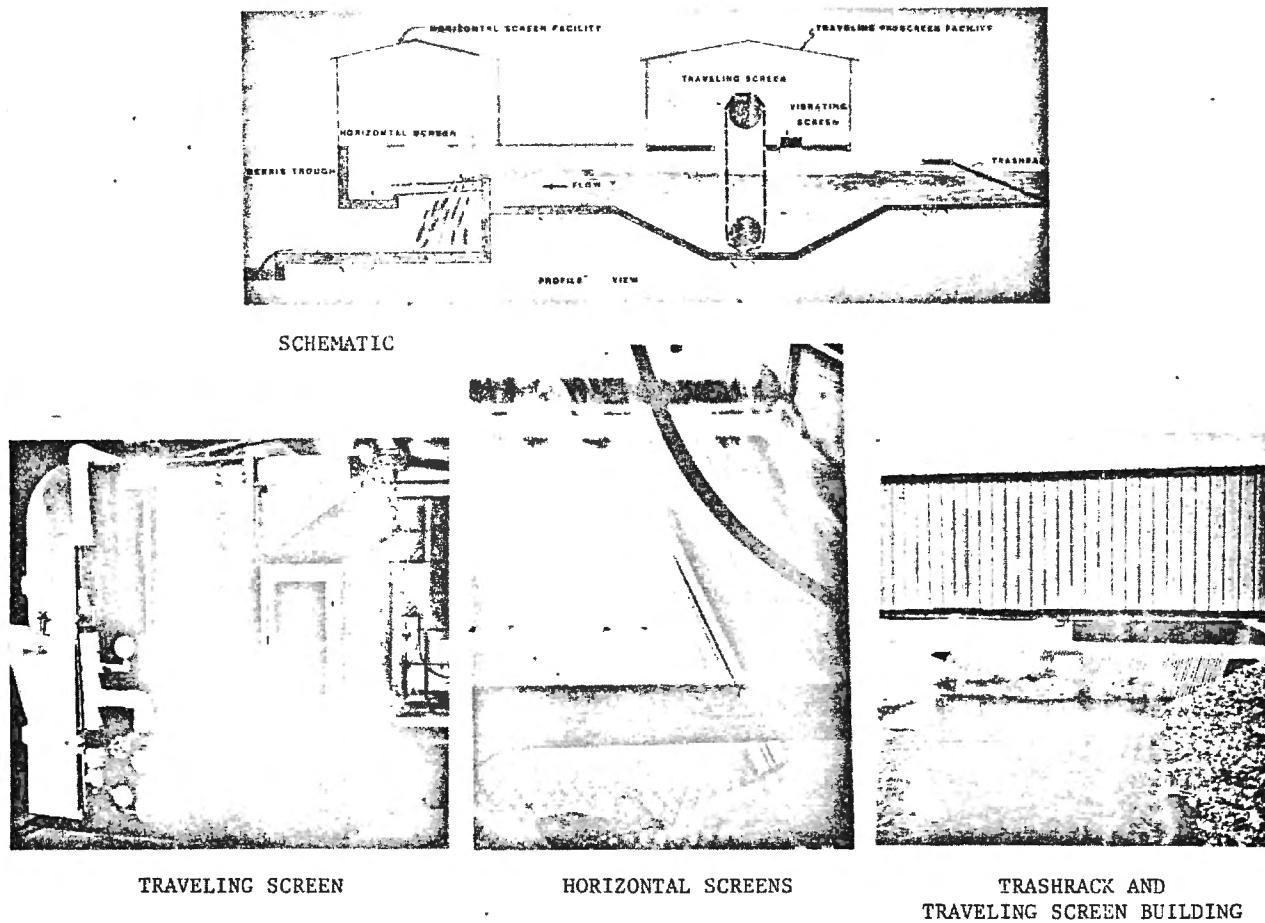
A vertical traveling water screen mounted with 70-mesh screen was installed in the feeder canal immediately upstream of the field model to evaluate the traveling screen's potential as a prefilter. The horizontal screen operation was then evaluated both with and without the traveling screen in operation.

Debris handling and removal were also evaluated. In general, most of the debris was pumped to a lagoon by the use of sewage chopper pumps. A vibrating screen (Figure 7) mounted with 80-mesh screen just upstream of the traveling screen is used to reduce water content of the debris. Coarse debris collected on the trashracks has been handled manually to date. Automatic trashrack rakes would be used in the final structure.

Testing at the field test facility began on October 1, 1979. On October 9, 1979, 24-hour continuous operation began and continued until October 19, 1979. In 1980, the facility was operated continuously from June 19 until December 1.

#### Biological and Water Quality Considerations

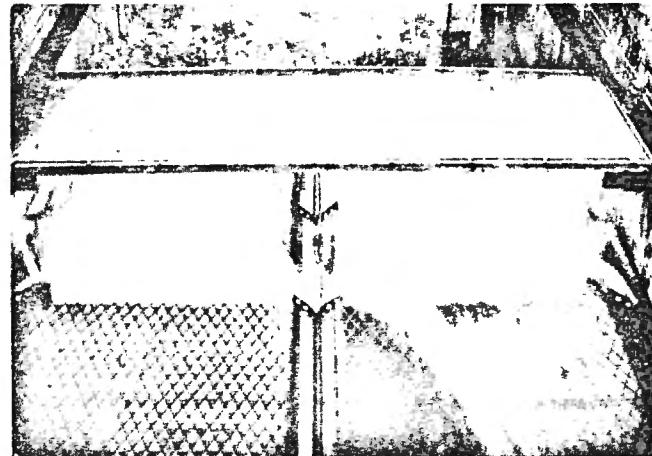
A monitoring program was established for the field test facility. This program included water quality



**Figure 3. Field model test facility**

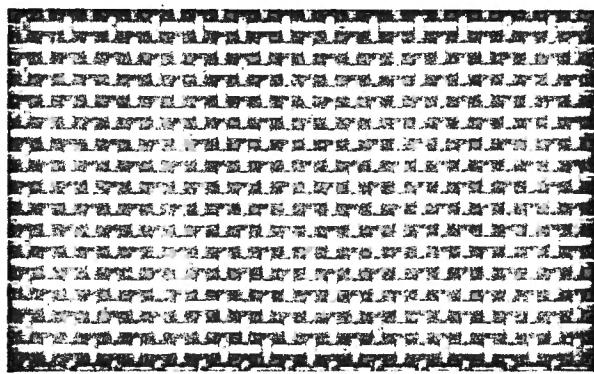


**Figure 4. Spray cleaner hardware (with screens removed)**

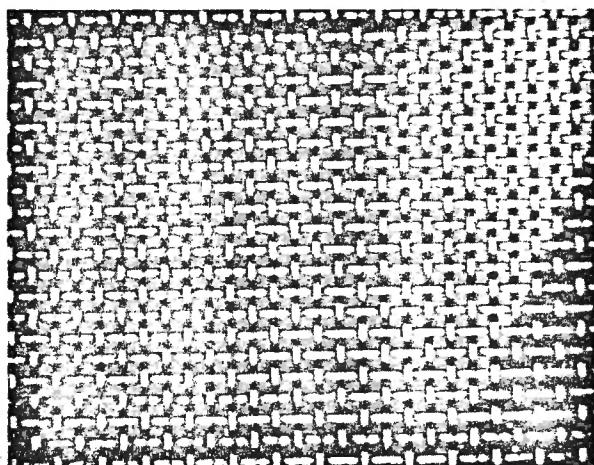


**Figure 5. Spray cleaner operating (with screens in place)**

analysis, analysis of biological material as related to screen loading and deterioration, and other environmental monitoring. Water quality analyses included complete chemistry (major cations, major anions, pH, EC, TDS), trace elements (Cu, Zn, Mn, Fe, Pb), and nutrients (NO<sub>3</sub>-N, NO<sub>2</sub>-N, NH<sub>3</sub>-N, TN, ortho-P, TP). Water samples for analysis were collected at three

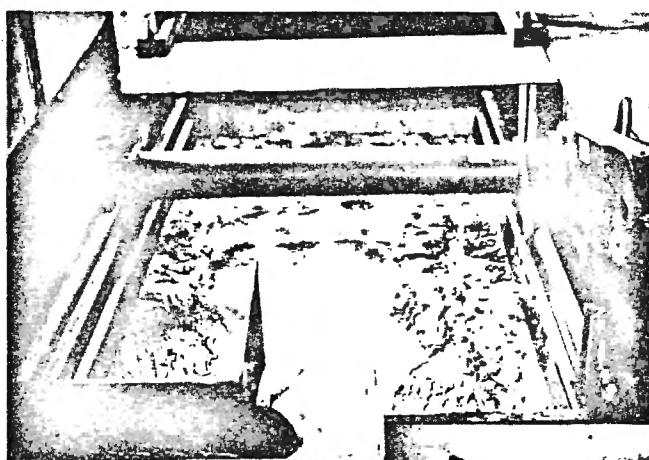


NEW SCREEN



SCREEN AFTER 3 MONTHS OF USE

**Figure 6.** Magnified photos of 70 mesh phosphor bronze screen



**Figure 7.** Field facility vibrating screen

sites at noon and midnight on Mondays and Thursdays during the operation of the field test facility, preserved with acid, frozen, or refrigerated, and analyzed according to established EPA water sampling and preservation protocol (*Methods for Chemical Analysis of Water and Waste Water*, U.S. Environmental Protection Agency, March 1979).

Twice each day phytoplankton and zooplankton samples were collected upstream of the traveling water screen, between the traveling water screen and the horizontal screens, and below the horizontal screens for laboratory identification and counting. Samples were preserved in 10 percent formalin. Fish and macroinvertebrates were sampled at random times from the horizontal screens and from the debris sumps and preserved in 10 percent formalin for laboratory identification. Samples for determination of dry weight biomass were collected at the three previously described sites to assess prefiltration potential of the traveling water screen.

#### PRESENT DESIGN

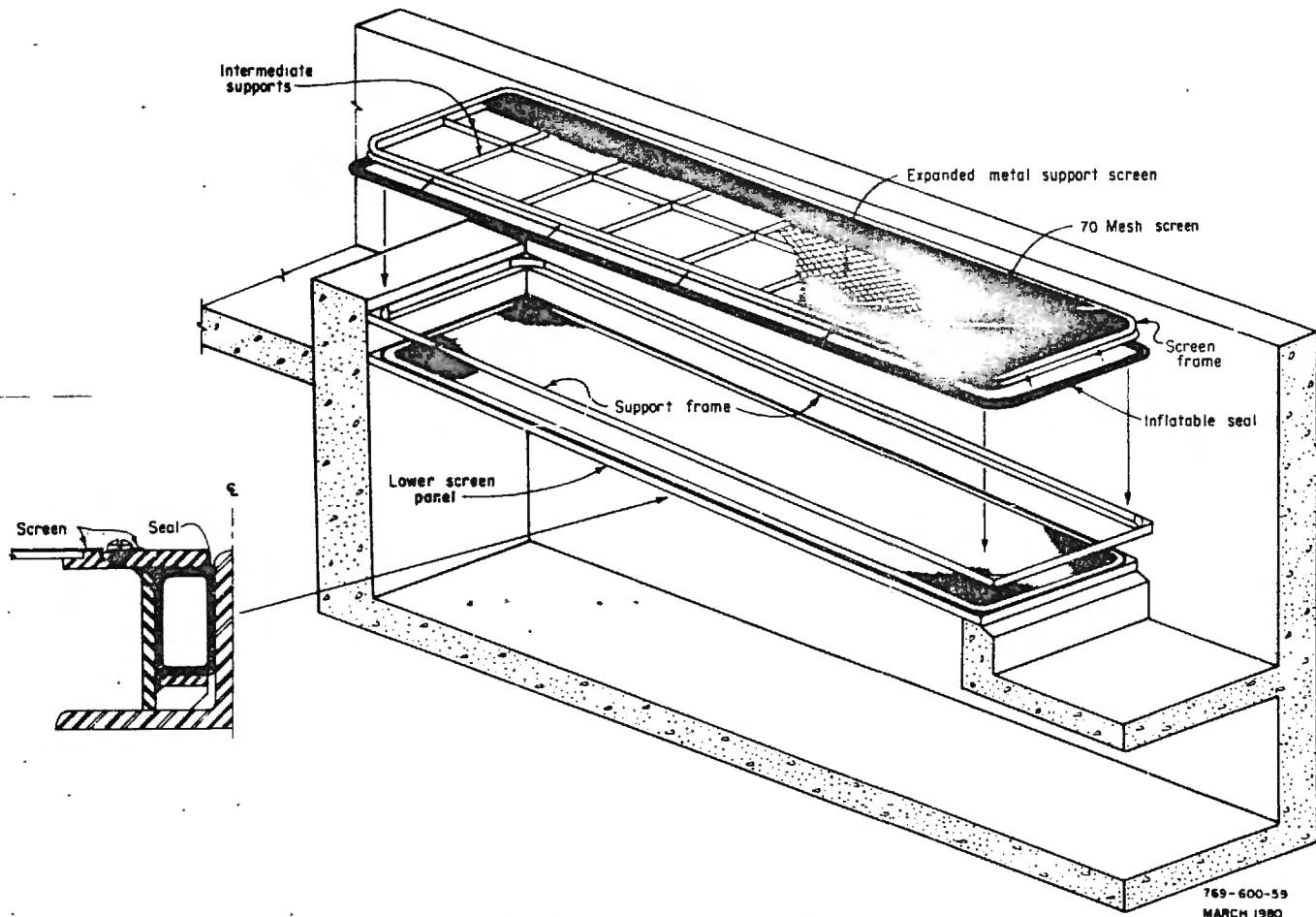
Figures 8 and 9 show the present horizontal screen panel and seal design and the supporting structure. Also shown is the backup lower screen. Testing and design improvement continue and further minor modifications of this design are expected. Major design efforts continue on the final facility.

The stainless steel framework provides corrosion-free seating surfaces which help to assure a positive seal. Stainless flattened expanded metal welded to the screen framework supports the fine-mesh screen and strengthens the frames. The frames have been designed to withstand complete screen plugging without failure.

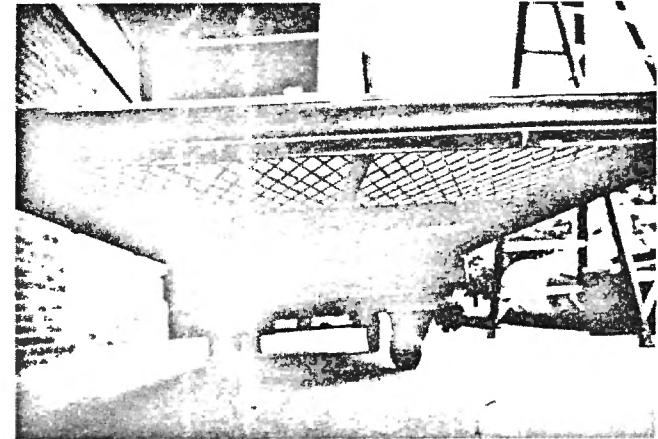
The pneumatic or inflatable seals have proven to be an excellent feature since they seat over a wide area, are not sensitive to minor irregularities in the seating surface or to debris on the seating surface, and are not sensitive to warpage in the welded framework. Quick disconnect couplings allow rapid installation and removal. Adequate sealing can be obtained with an air pressure of 83 kPa (12 lb/in<sup>2</sup>). However, an arbitrary operating pressure of 152 kPa (22 lb/in<sup>2</sup>) has been established. An alarm system signals pressure loss in individual seals and excessive airflow in the main air supply line.

#### Laboratory Results

All tests on the sectional model conducted to date have demonstrated that the 70-mesh screen and design concept is an effective filter which prevents the passage of eggs and larvae of fish species of concern. In 1979, in 12 test runs using 120,000 eggs and 120,000 larvae of rainbow smelt, no eggs or larvae passed the seals or 70-mesh screen. In 1980, in 24 test runs using 50,000 eggs and 170,000 larvae



**Figure 8. Present screen, frame, and seal design**



**Figure 9. Present screen and seal design**

of rainbow smelt, no eggs or larvae passed the screen or seal. Also in 1980, with 40,000 eggs and 30,000 larvae of Utah chub, 50,000 eggs of carp, and 30,000 eggs of gizzard shad, no eggs or larvae passed the screen or seal. Additional testing is planned in 1981.

With clean laboratory water the screen was found to have a maximum discharge capacity of  $0.465 \text{ m}^3/\text{sec}$  per meter width or  $0.425 \text{ m}^3/\text{sec}$  per screen frame. Laboratory sectional model studies have also shown that effective screen cleaning could be obtained with a traveling spray cleaning system.

This spray cleaning device was effective either spraying down from above or up from below onto the operating screen.

## Field Results

In general, the horizontal screen design with pneumatic seals, an automated spray cleaning system, and a pumped debris handling system has operated efficiently at the field test facility. The pneumatic seals were very effective and have withstood pressure from 6 feet of pooled water. The spray cleaning system operated by a continuous drive cablepulley system has also proved effective in dislodging impinged debris using an operating water pressure of 207 kPa (30 lb/in<sup>2</sup>). The spray cleaning system will be automated for future operation.

The spray cleaning system removed impinged debris equally from both the Monel and phosphor-bronze screen. The expected algicidal trait of phosphor-bronze screen was, therefore, unimportant. In addition, a high degree of pitting and deterioration occurred on the phosphor-bronze screen while very little occurred on the Monel screen. These factors, as well as reduced discharge capacity of the phosphor-bronze screen, lead to the selection of Monel screen for additional field testing and for use in the final structure.

Debris loading was the major factor that controlled the maximum discharge capacity of the screens. As the debris load in the canal water became heavier, the screens fouled more rapidly. Increased fouling reduced the discharge capacity by reducing the effective filtration area of the screen. The criterion for screen cleaning was water flowing over the downstream end of the screens and into the debris trough. Consequently, as the debris load and fouling increased, the interval between spray cleanings was reduced. When debris loading got so heavy that the cleaning device could not keep the screens clean, the discharges were reduced. Under high fouling conditions, such as in midsummer with the *Aphanizomenon* load, discharges were substantially reduced. Continuous discharges of up to 0.279 m<sup>3</sup>/sec per meter width of screen were obtained in spring and fall while midsummer discharges dropped as low as 0.062 m<sup>3</sup>/sec per meter width of screen. Both of these discharges are considerably below those observed in the laboratory.

To date, for the types of debris encountered (copepods, cladocerans, rotifers, *Aphanizomenon* and *Anacystis*) it appears that the vertical traveling water screen is not an effective prefilter. The traveling water screen does not appreciably improve horizontal screen discharge capacity.

The pumped, closed conduit, debris handling system has proved effective. The commercially

available vibrating screen has also been used successfully to dewater this debris.

Water quality analyses for complete chemistry, trace elements, and nutrients are not yet completed. Generally, the canal water had a pH around 8.4 and conductivity around 1,100 to 1,200. Dry weight biomass analyses are currently being conducted. Preliminary analysis indicates that the traveling water screen with 70-mesh screen does not prefilter canal water effectively. Evaluation of water quality effects on component corrosion and traveling water screen prefiltration efficiency is planned for 1981.

## Present Direction

The photographic work to define the size distribution of openings in new and used screen and the size distribution of fish eggs and fish larvae will continue. Additional photographs will be taken as necessary and analyzed. Work has started on statistical analysis of data collected to date. No conclusions have been reached.

Tests are being conducted to evaluate the durability of various repair materials on 70-mesh Monel screen. Lead-tin solder, silver solder, and epoxy patches on Monel screen are being exposed to highvelocity sprays. With 200 hours of exposure, no patch failures have been noted.

The final structure is being designed to filter a discharge of 28.3 m<sup>3</sup>/sec. Additional structure can be added to increase the discharge capacity to 55 m<sup>3</sup>/sec, the maximum final design discharge. This staged development recognizes that demand for irrigation water increases gradually and that a structure that can adequately filter 50 percent of the ultimate discharge should meet all needs for 10 to 20 years.

Along with the final design a recommended operating criteria will be developed. This is a critical aspect of the entire concept. Improper operation or improper maintenance could lead to filtration failure. The structure is being designed to minimize the possibility of failure if it is operated improperly. Design improvements are intended to reduce maintenance needs. Efforts are also being made to identify potential failure points in maintenance routines. Maintenance personnel will require extensive training to assure maintenance quality control.

## ACKNOWLEDGMENTS

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