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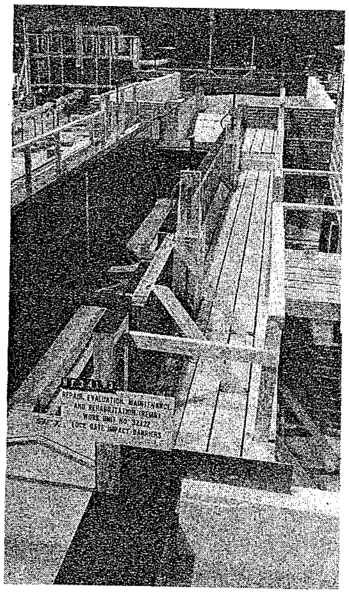
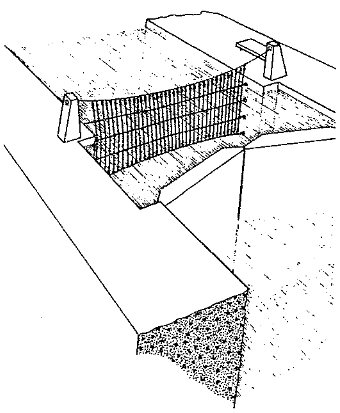
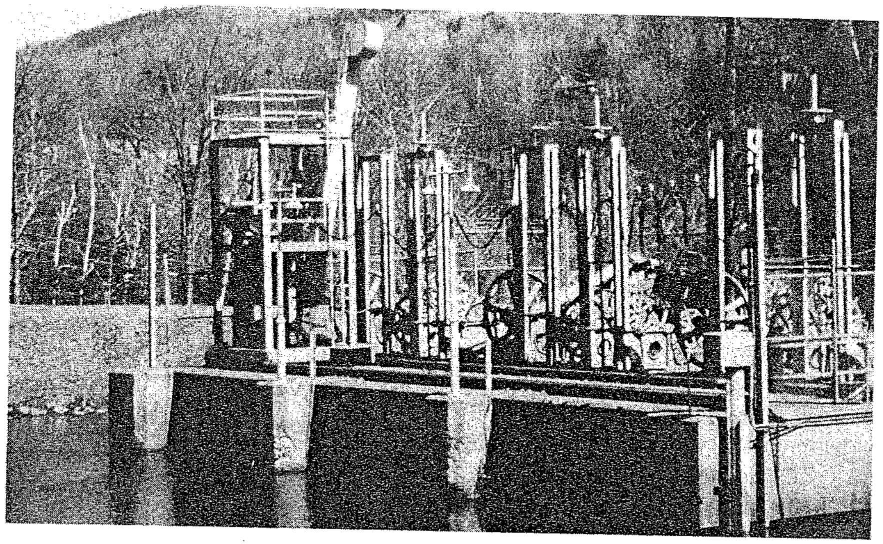




The REMR *Bulletin*

News from the Repair, Evaluation, Maintenance, and Rehabilitation Research Program

VOL 3, NO. 2 **INFORMATION EXCHANGE BULLETIN** **SEP 1986**



Berry Trash Rake at the left end of an intake structure at New England Power Company's Hydroelectric Station No. 3, Deerfield River, at Shelburne Falls, Mass. The top of the telescoping rake arm is visible above the traveling gantry. A skimmer wall obscures the view of the trash racks.

Floating Debris Control Systems for Hydroelectric Plant Intakes

by Roscoe E. Perham
US Army Cold Regions Research and Engineering Laboratory

Hydroelectric plant intakes are usually protected by sets of vertical parallel steel bars called trash racks. Like sieves, trash racks keep floating debris and trash from entering a plant's valves, gates, and turbines, where it could damage them or become lodged in vital components. In sieving material from the water, however, trash rack openings can become clogged. When this happens, head loss increases and power generation decreases.

This problem can be managed successfully by cleaning the trash racks, but cleaning methods are few and usually laborious. The most common methods have been the use of hand rakes for small hydro plants; large, cable-supported mechanical rakes for larger plants, and air bubbler systems to raise debris up to a sluiceway.

RACINE HYDROELECTRIC PLANT: THE PROBLEM

Racine Hydroelectric Plant is an example of a plant at which severe difficulties have been encountered in intercepting and removing floating debris. Racine, on the Ohio River 40 miles downstream of Parkersburg, West Virginia, is operated by Ohio Power Company. Both turbine units at this plant have dual inlets protected by parallel bar trash racks made of

5/8-inch-thick by 6-inch-wide steel flat stock set on edge and spaced 6 inches apart. The forebay is roughly triangular and is about 240 feet wide at the powerhouse and 300 feet long. (The underwater width is less because the right bank slopes toward the face of the powerhouse.)

Initially, the forebay was provided with a 300-foot-long debris boom anchored at each end to cell structures with floating connection points. The boom proved ineffective because of two characteristics: First, when flow to the turbines was initiated, the boom would tilt up and let floating debris pass beneath it. Second, openings in the face of the boom caught and held debris so that it could not move laterally to a discharge or pickup point. Eventually the boom was removed in hopes that the flow characteristics of the forebay would be improved and that it would be easier to remove the debris from the trash racks. The open boom arrangement is shown in Figure 1. A typical view of floating debris in front of the trash racks is shown in Figure 2.

After the boom was removed, debris continued to accumulate in front of the trash racks, and the conventional traveling rake built for the racks could not handle it. In time it was determined that the debris floating on the surface was only a small fraction (estimated as one-fifth) of the total debris collecting in front of the hydroelectric plant. A contractor hired by the power company removed the submerged material in three days using a barge-mounted crane with a clamshell bucket. The material was over 99% wood and was composed of whole trees, logs up to 40 feet long, limbs, branches, and leaves. All of it was completely waterlogged and very heavy. A jumbo barge was filled with 900 yards of debris before divers reported that the racks were clean.

With the clean-up accomplished, the turbines began operating once more at full flow and efficiency. But within six weeks the units began vibrating again. Divers sent down to investigate found another large accumulation of debris. Again, the traveling rake was inadequate, so operators rented a 40-ton crane with a 2-yard clamshell bucket. In addition they used a 10-ton cherry picker and a powerhouse overhead crane to handle the largest pieces. One 70-foot-long piece had to be cut in two in order to fit it in a truck. The saw blade employed was rendered virtually useless by this operation due to the effects of embedded sand and silt. Approximately 600 yards of debris was removed before the racks were again clean. The debris was taken to a dump site in a tractor trailer dump truck.

The average trash removal rate at Racine in January 1985 was two truck loads per day. During low flow periods, however, the rate was about one truck load every two days.

The experience at Racine points out a number of important considerations when removing debris from trash racks. The face of a trash rack slopes upstream, so the lifting equipment must have a good extension. Water flowing into the trash rack will suck a clamshell bucket toward or against it, so the intake being cleaned should be cut back to half flow. Reducing flow through the powerhouse also helps diminish the rate at which debris accumulates; the difference goes through the spillway gates instead. At Racine it was found that trash racks need to be cleaned on a daily basis in order for full flow to be maintained.

A 40-ton crane with clamshell bucket has now been purchased for Racine Hydroelectric Plant

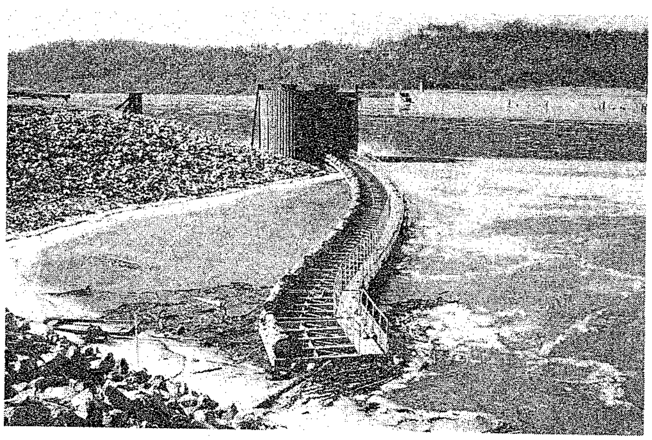


Figure 1. A 300-foot-long debris boom that proved ineffective in controlling floating debris at Racine Hydroelectric Plant, Ohio River, near Parkersburg, West Virginia.

Figure 2. Floating debris trapped against the trash racks at Racine Hydroelectric Plant.

for use in collecting debris. While trash removal costs, including manpower and hauling, are higher than originally anticipated, the units now operate unimpaired by debris. Future "main stem" hydroelectric developments on rivers such as the Ohio will need to evaluate potential debris problems very carefully.

BERRY TRASH RAKE: A SOLUTION

A power-driven trash rake developed by Mr. Lincoln Berry of Conway, New Hampshire, may help to lessen debris control problems at some hydroelectric plants. The Berry Trash Rake consists of an open frame gantry which travels on rails from one side of the intake structure to the other while a rake on a telescoping arm moves up and down the trash rack face. It has a hydraulic power system which is driven by a single electric motor. The trash rake and gantry are operated manually, and in units designed for use outdoors the hydraulic control console is enclosed in a steel cab, a useful feature in cold weather. The system's hydraulic reservoir is heated in winter.

The telescoping arm is extended and retracted by a long double-acting cylinder, and a second cylinder rotates the arm to move the rake away from or closer to the trash rack. The rake head, shown in Figure 3, is approximately 20 inches wide and 5 feet long. The rake teeth do not penetrate the trash rack openings, and the mechanical-structural arrangement is such that very little pressure is exerted on the surfaces during raking.

A Berry Trash Rake has been in operation since 1979 at New England Power Company's (NEPCO) Hydroelectric Station No. 3 on the Deerfield River at Shelburne Falls, Massachusetts. The intake structure at Station No. 3 has three inlets protected by trash racks. Prior to installation of the Berry Trash Rake, heavy trash run periods necessitated that four men work continuous 12-hour shifts for several days at a time, hand raking from one side of the dam face to the other. With the Berry Trash Rake, one man working part time can easily clean the trash racks. At Station No. 3 the Berry Trash Rake gantry travel is 62 feet, the rake travel is 30 feet, and lift capacity is 2,500 pounds. The trash is pushed by hand onto a conveyor, which carries it to a waiting trailer. NEPCO personnel are especially pleased with the trash rake because they can clean the racks without interrupting full flow through the turbines.

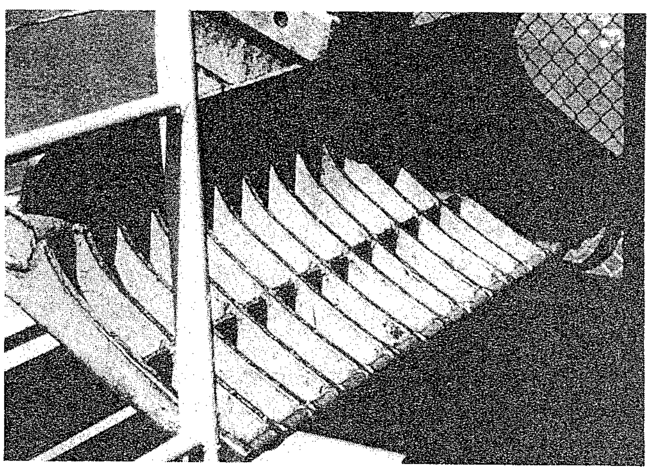


Figure 3. Five-foot-long rake head of the power-driven Berry Trash Rake installed at New England Power Company's Hydroelectric Station No. 3.

The first Berry design was installed at Gorham, New Hampshire, while Mr. Berry was superintendent of Public Service Company of New Hampshire's Upper Hydro Group. Since then 21 more units have been installed in the Northeast. The greatest gantry travel to date is 257 feet at the International Paper Company plant in Jay, Maine, and the deepest trash rack serviced is 65 feet at the Central Maine Power Company hydroelectric plant in Brunswick, Maine. The lifting capacity of the boom is not large, but very heavy logs can be pulled partway up the intake face where they can be tied off and cut up. The Berry Trash Rake can be readily pushed down through floating debris to clean the central water flow portions of the trash racks. Cable-lowered rakes are usually not heavy enough to penetrate this material when the trash accumulation is extensive.

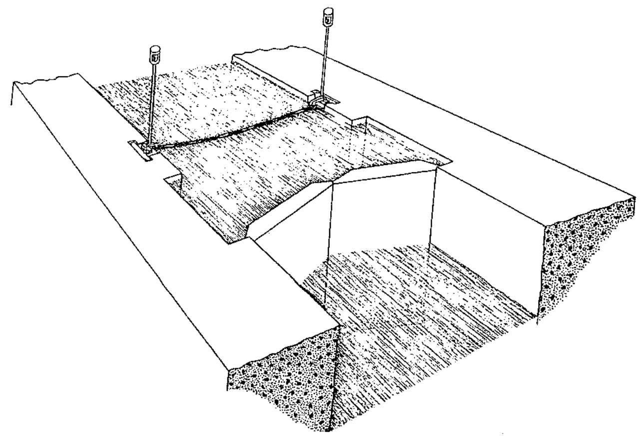
For more information about floating debris control systems or their components, contact the author, Russ Perham, at 603-646-4309. For more details concerning the Berry Trash Rake, write L. H. Berry, Inc., P. O. Box 501, Conway, NH 03818 or telephone 603-447-2701.

Russ Perham is a mechanical engineer in the Ice Engineering Research Branch, Experimental Engineering Division, US Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, and has been with the laboratory since 1962 working in various areas including ice control. He received his B.S. in mechanical engineering from the University of Maine, an M.S. from Rensselaer Polytechnic Institute, and has taken advanced courses at Dartmouth College. He is principal investigator for REMR Work Unit 32320, "Floating Debris Control Systems."

Protection of Lock Gates from Vessel Impact

by Sandra K. McKay
US Army Engineer Waterways Experiment Station

Vessel impact often damages gates at Corps of Engineers' navigation locks, necessitating costly repairs to towboats, barges, and cargo, as well as to the gates themselves. Shipping interests incur additional expenses due to delays while waiting for repairs. Property damage resulting from flooding in instances of complete failure of a gate can translate into extensive monetary losses. REMR research is presently under way at the Waterways Experiment Station to develop a means to protect lock gates from vessel impact and thereby reduce or eliminate the resulting damage.



Schematic of a deformable bar impact barrier similar in design to a system in use on many locks in Czechoslovakia.

CURRENT PRACTICES

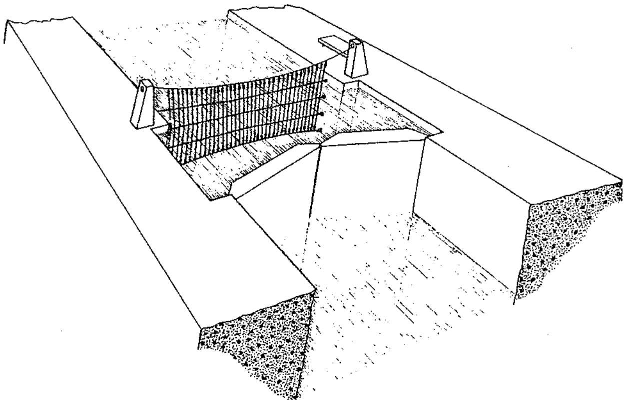
A thorough literature search has revealed that use of impact barriers (structural devices which prevent vessels from contacting the gates) is common on many locks abroad. Several references implied that such devices would be of benefit on U.S. waterways, but provided little if any information concerning their design. Additionally, responses to a survey of Corps District offices indicated that several Districts have studied the feasibility of barriers, and that one (Detroit) is using a barrier designed for ship traffic on the St. Marys Canal Lock, Saulte Ste. Marie. None of the barriers in use have been designed for the towboat and barge configurations commonly seen at the many inland facilities the Corps operates.

Among the barriers for ship traffic which are in operation:

1. ***Wire Rope Fender.*** This barrier is recommended in the Corps design manual (Engineer Manual 1110-2-2602) and consists of a boom with a cable which arrests the ship's motion by catching the bow. The barrier is raised and lowered into position by a lever arm on the side of the lock which can be either hydraulically or mechanically operated. The safety boom on the St. Marys Lock is designed similarly to this.
2. ***Piston-Type Energy Absorber.*** With this system, designed for the Manchester Ship Canal in the U.K., when a vessel impacts a cable placed in its path, an energy-absorbing piston assembly along the lock wall is activated.
3. ***Deformable Bar.*** Proceedings from a 1981 meeting of the Permanent International Association of Navigation Congresses (PIANC) described this device as a widely accepted barrier in use on many locks in Czechoslovakia. The barrier is essentially a rod comprised of a caisson filled with mild-steel reinforcing bars which is lowered across the width of the lock by a pulley assembly. After each impact of a vessel on the rod, the caisson and those reinforcing bars that have been damaged are replaced by new ones.

A number of conceptual designs for impact barriers were found in Appendix IX of Design Memorandum No. N-12 prepared for Bay Springs Lock and Dam on the Tennessee-Tombigbee Waterway. The feasibility of barriers specifically designed for characteristic U.S. barges is described in this report, including:

1. ***Steel Barrier.*** This design employs a rigid barrier spanning the lock which distributes the load from impact to the lock walls. Blockouts in the lock wall guide the vertical movement of the barrier as it floats to provide an obstacle at all upper pool elevations. It is only designed for use at the lower gate.
2. ***Concrete Barrier.*** This is also a rigid barrier but is made of reinforced concrete rather than steel.
3. ***Rope System Impact Barrier.*** The rope system consists of an energy-absorbing nylon net which can be raised or lowered as necessary for operations. The ropes are prestretched and connected at their intersection with a "U" bolt-plate connector to force interaction.



Schematic of a rope system impact barrier being studied as a means of preventing tows from damaging lock gates.

Vertical lift gate at Wilson Lock, Tennessee River, above Florence, Alabama, damaged by a loose barge during filling. The barge caught under the gate, necessitating shutting down the lock, pulling the gate out, and reworking much of its mechanical system.

ACCIDENT CAUSES

A study of accident reports at Corps locks in which the gates were damaged by impact revealed a number of causes which can be qualitatively assessed and prioritized. Primary causes of accidents appear to be:

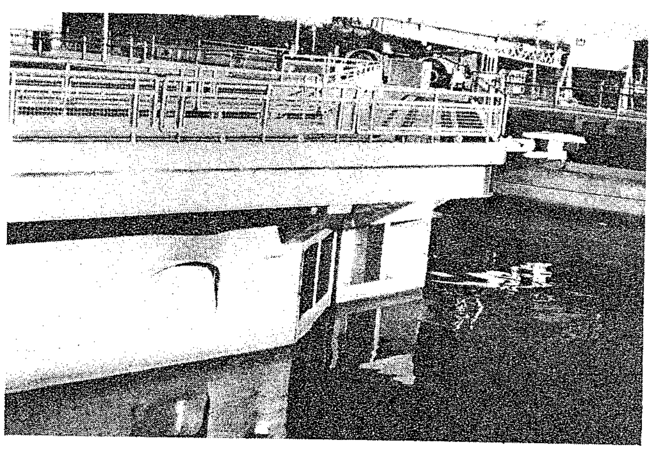
- Excessive speed or inability to stop
- Misalignment of the tow
- Faulty communications between the lockmaster and tow operator
- Equipment failure on the tow or the lock
- Pilot error
- Surge in the lock chamber
- Improperly secured lines
- Improper loading or lashing of barges

The first two causes listed were the most frequent ones.

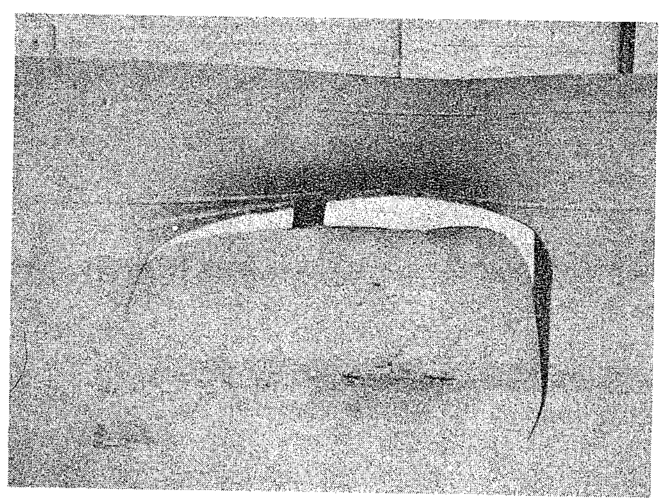
Other, indirect factors, such as river stage and discharge, direction of travel, horsepower of the vessel, and visibility during approach, can affect the tow operator's ability to maneuver safely into the lock and increase the likelihood an accident will occur.

Higher stages can produce treacherous or swift currents making misalignments more likely in a downstream direction and excessive speed accidents more probable in an upstream direction. There is some evidence that a relationship exists between accident frequency and tow power. Whether a tow is underpowered or overpowered can affect the operator's ability to maneuver into the lock chamber.

Visibility at the lock cannot only affect the operator's ability to maneuver, but can also hinder communications. Visibility problems include fog, rain, location of the lock (e.g., in a bend of the river), and a cargo load which obstructs the pilot's view.



Damage resulting from barge impact of a miter gate section, Pickwick Lock and Dam, Tennessee River, near Hamburg, Tennessee.



Closeup view of damage.

REMR Research Program

KEY PERSONNEL

	Office	Office Symbol	Commercial No.	FTS No.
DRD Coordinator, HQUSACE				
Jesse A. Pfeiffer, Jr.	Civil Works Programs	DAEN-RDC	202-272-0257	272-0257
Overview Committee, HQUSACE				
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Tony C. Liu	Structures Branch	DAEN-ECE-D	202-272-8672	272-8672
Bruce L. McCartney	Hydraulic Design Branch	DAEN-CWH-D	202-272-8502	272-8502
Program Management				
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G. Britt Mitchell (Geotechnical—Soils)	Geotechnical Laboratory, WES	WESGE-E	601-634-2640	542-2640
Jerry S. Huie (Geotechnical—Rock)	Geotechnical Laboratory, WES	WESGR-M	601-634-2613	542-2613
Glenn A. Pickering (Hydraulics)	Hydraulics Laboratory, WES	WESHS-L	601-634-3344	542-3344
D. D. Davidson (Coastal)	Coastal Engineering Research Center, WES	WESCW-R	601-634-2722	542-2722
Paul A. Howdyshell (Electrical and Mechanical)	Construction Engineering Research Laboratory	CERL-EM	217-352-7244	958-7244
Jerome L. Mahloch (Environmental Impacts)	Environmental Laboratory, WES	WESEP-W	601-634-3635	542-3635
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John J. Sirak, Jr.	Ohio River Division	ORDCO-M	513-684-3418	684-3418
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Neal H. Godwin, Jr.	Southwest Division	SWDCO-O	214-767-2429	729-2429
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Eugene Brickman	North Atlantic Division	NADEN-MG	212-264-7141	264-7141
John G. Oliver	North Pacific Division	NPDEN-T	503-221-3859	423-3859
Karl V. Keller	Pacific Ocean Division	PODEN-T	808-438-1635	
James W. Erwin	South Atlantic Division	SADEN-F	404-221-4256	242-4256

CALCULATING THE COSTS

Since some lock locations are more susceptible to accidents than others, they are in greater need of protection in the form of impact barriers. From an analysis of the frequency of occurrence of accidents and the extent of damages at a given lock, a decision could be made as to the cost-effectiveness of providing protection to lock gates.

Data from Coast Guard reports and from Corps maintenance records appear to support the use of barriers for reducing damage to locks and vessels. A report published in 1981 by Ohio River Division categorized and analyzed 427 accidents which occurred at 34 locks during a ten-year period.* These accidents resulted in nearly $5.5 million in damages to government property. Seventy-six accidents at four locks on the Upper Mississippi River during a five-year period resulted in approximately $869,000 in damages to government property.

At both the Upper Mississippi and Ohio River locks, damages ranged from less than $500 per accident to more than $50,000. Four of the 76 accidents at the Upper Mississippi locks accounted for 65% of all damages to government property. In the Ohio River accident study, 21% of the accidents accounted for 93% of the total damages to government property.

Although minor repairs to a gate can often wait until periodic dewatering and maintenance are performed, major incidents may require immediate repair. Emergency dewatering procedures are available at most major locks by means of spare gates or emergency closure gates. However, the time involved in repairing the damage and restoring any loss of pool can result in extended delays and a backlog of tows awaiting lockage.

In April 1984, the miter gates at Gallipolis Lock and Dam on the Ohio River sustained extensive damage from a collision which required the lock to close for 17 days at an estimated cost to industry of $1.96 million. An accident at Lock and Dam 25 on the Mississippi River caused a 5-day closure in August 1985. When the gates reopened, 17 downbound tows were awaiting lockage at Lock and Dam 24, and 9 were waiting at Lock and Dam 25.

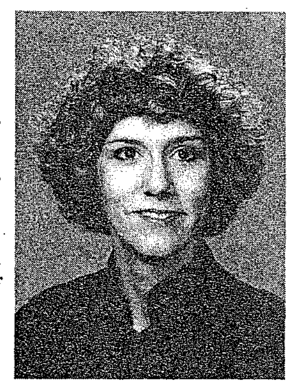
* "A Study of 427 Navigation Accidents at Ohio River Locks."

REMR RESEARCH OBJECTIVES

REMR research in this area is focusing on developing an impact barrier which will effectively prevent tows from damaging lock gates with minimal sacrifices to lock chamber length and lockage time. The barrier will be adaptable to upstream and downstream gates of various types, be simple to operate and maintain, have low initial and replacement costs, be adaptable to high and low lifts, and be effective for various types of vessels.

A physical model of a lock approach and lock chamber (see cover photo) are being used for this study. A remotely operated scale-model vessel reenacts typical accident scenarios, which can be investigated to determine the forces involved at impact and evaluate the effectiveness of various impact barriers.

For more information on the study under way on impact barriers, contact the author, Sandra McKay, at FTS 542-4285 or 601-634-4285.



Sandra McKay, a Hydraulic Engineer in the Hydraulic Structures Division, Hydraulics Laboratory, Waterways Experiment Station, is principal investigator for REMR Work Unit 32322, "Lock Gate Impact Barriers." She received her B.S. in civil engineering from Memphis State University and is a registered professional engineer in Tennessee. Prior to joining the staff at WES, she worked in both the Memphis and Vicksburg Districts of the Corps of Engineers.

Request for Articles

If you have experience in any of the areas being addressed by the REMR Research Program which might be of interest to our readers, we would appreciate your drafting an article describing your work or contacting us for assistance in doing so. Articles by persons outside the Corps are welcome and will be considered for publication so long as they are relevant to REMR activities of the Corps.

Write to: Commander and Director, US Army Engineer Waterways Experiment Station, ATTN: WESSC-A, PO Box 631, Vicksburg, MS 39180-0631. Or call Tim Ables at 601-634-2587 (FTS 542-2587).

Seminar Scheduled on New Remedial Seepage Control Methods for Dams and Soil Foundations

A REMR-sponsored seminar on new remedial seepage control methods for dams and soil foundations will be held 21 and 22 October 1986 at the Waterways Experiment Station (WES), Vicksburg, Mississippi.

The purpose of the seminar is to stimulate exchange of ideas and information among leading practitioners, and to provide an authoritative review of the state of the art for potential users, primarily those within the federal government.

Topics and speakers will be as follows:

Chemical and Microfine Grouting	R. H. Karol Rutgers University
Drains	W. C. Sherman Tulane University
Upstream Impervious Blankets	W. R. Morrison Bureau of Reclamation
Use of the Hydrofraise to Construct Concrete Cutoff Walls	J. J. Parkinson Recosol, Inc.
Plastic Concrete Cutoff Walls	G. J. Tamaro Mueser Rutledge Consulting Engineers
Jet-Grouted Cutoff Walls	G. Guatteri Novatecna
Reinforced Downstream Berms	J. M. Duncan Virginia Tech
Ground Freezing as a Construction Expediency for Cutoff Walls	J. A. Shuster Geofreeze, Inc.
Panel Discussion	J. L. Kauschinger Tufts University

Participants will be staying at the Holiday Inn in Vicksburg. If you wish to reserve a room, please call the WES Public Affairs Office at FTS 542-2502 or 601-634-2502. For more information on the seminar, call Ed Perry at FTS 542-2670 or 601-634-2670.

News In Brief

Jim Crews, Chief, Operations Branch, at Corps Headquarters, has been named Chairman of the REMR Overview Committee. He replaces John Mikel who has assumed new and expanded duties as civilian Assistant Chief, Operations and Readiness Division, Directorate of Civil Works. Jim has been with the Corps for 21 years working largely in water resources planning. He served previously in the Louisville and Baltimore Districts and at the Institute for Water Resources. He holds a B.S. in civil engineering from Tennessee Tech and an M.S. degree in civil engineering from Catholic University and from the University of Maryland.

* * * * * *

Special thanks are due to John Mikel for his outstanding leadership in getting the REMR Research Program started and for guiding the REMR Overview Committee through its deliberations on research priorities and funding. He has been an effective advocate of keeping the REMR program focused on field-identified needs, yet has encouraged innovation as opportunities have arisen. The "Godfather" will be missed.

* * * * * *

A revised list of key personnel for the REMR Research Program is included as an insert to this issue of *The REMR Bulletin.* Save it for a handy reference.

COVER PHOTO

Overall view (looking upstream) of 1:25-scale model of Bay Springs Lock, Tennessee-Tombigbee Waterway, being used in testing candidate lock gate impact barriers.

COVER DRAWING

Schematic of a rope system impact barrier being studied as a means of preventing tows from damaging lock gates.

The REMR *Bulletin*

The REMR Bulletin is published in accordance with AR 310-2 as one of the information exchange functions of the Corps of Engineers. It is primarily intended to be a forum whereby information on repair, evaluation, maintenance, and rehabilitation work done or managed by Corps field offices can be rapidly and widely disseminated to other Corps offices, other US Government agencies, and the engineering community in general. Contributions of articles, news, reviews, notices, and other pertinent types of information are solicited from all sources and will be considered for publication so long as they are relevant to REMR activities. Special consideration will be given to reports of Corps field experience in repair and maintenance of civil works projects. In considering the application of technology described herein, the reader should note that the purpose of *The REMR Bulletin* is information exchange and not the promulgation of Corps policy; thus, guidance on recommended practice in any given area should be sought through appropriate channels or in other documents. The contents of this bulletin are not to be used for advertising, publication, or promotional purposes. Citation of trade names does not constitute an official endorsement or approval of the use of such commercial products. *The REMR Bulletin* will be issued on an irregular basis as dictated by the quantity and importance of information available for dissemination. Communications are welcomed and should be made by writing the Commander and Director, US Army Engineer Waterways Experiment Station, ATTN: T. D. Ables (WESSC-A), PO Box 631, Vicksburg, MS 39180-0631, or calling 601-634-2587 (FTS 542-2587).

DWAYNE G. LEE
Colonel, Corps of Engineers
Commander and Director

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