The REMR Bulletin

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

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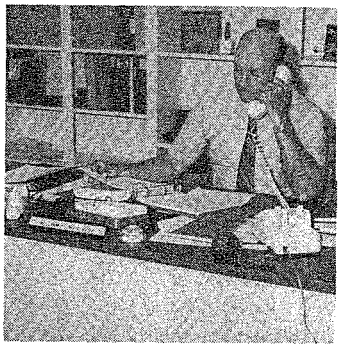
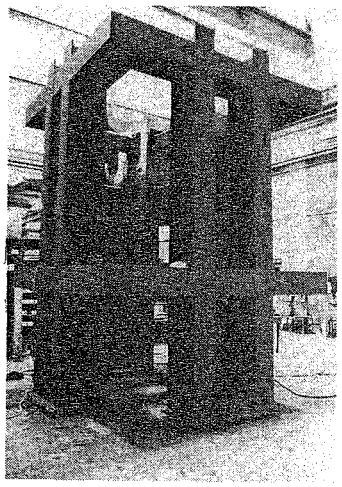
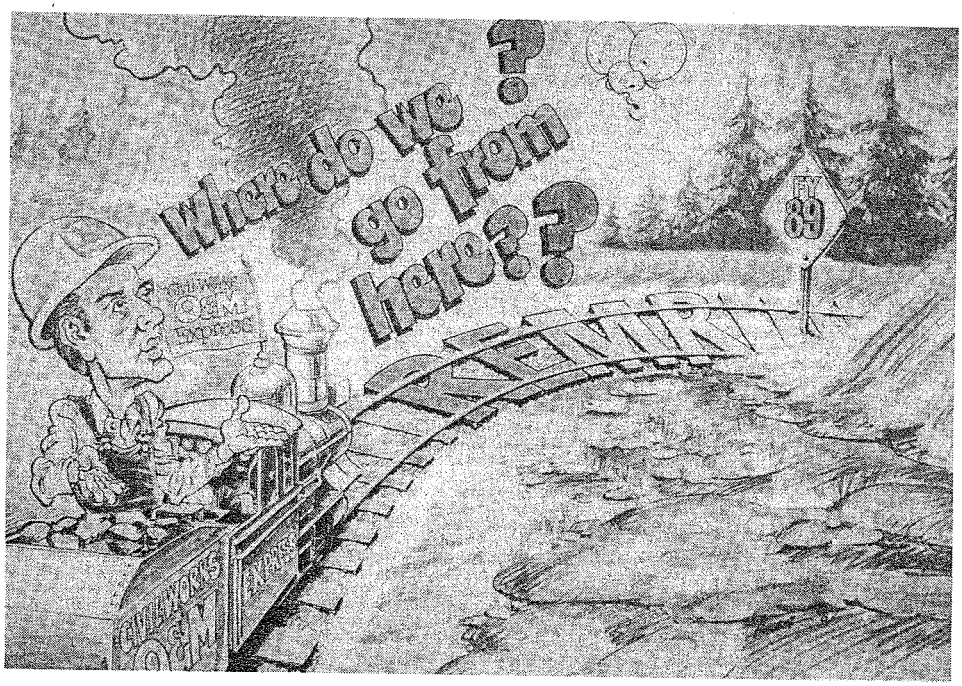






Uncertainty ends with start of new REMR effort

REMR Research Program Continues with Renewed Emphasis on Developing Useful Technology

The end of Fiscal Year 1990 marked also the end of a very successful research effort, the Repair, Evaluation, Maintenance, and Rehabilitation Research Program. Due to this program's successes, with estimated savings to approach $200-million over the next few years, another research effort will continue to develop REMR technology. Thus, REMR II is a continuation of the REMR Research Program, and is scheduled to extend from Fiscal Year 1991 to 1997.

FIELD REVIEW GROUP MEETING

The first Field Review Group meeting for the REMR II Research Program was held at the US Army Engineer Waterways Experiment Station on August 28 and 29, 1990.

Field review group members were newly appointed for this second phase of the program and represent the Corps of Engineer from throughout

the United States. A listing of the members can be found elsewhere in this bulletin.

The meeting, which was also attended by problem area leaders, served to familiarize field review members with research proposed for six problem areas: Concrete and Steel Structures, Operations Management, Geotechnical, Coastal, Hydraulics, and Electrical and Mechanical. Some 56 work units were formally presented, supported by visuals. Speakers addressed problem, objective, approach, product, and benefits for each work unit, ending with a question and answer period.

In a subsequent, closed meeting, the Overview Committee members ranked each proposal based on input from the Field Review Group. Those work units that emerged as "most needed," as well as lying within the funding restrictions, were tagged for inclusion into the seven-year program. The program manager, William (Bill) F. McCleese, then forwarded the list of selected work units to the Technical Monitors at Headquarters, US Army Engineer for final comments.

In all, 40 work units were adopted into the REMR II program, with several scheduled to begin during Fiscal Year 1991. Research will encompass all six problem areas. Funding is at 35-million for the life of the program.

PROPOSED RESEARCH

A broad description of the research planned is as follows:

- Concrete and Steel Structures. Studies are addressing improved nondestructive testing systems; dynamic stability assessment and upgrading concepts; and maintenance, repair, and rehabilitation of concrete and steel structures.
- Geotechnical. Primary concerns are maintenance and rehabilitation of earth structures, and remedial treatment of foundation problems.
- Hydraulics. Studies are investigating ways to improve navigation conditions of waterways and the effectiveness of hydraulic structures.
- Electrical and Mechanical. Primary concerns are maintenance of corrosion susceptible components through the use of proper coatings and cathodic protection systems.
- Operations Management. Management systems for each type of Civil Works structure are being developed to include condition rating procedures, maintenance and repair alternatives, life cycle costing procedures, and automated data storage and retrieval.

TECHNOLOGY TRANSFER

Technology transfer programs, in place from the prior REMR effort, will continue in the same format. Thus, REMR technical reports, *The REMR Notebook*, and *The REMR Bulletin* will continue to serve as the primary vehicles to bring information about new technology to the broadest audience.

Video Report Added to REMR Publications

A video report entitled "Electrical/Mechanical Problems Area" has been added to the library of REMR Video Reports. Produced by US Army Construction Engineering Research Laboratory, Champagne, Illinois, the tape gives an overview of the technology developed under the initial REMR Research Program. Alfred D. Beitelman was principal investigator for this report.

Summaries of the following work units are addressed:

- Evaluation of Seals and Gate Seal Heaters
- Stainless Steel for Locks, Dams, and Hydroelectric Performance Applications
- Ceramic Anodes to Prevent Corrosion
- Underwater Applied Coatings
- High Solids Coatings
- Lubricants for Hydraulic Structures
- Evaluation of Hydroelectric Generators

The report is 16 minutes and 37 seconds long, and is available on 1/2-in. cassette through inter-library loan from the Waterways Experiment Station Library, telephone (601) 634-2355. The report number is Video Report REMR-EM-1. REMR video reports may be copied and can be used for private viewing, to support classroom instructions, or during presentations.

Nondestructive Testing of Concrete with Ultrasonic Pulse-Echo

by
A. Michel Alexander
US Army Engineer Waterways Experiment Station

Scientists at the US Army Engineer Waterways Experiment Station (WES) continue with the development of hardware (patent pending) capable of "seeing into" concrete. Using a non-destructive, acoustic technique known as Ultrasonic Pulse-Echo or UPE, the equipment introduces ultrasonic stress waves into concrete electronically. Signal generation and detection is accomplished with piezoelectric crystals. The diagnostic capacity of this device represents a significant breakthrough for evaluating a difficult non-homogeneous composite material such as concrete.

UPE is routinely used for metals testing, underwater detection and ranging (sonar), medical diagnosis, and testing and evaluating homogeneous and fine-grained materials. The WES developed system will work especially well on concrete walls or slabs up to 1 ft. thick. Concrete sea walls, pavements, walls, floors, parking garages, bridge decks, etc., are ideally suited for the device.

DEVELOPMENT

A literature search for nondestructive test methods for concretes revealed a need for more pulse-echo research. Commercial systems were not available. Prior pulse-echo research showed poor resolution due to long pulse lengths (high Q value) for transducers. Investigators also had problems with interfering Rayleigh waves at low frequencies, and signal-to-noise ratios (SNR) ranged from only about 2 to 6.

The WES research was part of the Repair, Evaluation, Maintenance and Rehabilitation (REMR) Research Program. Investigations resulted in the development of a pitch-catch system that operates at a center frequency of 200 kHz with a signal to noise ratio of 18. Mass and dimensions of the improved system have been reduced 90 percent from the prior state-of-the-art system. The WES system is able to measure thickness of portland-cement concrete floors and walls, and it can indicate the presence of voids to a depth of approximately 12 inches.

PRINCIPLE OF OPERATION

An ultrasonic (acoustic) wave is generated by exciting a piezoelectric material with a high-amplitude, transient electrical pulse from a high-voltage, high-current pulser. The short burst of ultrasonic energy from the crystal is transmitted into the concrete and impinges upon the various interfaces within. The change in acoustic impedance at the various interfaces, air voids, water-filled voids, reinforcing bars, cracks, delaminations and other interfaces or inclusions within the concrete causes a portion of the input energy to reflect (echo) back to the surface. That energy is detected by a second piezoelectric element. A larger portion of the energy continues to travel forward and strike other interfaces and return an amount of energy based on (1) the area of the reflecting surface, (2) the angle of the reflecting surface, and (3) the acoustic impedance of the reflecting material. The time for the echo to return is accurately measured by an oscilloscope.

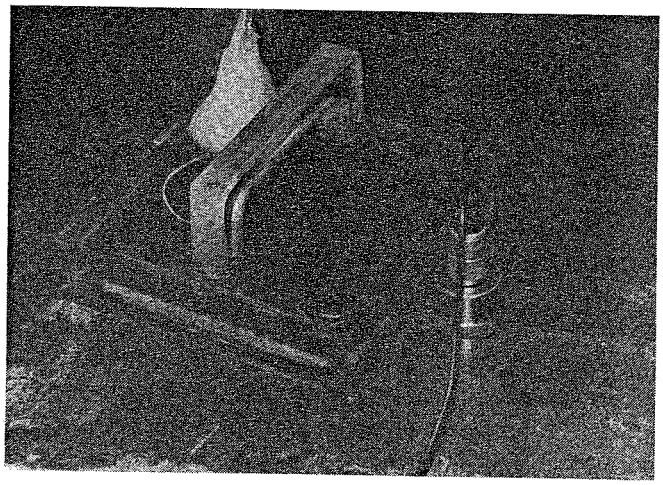


Figure 1. Ultrasonic Pulse-Echo Transducer consisting of lead metaniobate transmitter (6 by 6 in.), and lead zirconate titanate (PZT) receiver (1 in. diam.)

The complete signal is stored on magnetic disc and can be retrieved at any time for further analysis. This applies especially to noisy signals, which can be brought back to the laboratory. There, digital signal processing (DSP) can be applied to recover hidden information.

It is well known that the ultrasonic pulse velocity of concrete is an indicator of its condition. For a known thickness of concrete (such as a bridge deck for example), the velocity, v, of the concrete can be determined by the equation $v = 2L/t$ where L = thickness of the concrete and 2L is the two-way travel distance of the ultrasonic pulse and t = time of arrival of backwall (BW) echo.

Generally, structural concrete will have a very narrow range of velocity when it is sound because structures generally consists of one concrete design mixture. When deterioration or microcracking has taken place the concrete will have a noticeably reduced velocity.

APPLICATION

During preliminary tests on a concrete sea wall, the UPE system pinpointed sound and deteriorated concrete areas. The presence or absence of the BW echo is significant in determining the condition of the concrete. Typical SNR readings of the BW echo for the nominally 9-in.-thick concrete wall were 3 to 6. Unsound concrete produced backscattering and dissipation of the introduced energy. Occasionally, the noise in front obscured or eliminated the BW echo altogether. In some cases, where the concrete surface was pitted, chipped, corroded with barnacles, or otherwise deteriorated, surface preparation was necessary. Even in sound concrete the BW echo can be absent (for dry surface measurements) unless the small air voids between the transducer face and the concrete surface can be squeezed out with couplant grease to bring about the necessary intimate contact. This is not a problem in underwater measurements.

Approximately 60 to 70 percent of the available information can be extracted from the raw signal measured in the field. Subtle information hidden by the noise in the signal can be restored with DSP at the laboratory. DSP is a high-technology operation used by NASA and others to recover information hidden in noise from communications with space vehicles, submarines, satellites, etc.

For the WES system, plans are underway to develop a real-time system with the DSP performed in the field. However, some of the noise is an inherent part of the measurement hardware and cannot be eliminated until the state-of-the-art of piezoelectric materials can be improved. That particular noise has been analyzed in terms of its frequency components, and its characteristics have been defined. With the known information about the noise, digital filters can be built that are capable of attenuating the noise while retaining the valid information hidden in the raw signal.

ADVANTAGES

UPE is nondestructive and can be used in the dry or underwater. Significant savings are gained by eliminating the bulk of coring that normally is needed for evaluation of concrete. UPE evaluation allows precise mapping of regions of quality concrete and regions that have deterioration. Since faulty zones can be pinpointed, repairs will be less expensive.

An important feature of UPE is the ability to monitor the condition of a structure over time. The first set of measurements (original construction and restored areas) serves as baseline data that can be compared with later measurements. The baseline data is stored on magnetic disc (fixed or floppy) and can be retrieved and plotted either over or adjacent to the new signals for comparison purposes. This ability to monitor the condition of a structure for years to come is important in investigating the causes of deterioration, the effectiveness of remedial repairs and the prevention of future problems.

LIMITATIONS

Considerable engineering judgment is needed to properly evaluate a measurement. Presently the system is limited to penetration depths of 1 foot.

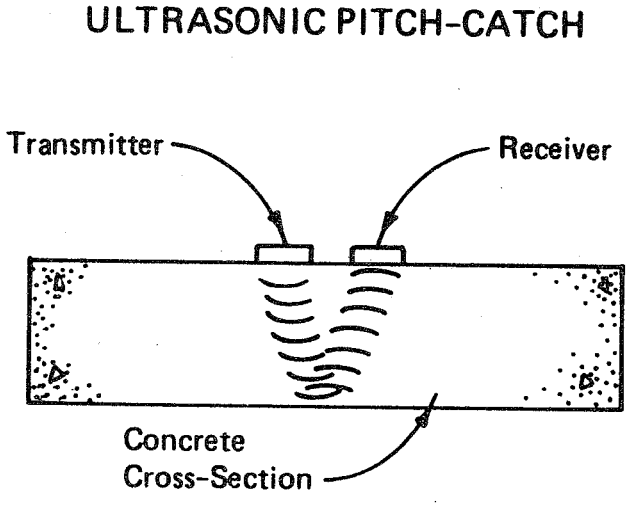


Figure 2. Ultrasonic pulse-echo technique illustration

FUTURE DEVELOPMENT

Research is ongoing

- to develop a system that can penetrate to a depth of ten feet or more,
- develop improved measurement criteria for deteriorated concrete,
- develop new algorithms to retrieve hidden information in the signal using DSP, and
- develop a real-time system so that DSP can be performed in the field rather than brought back to the laboratory.

For more information contact A. Michel Alexander at U.S. Army Engineer Waterways Experiment Station, telephone (601) 634-3237.

A. Michel Alexander is a research physicist at Concrete Technology Division, Structures Laboratory, US Army Engineer Waterways Experiment Station. He received his B.S. degree in physics from Western Kentucky State University and has completed course work for a Master's degree in electrical engineering from Mississippi State University. He is a recipient of the Army Research and Development Achievement Award for technical achievements in nondestructive testing of concrete.

Wanted: Articles that Describe REMR Activities

The REMR Bulletin will print articles about REMR technology application and other REMR activities.

Material is published with the author's byline. Contribution from all REMR problem areas are welcome. The bulletin has a circulation of approximately 2,800. Occasionally, REMR-published articles are reprinted in other publications, thus multiplying the readership considerably.

Manuscripts may be submitted in either draft format or on floppy disk (Word Perfect 5.0 or 5.1, Word Star 3, or ASCII). Photos and illustrations enhance any submission and are requested, although not as a prerequisite for acceptance. A biographical sketch of the author accompanied by a head and shoulder, passport style photo will also be needed.

For more information call Elke Briuer, (601) 634-2587, or send your manuscript to Commander and Director, US Army Engineer Waterways Experiment Station, ATTN: CEWES-SC-A (TTS), 3909 Halls Ferry Road, Vicksburg, MS 39180-6199.

Corps Computer Program Helps Select Concrete and Steel Repair Materials

by
Elke Briuer

Selecting the most effective repair material for a particular job has never been easy. Today, with a proliferation of products on the market, that task is even more challenging.

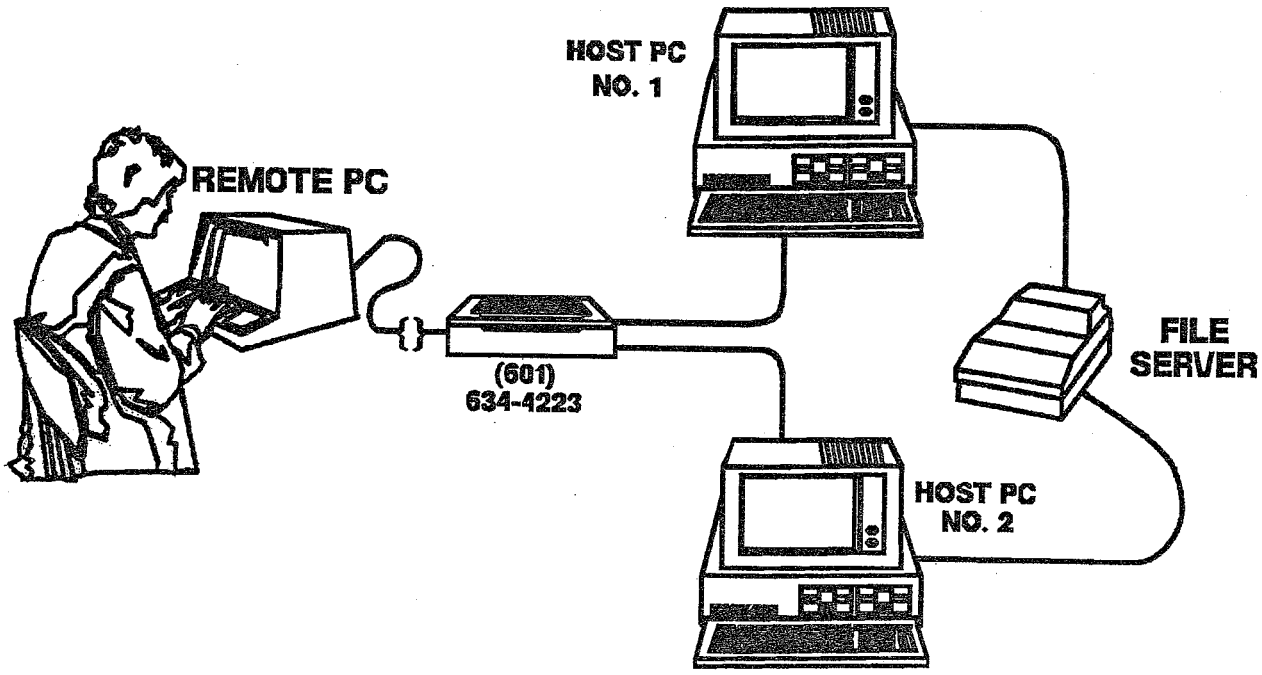
The US Army Corps of Engineers, as one of the guardians of the nation's infrastructure, performs a great deal of concrete maintenance and repair work. To support the need for a central point of reliable product-performance information, the "Maintenance and Repair Materials Database" was developed.

The database holds information about existing maintenance and repair materials. It was developed under a study conducted as part of the Corps' REMR Research Program. Work on the data base will continue with REMR II.

"We developed the database to give the people in the field a place to find answers to their questions about what might be the best product for their specific needs," said William F. (Bill) McCleese, REMR program manager. "REMR technology is available in reports, bulletins, technical notes, and videos. But to be able to call up and have instant access to some of the latest Corps information on a commercial product and its use for a specific repair--that is of real value to the field."

Roy L. Campbell, Sr., is the "Maintenance and Repair Materials Database" manager. Campbell has been fine-tuning the database to turn it into a useful tool for field application. Campbell designed the database to identify primarily products for use in concrete and steel structure maintenance and repair. Also available is supplemental information from the manufacturer, from Corps tests and users, and from other sources. Information supplied addresses a product's uses, applications, limitations, and technical properties.

"The database identifies either end-use or additive products. End use means that the product bought for the repair will be used as purchased. An additive product is one that is used in combination with other materials to



The hardware configuration for the "Maintenance and Repair Materials Database" network serves the user of a remote PC. Modems and telephone lines link remote PCs with the host computers at the Waterways Experiment Station. Two host PCs allow simultaneous use of the database. An automatic roll-over device provides access to one or the other PC.

produce an end-use product, like a latex admixture for concrete," Campbell said.

The database can be accessed by calling (601) 634-4223 through a PC with a modem. Telecommunications parameters are: baud rate - 1,200; parity - none; emulate - VT-100; duplex - full; data bits - 8; stop bits - 1.

"All user operations are menu-driven and easily understood by even novice computer users," said Campbell. "Once users enter the database, they can search for information needed, display results, and exit the system through the menus. Data displayed can be printed or saved to disk. We have included help options that provide definitions of product categories and uses for end-use and additive products," added Campbell. New 386-computer technology is planned to enhance the presently sluggish performance of the data base in the near future.

To learn more about the database, contact Roy L. Campbell, Sr., CEWES-SC-CG, U. S. Army Engineer Waterways Experiment Station, 3909 Halls Ferry Road, Vicksburg, MS 39180-6199 or call (601) 634-2814. Government employees may also use the FTS line at 542-2814.

Elke Briuer, Information Technology Laboratory, is technology transfer specialist for the REMR Research Program at the US Army Engineer Waterways Experiment Station. She received her B.A. degree from the University of Maryland and is a Master's Candidate in Mass Communication at Mississippi College. She is a graduate of the Army's Public Affairs Advanced Course.

Reference Books Assist with Information about REMR Technology

Two reference publications of the REMR Research Program went to print during 1990 at the US Army Engineer Waterways Experiment Station. Both provide information about available REMR technology, each in a different format. REMR technology encompasses seven broad problems areas: Coastal, Concrete and Steel Structures, Electrical and Mechanical, Environmental Impacts, Geotechnical, Hydraulics, and Operations Management.

With a cover date of March 1990, *An Overview of the Repair, Evaluation, Maintenance and Rehabilitation (REMR) Research Program 1984 - 1989* reports research results of various work units in the seven broad problem areas. As such, it can only provide a brief look at the highlights of REMR research. A listing of technical reports published (and to be published) is included, referring readers to more detail about the various work units.

The *Index of REMR Technology and Listing of REMR Research Publications* was published in October 1990. This volume is divided into five parts: (1) A subject index of REMR technology with separate listings for all seven problem areas, (2) a listing of technical reports published through September 1990, (3) a listing of technical notes and material data sheets as published in *The REMR Notebook*, (4) a listing of *The REMR Bulletin* articles through Volume 7, Number 2, and (5) a listing of REMR Technology Video Reports.

The two publications were distributed to all Corps of Engineer Divisions and Districts. For copies and information call the REMR technology transfer specialist at (601) 634-2587 or write to Commander and Director, US Army Engineer, Waterways Experiment Station, ATTN: CEWES-SC-A (TTS), 3909 Halls Ferry Road, Vicksburg, MS 39180-6199.

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(Continued)

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COVER PHOTOS:

REMR Program Manager William F. (Bill) McCleese on the job

REMR developed crack-and-joint testing apparatus

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. Contribution 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, or promotional purposes, nor are they to be published without proper credits. Any copyright material released to and used in *The REMR Bulletin* retains its copyright protection, and cannot be reproduced without permission of copyright holder. Citation of trade names does not constitute an official endorsement or aproval 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 Comander and Director, US Army Engineer Waterways Experiment Station, ATTN: Elke Briuer (CEWES-SC-A), 3909 Halls Ferry Road, Vicksburg, MS 39180-6199, or calling 601-634-2587.

LARRY B. FULTON
Colonel, Corps of Engineers
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