

STREAM NOTES

To Aid In Securing Favorable Conditions of Water Flows

Rocky Mountain Research Station

July 2002

Viewing Bedload Movement in a Mountain Gravel-bed Stream

Have you ever wondered what the bottom of a stream looks like during peak flow events? Is the channel bottom re-arranged gradually in small increments or do all of the particles pick up and move at once? Do small sand-sized particles move all the time? Do they move at a constant rate of speed or do they stop and rest periodically behind larger rocks? When and how do the larger gravels and cobbles move? Does gravel move before cobbles? Do they move as individual rocks or as clusters of similar-sized particles? Is bedload movement an orderly or a chaotic process?

To answer these and other questions, Rocky Mountain Researchers **Sandra Ryan**, Research Hydrologist, and **Mark Dixon**, Hydrologic Technician, obtained an inexpensive underwater black and white video camera and began to view bedload transport in Colorado streams. They used a Seaviewer™ underwater video camera and attached it to a consumer grade Sony Digital 8™ camcorder.

A short 30 second video clip of bedload movement in Halfmoon Creek near Leadville, Colorado is available for viewing on the STREAM Web page (www.stream.fs.fed.us) if you'd like to see what they saw.

Halfmoon Creek is about a 24 square mile watershed in mountainous terrain. Bedload transport at the time of filming was about 19 tons/day. The channel flowed at a rate of 183 cfs, or 83 percent of bankfull discharge, and had an average velocity of 4.2 ft/s.

Preliminary results of their observation are published in the Proceedings of the Seventh Federal Interagency Sedimentation Conference under the title, "Using an underwater video camera for observing bedload transport in mountain streams." While motion picture photography has been used by others to observe fine gravel transport, this the first published work where a digital video camera was used in a natural stream setting to observe bedload sediment movement, interaction of bed particles, or the interaction of a sampling instrument with the streambed.

Researchers wanted to know:

- Whether there is sufficient visibility to record video under turbid and turbulent flow conditions,
- Whether the underwater camera had sufficient resolution to pick up the movement of individual grains, and
- If the camera is rugged enough for typical field applications.

STREAM NOTES is produced quarterly by the Stream Systems Technology Center, Rocky Mountain Research Station, Fort Collins, Colorado. Larry Schmidt, Program Manager

The PRIMARY AIM is to exchange technical ideas and transfer technology among scientists working with wildland stream systems.

CONTRIBUTIONS are voluntary and will be accepted at any time. They should be typewritten, single-spaced, and limited to two pages. Graphics and tables are encouraged. E-Mail: jpotyondy@fs.fed.us

Ideas and opinions expressed are not necessarily Forest Service policy. Citations, reviews, and use of trade names do not constitute endorsement by the USDA Forest Service.

CORRESPONDENCE:
E-Mail: rmrs_stream@fs.fed.us
Phone: (970) 295-5983
FAX: (970) 295-5988

Web Site:
www.stream.fs.fed.us

IN THIS ISSUE

- **Viewing Bedload Movement**
- **David Merritt Joins STREAM**
- **New Instream Flow Book**
- **Videos on Road Maintenance**
- **Doc Hydro: Current Meters**
- **Wildland Waters**

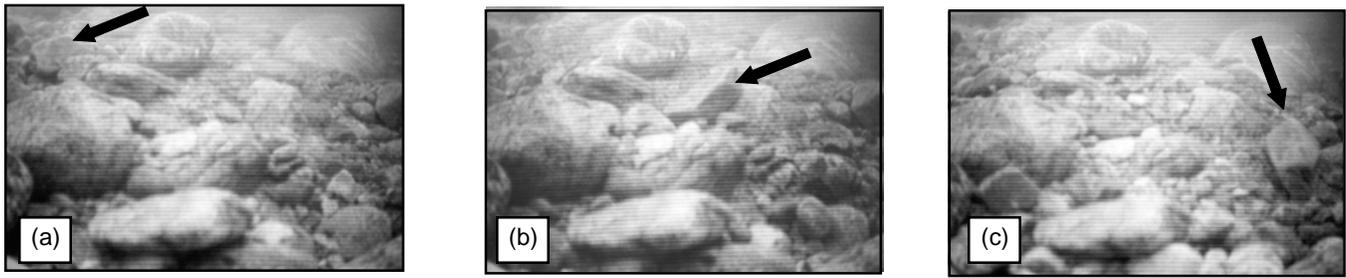


Figure 1. Track of a single particle at Halfmoon Creek. (a) The particle moves into view and comes to rest, (b) after 17 seconds the particle moves 23 cm and comes to rest again, (c) after being stationary for over 7 minutes, the particle moves out of the view. The video image is much clearer than these reproductions.

With respect to long-term research objectives they hoped to determine if the equipment has potential for making quantitative measurement of sediment transport, including identification and measurement of the trajectory and velocity of individual particles.

Simply put, Ryan and Dixon concluded that the video camera is particularly well suited for viewing bedload sediment movement along mountain streams with relatively low suspended sediment loads. However, the system is less useful for turbulent streams where entrained air bubbles obscure viewing and it is difficult to distinguish air bubbles from moving grains. The camera can be used to directly measure particle sizes with a b-axis greater than about 15 mm and appears to be especially suitable for estimating the maximum particle size moved and its velocity.

How Does the Sediment Move?

Viewing the video helps one to appreciate the complexity of the transport process and why it is so difficult to obtain accurate and consistent measurements of bedload transport. “Ordered chaos” might be one way to characterize the phenomena.

Coarse gravel movement appears to occur in noticeable pulses. According to Ryan and Dixon, frequently an accumulation of an assemblage of particles would persist for a short time and then be disassembled. Sequentially, a particle would become lodged, then other particles in transit would catch on the original particle. As the number of particles increased the entire structure would become increasingly unstable and the initial particle would begin to vibrate. A short time later, particles were plucked away until all were removed, returning the streambed close to its original configuration.

Occasional sweeps were observed that would briefly entrain small to medium sized gravel. The sequence of pictures in Figure 1 illustrated this. For example, in Figure 1a, a

relatively large particle (b-axis = 46 mm) moved into the frame and came to rest behind a similar-sized stationary particle. This particle adjusted its orientation slightly during the next 17 seconds. The particle then rolled over and came to rest downstream against a partially buried large cobble (Figure 1b). The particle adjusted its position slightly during the next 7 minutes and 19 seconds as smaller particles filled in and subsequently scoured away both on top and beneath. Just before the particle moved, there was a sweep of sediment followed by the particle being struck by another particle (b-axis = 26 mm) that initiated its movement out of the view frame.

In summary, most bedload moves as swirling finer grained patches associated with flow obstructions. Although smaller particles are difficult to see, they appear to be liberated from the swirling cloud and move to the next patch where they are caught for an indeterminate period of time.

Sandra Ryan, Research Hydrologist, Rocky Mountain Research Station, Laramie, WY, sryanburkett@fs.fed.us.

Mark Dixon, Hydrologic Technician, Rocky Mountain Research Station, Laramie, WY, mdixon01@fs.fed.us.

Copies of: Dixon, M. and S. Ryan, 2001. Using an underwater video camera for observing bedload transport in mountain streams. Proc. Seventh Fed. Interagency Sedimentation Conf., March 25-29, Reno, NV, pp. Poster 70 –73, are available for downloading from the “Download PDF Documents” section of the STREAM Web page (www.stream.fs.fed.us). The 30 second video clip is also available from this Web page. A longer 2.5 minute video clip is available from the Stream Systems Technology Center. Send e-mail requests to: rmrs_stream@fs.fed.us.



Riparian Plant Ecologist David Merritt Joins Stream Systems Technology Center Staff

Dr. David M. Merritt is the newest addition to the Stream Systems Technology Center. A few years ago, STREAM's charter focusing on instream flows and channel maintenance was slightly revised and expanded to address flows to sustain riparian vegetation. As the Streamside Vegetation Specialist, Dr. Merritt will serve as a technical specialist for STREAM and be responsible for synthesizing information about the relationship between flow regimes, streambanks, and floodplain vegetation.

Among his duties, Dr. Merritt will:

- Assess the status of knowledge regarding the relationship between streamflow hydro-period characteristics, water stage, and water dependent streamside and floodplain vegetation on public lands throughout the United States.
- Synthesize and publish a comprehensive peer reviewed status of knowledge paper on the relationship between flow regimes, seasonal water temperatures, and plant characteristics based on information available in the scientific literature and from sources with expertise throughout the temperate world.
- Review and develop protocols for acquiring and compiling the necessary data to determine minimum flows necessary to sustain streamside and floodplain vegetation.
- Develop appropriate cost effective monitoring protocols to determine if acquired flow regimes are adequate to sustain plant communities and the beneficial effects plants have in regulating bank and floodplain erosion.

David Merritt received his Ph.D. in Ecology in 1999 from Colorado State University as a graduate student of Dr. Ellen E. Wohl of the Department of Earth Resources. David brings much relevant plant ecological and geomorphic experience and expertise to STREAM. For his Ph.D. dissertation he studied the effects of mountain



reservoir operations on the distribution and dispersal mechanisms of riparian plants. He conducted field and flume experiments to examine the effects of dams and their reservoirs on upstream and downstream connectivity in riparian ecosystems and tested the effects of natural and managed flows regimes on patterns of plant seed dispersal and riparian plant communities. His M.S. thesis from the Department of Fishery and Wildlife Biology, also at Colorado State University, examined riparian vegetation and geomorphic features on regulated and unregulated rivers in northwest Colorado.

Dr. Merritt also maintains a strong research relationship with the Landscape Ecology Group at Umeå University in Sweden on a long-term effort investigating the factors governing plant species diversity in riparian corridors, connectivity/fragmentation, mechanical and chemical stresses along river margins, hydrochory (water dispersal of plants), and floodplain nutrient cycling. Dr. Merritt is specifically studying the source-sink dynamics of vascular plants and bryophyte populations as well as plant community development through time in sites along the margins of regulated and free-flowing boreal streams.

David Merritt can be contacted by e-mail at dmmerritt@fs.fed.us.



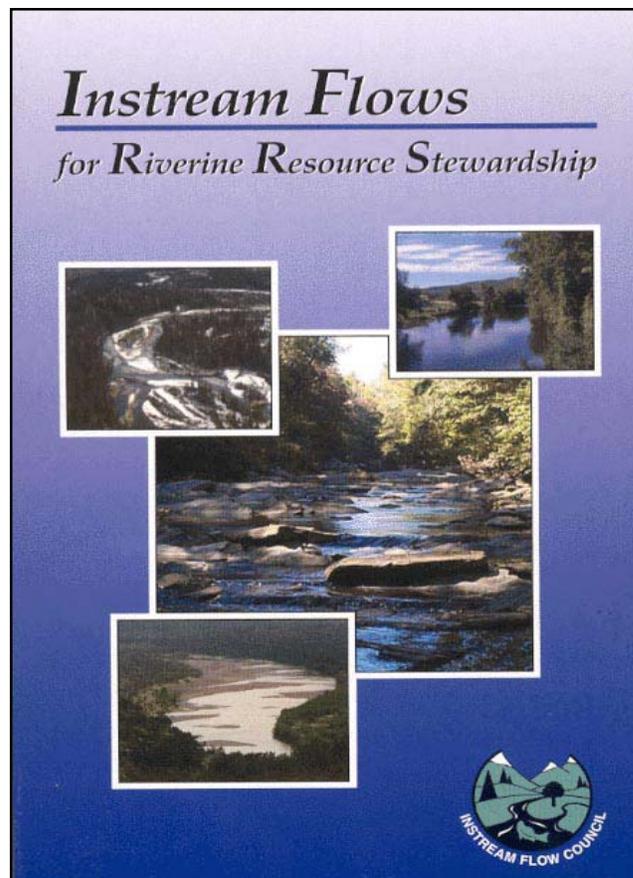
Instream Flows for Riverine Resource Stewardship

Instream Flows for Riverine Resource Stewardship is a new book by the Instream Flow Council (IFC), a nonprofit organization of state (United States) and provincial (Canada) fishery and wildlife agencies whose mission is to improve the effectiveness of instream flow programs for conserving aquatic resources.

One of the purposes of the book is to recommend tools and approaches that are most appropriate in various geophysical and legal settings for developing instream flow programs. The book succeeds in describing appropriate tools in that it provides a comprehensive review of 29 techniques including the appropriate scale of use, assumptions, level of effort required, strengths, weaknesses, limitations and most importantly offering a critical opinion of why or why it should not be used in certain situations. Anyone needing a good overview of available techniques would profit from this portion of the book.

The book however falls short in the legal arena because it primarily discusses approaches to protecting instream flows that arise from state and provincial governmental agencies. Consequently, instream flow protection strategies that involve private and or federal government strategies are largely ignored. This is done in spite of a stated recognition that “some states and provinces provide at least partial legal mechanisms for allocation of instream flows, but many do not.” This approach may be understandable given the genesis of the book by an organization of states and provinces, but it results in an incomplete analysis of available instream flow protection approaches.

Instream Flows for Riverine Resource Stewardship contains a list of recommended principles and policy elements. The book consistently argues for an ecosystem approach that strives to maintain or restore natural ecosystem functions and processes as the proper way to approach instream flow issues. It also advocates an interdisciplinary approach that addresses the five riverine components of hydrology, biology, geomorphology, water quality, and connectivity. However, the book was largely written by a team of biologists and this is



Annear, T., I. Chisholm, H. Beecher, A. Locke, and 12 other authors, 2002. *Instream Flows for Riverine Resource Stewardship*. Published by Instream Flow Council, Cheyenne, WY.

especially evident in the section on flushing flows and sediment transport modeling, which demonstrates an incomplete understanding of sediment transport processes and technology.

Other than these shortcomings, the book is a useful addition to the debate over instream flow and provides valuable insights into instream flow issues.

Instream Flows for Riverine Resource Stewardship can be purchased by going to the Instream Flow Council Web page (<http://www.instreamflowcouncil.org>). The 410 page paperback book sells for \$40 plus \$6.50 for shipping and handling.



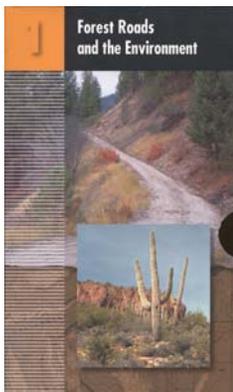
STREAM SYSTEMS TECHNOLOGY CENTER

Road Maintenance Training Videos



Controlling sediment production from roads is one of the biggest challenges in protecting stream water quality. Proper road maintenance is a key aspect of control. Toward that end, the San Dimas Technology and Development Center developed a set of videos to help road maintenance field crews do a better job with this important task.

The road maintenance training videos were funded through a partnership with the Federal Highway Administration, Bureau of Indian Affairs, National Park Service, and the Forest Service. The videos are primarily designed with the operator as the target audience. However, they can be used for a variety of audiences including management, field professionals, and seasonal employees.



Video 1 *Forest Roads and the Environment*

- A visually pleasing overview of how the road and environment interact with each other.



Video 2 *Reading the Traveled Way*

- Focuses on understanding what the condition of the road is and providing insights on how to proactively avoid costly repairs by properly addressing the road in its current condition.



Video 3 *Reading Beyond the Traveled Way*

- Considers the natural functions happening beyond the roadway and how to use that knowledge before beginning maintenance operations to help minimize significant impacts on the road.



Video 4 *Smoothing and Reshaping The Traveled Way*

- Covers detailed step-by-step processes used for both smoothing and reshaping a road.



Video 5 *Maintaining the Ditch and Surface Cross Drains*

- Provides comprehensive instructions for correctly constructing and maintaining ditches, culverts and various surface cross drains.

Send e-mail requests for videos to Shawna Hilgert (shilgert@fs.fed.us) or Anthony Edwards (aedwards@fs.fed.us). Include your name, job title, agency or business, mailing address, phone number, and e-mail address.



Ask DOCTOR Hydro

Dear Doc Hydro: We are gathering opinions on what type of flow meter to acquire. We are interested in obtaining flow data at channel geometry and stream temperature stations but are not necessarily interested in quantification for legal purposes. We have the AA and mini types on the Forest but are interested in your opinion on the “easy to use” flow probes or a Marsh McBirney type meter.

Most streamflow or discharge measurements are made by hydrographers from observations of flow width, water depth, and point velocity measured at intervals in a cross section of the stream. The reliability of these measurements depends to a large extent upon the accuracy and consistency of the current meters used to measure water velocity.

A recent study by hydrologist Janice Fulford, U.S. Geological Survey, Hydrologic Instrumentation Facility (HIF), provides objective information about the accuracy and consistency of a number of current meters commonly used to make discharge measurements in rivers and streams in the United States. Complete results are published in the October 2001 issue of the *Journal of the American Water Resources Association*, “Accuracy and Consistency of Water-Current Meters,” pages 1215-1224.

The study tested four relatively inexpensive (less than \$5,000) models of water-current meters manufactured in the United States (Figure 1):

- Price Type-AA
- Price Pygmy
- Marsh McBirney 2000
- Swoffer 2100.

The Price vertical-axis meters (Type-AA and Pygmy) have long been the standard current meters used by the U.S. Geological Survey. The meters made of stainless steel and plated brass have a rotor consisting of six conical cups fixed to a hub that revolves around a vertical shaft. The Pygmy version, with a 2.5-inch diameter rotor, is about one-half the size of the larger Type-AA. Velocity is measured by translating the linear motion of the water into angular motion of the rotor. Traditionally, rotor revolutions were counted using a headset to count the audible contact made with a simple wire switch but this is increasingly being replaced with optical and electronic devices to count and time revolutions.

The Marsh McBirney 2000 is a more modern electromagnetic meter made primarily out of plastic. The velocity probe has a 1.5-inch symmetrical teardrop shape and has no moving parts making it attractive for fieldwork. The probe generates a magnetic field and produces a voltage that varies linearly with the flow velocity of the water. An electronic readout box converts the voltage detected by the probe into velocity readings for numeric display.

The Swoffer 2100 meter is a mechanical meter like the Price meters except that it is a horizontal-axis meter with a 2-inch diameter screw-type impeller that rotates due to the force exerted by the moving water. The meter is made primarily of plastic with a metal shaft and nose bearings and a fiber optic switch. An electronic readout box converts meter revolutions into a velocity reading for numeric display.

Consistent meter performance depends on design and the manufacturing tolerances of individual meters. In the past, each meter was individually calibrated in a tow tank facility to account for variations in manufacturing adding significantly to the cost of production. Today, to reduce costs, manufacturers rely on other ways to calibrate meters individually (such as electronic testing and adjustment) or use a standard rating or calibration equation determined from testing a limited sample of the meter model in a tow tank. For federal users, it pays to acquire tested meter through HIF. The increased cost assures accuracy and meter operation.



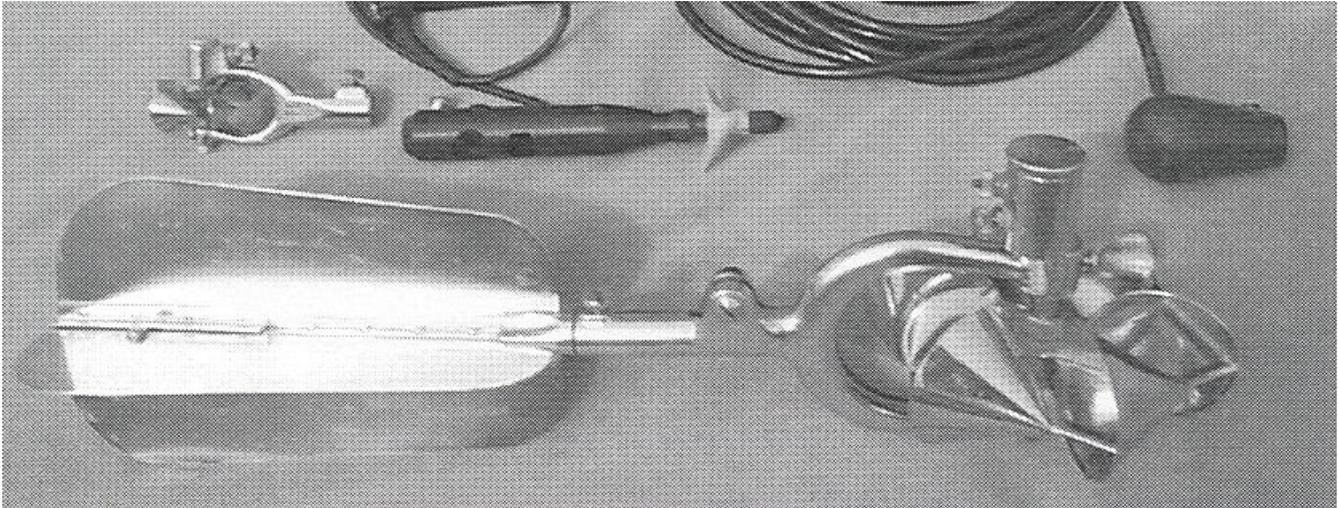


Figure 1. Meters tested (top row, left to right) - Price Pygmy, Swoffer 2100, Marsh McBirney 2000, and (bottom row) Price Type-AA. Photograph courtesy of U.S. Geological Survey.

This study tested six meters of each model in the tow tank at the USGS Hydraulic Laboratory Facility at the Stennis Space Center, Mississippi. Test flows ranged from 0.25 to 8.0 ft/s except for the Pygmy model, which was limited to an upper flow velocity of 3.0 ft/s. All tests were conducted under steady flow conditions normal to the meter. This is unlike natural flows where the current meter may be exposed to occasional pulsing or oblique flows that may worsen the accuracy of the velocity measurement and alter the relative performance of the meters tested.

Consistency was evaluated based on the variation of meter performance for a model. Accuracy was evaluated as the percent velocity error compared to a measured reference velocity (the tow tank cart velocity) for each model. Measured velocities were also compared to each manufacturer's published or advertised accuracy limits.

The study found the Price models to be more accurate and consistent than the other models. All Price meters (Type-AA and Pygmy) met the accuracy limits fairly well over the range of velocities tested, including at the lowest velocity measured of 0.25 ft/s.

The Marsh McBirney model also met stated accuracy limits fairly well, except at the lowest velocity tested, 0.25 ft/s.

The Swoffer model did not meet the stringent accuracy limits for all the velocities tested. The Swoffer model, tested with the factory supplied calibration, failed to meet accuracy limits as well as the other meters. However, individual meter rating equations determined using manufacturer instructions resulted in improved accuracy.

Every model tested had meters that failed to meet their manufacturer's stated accuracy limits. Because current meters have inconsistent accuracy within a model, users should periodically check meters against a calibrated meter or at a laboratory test facility. For stringent accuracy requirements, meters should be individually calibrated in water at a laboratory facility with traceable standards.

Dear Doc Hydro: Where can I get my current meter calibrated and how much will it cost?

The U.S. Geological Survey's Office of Surface Water Hydraulics Lab calibrates all kinds of current meters for federal agencies and others. The cost of calibrating a Price Pygmy current meter in good working condition is about \$125.00. The cost of calibrating a Price Type-AA meter is about \$250.00. Arrangements can also be made to repair meters in poor condition. Calibration costs for other meters depend on the individual types and their configurations. For more information, contact Kirk Thibodeaux (228) 688-1508; kgthibod@usgs.gov.



STREAM NOTES



PRSR STD
POSTAGE & FEES PAID
USDA - FS
Permit No. G-40

OFFICIAL BUSINESS
Penalty for Private Use \$ 300

STREAM SYSTEMS TECHNOLOGY CENTER
USDA Forest Service
Rocky Mountain Research Station
2150 Centre Ave., Bldg A, Suite 368
Fort Collins, CO 80526-1891

July 2002

IN THIS ISSUE

- Viewing Bedload Movement
- David Merritt Joins STREAM
- New Instream Flow Book
- Videos on Road Maintenance
- Doc Hydro: Current Meters
- Wildland Waters

STREAM NOTES



Wildland Waters is a new USDA Forest Service quarterly publication that will highlight news, views, and current technological and public policy information on local, national, and international water issues. The goal of the publication is reach a large, diverse audience including conservation districts, local watershed groups, state and local officials, and tribes and provide for collaborative solutions to water issues.

In the Spring 2002 inaugural issue, science specialist Sally Duncan provides a broad view of the current ecological, political, and social status of water issues in the United States.

Wildland Waters is published by the Policy Analysis Staff and Private Forestry Deputy Area of the USDA Forest Service, Washington Office. To subscribe to or obtain a free electronic or hard copy of *Wildland Waters* go to <http://www.fs.fed.us/wildlandwaters/>. Comments or questions should be directed to: James Sedell, jsedell@fs.fed.us, (202) 205-1038; or Daina Dravnieks Apple, dapple@fs.fed.us, (202) 205-1365.

The United States Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, sex, religion, age, disability, political beliefs, sexual orientation, or marital or family status. (Not all prohibited bases apply to all programs.) Persons with disabilities who require alternative means for communication of program information (Braille, large print, audiotape etc.) should contact USDA's TARGET Center at 202-720-2600 (voice and TDD). To file a complaint of discrimination, write USDA, Director, Office of Civil Rights, Room 326-W, Whitten Building, 1400 Independence Avenue, SW, Washington, DC 20250-9410 or call 202-720-5964 (voice or TDD). USDA is an equal opportunity provider and employer.