WATER OPERATION AND MAINTENANCE

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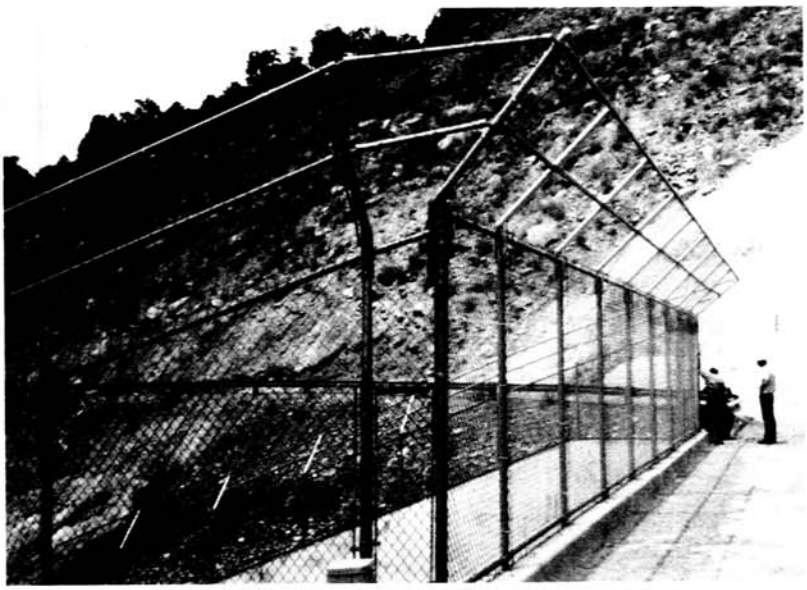

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Bureau of Reclamation

The Water Operation and Maintenance Bulletin is published quarterly for the benefit of those operating water supply systems. Its principal purpose is to serve as a medium of exchanging information for use by Bureau personnel and water user groups for operating and maintaining project facilities.

While every attempt is made to insure high quality and accurate information, Reclamation cannot warrant nor be responsible for the use or misuse of information that is furnished in this bulletin.

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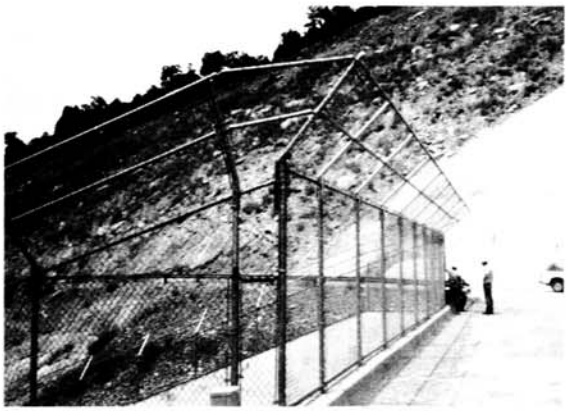

Spillway fence extension, McPhee Dam, Colorado.

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FENCE EXTENSION MAY DETER ROCK TOSSERS

By Bill Bouley and Neil Gillis[1]

Most dam tenders get noticeably upset when they see a concrete spall in their hydraulic structures. They may wonder if more site visits, less sleep, etc., could have stopped the individuals from throwing damaging debris. Once the vandals are apprehended, the dam tender and local law enforcement could steer them into a better understanding of proper operation and maintenance practices.

Normally, safety fences around spillway and outlet work chutes and stilling basins consist of chain link fence fabric topped with strands of barbed wire. These fences are all that separate the rock throwers from their intended target.

On a recent inspection of McPhee Dam, Dolores Project, Colorado, Neil Gillis of the Operation and Maintenance Engineering Branch noticed an improvement to the safety fence around the spillway chute. An extension connected to the fence posts allows an inclined chain link fence fabric to be installed. This extension makes it exceptionally difficult for would-be rock throwers, out-of-work shot putters, disgusted bowlers, and other pranksters to toss their concrete-damaging debris into the spillway chute.

Spillway fence extension to prevent rocks from being thrown onto the chute floor.

[1] Bill Bouley is a Civil Engineer and Neil Gillis is a General Engineer, Bureau of Reclamation, Denver Office.

Spillway fence extension connectors.

TESTING CLOSE-COUPLED OUTLET WORKS GATES AND VALVES UNDER UNBALANCED HEAD CONDITIONS

By Ernie Bachman[1]

The Bureau (Bureau of Reclamation) has developed two primary programs for testing dam outlet works guard gates and valves upstream of the main regulating gates or valves. (*Also see "Penstock and Outlet Works Guard Gate and Valve Testing," Bulletin No. 163, p. 25*). The purpose of the tests is to determine if the primary function to shut off waterflow in the event of a downstream failure can be served. The oldest program is the Bureau-wide Power Penstock Guard Gate and Valve Test Program, and the newest is the Outlet Works Emergency/Guard Gate and Valve Test Program. The outlet works program is also divided into two sections: Group 1 comprising facilities with "close-coupled" guard and regulating gates and valves and Group 2 comprising facilities with "distant-coupled" guard and regulating gates and valves. "Close-coupled" means less than five pipe diameters between the two. Group 2 facilities, having a risk of pipe collapse downstream of the guard gate upon emergency closure of that gate, have been analyzed for air venting demand and retrofitted in most cases with upgraded air/vacuum valves before testing is carried out. Group 1 facilities have been considered for unbalanced testing as they stand, since the close-coupled arrangement allows for sufficient air displacement for testing.

As a case of study for a close-coupled system, the unbalanced opening and closure test carried out during an RO&M (Review of Operation and Maintenance) examination at the Yellowtail Dam and Powerplant in May of 1992 will be described. Yellowtail Dam is a Bureau facility located in South-Central Montana on the Bighorn River. The outlet works consist of two 84-inch-diameter outlet pipes, the irrigation and evacuation conduits, which begin at the upstream face of the dam and extend through the dam to the ring-follower gates at the downstream side of the dam, and then to the hollow-jet valves immediately downstream of the ring-followers. The ring-follower gates serve as guard gates, which are normally operated in the fully open or fully closed position. The hollow-jet valves serve to regulate the flow and can be operated at any given setting. The maximum water surface elevation is 3660 feet (1116 meters) and the elevation of the ring-follower gates and hollow-jet valves approximately 3200 feet (976 meters) yielding a maximum pressure head on the gates and valves of 460 feet (140 meters).

A brief description of the ring-follower gates and hollow-jet-valves follows:

The ring-follower gates (fig. 1) are constructed of cast and welded steel and consist of a body, a leaf, and a hydraulic hoist. The leaf includes a follower ring having a circular opening equal to the inside pipe diameter, such that an unobstructed flow of water through the body is permitted in the open position. These ring-follower gates are designed to operate under maximum reservoir head, using a maximum oil pressure of 2,000 lb/in^2 (13.79 MPa) and have a total vertical travel of 7 feet 8 inches (2.3 meters). Normally, the gates are operated under balanced head with no flow through the outlet works, but they are designed for emergency closure with full flow under maximum reservoir head.

The hollow-jet valves (fig. 2) are constructed of cast and welded steel and consist of a circular body and a conical, moveable needle which forms an annular water passage and moves upstream to seal against the entrance throat. There is no downstream convergence of the water passage, resulting in a hollow jet with a column of air inside. Movement of the needle varies the cross-sectional area of the annular opening between the conical needle and the body and thus controls the amount of discharge.

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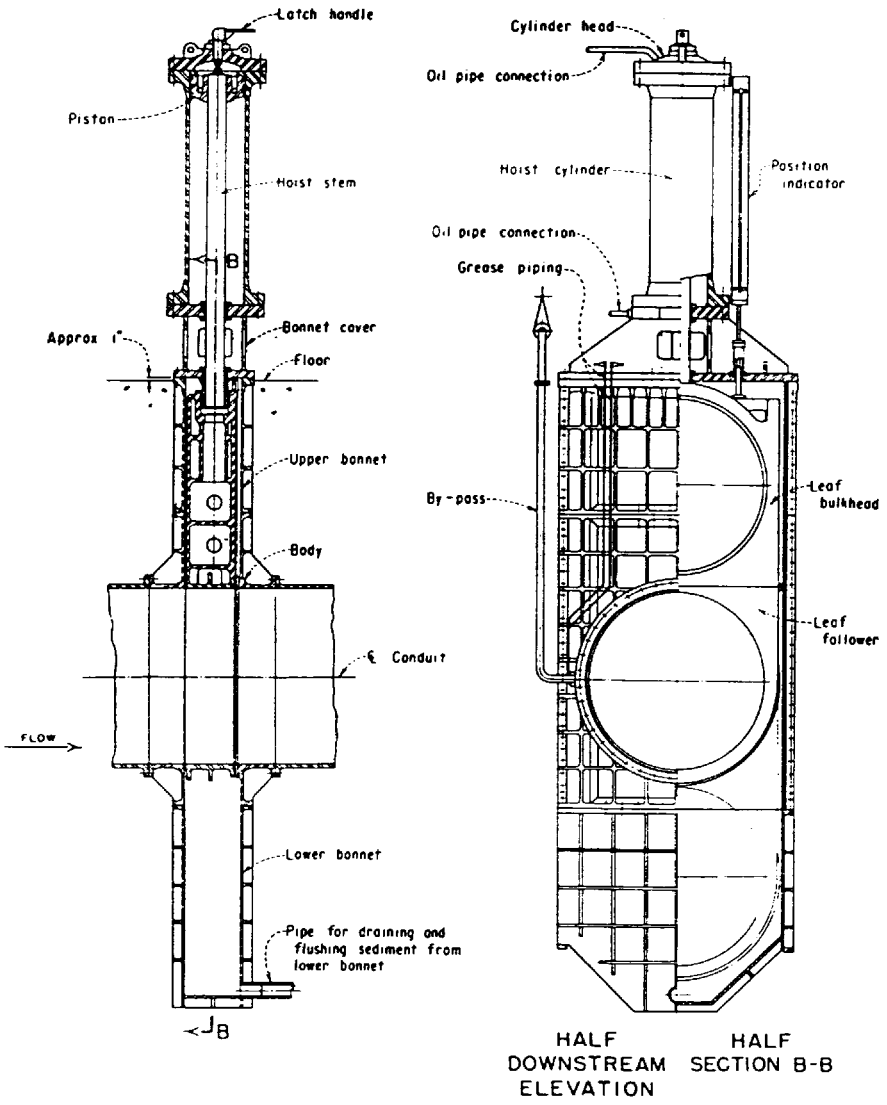


Figure 1. – Hydraulically operated ring-follower gate.

The hub or stationary body of the needle is supported by six radial members extending out to the valve body, splitting the jet into six sectors. The hollow-jet valves in the Yellowtail installation are hydraulically operated, using a hydraulic cylinder mounted inside the needle and effecting a total movement of 29-1/2 inches (74.9 cm) from the fully open to fully closed position. The valves are designed to regulate the discharge under any head up to 465 feet (141.7 meters); and at that maximum head, an oil pressure of 726 lb/in^2 (5.0 MPa) in the closing chamber of the cylinder is required to hold the valve in a closed position. Any intermediate position is maintained by confining oil in the opening and closing chambers of the cylinder. As a background for further discussion, note in figure 2 that the closing chamber has a much larger cross-sectional area than the opening cylinder, matching the normal operating demands of the valve.

A single hydraulic system (including two pumps, two 4-way valves, pressure relief valves, and limit switches) operates both the ring-follower gates and hollow-jet valves. Oil pressure for opening the hollow-jet valves is limited to 500 lb/in^2 (3.45 MPa) by relief valves. Closing pressure of 900 lb/in^2 (6.21 MPa) for the hollow-jet valves and operating pressure of 1,800 lb/in^2 (12.42 MPa) for the ring-follower gates are limited by pressure switches.

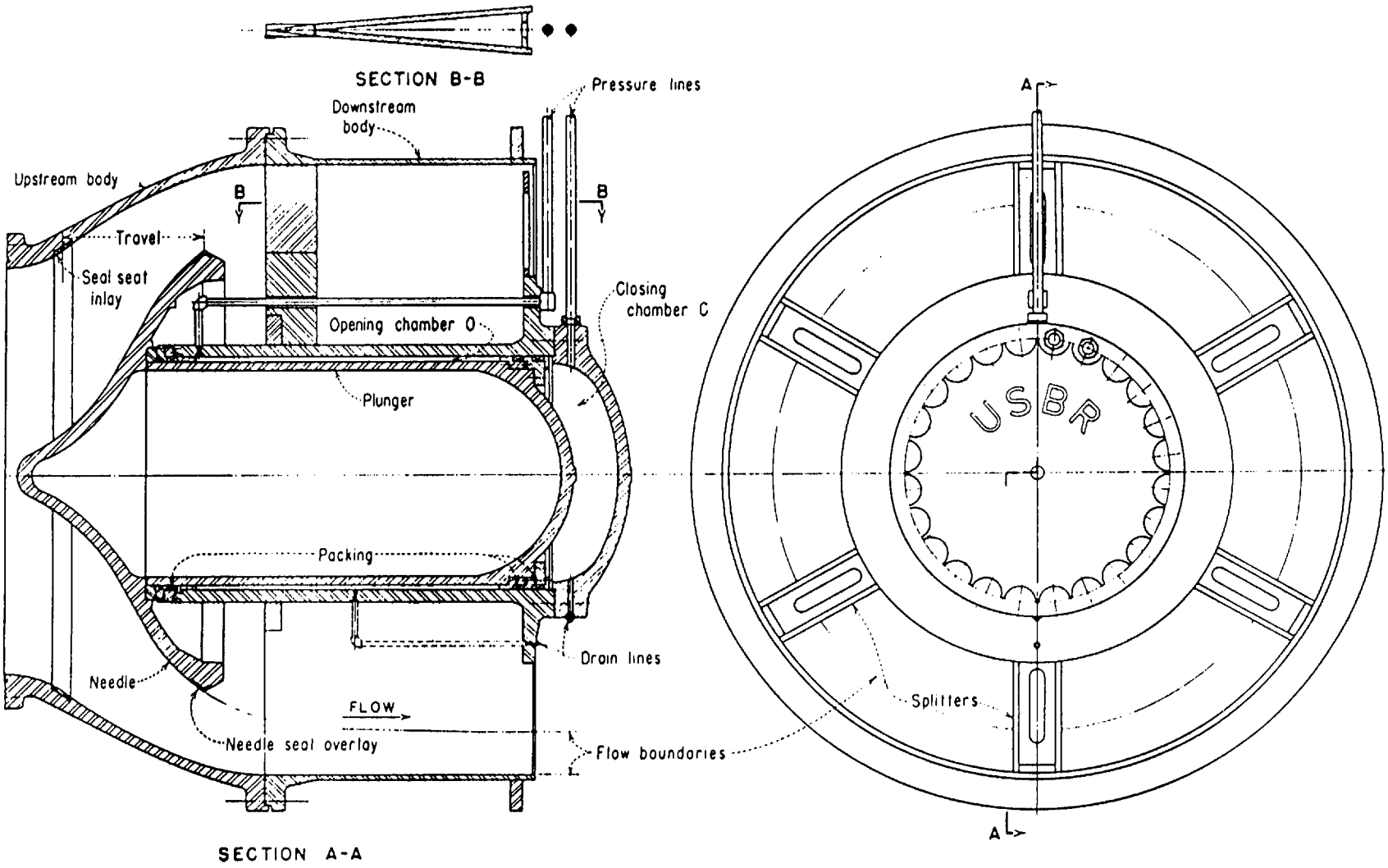


Figure 2. – Hydraulically operated hollow-jet valve.

The gate and valve test procedure was carried out for both outlet works. A summary of the test results for only the evacuation outlet works follows:

The manually operated air valve immediately downstream of the ring-follower gate, used for bleeding air during the filling of the discharge pipe between the ring-follower gate and hollow-jet valves, was examined and found to function satisfactorily. The ring-follower gate was first opened under balanced head with the hollow-jet valve closed, requiring a hydraulic pressure of 125 lb/in^2 (862 KPa), and an opening time of 6:41 (minutes and seconds).

The hollow-jet valve was opened and closed under unbalanced conditions through the maximum allowable opening of 18 percent, due to the riverflow conditions. This operation required an opening pressure of 625 lb/in^2 (4.31 MPa), an opening time of 1:24, a closing pressure of 700 lb/in^2 (4.83 MPa), and a closing time of 1:48. The ring-follower gate was then closed under balanced head requiring a closing hydraulic pressure of 170 lb/in^2 (1.17 MPa) and a closing time of 7:34.

The unbalanced guard gate test was then executed, first opening the hollow-jet valve with the ring-follower gate closed and then attempting to open the ring-follower gate to 10 percent of total opening height. The time required to open the hollow-jet valve with the ring-follower gate closed (under balanced conditions) should be noted. It required over 13 minutes to open the valve to 10 percent versus about 1-1/2 minutes to attain an 18 percent opening, under unbalanced head. Referring back to the hollow-jet valve description, note that normal operation under unbalanced conditions does not require much capability to open the valve because the movement is assisted by the waterflow and pressure. Under balanced head conditions, the valve is opened by hydraulic pressure alone, requiring a much longer time period to attain the required opening.

The above scenario presents an interesting problem. In preparing for the unbalanced test of the guard gate, some of the results of the close-coupling between the gate and the regulating valve were not expected. Operating the guard ring-follower gate under the unusual condition of unbalanced head requires operating the regulating hollow-jet valve under the unusual condition of balanced operation, with atmospheric pressure on either side of the valve, placing a limit on the conditions under which the ring-follower gate can be tested, unbalanced. The hollow-jet valve can only be opened 10 percent in a reasonable period of time, which could have some bearing on the performance of the guard ring-follower gate in the unbalanced test.

After opening the hollow-jet valve to 10 percent, an attempt was made to carry out the unbalanced opening of the guard ring-follower gate. The gate would open less than 1 percent, at which time the pressure limit switch shut down the hydraulic system at 1,900 lb/in^2 (13.1 MPa).

Similar results had also occurred for the testing of the irrigation outlet works, with the hollow-jet valve requiring 54 minutes to open 45 percent under balanced conditions, and the ring-follower gate failing to open beyond 1 percent before the hydraulic system shut down at 1,900 lb/in^2 (13.1 MPa). The tests were terminated without attempting to close either ring-follower gate under unbalanced head conditions.

As stated before, the unbalanced opening and closing of the ring-follower gate through 10 percent provides a maximum test of the hydraulic system without putting the outlet works at risk. The test assumes that if the gate can be opened 10 percent under unbalanced head, it can be closed under full-flow conditions, as required by the design criteria. One would expect this to be true since the friction and hydraulic down-pull forces are greatest over the 0 to 10 percent range, and since there is a greater available piston area for closing than for opening the gate. The ring-follower gates were designed to close under full flow, but the Designers' Operating Criteria do not mention opening under unbalanced head. The

possibility that the need would ever arise to actually open the gate under unbalanced conditions is very remote, because of the multiple outlet works and power waterways that exist at Yellowtail.

In 1975 a similar test was carried out at Flaming Gorge Dam in Wyoming, another Bureau facility, which also has close-coupled ring-follower gates and hollow-jet valves. The test was done as a part of a study of the feasibility of automatically bypassing to the river a required minimum flow in the event of a shutdown of the Flaming Gorge Powerplant. The study was carried out to determine if one of the ring-follower gates could be operated unbalanced with the downstream hollow-jet valve preset to discharge 400 ft^3/s in the event of a plant shutdown.

The purpose of this procedure was to keep the hollow-jet valve unwatered and eliminate the possibility of freezing the valve during cold weather. The tests were completed, doing both unbalanced opening and closing of the ring-follower gate with a range of hollow-jet openings from 20 to 75 percent. The rate of gate closure varied with different valve settings due to the down-pull on the leaf, which over-ran the normal speed of the hydraulic system until frictional forces balanced the down-pull forces. In the process, a small amount of oil was spilled from the control system oil tank; some vibration was observed in the hollow-jet valve vicinity; and some minor paint damage occurred downstream of each ring-follower gate leaf. These minor damages occurred after doing five or six closures and openings and it was still concluded that it would be feasible to automatically bypass to the river a flow of 400 ft^3/s, operating the ring-follower gates unbalanced.

However, because of the minor damages that occurred at Flaming Gorge and the problems encountered at Yellowtail, the Bureau has deferred further unbalanced testing of guard ring-follower gates until further review can ensure that adequate control is maintained during the testing. There are several approaches to the problem. One approach is to acquire and analyze data from facilities with close-coupled ring-follower gates guarding power penstock wicket gates. Most of these facilities accomplish regularly scheduled full-flow closures of the guard with little or no damage occurring. Granted, the penstocks are designed for this, but there are enough similarities to warrant a comparison with outlet works. There are some data available from regularly scheduled tests eliminating the need to schedule special tests requiring the interruption of power production.

Another approach to unbalanced outlet works ring-follower gates testing is to work with laboratory models. A ring-follower gate is available in the Bureau's Hydraulics Laboratory, but funding would be needed to build an outlet works model, perform the testing, and analyze the data.

This past July and August, field prototype tests have been conducted at Anderson Ranch Dam and Navajo Dam outlet works by personnel from the Hydraulics Branch and the Operation and Maintenance Engineering Branch. Both facilities have ring-follower gates as intermediate guard gates, with fixed-wheel gates upstream acting as the primary emergency gates. The tests have been conducted, using additional instrumentation to document the performance of the ring-followers under unbalanced conditions.

Unbalanced operation was also attempted on the fixed-wheel gate at Navajo, which failed to open under unbalanced conditions. As a result of these tests on both ring-follower and fixed-wheel gates, the test procedures for these gates may be modified from the standard test developed for high-pressure slide gates.

Conclusion

During the outlet works guard gate testing, problems are being encountered which were unforeseen. Each facility has its own unique combination of guard and regulating gates and valves, and control systems.

The basic distinction of close versus distant coupling between guard and regulating gates reduces the number of problems, but the different types of gates and valves in each category must be examined closely to ensure a safe test procedure. The basic test procedure was designed primarily for high-pressure slide guard gates which are present in many facilities. Other types of guard gates, and the effects of close-coupling with the regulating gate or valve must be analyzed, and modifications of the test procedures may be needed.

SILICA FUME CONCRETE PLACEMENT
KENT DIVERSION STRUCTURE – NEBRASKA

by Kurt von Fay and Kurt Mitchell[1]

Silica fume concrete was placed as a 6-inch-thick inlay to protect the undersluice base of the Kent diversion structure from abrasion erosion caused by water-borne abrasive sediments. Silica fume concrete was selected because it is much more abrasion resistant than conventional concrete under the conditions that were present at the site. The inlay is sacrificial and was designed for easy replacement.

Silica fume concrete is a high-performance material, and its use is relatively new to Reclamation. As such, special attention to mixture proportioning, mixing procedures, placement procedures, and finishing and curing is required. Standard practices followed for mixing and placing conventional concrete may not work well for silica fume concrete.

The mixing procedure for mixing silica fume concrete ingredients does not usually follow mixing procedures used for conventional concrete. Because of differences in concrete materials and admixtures, mixing procedures should be developed on a case-by-case basis. The mixing procedure for Kent diversion structure was developed by the contractor's (W. R. Grace) technical specialist and entailed the following:

- Emptying 50-pound bags of silica fume admixture into the transit mixer.
- Placing one-third of the high-range water-reducing admixture (HRWRA) in the transit mixer with the mixing water, and start mixing.
- Adding the sand, coarse aggregate, and cement; and mixing for 3 minutes.
- Adding the rest of the HRWRA, and mixing for 3 minutes.
- Adding the water-reducing admixture (WRA), and mixing for 2 minutes.
- Adding the air-entraining admixture (AEA), and mixing for 1 minute.

This mixing procedure was adapted from earlier procedures to eliminate the formation of cement balls that occurred during the first placement (left river gate). All the admixtures, including the silica fume, were added by hand to the transit mixer.

At the suggestion of the contractor's technical representative, when admixtures were added to the batch, the mixing drum was reversed, and the concrete brought to the top of the drum. Admixtures were then poured directly onto the concrete and mixed in. Two batches were required for the placement, which totaled about 12 yd^3.

The silica fume concrete placement, finishing, and curing operations are very important for a successful application. Speed of placement and finishing are even more critical with silica fume concrete than with conventional concrete. Specific plans need to be developed to ensure that the silica fume concrete is placed, finished, and cured as quickly as possible.

[1] Kurt von Fay is a Civil Engineer and Kurt Mitchell is a Civil Engineering Technician employed by the Bureau of Reclamation, Denver Office.

Placement and finishing operations were basically divided into three stages, corresponding to the level bottom area, the sloped middle area, and the level top area of the sluiceway. Two types of screeds were used - an H-beam with an attached vibrator and a vibrating screed. First the H-beam was hand winched, using winches attached to each end of the beam, over freshly placed silica fume concrete to spread and level it. Hand-held vibrators were used in front of the H-beam screed to assist with consolidation. After the bottom area of the placement was screeded with the H-beam, the beam was detached from the winching cables. The winching cables were then attached to winches at each end of the vibrating screed. The vibrating screed was hand winched over the previously screeded concrete to provide a smoother finish. After screeding, a bull float and hand troweling were used for final finishing. Placing and finishing of the sloped area and top level area were done similarly.

The sloped portion of the undersluice proved the most difficult to place and finish. Hand-held vibrators were used sparingly on the sloped portion since the vibration caused the silica fume concrete to flow downslope. Also, pulling the screeds up the slope seemed more difficult, particularly at the transition from the level bottom to the sloped middle section. The transition area was largely hand consolidated and finished. Concrete discharged from the bucket sat on the sloped portion for about 30 minutes before screeding.

In the Kent diversion structure application, liberal amounts of evaporation retarder were used throughout the placement to reduce water loss from the concrete and to ease finishing. The long-term impact of the use of large amounts of evaporation retarder is unknown. After finishing, a curing compound was applied with hand-held sprayers. Burlap was then placed over the concrete, with soaker hoses placed over the burlap, and all of that covered with plastic sheeting to keep the concrete wet.

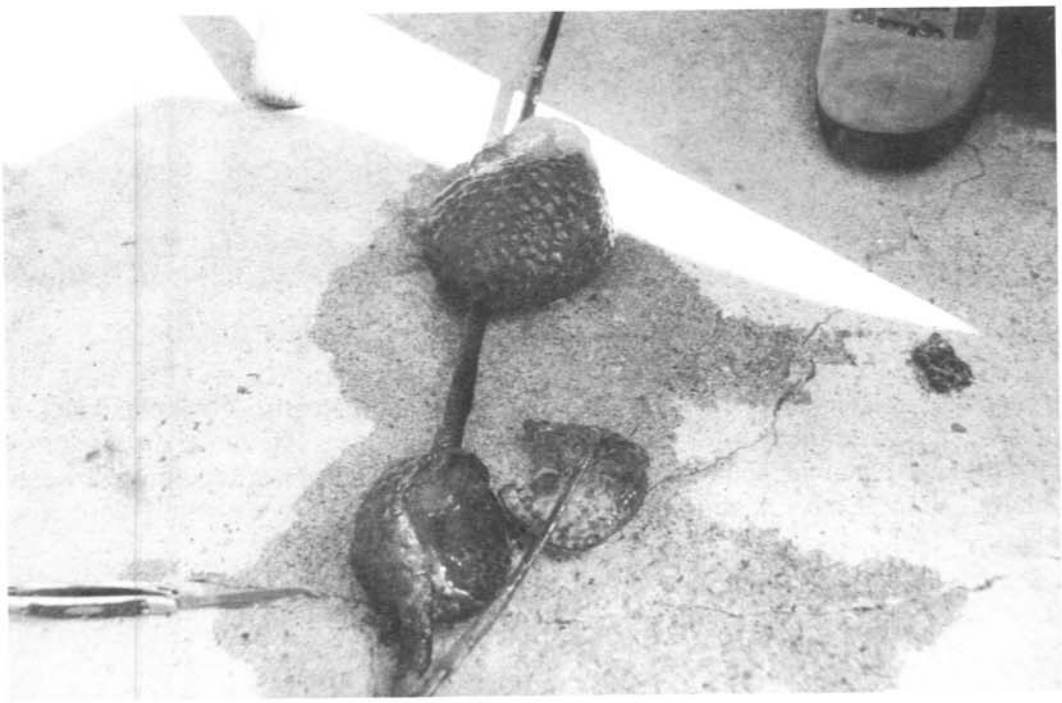
Rapid placement of silica fume concrete is extremely important to get adequate consolidation, to avoid shrinkage cracking, and to get a good finish. Mixing, placing, and finishing silica fume concrete requires more coordination, hard work, and skill than conventional concrete.

"MOSS ANIMALS" SIGHTED IN THE PACIFIC NORTHWEST

By Bill Bouley[1]

No, the "moss animals" are not the offspring of the science fiction "Swamp Thing." These invertebrate (spineless) animals were observed during a Review of Operation and Maintenance examination of Black Canyon Diversion Dam, on the Payette River, On July 7, 1992. The examination team first saw one of the animals carried by the current through the canal headworks trashracks. Another "moss animal" was captured on the trashrack debris.

At the intake structure for the power penstocks of the diversion dam, several of these creatures were found in communal bliss. They were attached to cattails, sticks, and other floating debris to form a gelatinous mass. Some of the sticks were removed to get a closer observation. We cut open one of the critters with a pocketknife. Their insides are like a bad batch of gelatin. Their exterior skin is bubbly in appearance with no identifiable features.

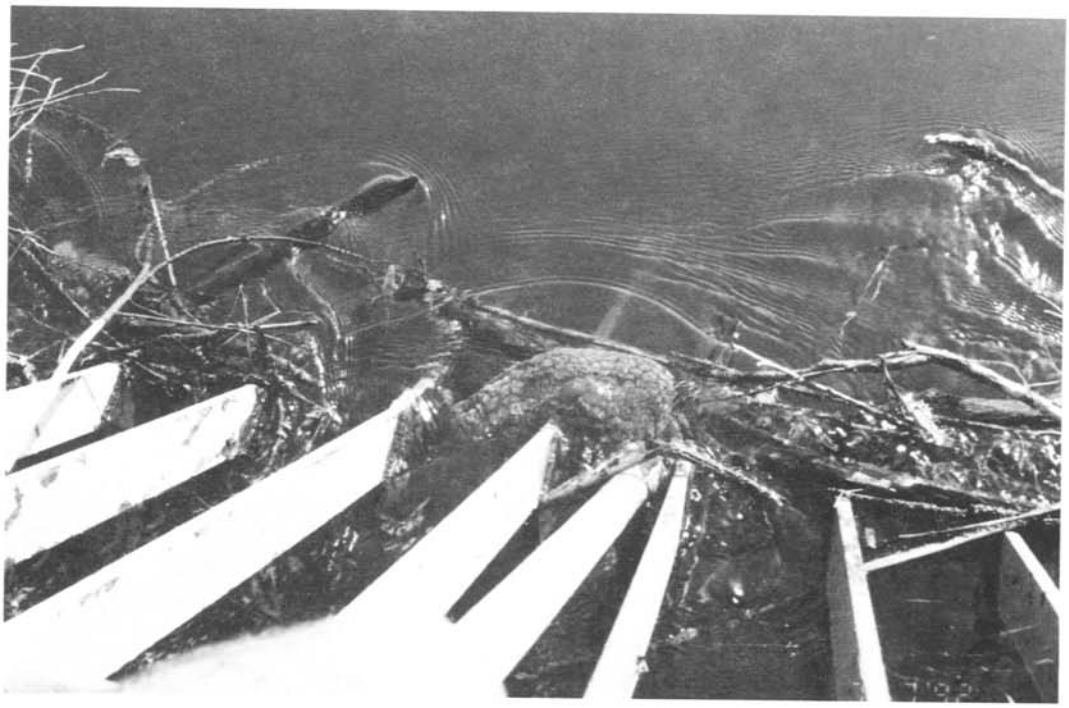


"Moss animals" on a stick (photo by Hope Cox, CSPO).

Hope Cox, a Mechanical Engineer in the Central Snake Projects Office (CSPO) contacted the biology department at Boise State University for information regarding these animals. They are members of the *phylum Ectoprocta* (Greek *ecto*, "outside"; *procta*, "anus"). Literal translation in science is generally unacceptable. Another way to describe these critters is their intake and outtake ports are very close to each other. Each creature consists of sessile colonies of zooids living in marine and freshwater environments. They reproduce asexually which is acceptable as long as you do not have a split personality.

[1] Bill Bouley is a Civil Engineer, Bureau of Reclamation, Denver Office.

It is their general plantlike appearance that earned them the common name "moss animal." Their exterior texture can be either gelatinous or chitinous (with overlap[ping transverse plates). These animals are found in shoreline regions throughout most parts of the world. They have even been found in Antarctica on floating pieces of ice.



"Moss animal" at canal headworks (photo by Hope Cox, CSPO).

Needless to say, these creatures posed no threat to the examination team. CSPO personnel removed the accumulations of sticks and "moss animals" from the intake structure. After later discussions with CSPO personnel, it was determined that these animals have been found in the past at other freshwater reservoirs in central Idaho. I hope I have supplied you readers with new high-point value words for your next "scrabble" game.

SPRING CLEANING[1]

Vacuum cleans reservoir without draining the water.

When San Joaquin Reservoir's water quality deteriorated last year, one of the major problems was traced to silt collecting on the reservoir's floor.

In the past, Metropolitan Water District drained the reservoir and hauled away the silt, but federal regulations prohibit releasing the water or working in a streambed without obtaining permits — a process that can take years. And Metropolitan didn't want to lose the water stored in the reservoir. That left few options. The challenge became to remove the silt without draining the reservoir.

District divers, accustomed to diving in San Joaquin, vacuumed the lake about twice a week to remove the silt from the outlet screens.

"One of the divers came up with the idea of using that principle on a larger scale," says Kent Brownsberger, who oversees the divers' activities. "Rather than a pump or motor, this process uses the natural pressure of the water in the reservoir.

[1] Reprinted with permission from the Editor, FOCUS, Metropolitan Water District of Southern California, Los Angeles, California, issue Number 3, 1993.

The vacuum resembles a flattened funnel on wheels with a 4-foot mouth. Scooting across the floor of the reservoir, it gobbles up tons of silt and debris each day.

From the reservoir, the silt moves to a settling basin where it is pumped to a belt press and the excess water is squeezed out before the solids are shipped to a landfill. Since mid-April, Sajal Mitra, engineer in charge of field services, says the process has removed nearly 400 tons of silt.

"This process is unique to Metropolitan," says Mitra, who points out that permit delays are not the only reason this is a better way to go. "Draining a reservoir to clean it, as has usually been done, involves a lot of time and loses a lot of water."

With Southern California being a region that has no water to waste, the vacuum was developed as an all-around better way to clean a reservoir. And other agencies are indicating they may think so too. The Orange County Water District, for instance, wants to see if the process can be adapted to remove silt from groundwater recharge basins.

PROBING THE DEPTHS OF RECLAMATION TUNNELS

By Bill Bouley[1]

With over 275 miles of water distribution tunnels administered by the Bureau of Reclamation in the western United States, the pressure is on operation and maintenance personnel to keep the system running. To ensure that there are no unanticipated emergencies, the Review of Operation and Maintenance (RO&M) Program and annual project reviews are used to examine tunnel interiors after water deliveries have been concluded each water year to identify areas needing special attention prior to initiating waterflows the following water delivery season.

On the Colorado-Big Thompson Project, Gene Price of the Eastern Colorado Projects Office uses a diesel-fueled jeep equipped with a detergent exhaust scrubber to transport examination personnel into the larger tunnels in their projects area. The automobile is generally reliable, except once when a television news crew was allowed to film the tunnel trip through Alva B. Adams Tunnel. On that occasion, after the RO&M team completed its examination, the news crew climbed aboard to film the tunnel. Unfortunately, for the crew, the radiator fan broke free of its mounting and damaged the radiator, shutting the jeep down. The group had a choice – walk 5 miles uphill in the tunnel to the locked west portal or walk 8 miles downhill to the open east portal. Naturally, they chose to walk downhill, with the wind at their backs.

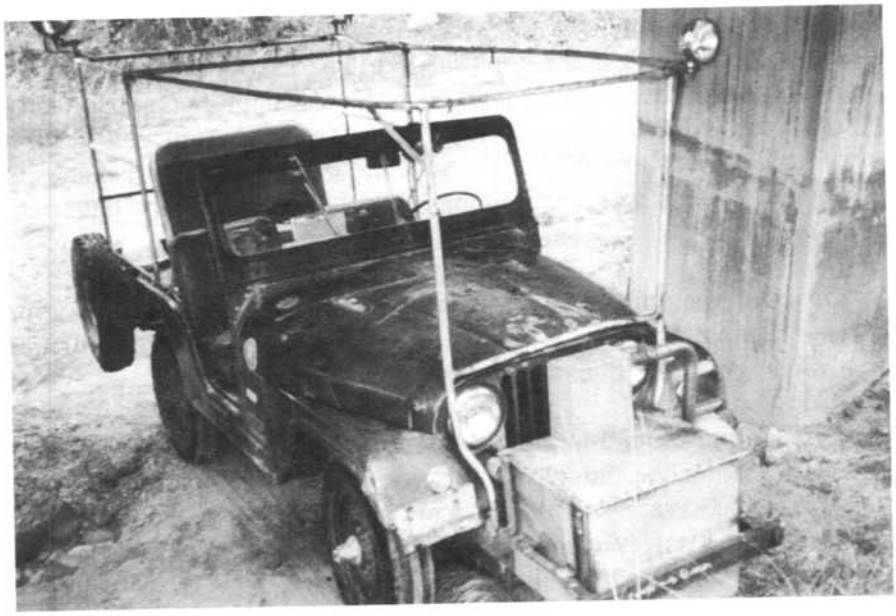


Photo 1. – Diesel-fueled jeep used in larger tunnels.

The largest tunnel in the California Central Valley Project is the 17.5-foot-diameter, 10-mile-long Clear Creek tunnel. Water flows from the Trinity River watershed through the tunnel to the 150-megawatt Judge Francis Carr powerplant and the Sacramento River near the city of Redding. At one point, the tunnel is 2,735 feet below the surface and it passes through five significant fault zones. There are approximately 3,000 joints in the reinforced-concrete lining. Ridges tend to grow at each joint. The ridges grow to no more than 1/2 to 3/4 inch high; however, the sum of their resistance is enough to reduce the

[1] Bill Bouley is a Civil Engineer, Bureau of Reclamation, Denver Office.

maximum output of the powerplant by 6 megawatts. For the above reasons, it is important to periodically inspect the tunnel.

The mode of transportation for inspecting Clear Creek Tunnel is a 1941 diesel-fueled jeep equipped with a catalytic exhaust gas scrubber. The jeep is lowered down the air shaft near the inlet of the tunnel and driven in reverse for 10 miles to the Crystal Creek Adit. The inspection team can exit the tunnel at that point and the jeep is normally driven back the next day.

The following is a true story of one inspection as described by Bill Nixon, Mid-Pacific Regional Office:

> Safety is the number one item. The tunnel was dewatered. The job hazard analysis had been laboriously reviewed many times. The oxygen sensor was working; it always worked "before" starting down the tunnel. The air velocity was measured and recorded. The jeep was placed in the tunnel. A ladder was attached to the jeep so that the top of the tunnel could be examined. The men with all sorts of safety equipment were on board. The engine started and the party drove away. One hundred yards down range, the engine died. Extensive investigation determined that no one had thought to put **fuel** in the jeep!

The San Juan-Chama Project has a series of tunnels totaling over 26 miles in length. The Chama Field Office uses a three-wheeled modified electric cart to inspect the tunnel interiors. On a recent RO&M, the Albuquerque Projects Office also rented a four-wheeled electric (golf) cart to assist in the inspection which required a survey of tunnel invert erosion (see Bulletin No. 162, pp. 48-50), and cracks in the concrete lining. Because of the circular cross section, a template was used to measure eroded and offset lining. The three-wheeled cart with headlamps is excellent for viewing the system, but echoes of expletives were heard whenever the middle wheel encountered an eroded section deeper than 6 inches. The four-wheeled cart straddled the eroded invert sections; but, when driven by an operator unaccustomed to tunnel work far from the light of day, it had a tendency to ride up the sides of the tunnels. The other disadvantage to electric carts is that if someone forgets to recharge the batteries, one may have to walk out of the tunnels.

The Provo Projects Office uses a more environmentally conscious approach in examining tunnels in its projects area. They use mountain bikes (hopefully going downhill). The disadvantage to this method may be the wet streaks one gets if he does not use raingear.

Other tunnels, such as Tecolote Tunnel in the Cachuma Project, are walked on foot due to the number of hot water springs which enter the tunnel. Because of the hot springs, there is a potential hazard of hydrogen sulfide gas and explosive gases. A physical examination is required to certify fitness for the tunnel examination walk, but a safety wagon is still brought along in case someone succumbs to the effort required to walk through the heat and humidity of the tunnel.

Air quality is evaluated prior to any tunnel inspection to determine the need for personal breathing apparatus. Canister-type air-monitoring devices are more effective where water spray is a problem. Monitors detecting levels of explosive gases, oxygen content, and presence of hydrogen sulfide have been used to ensure air suitability. It is no fun being a "mole" if you cannot stop and smell the concrete or rock lining.

Itineraries are left with surface crews to watch for the exit of the examination teams from the tunnels. This is because radio communications from inside a tunnel are not usually feasible. On shorter tunnels, air horns could be used to broadcast a predetermined distress signal to crews waiting at the exit portal.

Photo 2. – Modified electric cart used in RO&M exam.

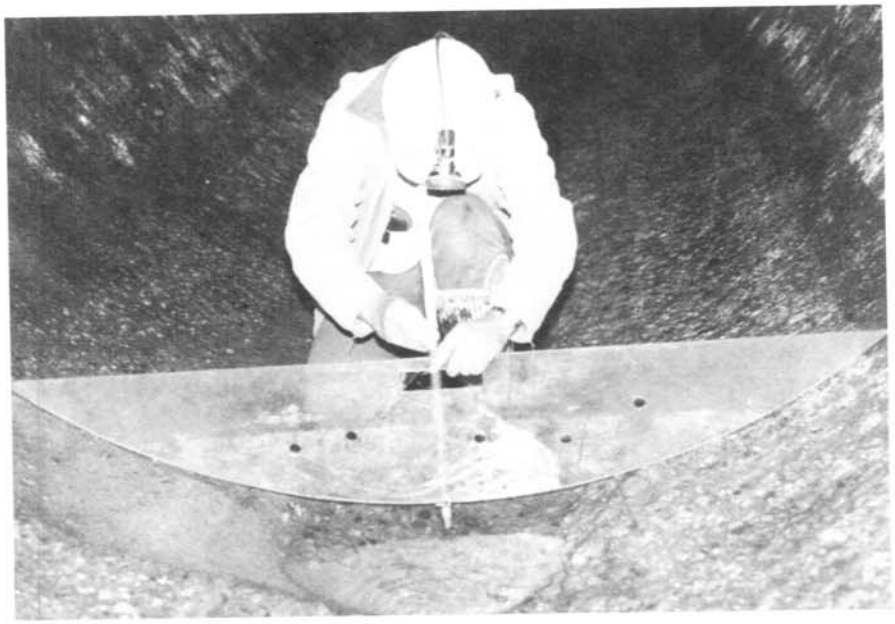


Photo 3. – Measuring the tunnel invert erosion using template and measuring device.

Additional technical information on tunnel examinations may be found in Reclamation's "Review of Operation and Maintenance Program Field Examination Guidelines," October 1991. This publication is available from the "Publications for Sale" booklet, Bureau of Reclamation, Attention: D-7923H, PO Box 25007, Denver CO 80225; price $3.30 plus postage.

Editor's Note: This article is a followup to one that appeared in Bulletin No. 162, December 1992, pp. 1-6.

PRIORITIES FOR RECLAMATION'S ZEBRA MUSSEL PROGRAM

By Cal McNabb[1] and Charles Liston[2]

Introduction

The purpose of the article is to review the spread of zebra mussels in North America since their introduction in the St. Lawrence Seaway in about 1986 (Hebert et al. 1989), and to suggest procedures to minimize the risk that these animals pose to facilities, recreational fisheries and endangered fish species in which Reclamation has made investments.

Photo 1. – Zebra mussels find intake pipes particularly hospitable environments for development of colonies. In pipes, they are protected from predatory waterfowl and fish, and suspended food particles are brought to them in the water stream. In infested waters, small-diameter pipes like the section of 4-inch PVC shown here frequently become clogged by the animals (photo by Peter Yates).

The zebra mussel is a small clam-like animal that has become a major aquatic pest in the United States during the past 5 years. The first occurrence of the animals in North America was reported from a location in the St. Lawrence Seaway near Detroit. Dispersal from that location over distances of 500-900 miles has resulted in the current distribution of zebra mussels shown in figure 1. The mussels moved outward from Detroit primarily through waters that are continuous with the location of the first reported infestation. Waters now occupied outside of the Great Lakes are primarily on inland commercial navigation channels. Examples of the latter are the St. Lawrence River, the Illinois-Mississippi-Ohio-Cumberland-Tennessee-Arkansas River waterway, and the Erie Canal-Mohawk-Hudson River waterway. Keevin et al. (1993) have shown that boats and barges carrying zebra mussels on their hulls have

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aided the rapid spread of the animals through navigation channels in the eastern portion of the United States.

Zebra mussels are expected to extend their range westward across the conterminous United States during the years ahead. They are likely to move westward most rapidly along inland navigation channels connected to infested waters. Such channels exist in the lower Missouri River between St. Louis and Sioux City, Iowa; the Arkansas River from its mouth to the vicinity of Tulsa; and the lower Red River in Louisiana (figure 1). Zebra mussels that reach heads of navigation channels in these rivers will be on the doorstep of waters in Reclamation service areas on the Great Plains. They will need to cross land barriers to infest waters on the Great Plains and those further west.

Photo 2. – When surface waters become infested with zebra mussels, the animals attach to trashracks and screens of nearby facilities. With early detection, these structures can be cleaned manually with minimum impact on operations. If mussels are allowed to build up on these structures, they impair flow; and cleaning the structures releases shells that often become a nuisance as they are carried downstream by currents.

Relatively few sightings of mussels have been made to date in waterbodies separated from infested waters by land barriers. Three noteworthy examples of movement across land barriers are accentuated in figure 1 with a bullseye. These sites in northern Indiana, central Ohio, and southern New York were each colonized by mussels that were moved overland from infested waters for a distance of at least 100 miles. The historical record of the animal in North America shows that this movement and colonization of isolated waterbodies took only a few years. Recreational boaters or professionals engaged in water-related work are thought to be likely carriers of these translocated mussels. Whatever the mechanism of dispersal has been, this experience in eastern portions of the country suggests that zebra mussels will somehow hop-scotch across the West in the years ahead.

From among various types of surface waters that exist in the West, reservoirs are the most probable targets for zebra mussel invasions. There are several reasons for this. Activities associated with reservoirs involve the principal agents of dispersal of the mussels; movement of infested boats, barges, and water. A significant portion of those individuals who move boats, barges, and water into western reservoirs do so from a waterbody located at a considerable distance. Recreational fishing and pro-tournament fishing are widely practiced examples of such movements. Ancillary to these activities is the transfer of water

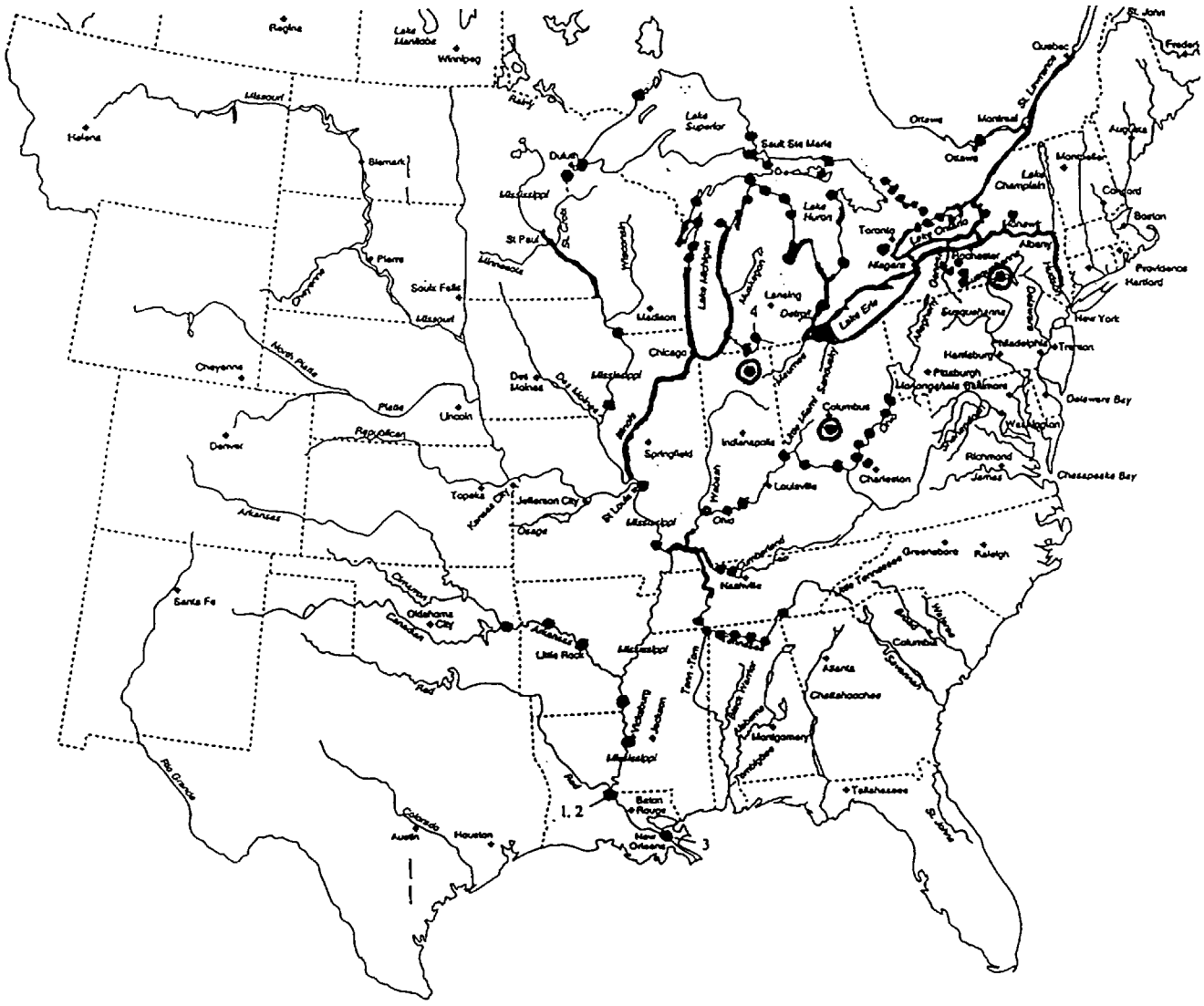

Figure 1. – North American range of the zebra mussel as of May 21, 1993. Prepared by New York Sea Grant. (Locations of mussels on the Arkansas River in eastern Oklahoma; on the Mississippi River at St. Paul, just north of confluence with Des Moines River; and above Baton Rouge were used as centers for arcs drawn on figure 2 – see text.)

with live bait from one region of the country to sell in another, and similar transfers of water with live fish stocks that are cultured to enhance reservoir fisheries. Dredging, weed harvesting and chemical control, and recreational and professional diving are other examples of activities that move gear upon which zebra mussels can ride. For these reasons, reservoirs are the principal focus of the discussion that follows. Additionally, reservoirs are of high concern for Reclamation because of important civil engineering facilities located on them. Operations of these facilities are at risk if invasions of zebra mussel do occur. Drift of larvae and juvenile mussels make downstream facilities equally at risk.

Geographical Priorities

With information presently at hand, guidelines can be established for prioritizing concern for invasion of reservoirs by zebra mussels. Present distribution of the animals shows the reservoirs in portions of the Great Plains Region are in close proximity to infested waters (fig. 1). These reservoirs appear to be at high risk from invasion. On the other hand, reservoirs further removed from existing colonies of zebra mussels appear to be at lower risk. Using these observations, reservoirs in Reclamation service areas are placed in the following geographical categories:

Tier 1
- Those located on the near-fringe of the current distribution of zebra mussels.
- In geographical settings where boat landings are readily accessible, well developed highway networks exist, and movement from infested to uninfested waters can occur in less than 1 day (i.e. several hours).
- Where movement of recreational boats and work vessels from infested to uninfested waters is probable.
- The risk of introduction of zebra mussels is high.

Tier 1 reservoirs are located in figure 2 on the eastern edge of the Great Plains Region within 250 miles of existing colonies of zebra mussels in the Mississippi River drainage. Selection of 250 miles as the distal limit of this tier was dependent on time-in-travel from reservoir to reservoir in that particular part of the country. An assumption is that short time-in-travel (i.e., several hours) will enhance survival of translocated mussels. With the distribution of zebra mussels as it is at this time (fig. 1), reservoirs that fall into Tier 1 are in Oklahoma and Kansas; on Reclamation's Arbuckle, Norman, Washita Basin, Mountain Park, W.C. Austin, and Wichita Projects. Waters of these reservoirs are heavily used for boating and fishing (Anon. 1990).

Tier 2
- Reservoirs beyond the near-fringe of the current distribution of zebra mussels.
- In geographical settings where movement from infested to uninfested waters can occur in less than 2 days.
- Where movement of recreational boats and work vessels from infested to uninfested waters has lower probability than for Tier 1.
- The risk of introduction of zebra mussels is moderate.

At this time, Tier 2 reservoirs are those in figure 2 located between 250 and 500 miles from existing colonies of zebra mussels. Tier 2 reservoirs are widely scattered through the Great Plains Region from North Dakota to Texas. Included are reservoirs in Reclamation service areas on the Upper Arkansas River in Colorado and the Pecos River in New Mexico. Service areas in the Kansas River basin in

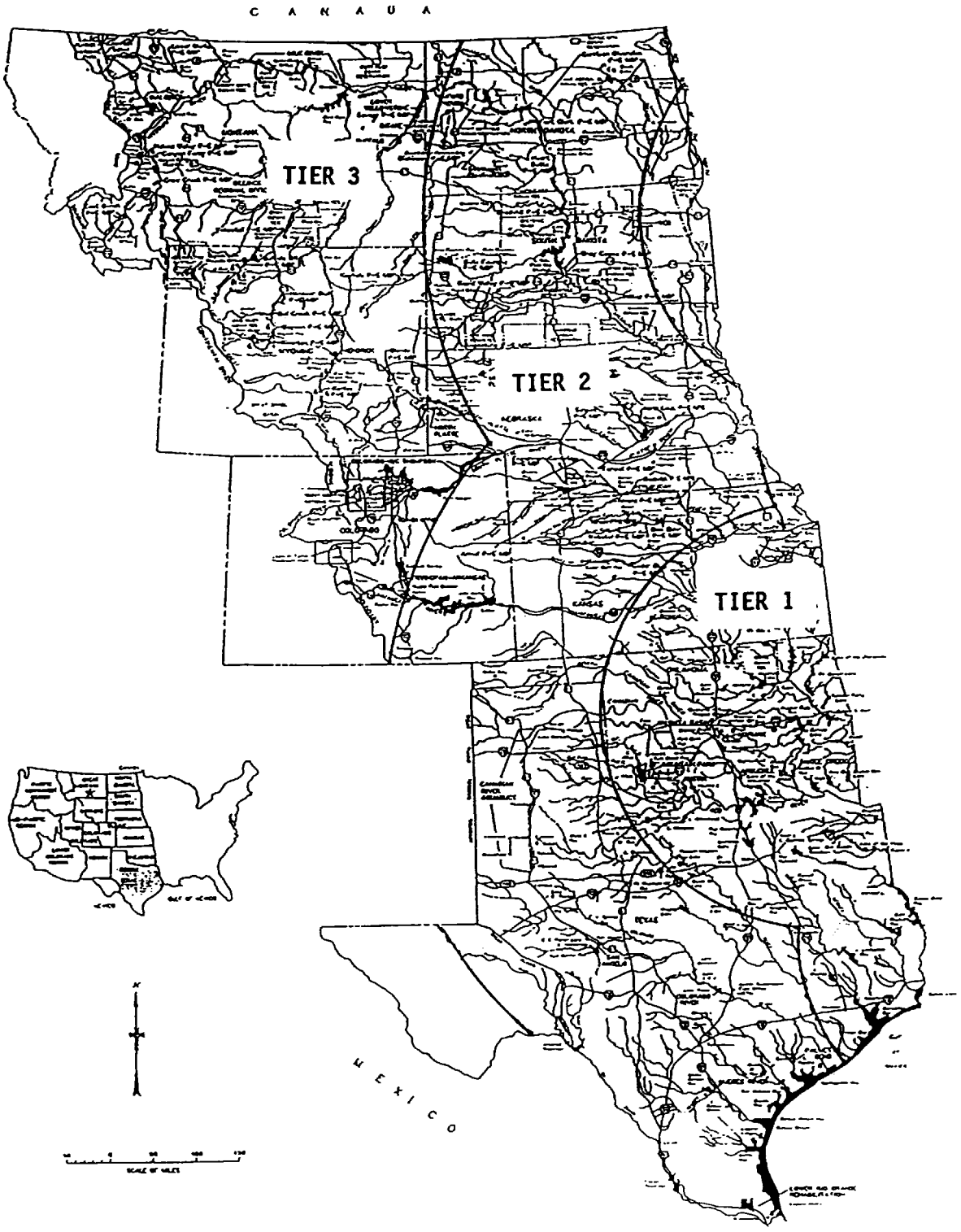

Figure 2. – Bureau of Reclamation's Great Plains Region. Arcs superimposed on the region are drawn on 250- and 500-mile radii from points on the western edge of the zebra mussels' current range (see fig. 1). The risk of Reclamation service areas in Tiers 1, 2, and 3 being invaded by zebra mussels is high, medium, and low for these areas, respectively (see text).

southern Nebraska and northern Kansas have the highest geographical concentration of Tier 2 reservoirs.

Tier 3
- Reservoirs remotely located relative to the current distribution of zebra mussels.
- In geographical settings where movement of recreational boats and work vessels from infested to uninfested waters has lowest probability of the three tiers.
- The risk of introduction of zebra mussels is low.

At the present time, reservoirs that fall in Tier 3 are located westward of the boundary that was drawn in figure 2 at a distance of 500 miles from existing colonies of zebra mussels.

As zebra mussels become established in various locations in the West in years ahead, geographical regions of high, medium, and low concern for invasion can be reordered using the general format described above. Specifics of this procedure can be modified as required, using experience from observations of the speed at which land barriers are crossed and new colonies are formed, and spatial patterns that will be evident in the record of western colonizations.

Field Sampling Priorities

Early Detection Program

The purpose of early detection studies is to minimize risks of economic losses in Reclamation service areas. Experience with zebra mussels in the Midwest has clearly shown that early detection and early response to the problem saves dollars. After successful colonization of a waterbody, larvae and juvenile mussels commonly become entrained in currents leading to intakes of civil engineering structures. Left unattended, layers of animals develop to plug screens, trashracks, small-diameter pipes, nozzles, etc. These buildups also reduce efficiencies for conveyance of water in large conduits, leading to increased energy costs for operating pumps to maintain water delivery schedules. In lakes and reservoirs, high densities of mussels alter food-webs by depleting food particles in the plankton and enriching the benthos with organic substrates used by heterotrophic microbes. Data from the Great Lakes region are not yet sufficiently developed to make accurate judgments on economic losses that might result from reductions of important fish species.

Experience with zebra mussel invasions in the midwest has shown that, if adults are detected in a locale in the first stages of colonization, nearby facilities ordinarily have a lead-time of at least 1 year to implement control procedures. Under usual circumstances, relatively few animals make up founder populations of zebra mussels in newly occupied locales. If habitats are suitable, prolific reproduction by these few increases populations geometrically. The 1-year lead-time to implement controls is the lag time in the geometric progression. Multiple layers of animals are expected on available solid surfaces in the span of 2 to 3 years. These high densities are difficult to control. Application of control procedures can result in downtime for impacted facilities.

Early detection of zebra mussels does not require an intense investigative effort. It does require routine inspection of solid surfaces on which zebra mussels are likely to settle and grow. Such surfaces are often not readily accessible for inspection. The animal prefers to attach in grooves and crevices on surfaces several feet below the waterline; deep enough to avoid bright light and be out of sight. The Environmental

Sciences Section (D-3742) has developed simple kits with solid-surface materials to sample at water depths that zebra mussels are likely to colonize. While these kits are useful, careful inspection of dewatered structures around conveyance systems is often equally productive for early detection of the animals.

The following protocols for early detection of zebra mussels have been developed. Recommendations for Regional Offices are as follows:

Tier 1
- Select reservoirs to be sampled.
- Obtain kits from the Environmental Sciences Section (D-3742) to monitor for presence or absence of larvae, juvenile and adult zebra mussels during spring, summer and fall. If larvae and juvenile mussels are present, they will collect in bits of nylon netting found in the kits. Adult mussels can be found attached to PVC plates that are in the kits.
- During the interval April-November, deploy samplers found in kits in the vicinity of intakes for facilities.
- Submit samples for detection of larvae and juvenile mussels to D-3742 at 4-week intervals until early November.
- In early November, submit samples from kits to D-3742 for detection of adults.
- For broader coverage on the reservoir, arrange sampling for adults by hanging ropes at additional sites during April-November, inspect these ropes for adult mussels at regular intervals (e.g., monthly), and inspect submerged structures for adult mussels during the September-November period.

Tier 2
- Select reservoirs to be sampled.
- Obtain early detection packets from D-3742 to monitor for presence or absence of adult zebra mussels. Samplers in these packets are sections of braided plastic rope on which mussels will attach and grow.
- During the interval April-November, deploy samplers found in kits in the vicinity of intakes for facilities. Inspect these samplers for adult mussels at regular intervals (e.g., monthly).
- In early November, submit samplers from kits to D-3742 for confirmation of presence or absence of adults.
- For broader coverage on the reservoir, arrange sampling for adults by hanging your own ropes at additional sites during April-November, inspect these ropes for adult mussels at regular intervals, and inspect submerged structures for adult mussels during the September-November period.

Tier 3
- Arrange for personnel at reservoirs to be alert for presence of adult zebra mussels on submerged solid objects.
- Arrange for annual inspections of submerged structures for adult zebra mussels during the September-November interval.

To date, field operations for early detection studies have varied among Reclamation regions. In 1992, studies were conducted by on-site personnel in the lower Colorado River, canals of the Central Arizona Project, in the Sacramento-San Joaquin Delta, and at Grand Coulee Dam on the Columbia River. Sampling stations in the first three of these locations functioned essentially under Tier 1 protocol; the last station operated at Tier 3 level. Zebra mussels were not observed at stations in the 1992 program. Through September 1993, zebra mussels have not been observed at 1992 stations or in any other Reclamation service area.

Larval Settlement and Mussel Density Program

When zebra mussels are first detected in Reclamation reservoirs, a program of regularly scheduled sampling should be started. Purposes of this work are to determine the time of year when zebra mussel larvae settle on structures in and around operating facilities, and to measure their abundance and post-settlement growth rates. Personnel from D-3742 will be available to cooperate with personnel from Regional Offices and Project Offices, and on-site staff, to get field sampling underway. Results of this work will be used to advise operators as to whether or not control procedures for zebra mussels are necessary. If control procedures are required, sampling data will be used to select least-time, least-cost control strategies. Results will also be used to advise fisheries management units regarding changes that may be eminent in food web relationships of reservoir and riverine fishes.

During early stages of mussel movement into the West, larval settlement and mussel density and growth rates should be studied on each newly colonized reservoir. As an increasing number of reservoirs become infested, techniques used in the program should be included in formal training activities conducted by Reclamation so that on-site personnel will be able to conduct sampling and apply results to operation of their facilities with reduced interaction with D-3742.

Reservoir Risk Assessment Program

The Environmental Sciences Section (D-3742) has initiated work on risk assessment for Reclamation reservoirs. The purpose is to identify those reservoirs that are at risk from zebra mussel infestations because they have suitable habitat, and to separate these reservoirs from those that do not have suitable habitat and are not at risk.

Strayer (1991), Griffiths et al. (1991), Neary and Leach (1992), and Ramcharan et al. (1992) are among those who have examined European literature to determine habitat requirements for zebra mussels. Various papers in Nalepa and Schloesser (1992) address this topic as well. Perusal of these works and other selected literature has resulted in development of the following table. It shows thresholds for factors that will limit zebra mussel colonization of waterbodies.

Table 1. – Levels of selected limnological parameters required for zebra mussel colonization of inland waters. Values listed for pH and salinity are annual means; other values are means for the growing season (water temperature >5 °C).

Parameter	Required level
pH	≥7.0
Salinity	<2500 mg/L
Calcium	≥20 mg/L
Temperature	Where monthly maximum 13 to 18 °C ≥4 months at ≥13 °C Where monthly maximum 20 to 25 °C ≥3 months at ≥13 °C Where monthly maximum >25 °C annual mean ≤23 °C
Turbidity	≤50 NTU
Eutrophy	Total phosphorus <0.25 mg/L or Total nitrogen <4.0 mg/L

Threshold values given in the table are for well oxygenated surface waters of reservoirs. Zebra mussels will not grow in deep anoxic waters that are sometimes present. Values given for various factors are intended to be conservative; that is, values selected are considered unlikely to eliminate low risk waterbodies from being judged at risk. Values for most factors listed in the table were extracted from the literature in a straightforward manner. Regimes for temperature deserve brief comment. Growth and reproduction of zebra mussels are keyed to the annual cycle of warm and cold conditions that exist in mid-latitude habitats of the temperate zone. The first temperature regime listed represents conditions for lakes on cold edges of the temperate zone. Such lakes are located, for example, near the southern boundary of the coniferous forest (taiga) that spans eastern Canada above 48° north latitude. They are also located at high elevations in mountain ranges of western North America. The second temperature regime listed is typical of lakes in temperate North America. The third regime is for lakes on warm edges of the temperate zone; lakes on the Florida peninsula are examples.

Risk assessment of Reclamation reservoirs will be conducted by D-3742 personnel. Selection of reservoirs for study has been prioritized using the Tier 1-2-3 system discussed earlier in this article. Procedures used for risk assessment will be as follows. Data bases available from Reclamation Regional Offices and Project Offices, local Water Districts, and state and federal agencies will be examined in relation to thresholds for factors given in the table. Determinations will be made of risk of colonization. Data for those reservoirs found at risk will be further queried regarding factors that are important in determining the size and severity of infestations. These additional factors include reservoir bathymetry, annual cycle of drawdown and refill, seasonal stratification of temperature and oxygen, area and depth distribution of solid substrates for colonization (e.g., rocks, reefs, cement work, aquatic plants), concentrations of toxic chemicals, and seasonal abundance of suspended particles used by zebra mussels as food.

Shorelines of western reservoirs generally have land developed for public recreation. Boat ramps provide ready access for recreational boating, water skiing, diving and fishing. Statistics on recreational use (Anon. 1990) will be examined for reservoirs that are at risk from the standpoint of environmental

suitability. Those that are intensely used for boating and fishing will be considered at higher risk from zebra mussels than those that are remote and poorly used. After judgments of risk have been finalized, programs will be initiated that focus on minimizing impacts of zebra mussels in reservoirs at high risk.

Program for Facilities and Fisheries at Risk

As of fall 1993, reservoir risk assessment studies are in an initial phase. Tier 1 reservoirs are objects of investigation. They are located in Oklahoma and south-eastern Kansas, and include McGee Creek, Arbuckle, Norman, Fort Cobb, Mountain Park, Altus, Foss and Cheney reservoirs. The proximity of these reservoirs to established colonies of zebra mussels (fig. 1), their high levels of recreational use, and high incidence of boat movement from one waterbody to another, put them at apparent high risk.

D-3742 proposes the following program for facilities that draw water from Tier 1 reservoirs. Structures whose operations are particularly susceptible to disruption by zebra mussels (trashracks, screens, gates, water-level control gages, small diameter piping, pumps, etc.) should be identified for each facility. Similar inventories are proposed for facilities downstream that would be at risk from settlement of the mussel's drifting larvae. Following inventories, *Plans of Action* should be developed for control and mitigation of problems that zebra mussels are likely to cause on susceptible structures (Anon. 1992, Anon. 1993). These *Plans of Action* should provide budget forecasts for contending with zebra mussels. This work with Tier 1 facilities would establish hands-on experience within Reclamation that could be applied in other locales when zebra mussels invade the West.

Food supplies for recreational fisheries and endangered fish species are likely to be reduced following zebra mussel infestations of reservoirs (Karnaukhov and Karnaukhov 1992). The reservoir risk assessment program will supply information to scientists in the Environmental Sciences Section to use for review of on-going fish management strategies, and for planning changes in management that might be required to protect fish resources. Results will be furnished to State fish-management offices, and to the U.S. Fish and Wildlife Service for the same purposes.

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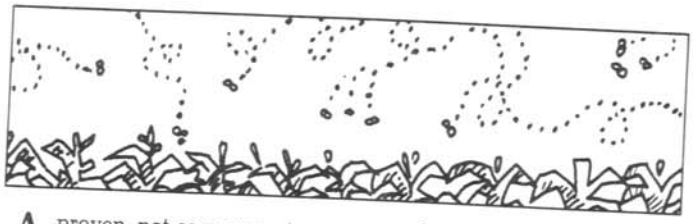
Making IPM Work For You



A proven, not-so-new pest control system that is gaining popularity is Integrated Pest Management, or IPM. Chances are likely that you already use some IPM practices, but you've never stopped to think of them that way. In practice, IPM blends chemical, biological and cultural pest control practices to produce a sound economic and environmental strategy.

Whatever you call IPM, it really involves putting the various pieces of the production or maintenance puzzle together to form the most profitable, sustainable and environmentally sensible pest control system for you.

As you evaluate your total IPM program, consider this:

SUPPRESS, DON'T EXTERMINATE. One focus of an effective IPM program is to suppress excessive pests, not try to wipe out an entire pest population.

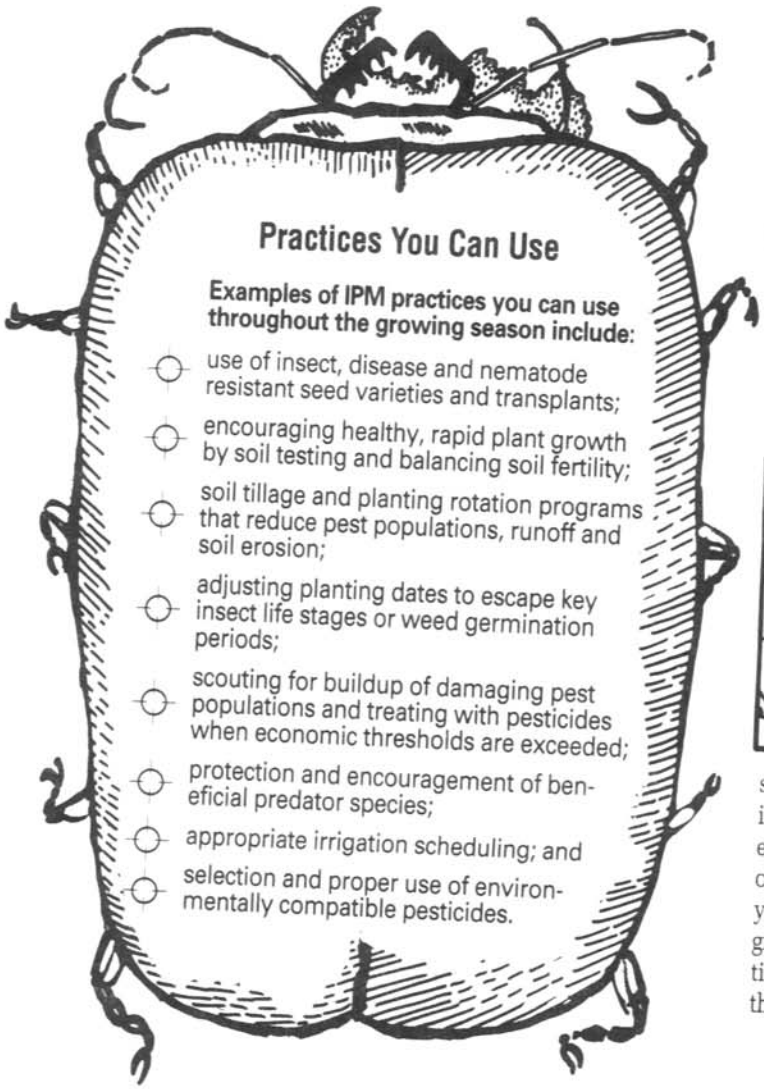
This permits a combination of techniques that might be used to limit weed, insect and disease pests to trivial levels, below damage that is serious and represents an economic threshold.

KNOW YOUR SITE'S ECOLOGY. You probably know the agronomic aspects of your property like the back of your hand, but you should also appreciate its ecological and environmental components. For example, how close are you to wells, wetlands, groundwater recharge areas, surface water supplies or aquatic wildlife habitats? Has the ecology of your property changed over the past five to 10 years? Have pest problems grown as you've changed practices or removed natural areas that might have been home to birds or natural insect predators? Keep records of these observations and look for ecological trends.

GET ADVICE FROM THOSE YOU TRUST. Developing a successful IPM program takes time and extra care to monitor, plan and implement. You can turn to your county Extension agent, local conservation district office or pesticide retailer for help.

Pesticide dealers frequently provide farm services such as field scouting, pest monitoring, field mapping, soil and plant analysis, determination of economic thresholds and suggestions on the most appropriate pest control methods. They also can determine if any of the new, more environmentally compatible, microdose pesticides are candidates for your IPM program.

MAKING IPM WORK. If you haven't already done so, consider incorporating an IPM approach into your pest control efforts. It's an environmentally sound approach to pest control that deserves your attention.



Practices You Can Use

Examples of IPM practices you can use throughout the growing season include:

- use of insect, disease and nematode resistant seed varieties and transplants;
- encouraging healthy, rapid plant growth by soil testing and balancing soil fertility;
- soil tillage and planting rotation programs that reduce pest populations, runoff and soil erosion;
- adjusting planting dates to escape key insect life stages or weed germination periods;
- scouting for buildup of damaging pest populations and treating with pesticides when economic thresholds are exceeded;
- protection and encouragement of beneficial predator species;
- appropriate irrigation scheduling; and
- selection and proper use of environmentally compatible pesticides.

This information is provided by the Alliance for a Clean Rural Environment, a non-profit, non-political organization encouraging environmental stewardship and protection of water quality, supported by the makers of crop protection chemicals.

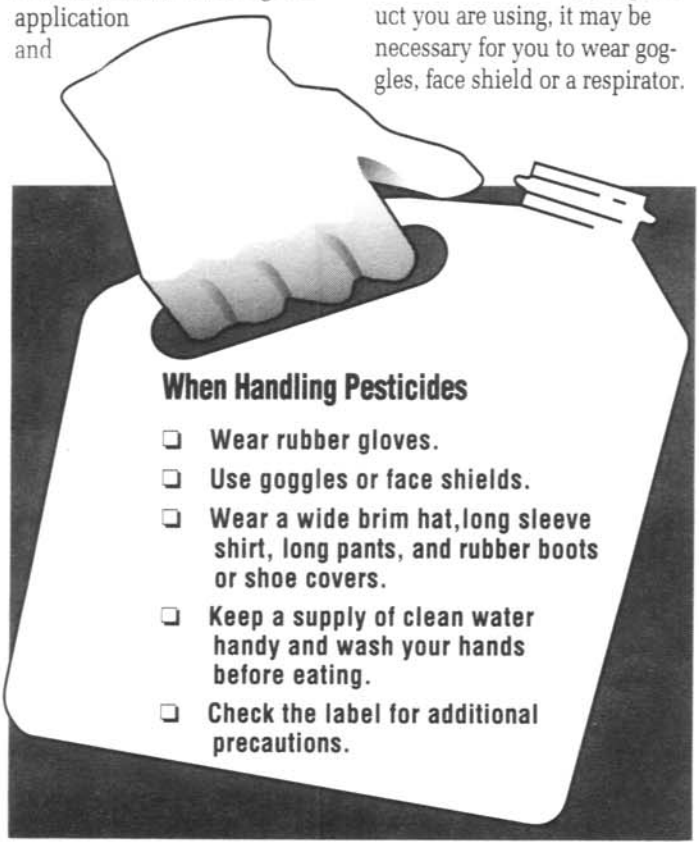
Pesticide Safety Checklist

In the seasonal pressure to control pests, it's easy to overlook important safety precautions when using pesticides.

The following checklist is a reminder that we can never be too busy for safety:

Read the label carefully and take notice of personal safety and environmental precautions. The label information isn't advertising – it's solid science. It also includes the proper rate of pesticide use for various conditions, the relative toxicity of the product, directions for safe mixing and application and any environmental precautions. It lists the product manufacturer's name and address, required protective clothing, and warnings about groundwater contamination and hazards to wildlife.

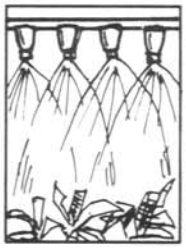
Wear appropriate personal safety equipment when handling pesticides. Start by wearing a wide-brim hat, long-sleeved shirt, long pants and chemical-resistant gloves. You should also wear sturdy work shoes or rubber boots, not sneakers or sandals when handling pesticides. Depending on the product you are using, it may be necessary for you to wear goggles, face shield or a respirator.



When mixing and loading ag chemicals, prevent spills that might contaminate water supplies. One key spill-prevention step: Prevent tank overflow by never leaving a sprayer unattended during filling. Mixing and loading operations should always take place as far away from your wellhead as possible to reduce the risk of contamination.

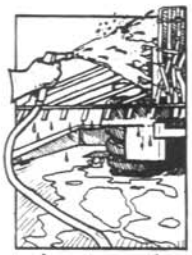
While filling sprayers, avoid backsiphoning by keeping the discharge end of the fill hose above the tank's water level. If you put the end of the hose down into the pesticide liquid in the tank, you run the very real risk that the hose will suck water and chemicals back into the well when you turn off the water.

Never exceed labeled chemical rates and calibrate your sprayer before application. After you've read the label and chosen the right product to apply at the prescribed rates, it's important to make sure your sprayer is delivering the right amount of product per acre. Calibration makes more than economic sense, it also helps protect your environment.



Prevent leftover pesticide by mixing only needed quantities. If you follow label instructions for rates per acre and mix carefully, your tank should be empty as you complete application in the targeted field.

Never rinse equipment near wellheads, ditches, streams or other water sources. If needed, install a longer rinse water hose to move the cleaning operations a safe distance from a well or other water source. Spray the rinse water in the spray tank out over the target area, following label instructions.



Always triple rinse or pressure rinse ag chemical containers before disposal or recycling. If it's been properly rinsed, the pesticide container is ordinary trash, but the best place for it is a pesticide container collection and recycling facility. Programs are being organized in several states. Call us for more information about recycling centers near you.

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A Chemical Mixing Checklist

The growing season is one of the busiest times of the year. With all the pressures of the job, it's easy to overlook safety precautions when handling ag chemicals. The following checklist is a reminder that we can never be too busy for safety:

☑ Read the label carefully and take notice of personal safety and environmental precautions.

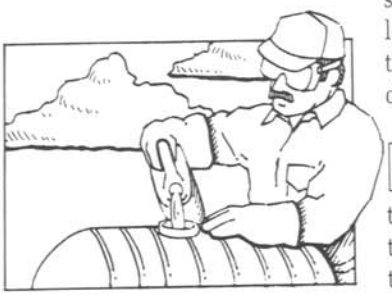
☑ Wear appropriate personal safety equipment when handling ag chemicals.

☑ When mixing and loading chemicals in the field, prevent spills that might contaminate water supplies.

☑ Prevent spray tank overflow by never leaving the filling station unattended.

☑ While filling sprayers, avoid backsiphoning by always keeping the discharge end of fill hoses above the tank's water level.

☑ Be certain pumping equipment has anti-backflow devices and check valves.



☑ Never exceed labeled chemical rates, always mix carefully, and calibrate your sprayer before applying ag chemicals.

☑ Prevent leftover chemicals by mixing only needed quantities.

☑ Never rinse equipment near wellheads, ditches, streams or other water sources. If needed, install a longer rinse water hose to move the cleaning operation to a safe distance from the well.

☑ Before disposing of chemical containers, triple rinse or pressure rinse them, and pour the liquid into the spray tank.

☑ Dispose of equipment and container rinse water by spraying it out over the soil, following label instructions.

When preparing your tank mix recipe, it's wise to take a few moments to prepare a record of the following items:

- ☐ the order in which to mix the products
- ☐ prescribed rates per acre for each product
- ☐ capacity of the spray tank
- ☐ amount of mix to be applied per acre
- ☐ types and rates of any additives
- ☐ acres covered per tank
- ☐ types of nozzle to be used
- ☐ nozzle pressure in psi
- ☐ tractor speed

This information, along with the field location, type of crop and date of product application will help provide you with an important record as well as a handy reference during this busy time of year.

Safety Precautions:

- **Wear rubber gloves.**
- **Use goggles or face shields.**
- **Wear a wide brim hat, long sleeve shirt, long pants, and rubber boots or shoe covers.**
- **Keep a supply of clean water handy and wash your hands before eating.**
- **Check the label for additional precautions.**

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Simple Steps to Calibrate and Maintain Your Spray Equipment

To avoid needless ag chemical waste, improper application and potential water contamination, calibrate your spray equipment at least once a year. Follow these 10 easy steps:

1 Fill your sprayer tank with water. Only use clean water to calibrate.

2 Measure the distance (in inches) between the nozzles on your spray boom. Then refer to the chart below.

3 Choose the Test Course Length (in feet) from the accompanying chart. For directed and band rigs use the row spacing of the field you plan to spray. Measure the course distance in the field and flag it for easy visibility.

4 Drive the test course at your normal spraying speed. Be sure to operate all equipment. The important step here is to record the seconds it takes to drive the measured distance. You'll use that number later. Be sure to take a "running start"at the starting flag so your tractor/sprayer reaches the desired speed before you begin timing.

5 Park you tractor/sprayer, set your brakes, but keep the engine rpm at the same setting used to drive the test course.

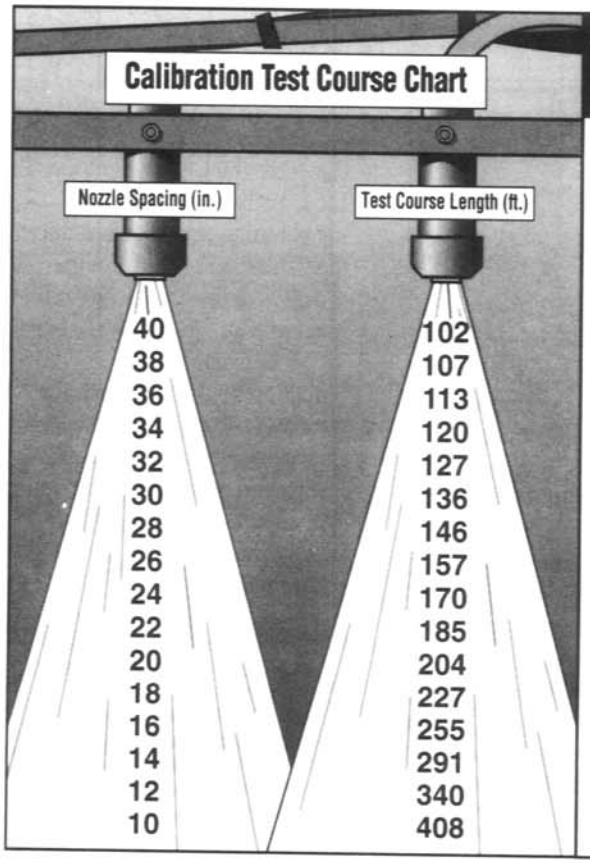
6 Set the desired pressure on your sprayer (this will vary with the type of spray tips you use and the gallons per minute you wish to spray through them).

7 Using a plastic container marked in ounces (a bottle or measuring cup works fine), collect the water sprayed from one nozzle during the same amount of time you found that it took you to drive the test course.

8 The amount of water collected in ounces per nozzle equals gallons per acre applied. Vary the sprayer pressure slightly to fine tune your overall output.

9 Be sure to check your nozzles by measuring the flow of each nozzle on the boom to assure uniform distribution. If the flow rate of any tip is 10% greater or less than that of the others, replace it. If two or more are faulty, replace all tips on the entire boom. The total expense involved is small compared to the cost of wasted product or environmental harm. Whatever type of spray tip you choose, be sure to use all the same type on your boom.

10 Last but not least, be sure to read the product label for proper application information.



Take Time to Calibrate

Faced with production deadlines, farmers' common sense often takes a back seat when it's time to calibrate spray equipment. Complex formulas and time-consuming calculations can be discouraging. But calibration errors add excess chemical costs, reduced yields and increased potential for water contamination. So, use this quick, 10-step method to calibrate your sprayer.

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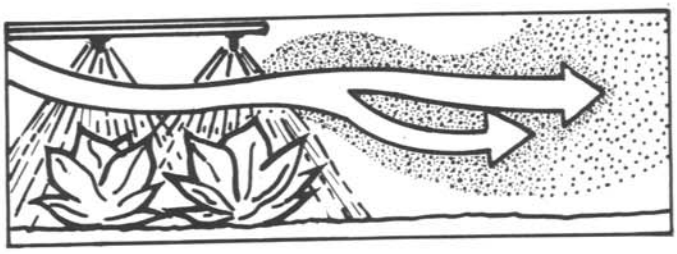
Prevent Pesticide Spray Drift



Whenever pesticides are applied, the potential exists for damaging off-target movement, or "drift". But attention to weather conditions and sound judgment can lead to decisions that will minimize drift and possible harmful effects.

Why is drift reduction so important? By preventing or minimizing drift, you avoid:

- ❑ Risks to nearby people, and wildlife;
- ❑ Damage to non-target crops;
- ❑ Potential pollution of surface and groundwater resources.

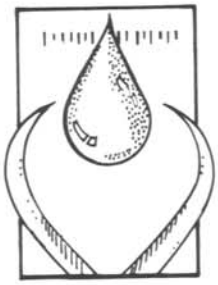
Planning Checklist

- ☑ Use nozzles that produce narrower spray-fan angles.
- ☑ Keep the boom as close to the spray target as possible while maintaining proper spray pattern.
- ☑ Use minimal spray pressure down and check pressure gauges for accuracy.
- ☑ Install shields or shrouds on booms.
- ☑ Avoid spraying on extremely hot and dry days.
- ☑ Do not spray when conditions are favorable for an atmospheric inversion.
- ☑ Do not spray when wind speeds are less than 4 miles per hour or more than 12 miles per hour.
- ☑ Leave an unsprayed strip of 50 to 100 feet near water supplies, abandoned wells, wetland areas, downwind neighbors or sensitive crops. If you must spray these areas, do so when the wind is favorable.

Many factors can affect drift:

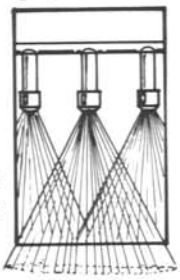
✔ Droplet Size

The most important factor is spray droplet size, since smaller droplets drift longer distances. Droplet size can be regulated by selecting the proper nozzle type and size, adjusting the spray pressure and increasing the viscosity of the spray mix.



✔ Equipment Adjustments

Routine sprayer calibration and replacement of worn spray nozzles should be high on your maintenance list. Other equipment adjustments can be made to further increase application efficiency and help reduce spray drift. These adjustments include partially shielded or completely shrouded sprayer booms, air-assisted spraying and electrostatic spraying. Still under development, electrostatic spraying creates an electrical field in which the droplet moves between the nozzle and the plant leaf. Preliminary studies show a reduction in drift deposits of up to 40 percent under experimental conditions.



✔ Weather Conditions

Wind speed and direction, relative humidity, temperature and atmospheric stability are critical weather factors that have an impact on drift. This impact can be minimized by increasing the size of droplets, using adjuvants, taking advantage of existing conditions, leaving unsprayed buffer strips and using other recommended practices.

✔ Sound Judgment

An extremely important factor in controlling spray drift is the judgment you use prior to and during application. Use the accompanying planning checklist to reduce the likelihood of drift, and be sensitive to the unique environment of your farm.

Make every attempt to reduce spray drift. It'll pay big dividends. You'll not only improve your application efficiency and bottom line, but you will eliminate concerns about downwind safety and the environment.

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Proper Cleanup of Pesticide Spills Protects Water Supplies

Spills when handling, transporting or using pesticides are a concern for every producer. But by knowing what to do if a spill occurs, whether it's on your property or on the road, you can help minimize the risk and prevent ground water and surface water contamination.

Control the spill as quickly as possible by restoring the container to its upright position, closing a leaking valve or hose or putting a secondary container in place to catch the leaking solution. Of course, appropriate personal safety equipment should be used, such as rubber gloves, rubber boots and eye protection.

Call your retailer for advice on cleanup of their chemical. They will also give you special safety advice and other information.

Contain the spread of the spill when the leak has been stopped by creating soil dams in the path of the spilled liquid. It may be most important to first divert a spill away from a nearby pond or stream and then attempt to stop the leak or spill. This is a judgement call that only you can make.

Begin cleanup as soon as the situation has been stabilized. Quick action on your part to clean up a spill is not only required in many states, but will prevent the chemical from leaching or washing away in a rainstorm.

Use absorbent materials on pavement or concrete to capture the spilled liquids. They can then be shoveled or swept. Non-chlorinated pet litter is an excellent, inexpensive absorbent material to keep on hand for such purposes.

Properly dispose of the drenched soil or absorbent material. This will depend on what and how much was spilled and the rules for disposal in your state. Contact state or local officials or your retailer for legally acceptable disposal options.

Report the spill, if required, before it threatens public health or the environment. If the spill is large or enters a waterway, you'll need to call the local EPA office, the local emergency planning office or the state health department. The reporting criteria vary with the chemical spilled, however, so ask your dealer to check the Material Safety Data Sheet or call the manufacturer for further details.

PROPER SPILL CLEANUP

Who To Call:	
EPA Hazardous Waste Hotline	
800-424-9346	
EPA Safe Drinking Water Hotline	
800-426-4791	
National Pesticides Telecommunications Network	
800-858-7378	
National Agricultural Chemicals Association	202-296-1585
Chemicals Referral Center	
800-262-8200	
Chemtrec Emergency Hotline	
800-424-9300	
EPA Pesticide Management & Disposal	
703-305-7385	

EPA Regional Offices	
Atlanta	404-347-3004
Boston	617-565-3420
Chicago	312-353-2000
Dallas	214-655-6444
Denver	303-293-1603
Kansas City	913-551-7000
New York	212-264-2657
Philadelphia	215-597-9800
San Francisco	415-744-1305
Seattle	206-553-4973

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Cleaning Up After Pesticide Use

At the end of a long day of field or yard work, your first thought is probably eating a hot meal or sinking into your favorite chair to relax. But if your work included applying pesticides, the first thing you should do is change your clothes and head for the sink or shower.

Like any hazard, the potential health risks associated with pesticide use not only depend on the toxicity of the product, but the extent of your exposure to it (Risk = Toxicity x Exposure). Reduce exposure – reduce risk.

One key way to reduce exposure – in addition to wearing personal protective equipment – is to make sure you properly clean yourself and your clothing following each contact with the product.

Here's how to wash pesticide contaminated clothing:

1 Assume clothing worn while working with pesticides to be contaminated. Be sure to keep them separate from your other clothes or the family washload before and during washing.

2 Pre-rinsing, followed by a regular wash, is the most effective method of removing contamination from clothing. Pre-rinse or pre-soak the clothing in a washing machine filled with hot water and heavy-duty liquid detergent. Then spin out and drain the contaminated water before running the wash cycle. Wash just a few items at a time, again using hot water and heavy-duty liquid detergent.

3 Clean the empty machine after washing contaminated clothing by running a complete wash cycle with detergent and hot water.

4 Line dry the clothing to avoid possible dryer contamination.

* You may also want to apply starch to your clothing as an added protective measure. Recent research by Cornell University textile scientists showed that starch provides a finish that traps pesticides and helps prevent their transfer to skin. The starchbound chemicals are then rinsed away in the wash.

From Hand To Mouth

Exposure studies show that when someone works with pesticides, the greatest amount of exposure occurs on the forearms and hands. In fact, the skin is the main route for chemical entry into the body. This isn't surprising when you consider a typical day – hands open containers, turn valves, adjust nozzles, carry hoses and sometimes clean up spills. There are plenty of opportunities to get chemicals on the skin.

In addition, consider the number of times you touch your face, neck or other parts of your body during the day; how you wipe perspiration from your face or blow your nose; and the conditions present when chewing gum or tobacco, smoking, drinking beverages or eating a sandwich or candy bar. It shouldn't surprise you that most chemical exposure comes from your hands.

Although chemical-resistant gloves make a big difference, a good safety practice before eating, drinking, smoking or going to the bathroom is to rinse gloves thoroughly before taking them off and then also washing your hands. At the end of each day, wash your gloves and hands again, but this time fill the gloves with clean water and squeeze. Throw away any gloves that leak.

Clothing In Contact With Chemicals

You should consider any clothing worn while handling, mixing or applying pesticides as being "contaminated." It's important to wash this clothing daily because the longer it is stored, the harder it is to remove contamination.

If liquid concentrated pesticide is spilled on clothing other than rubber gloves or boots, throw the clothing away; it can't be completely cleaned.

Follow the steps in the accompanying box whenever washing contaminated clothing.

Changing and washing work clothes daily and washing hands and other exposed skin frequently throughout the day will greatly reduce any potential adverse effects from contact with pesticides.

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Disposing of Empty Pesticide Containers

Farmers and ranchers are often concerned about disposing of potentially hazardous pesticides and their containers. Here are the disposal options available in most states:

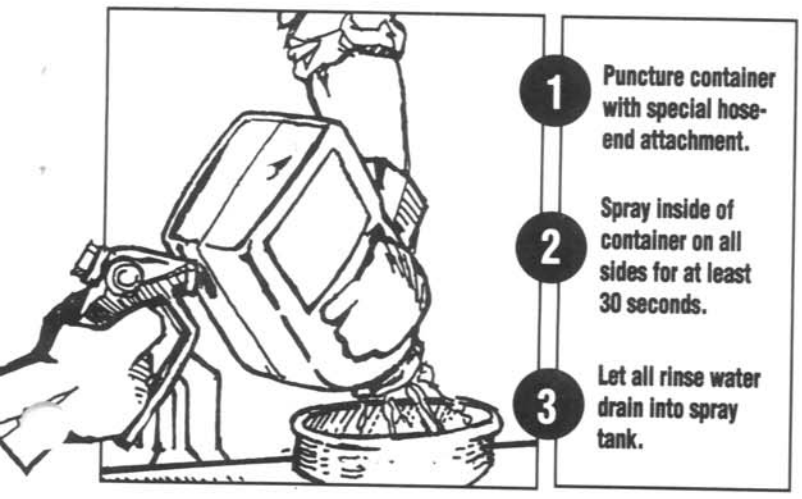
All Trash Is Not Alike

Most ordinary trash in the U.S. is disposed of in sanitary landfills. However, these sites are generally prohibited from accepting waste classified as hazardous by the federal Resource Conservation and Recovery Act (RCRA). Since contaminated pesticide containers and waste chemicals often fall into this category, farmers frequently have difficulty disposing of them properly.

An easy solution to this problem is to rinse the chemical containers properly. Rinsed containers aren't hazardous. Laboratory tests have shown that proper rinsing results in essentially harmless, 99.999% pesticide-free containers, regardless of which product they originally contained.

Probably the fastest, most efficient and convenient container rinse method is pressure rinsing. Special hose-end attachments are available which easily puncture plastic and metal containers, producing a forceful spray inside the empty container. By holding the container over the opening to the spray rig or holding tank while rinsing, rinse water can be captured as it drains from the container spout. Be sure to rinse any pesticide residue off the outside of the container, too.

Manual rinsing methods (i.e., triple rinsing) can be as effective as pressure rinsing, although they are more time-consuming and labor intensive.



Disposing of Rinsed Containers

Rinsed according to label directions, pesticide containers are classified as ordinary solid waste. Be aware, however, that some waste disposal operators will still turn away rinsed containers, even if they have adequate landfill capacity.

States also have jurisdiction over burning and burying containers on private property. While these disposal methods don't violate federal laws, the states frequently apply different rules. For example, open burning and burial of containers is outlawed in some states. Contact your ag chemical dealer for state disposal regulations.

Recycling Containers

Collection and recycling programs are being organized in a number of states as pilot programs. But the success of any disposal or recycling program hinges on the guarantee that only properly rinsed containers will be brought in by farmers. Without this guarantee, landfill operators and recyclers, wary of handling hazardous waste, won't accept the containers.

If you have the opportunity to participate in a recycling program, be sure to rinse all containers properly. Contact the Agricultural Container Research Council (919-549-2101) for more information about container recycling programs near you.

Leftover Chemicals

Applying leftover pesticides over as large an area of land as possible, such as on the field where the chemical was originally used, is a common disposal practice acceptable in most states. Off the farm, however, disposing of banned chemicals or hazardous ag chemical waste is generally much more difficult and expensive. Contact your chemical dealer for more information on amnesty (chemical return) programs near you.

To learn more about the requirements for hazardous waste treatment and disposal, contact the EPA hazardous waste hotline at 800-424-9346 or your pesticide retailer.

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Mission

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

The purpose of this Bulletin is to serve as a medium of exchanging operation and maintenance information. Its success depends upon your help in obtaining and submitting new and useful O&M ideas.

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