*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

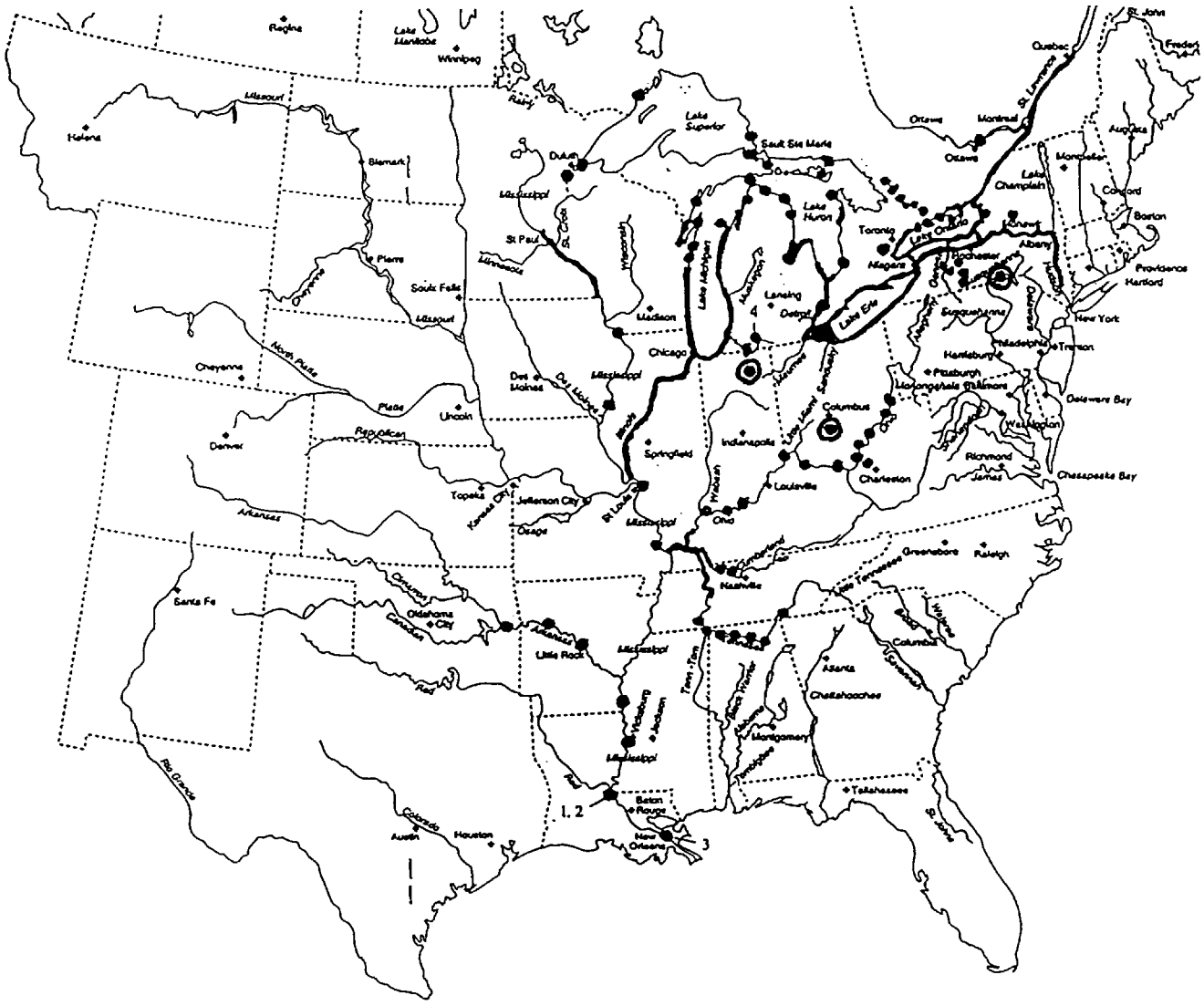


Figure 1. – North American range of the zebra mussel as of May 21, 1993. Prepared by New York Sea Grant. (Locations of mussels on the Arkansas River in eastern Oklahoma; on the Mississippi River at St. Paul, just north of confluence with Des Moines River; and above Baton Rouge were used as centers for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

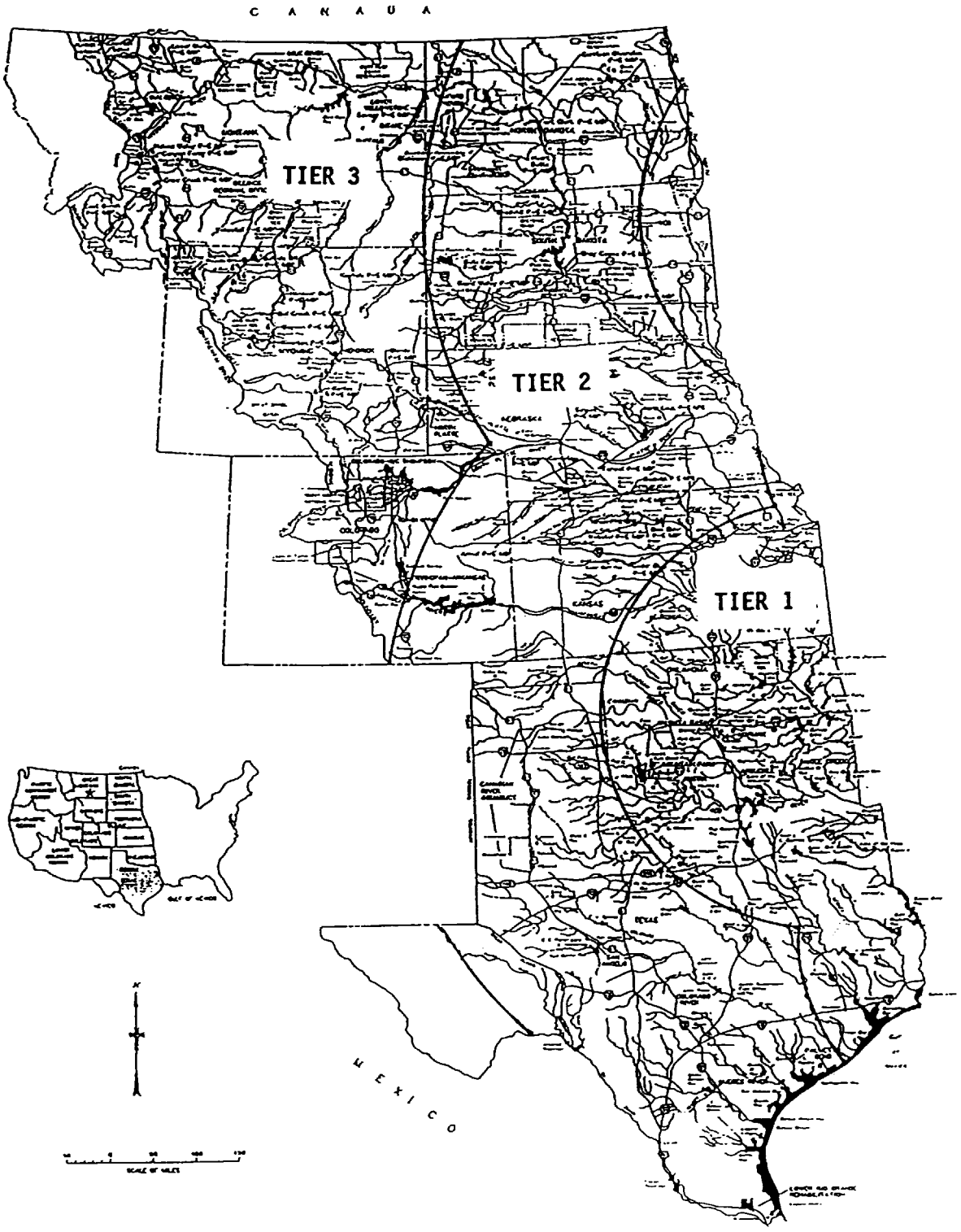


Figure 2. – Bureau of Reclamation's Great Plains Region. Arcs superimposed on the region are drawn on 250- and 500-mile radii from points on the western edge of the zebra mussels' current range (see fig. 1). The risk of Reclamation service areas in Tiers 1, 2, and 3 being invaded by zebra mussels is 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<br>≥4 months at ≥13 °C<br>Where monthly maximum 20 to 25 °C<br>≥3 months at ≥13 °C<br>Where monthly maximum >25 °C<br>annual mean ≤23 °C |
| Turbidity | ≤50 NTU |
| Eutrophy | Total phosphorus <0.25 mg/L<br>or<br>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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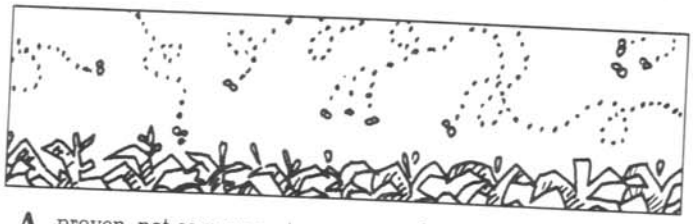
# Making IPM Work For You



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.

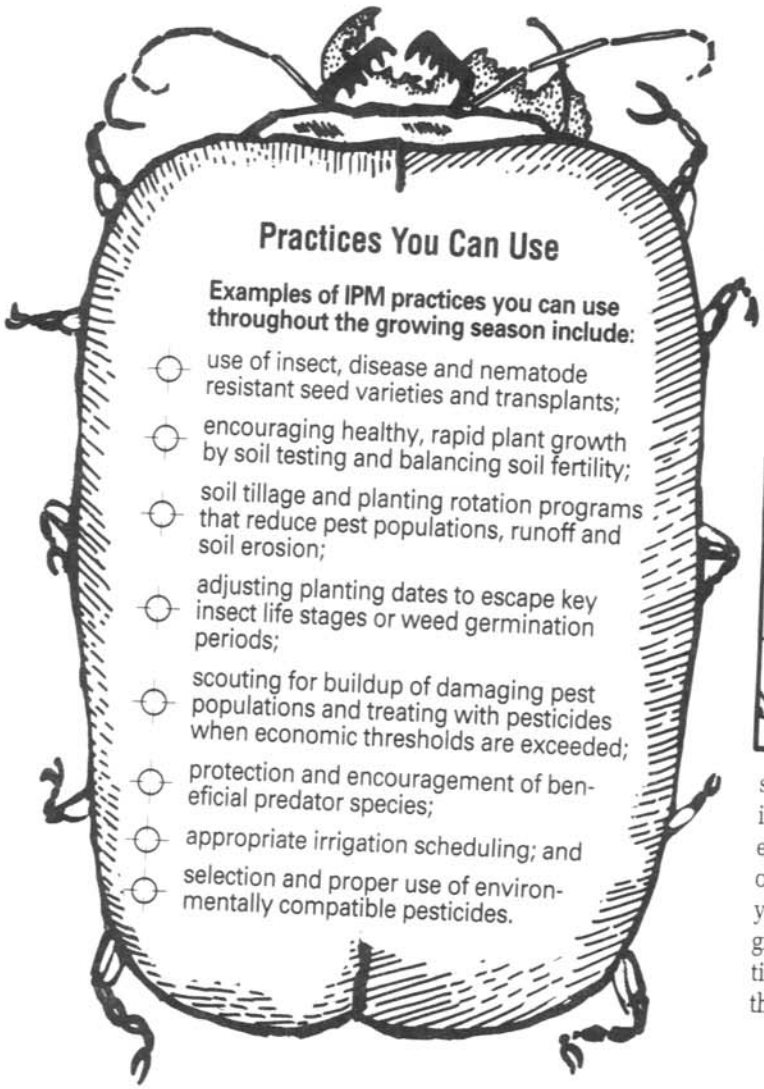
This permits a combination of techniques that might be used to limit weed, insect and disease pests to trivial levels, below damage that is serious and represents an economic threshold.

**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.

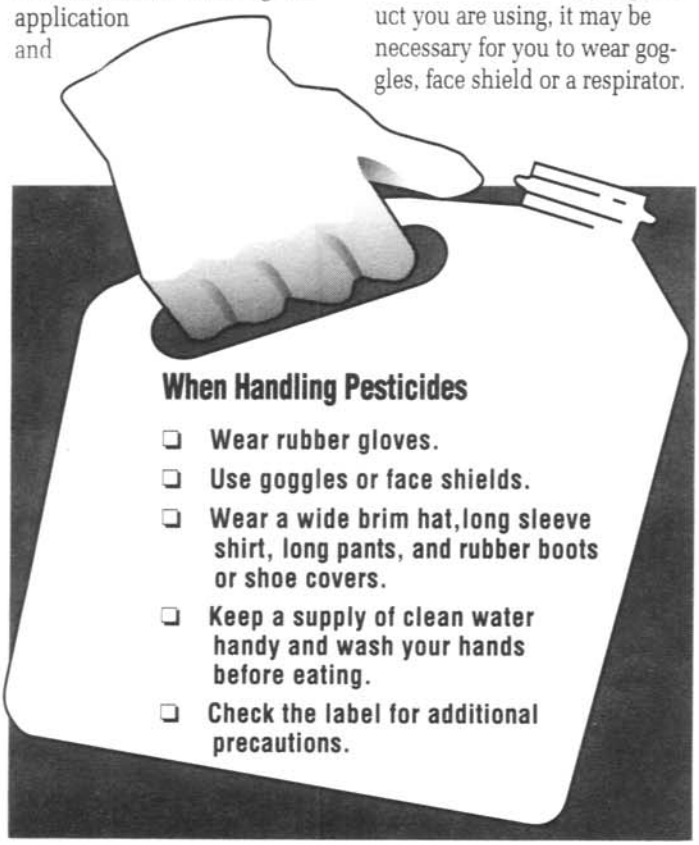
# Pesticide Safety Checklist

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.

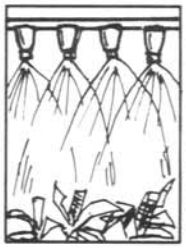

**Wear appropriate personal safety equipment when handling pesticides.** Start by wearing a wide-brim hat, long-sleeved shirt, long pants and chemical-resistant gloves. You should also wear sturdy work shoes or rubber boots, not sneakers or sandals when handling pesticides. Depending on the product you 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.

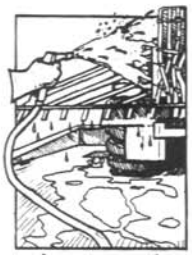
**While filling sprayers, avoid backsiphoning by keeping the discharge end of the fill hose above the tank's water level.** If you put the end of the hose down into the pesticide liquid in the tank, you run the very real risk that the hose will suck water and chemicals back into the well when you turn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

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.

# 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.

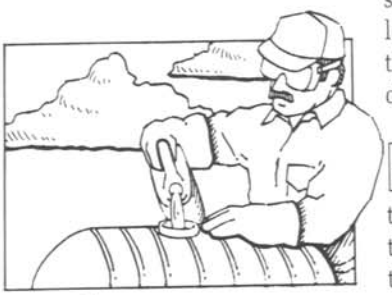
☑ Wear appropriate personal safety equipment when handling ag chemicals.

☑ 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.

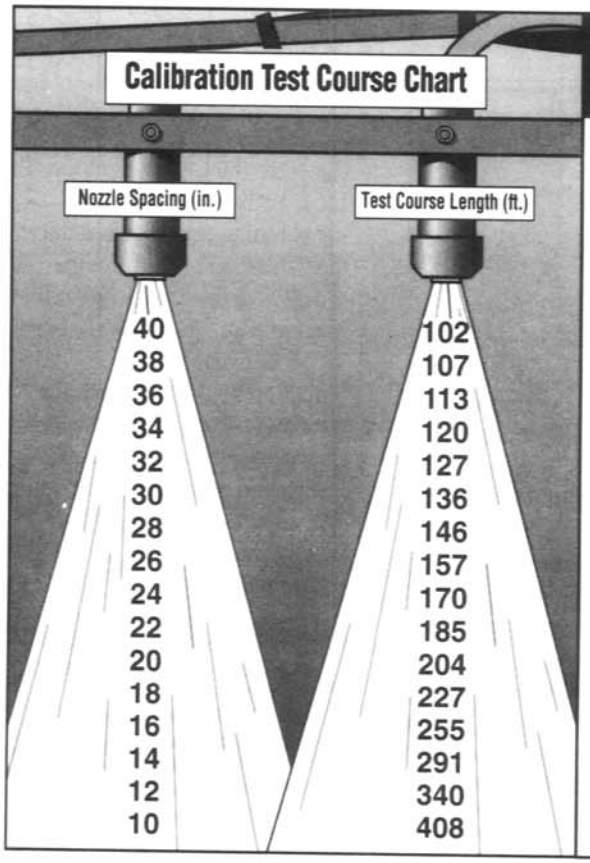
**6** Set the desired pressure on your sprayer (this will vary with the type of spray tips you use and the gallons per minute you wish to spray through them).

**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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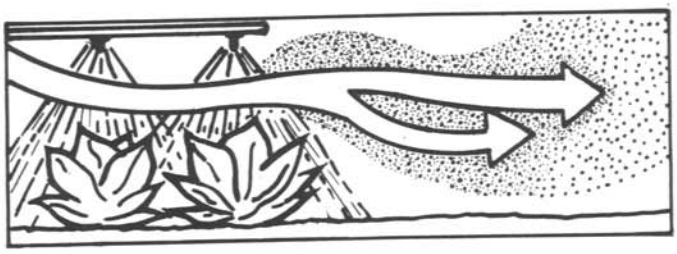
# Prevent Pesticide Spray Drift



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.

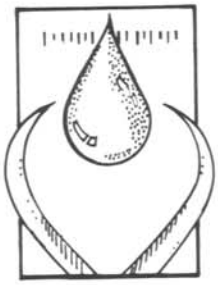
## Planning Checklist

- ☑ 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:**

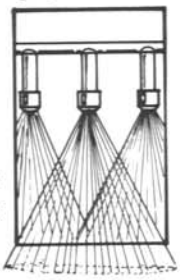
### ✔ Droplet Size

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:

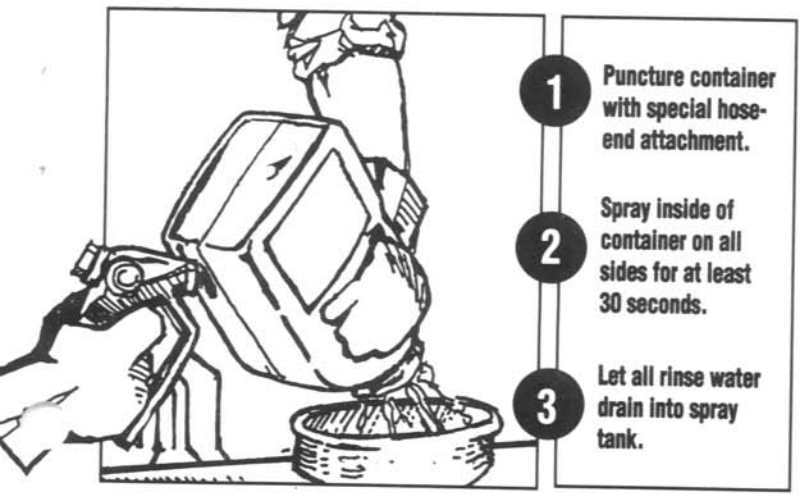
## All Trash Is Not Alike

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.

Advertise your district's or project's resourcefulness by having an article published in the bulletin! So let us hear from you soon.

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