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MTDC Portable Vehicle Washer

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MTDC Portable Vehicle Washer

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Introduction

Noxious weeds, invasive plants, and harmful fungi pose an increasing threat to native ecosystems, croplands, and other plant communities throughout the United States. While weeds have long been recognized as a problem for agriculture, now their potential to harm other plant communities, including those in forests and wildlands, is receiving greater attention.

An estimated 2,000 species of invasive and noxious weeds (figure 1) are already established in the United States. All ecosystems are vulnerable to invasion, even those that are largely undisturbed.

Land managers may use several methods to control noxious and invasive plants. These methods include chemical spraying, hand picking, and biological control. Prevention measures can help keep noxious and invasive plants from becoming established. For example, many States have implemented programs for certifying weed-free hay and straw for pack animals.

One measure that can help prevent the spread of weeds is to wash vehicles before they enter a weed-free area or when they leave an infested area. Weed seeds and fungal spores can be transported in the mud or dirt on vehicles. Firefighting vehicles can be deployed on fires throughout the country, giving them the potential to transport seeds to remote locations. Several Forest Service ranger districts and some contractors have assembled vehicle-washing systems that have been used to clean firefighting vehicles.

Some of these systems use high-pressure wands and nozzles (similar to those in a standard car wash) to wash the vehicles. Others use underbody spray systems to remove dirt and mud from the underbody of the vehicles. Because the wash water is not recycled, these systems use large amounts of water.

The Missoula Technology and Development Center (MTDC) was asked to design a portable vehicle-washing system that would:

- Wash a vehicle to remove dirt and mud deposits on the exterior of the vehicle in 5 minutes. The emphasis of the cleaning should be in the wheels, wheel wells, bumpers, and underbody of the vehicle where most mud and dirt collects.

Figure 1—Leafy spurge (left, by William M. Ciesla) and spotted knapweed (right, by Jim Story, Montana State University) are just two of the weed species whose seeds the MTDC portable vehicle washer can remove from fire vehicles.—*Photos courtesy of Forestry Images (http://www.forestryimages.org).*

The washing needs to be done quickly so it does not slow down firefighting and other operations.

- Fit on a single trailer that can be towed by a ¾-ton pickup truck. The system should be small enough to be transported easily an should not take up a lot of space when it is deployed.
- Reuse wash water. This requirement should eliminate the need to constantly fill holding tanks or have a water supply at the washing site. Also, spores and seeds can be filtered from the wash water for disposal.
- Be operated easily by no more than two persons with minimal training.
- Be inexpensive to produce. Low production costs will allow forests, districts, and private contractors to purchase them.
- Wash vehicles ranging from lowboy trailers to all-terrain vehicles (ATVs).

The MTDC Portable Vehicle Washer

The center has designed and fabricated a portable vehicle washer to meet the project's goals (figure 2). Operators use two high-pressure wands to wash the vehicle's sides, wheels, and wheel wells. A high-pressure, high-volume nozzle system washes the vehicle's underbody. An industrial rubber mat with foam-filled barriers on all sides confines the wash water. The used wash water is pumped from the mat to two 175-gallon settling tanks. Large particulate matter sinks to the bottom of the tanks. The effluent from the settling tanks is pumped through two filters. The filters have felt bags that can remove particulate as small as 3 microns. After the water has passed through the filters, it is dumped into a 550-gallon holding tank where a pump with high pressure (about 800 pounds per square inch) and high volume (about 20 gallons per minute) pushes the water through the wands and underbody washers. Figure 3 shows the flow of water. The washer does not use hot water nor does it use any soaps, chemicals, or detergents. The components are mounted on a twin-axle, 8- by 18-foot trailer that can be towed by a ¾-ton pickup truck (when the water tanks are empty).

The pumps, generator, tanks, and filter housings are permanently mounted on the trailer. The trailer also carries the mat, hoses, and miscellaneous equipment.

Figure 2—The MTDC portable vehicle washer being used in the field.

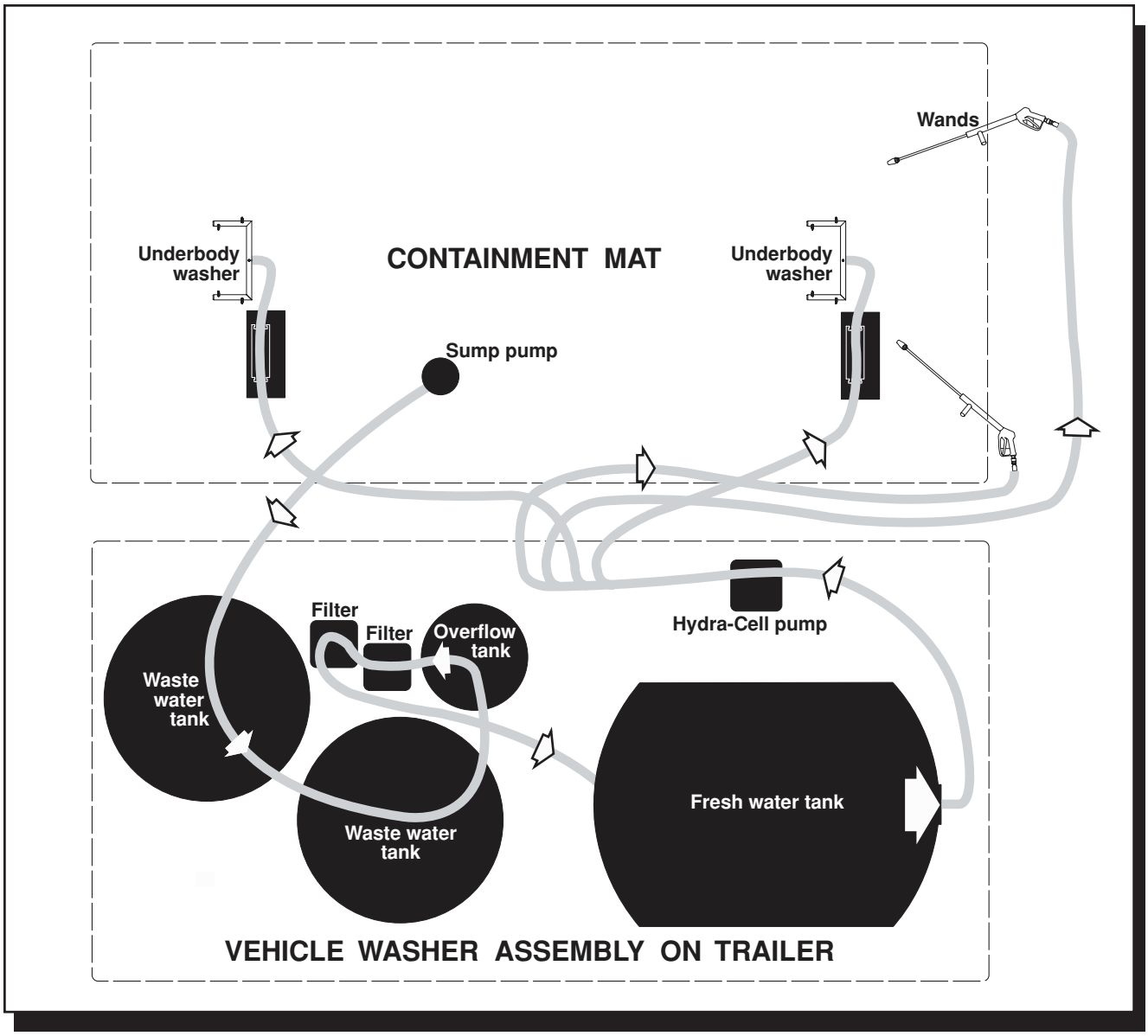

Figure 3—The flow of water through the vehicle washer system.

Wands and Underbody Washers

The MTDC portable vehicle washer uses two hand wands and two underbody washers. The two hand wands operate at a pressure of 800 pounds per square inch. Each wand sprays about 8 gallons of water per minute (figure 4). The wand has a rotating, single-stream nozzle that does a better job of cleaning than standard fan nozzles.

The underbody washer (figure 5) is one of the few components of the vehicle-washing system that is not commercially available. The underbody washers are made of 1-inch pipe, welded to form a U shape. Six high-pressure fan nozzles attached to each underbody washer provide complete coverage under the vehicle. The six nozzles operate at about 800 pounds per square inch of pressure and use a total of 18 gallons of water per minute.

During a typical washing operation, a vehicle drives ***slowly*** onto the mat and over the first underbody washer. Once the vehicle has been driven completely over the underbody washer,

Figure 4—The hand-operated, high-pressure wands are used to clean mud, dirt, spores, and weed seeds from a vehicle's wheel wells, tires, sides, and bumpers.

Figure 5—The underbody washer uses high pressure and a large volume of water to wash mud, dirt, and debris from underneath the vehicle. Nozzles are mounted so that they provide complete coverage under the vehicle. The ramp protects the hose that supplies water to the underbody washer. One underbody washer cleans vehicles as they drive onto the mat and another cleans them as they drive off.

operators close a valve on the wash system's trailer, stopping the flow of water to the underbody washer. Operators wash the vehicle with the two high-pressure wands, removing all mud and dirt on the sides, wheels, wheel wells, and bumpers. Operators turn on the valve to the second underbody washer, which cleans the underbody again as the vehicle drives off the mat.

Containment Mat

The containment mat, a Latimat Containment Pad, is distributed by Environmental Cleaning Systems, Inc. (figure 6). The rubber mat is 19 feet wide and 33 feet long. Cylindrical pieces of foam are inserted into sleeves along the sides of the mat, forming raised sides (3 inches high) that contain the wash water. A reel has been fabricated and mounted on the back of the trailer to make the mat easier to set up and store.

The mat is very durable, but users should ensure that sharp debris is not underneath it. Rubber-tired vehicles probably will not puncture or rip the mat unless the mat is placed over an extremely sharp object. A felt liner the same size as the mat helps protect the mat from cuts or punctures. The liner, stored in a box on the trailer, is unfolded on the ground before the mat is unreeled.

Tracked vehicles, such as dozers or small excavators, require special attention. Place industrial strength conveyor belting under their tracks to prevent them from damaging the mat. Long vehicles, such as school buses, also require special handling. Typically, half of the vehicle is driven on the mat and washed, then the vehicle is moved to wash the other half.

Patching material that comes with the mat can repair punctures or holes. The patching material is the same

Figure 6—A 19- by 33-foot mat keeps the wash water where it can be recycled. Foam tubes are placed in slots along the mat's edges to create a 3-inch lip on all sides. The mat shown here was set up at the Cathedral Fire near Darby, MT, during August 2002. The wash water drains to the lower right corner of the mat, where a sump pump draws water for filtering and reuse.

material as the mat and can be cut to any size. The patch is applied to the mat by heating the edges with an industrial heat gun, melting the patch to the mat.

Holding Tank and High-Pressure Pump

Water is stored in a 550-gallon tank mounted on the trailer (figure 7). A high-pressure, high-volume diaphragm pump (figure 8) supplies water to the underbody washer and wands at a pressure of 800 pounds per square inch and a flow of 20 gallons per minute. The diaphragm pump is powered by a 25-horsepower, two-cylinder gasoline engine. A 40-micron strainer between the tank and the pump prevents particulate from damaging the pump.

Figure 7—A 550-gallon tank is the main storage tank that supplies water to the washer.

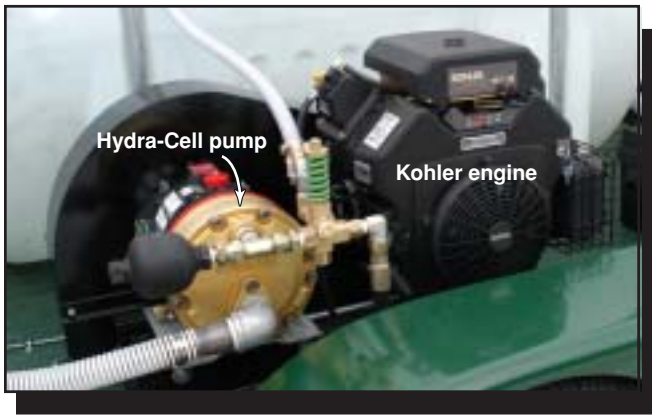

Figure 8—A high-pressure and high-volume diaphragm pump provides water to the wash wands and underbody washers. A 25-horsepower, two-cylinder engine powers the pump.

An overflow bypass valve (figure 9) protects the pump. Between washings, when no water is needed, the valve routes unused water back to the holding tank to prevent damage to the pump. The valve is one of the few consumable parts of the washer. The internal stainless steel seats can wear if the wash water contains a lot of grit or fine particles. As the seats wear, pressure to the wands and underbody washer will decrease, because water will be diverted continuously to the main holding tank.

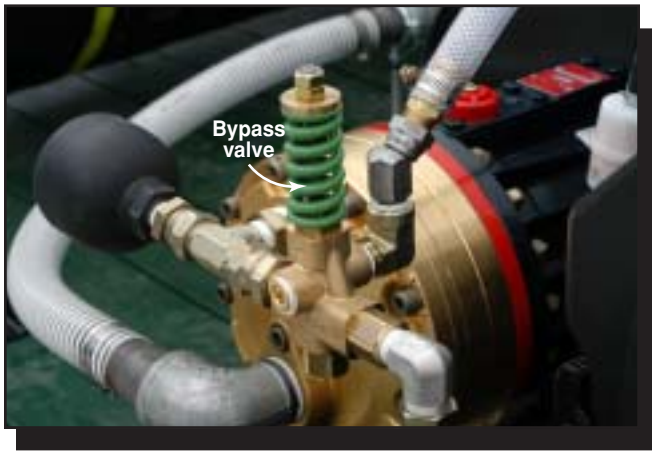

Figure 9—A bypass valve directs water back to the holding tank when water is not needed for the wands or underbody washers. This valve will prevent damage to the pump, but its internal parts can wear and require replacing. Hydraulic fittings make the valve easier to replace.

Sump Pumps and Settling Tanks

An electrically powered sump pump moves wash water collected on the mat into two 175-gallon, cone-bottom settling tanks (figure 10). The water flow enters the first settling tank through large PVC pipes near the bottom of the tanks. The water flow enters near the bottom to minimize flow velocities and turbulence, increasing the likelihood that particulate will settle in the tanks.

A 2-inch connector near the top of each tank allows overflow water from the first settling tank to flow into the next settling tank. Water enters the second settling tank near the bottom of the tank through PVC pipe attached to the overflow connector between the two tanks.

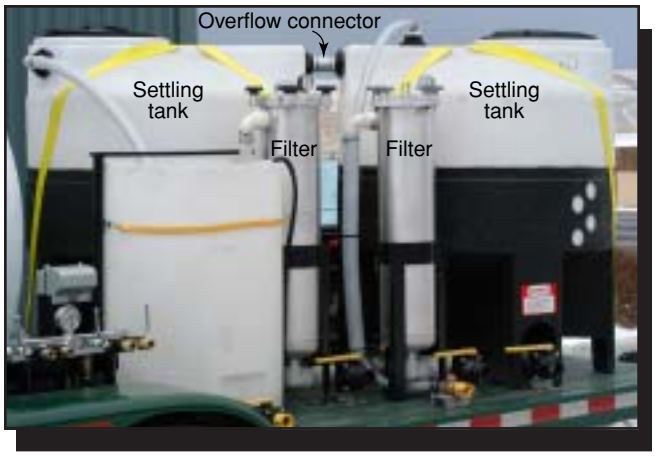

Figure 10—Two cone-bottomed tanks (background) are used as settling tanks to remove the larger particulate. Used wash water from the mat flows to these tanks before it is filtered.

The overflow from the second settling tank flows into a smaller open-barrel tank (figure 11). A filter housing with a large-mesh filter (800 microns) is attached to the overflow pipe, trapping debris such as needles or leaves and most large seeds. Another sump pump in this open tank moves the water through two filters and back to the main 550-gallon holding tank.

Figure 11—Overflow from the settling tanks flows to the overflow tank (left). A sump pump inside the overflow tank pumps water through two filter housings to the holding tank. The filter housings use polypropylene or polyester felt and nylon monofilament filters to remove particulate of different sizes, depending on the user's requirements. The size of particulate filtered can range from 800 microns to as fine as 3 microns.

Ball valves and hoses attached to the bottom of each of the settling tanks allow them to be drained.

Filter Housings and Filters

The wash water is pumped through two filter housings and back to the main holding tank. Each filter housing uses felt filter bags rated at sizes ranging from 800 microns down to 3 microns to remove particulate matter or seeds larger than the bag's rating. Any combination of bags can be used, depending on the size of seeds or spores that are targeted. A 100-micron filter bag should catch all seeds, while bags with smaller mesh sizes could be used to trap spores.

Each housing is equipped with pressure gauges to determine when the filters are clogging. A pressure of 15 to 20 pounds per square inch indicates that the filters are nearly full. The filters can be stored for analysis or backwashed to remove all the debris and reused.

Electrical Power

A 5,000-watt gasoline generator (figure 12) provides electrical power to operate the two sump pumps. The generator can also be used to power lights and any other electrical accessories.

Figure 12—A 5,000-watt gasoline generator supplies power for the two sump pumps and can provide power for other electrical needs.

Mat Reel

A manually operated reel has been fabricated to help set up, transport, and store the mat (figure 13). The reel is designed so that the mat can be unrolled easily when the washing station is being set up. An operator holds one end of the mat down, releases the reel's locking mechanism, and pulls the trailer forward over the mat's felt underlayment. Once the mat is in place, it can be unfolded for use.

Before storage, the mat should be thoroughly washed to remove any rocks and debris, dried as thoroughly as possible, and folded to a width of 46 inches. The front end of the mat can be lifted, locked into the reel, and reeled in. A locking mechanism (figure 14) prevents the reel from unwinding. Tiedowns and straps hold the mat in place.

Figure 13—The mat reel is used to roll up the mat for transportation and storage.

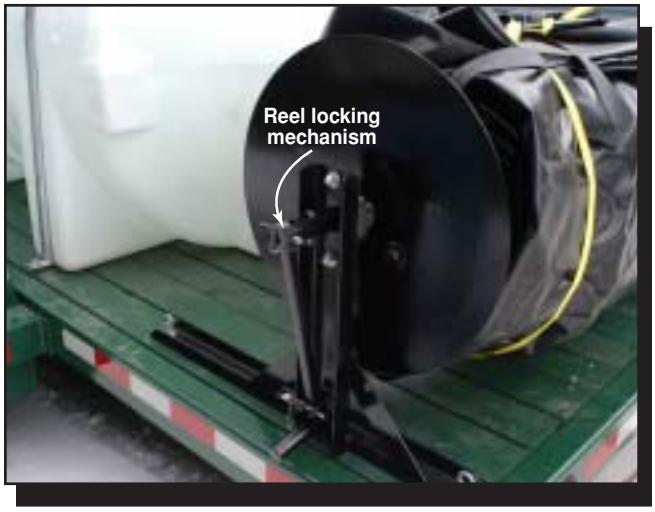

Figure 14—The mat reel's locking mechanism prevents the mat from unrolling accidentally.

Field Testing

Field testing of the portable vehicle washer was completed in 2002 and 2003. Our original prototype (slightly different from the unit described previously) was used during the field testing. The final design addressed problems observed during field testing.

Cathedral Fire

From August 6 through 9, 2002, the prototype vehicle washer was set up and operated during demobilization of the Cathedral Fire camp near Darby, MT. The vehicle washer was set up on a level spot at the Deer Creek trailhead in the Bitterroot National Forest about 1½ miles from the fire camp.

The location's one drawback was that vehicles could not drive through the washing station. Instead, they had to drive forward onto the mat and back out. This presented problems when other vehicles were lined up and the vehicles being washed did not have enough room to turn around and leave.

A total of 74 vehicles were washed. The vehicles included cars, pickup trucks, sport-utility vehicles, hotshot crew vehicles, fire engines, and a school bus. All the used water ran down to one corner of the mat where it was pumped into the settling tanks. The wash water supply tank had to be refilled three times (about 175 gallons per refill).

The washing system did an excellent job. Washing a standard pickup truck, sport-utility vehicle, or car took about 2 to 3 minutes. Hotshot crew vehicles, fire engines, or tankers took about a minute or so longer.

The MTDC underbody washer did an excellent job, as evidenced by the amount of dirt on the mat and dirty (but filtered) water that was being used to wash the vehicles. The vehicles appeared clean after drying and were mud free. After the washer was returned to MTDC, the settling tanks had a lot of sediment in the bottom and were difficult to drain. Tanks should be partially drained daily to remove sediment, preferably early in the morning after the sediment has settled overnight.

The filters used on the last day of testing were kept for analysis. About 40 vehicles were washed that day. The filters were backflushed with water to remove all the particulate, seeds, and debris that had collected on them. This material was sent to the Montana State Seed Testing Laboratory in the Department of Plant Sciences at Montana State University in Bozeman, MT.

The laboratory's results indicated that the following seeds were collected in the 20-micron filter:

- Bluebunch wheatgrass (*Pseudoroegneria spicata*)
- Bluegrass (*Poa spp.*)
- Crested wheatgrass (*Agropyron spp.*)
- Orchardgrass (*Dactylis glomerata*)
- Reed canarygrass (*Phalaris arundicacea*)
- Sedge (*Carex athrostachya*)

No seeds were found in the 5-micron filter.

Mineral-Primm Fire

The portable vehicle washer was set up and used at the Mineral-Primm Fire camp (Lolo National Forest) at Potomac, MT, from August 19 to August 31, 2003 (figure 15). The Mineral-Primm Fire was a Type I fire. Vehicles that were washed ranged from small cars to excavators/harvesters and dozers loaded on lowboy trailers (figure 16). Most of the vehicles were pickup trucks and fire engines.

Figure 15—The vehicle washer set up for operation at the Mineral-Primm Fire camp near Potomac, MT.

The washer was set up in a field on a fairly level ground. This location provided enough space for vehicles to line up to drive onto the mat and plenty of room for water tenders to refill the tanks.

The Mineral-Primm Fire was a good test for the vehicle washer. It performed well during the first week of testing. The volume of vehicles was fairly low, under 20 vehicles a day, and operators had plenty of time to clean the vehicles and keep the mat, tanks, and filters clean.

After the first week, excessive mud became a problem. The roads from the camp to the firelines were being heavily watered to keep dust down. Vehicles were returning with plenty of mud, many with more than 4 inches of mud in the wheel wells, mud flaps, bumpers, and underbody.

Figure 16—The vehicle washer cleaned many pieces of large equipment used to construct fire line at the Mineral-Primm Fire near Potomac, MT.

This mud caused several problems. One problem was with the filters. They clogged very quickly, which required replacing them after nearly every other vehicle.

The large quantities of mud also caused problems with the mat. Because the washer was set up on a field, the mat had many dips. Sand and dirt collected in the dips. Removing the dirt from the mat proved difficult after much of the water had been removed.

Finally, the fine silt from the mud wore out the high-pressure bypass valve quickly. The valve had to be replaced twice.

One pass over the underbody washer did not remove all the mud under the heavily muddied vehicles. Operators had to spend more time with the wands to clean under the vehicles.

We also had problems with the sump pump used on the mat. The pump was difficult to prime and was clogging repeatedly. A larger sump pump used later in the test worked better, but it too was difficult to prime.

Final Design

A final design was completed to overcome some of the problems encountered on the Mineral-Primm Fire. These changes include:

- Larger filter housings and filters. The new filter housings use filters that have 120 percent more surface area than the original prototype. This should decrease the number of filter changes, especially when washing extremely muddy vehicles.
- The flow of water to the settling tanks has been rerouted. The original washer split the flow and had the water enter both settling tanks at the same time. The new design has the settling tanks in series, so the water from the mat flows into one settling tank and the overflow goes to the second tank. We believe this should improve settling of the particulate.
- A valve on the mat sump pump helps prime it (figure 17). Opening the valve allows water to flow without the head pressure from the tank and hose.
- All the tanks and filter housings have been plumbed for easy draining. All hoses and drain fittings have cam/lever coupling fittings for easy connections.
- Hydraulic fittings have been used for the high-pressure plumbing from the pump and manifold to the wands and underbody washers. This allows operators to change the high-pressure bypass valve easily.

Figure 17—The mat sump pump has a valve attached to the outflow. This valve is used to prime the pump. Opening the valve allows water to flow through the pump without any head pressure. Once the flow is established, the valve is closed and water is pumped to the settling tanks.

- The engine was increased to 25 horsepower. The sheaves used to power the pump were resized for better efficiency and an extra belt was used to prevent slipping.
- An additional underbody washer was incorporated to spray the vehicles twice.
- Other miscellaneous changes included increasing the size of the holding tank from 350 to 550 gallons, redesigning the locking mechanism on the mat reel, purchasing commercial rubber ramps to protect the hoses, and lengthening the trailer from 16 to 18 feet.

Conclusions and Recommendations

Field testing proved that the overall concept of the prototype vehicle washer was sound. Most vehicles were washed in about 2 to 3 minutes, depending on the vehicle's size and the amount of dirt. The underbody washer did a good job under most circumstances. Unless *very* muddy vehicles were being washed, all of the mechanical components (pumps, tanks, nozzles, and generators) performed as planned. The filters collected seeds of various sizes and from many different plant species.

The original prototype vehicle washer was redesigned to make operation easier and to compensate for several problems, notably when it was used to wash vehicles that were particularly muddy. However, at times the mud may be so excessive that it is not possible or practical to filter the used wash water. In these cases, we recommend using two 1,500- to 5,000-gallon portable, soft-sided Fol-Da-Tanks (figure 18).

Figure 18—When vehicles are so muddy that it is impractical to reuse wash water, portable, soft-sided Fol-Da-Tanks could be used to store supply water and used water.

One tank will be used for the supply water and the other for storing used water collected from the mat. The 1,500 to 5,000 gallons of water should be enough for several days of washing, depending on the number of vehicles.

The pump will need to draw water from one of the soft-sided tanks rather than from the 550-gallon holding tank on the trailer. Also, the tubing coming from the sump pump on the mat should be directed into the other soft-sided holding tank rather than to the settling tanks on the trailer. A sewage pump truck or similar type of truck will probably be needed to dispose of the used water.

Fabrication drawings (MTDC–1020) are available by contacting Deb Mucci at MTDC (phone: 406–329–3999, fax: 406–329–3719, or e-mail: *dmucci@fs.fed.us*). An operator's manual (0434–2826–MTDC) is also available from MTDC by contacting pubs distribution, Cailen Hegman (phone: 406–329–3978, fax: 406–329–3719, or e-mail: *cahegman@fs.fed.us*).

About the Authors

Andy Trent is a project engineer at MTDC. He received his bachelor's degree in mechanical engineering from Montana State University in 1989. Before coming to MTDC in 1996, he worked as a civilian engineer for the U.S. Navy. Andy works on projects in the nurseries and reforestation, forest health protection, and watershed, soil, and air programs.

Dick Karsky has been program leader for forest health protection since the fall of 1999. Dick has been a project leader at MTDC in the resource areas of global positioning system, range, cooperative forestry, engineering, fire, reforestation and nurseries, residues, recreation, and forest health protection. He obtained a bachelor's degree in agricultural engineering from North Dakota State University and a master's degree in agricultural engineering from the University of Minnesota. He worked for private industry before coming to the MTDC in 1977.

Chuck Harding is a mechanical engineering technician in MTDC's equipment fabrication shop. He came to the center from the U.S. Air Force Reserve where he worked as a metals technology technician. He has been with the center since 2000.

Scott Gilmour has been a mechanical engineering technician in MTDC's shop since 2001. Scott worked as a submarine tender for the U.S. Navy on nuclear subs in the San Diego area and as a machinist for the aerospace industry in Utah before returning to Montana in 1992 to work on mechanized logging equipment.

Library Card

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Describes a vehicle washer that is mounted on a flatbed trailer and can be towed by a ¾- ton pickup truck when the water tanks are empty. The washer can be used at fire camps where weed seeds need to be removed from vehicles before and after they leave the area. Operators use two high-pressure wands to wash the vehicle's sides, wheels, and wheel wells. One high-pressure underbody washer cleans the vehicle's underbody when the vehicle drives onto the wash mat and another cleans the underbody again as the vehicle drives off. Vehicles are washed on an industrial rubber mat that has 3-inch-high, foam-filled barriers on all sides to hold the wash water. The water is filtered before being reused. The prototype washer was tested at fire camps in Montana during the 2002 and 2003 fire seasons. Operators took 2 to 3 minutes to wash a standard pickup truck, sport utility vehicle, or car and another minute or so longer to wash hotshot crew vehicles, fire engines, and school buses. When vehicles are especially muddy, the wash water cannot be reused without clogging filters and wearing out bypass valves. In such cases, clean and used water can be stored in large, folding tanks. The dirty water can be hauled away by trucks for disposal. Drawings for the vehicle washer (MTDC–1020) and an operator's manual (0434–2826–MTDC) are available from the Missoula Technology and Development Center.

Keywords: cleaning, fire camps, fire fighting, firefighting, washing, weed control, weeds

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Additional single copies of this document may be ordered from:
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Electronic copies of MTDC's documents are available on the Internet at:
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Copies of the fabrication drawings (MTDC–1020) are available by contacting Deb Mucci at MTDC:
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