United States
Department of
Agriculture

Forest Service

**Technology &
Development
Program**

3400 FHP
December 2002
0234-2836-MTDC

MTDC Portable Vehicle Washer

Interim Report

MTDC Portable Vehicle Washer

Interim Report

Andy Trent
Project Leader

Dick Karsky
Program Leader

Scott Gilmour
Mechanical Engineering Technician

USDA Forest Service
Technology and Development Program
Missoula, MT

1E12D75—Power Washer

December 2002

Contents

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, their potential impact to other plant communities, including those in forests and wildlands, is receiving greater attention.

An estimated 2,000 invasive and noxious weed species are already established in the United States. All ecosystems are vulnerable to invasion, even those that are largely undisturbed.

On Federal lands in the Western United States, weeds occur on an estimated 17 million acres, with similar infestations occurring in Canada and Mexico. On National Forest System lands, an estimated 6 to 7 million acres are infested with noxious weeds. The rate of infestation is potentially increasing from 8 to 12 percent per year.

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 prevention measure is to wash vehicles before they enter a weed-free area or when they leave an infested area. Weed seed and fungal spores can be transported in the mud or dirt on vehicles. This is especially true for firefighting vehicles that can be deployed on fires throughout the country and can transport seed to remote locations. Several Forest Service ranger districts and some contractors have assembled vehicle-washing systems to prevent the spread of weeds. Some systems use high-pressure wands and nozzles (similar to those in a standard car wash) to wash the vehicles. Other systems use underbody spray systems to remove the dirt and mud from the underbody of the vehicles. These systems use large amounts of water because the wash water is not recycled.

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

❑ Wash a vehicle to remove dirt and mud deposits on the exterior (top and bottom) of the vehicle in 5 minutes. The emphasis of the cleaning should be in the wheels, wheel wells, bumpers, and undercarriage of the vehicle where most mud and dirt collects. 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 easily transported and 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 seed can be filtered from the wash water for proper disposal.

❑ Be easily operated 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).

Portable vehicle-washer components.

The MTDC Portable Vehicle Washer

The center has designed and fabricated a prototype portable vehicle washer to meet the project's goals (figure 1). Operators use two high-pressure wands to wash the vehicle's sides, wheels, and wheel wells. An oscillating, high-pressure, underbody washer washes the vehicle's undercarriage. 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 will sink 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 350-gallon holding tank where a high-pressure (about 800 to 1,000 pounds per square inch), high-volume (about 20 gallons per minute) pump pushes the water through the wands and underbody washer. The system does not use hot water nor does it use any soaps, chemicals, or detergents. The whole system is mounted on a double-axle, 8- by 16-foot trailer that can be towed by a $\frac{3}{4}$-ton pickup truck.

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

Figure 1—The MTDC prototype vehicle washer is used to wash a fire engine on the Bitterroot National Forest.

Figure 2—The hand-operated, high-pressure wands are used to thoroughly clean a vehicle's wheel wells, tires, sides, and bumpers where mud, dirt, spores, and weed seeds can collect.

Wands and Underbody Washer

The MTDC portable vehicle washer uses two hand wands and an oscillating underbody washer. The two hand wands operate at a pressure of 800 pounds per square inch and spray about 8 gallons of water per minute (figure 2). Each wand has a rotating nozzle that does a better job of cleaning than standard fan nozzles.

The underbody washer (figure 3) is one of the few components of the vehicle-washing system that is not commercially available. The washer uses two pipes mounted parallel with three high-pressure nozzles attached to each pipe at different angles, one vertical, one 30 degrees left of vertical, and the other 30 degrees right of vertical. The pipes are rotated 26 degrees to either side of top-dead-center by a series of lever arms driven by an electric motor, a flexible drive shaft, and a gearbox. A generator located on the trailer powers the electric motor. A speed controller on the trailer controls the speed at which the underbody washer oscillates. The six nozzles operate at about 800

Figure 3—The underbody washer uses high pressure and a large volume of water to thoroughly wash mud, dirt, and debris from under the vehicle. The nozzles oscillate for complete coverage.

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 underbody washer. Once the vehicle has driven completely over the underbody washer, 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.

Containment Mat

The containment mat, a Latimat Containment Pad, is distributed by Environmental Cleaning Systems, Inc. (figure 4). The rubber mat is 19 feet wide and 33½ feet long. Cylindrical foam sections are inserted into sleeves along the sides of the mat, forming raised sides that contain the wash water. A felt liner is placed under the mat to protect the mat from cuts or punctures from rocks or other debris. A reel has been fabricated and mounted on the back of the trailer to make it easier to store and set up the mat.

The mat is very durable, but users should take care to ensure that sharp debris is not underneath it. Rubber-tired vehicles should not puncture or rip the mat unless the mat is placed over an extremely sharp object. Industrial conveyor belting should be placed under the tracks of dozers or small excavators when they are being washed.

Long vehicles, such as school buses, will 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.

Figure 4—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 barrier on all sides. The mat shown here was set up at the Bitterroot National Forest's Cathedral Fire in August 2002. The wash water drained to the lower right corner of the mat where a sump pump drew water for filtering and reuse.

Holding Tank and High-Pressure Pump

Water is stored in a 350-gallon tank mounted on the trailer (figure 5). A high-pressure, high-volume diaphragm pump supplies water at a pressure of 800 to 1,000 pounds per square inch and a flow of 20 gallons per minute to the underbody washer and wands. The diaphragm pump is powered by a 23-horsepower, two-cylinder gasoline engine. A 40-micron strainer between the tank and the pump prevents particulate from damaging the pump.

Pressure-relief valves also protect the pump. Between washings, these valves reduce the pump pressure by routing unused water back to the holding tank.

Figure 5—A 350-gallon tank is the main holding tank for the wash water.

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 6). The water flow from the sump pump is split before the water enters the tanks. Each flow enters the settling tanks through large PVC pipes near the bottom of the tanks. The flow is split to minimize the flow velocities and turbulence, increasing the likelihood that particulate will settle in the tanks.

A 1½-inch hose near the top of each tank directs overflow water to a smaller holding tank. Here, a sump pump moves the water through two filters and back to the main 350-gallon holding tank. A filter housing and filter bag can be mounted on the outlet end of the 1½-inch hose to trap debris such as needles or leaves.

Gate valves and hoses are attached to the bottom of each of the settling tanks so they can be drained.

Figure 6—Two cone-bottom tanks are used as settling tanks to remove the larger particulate. The overflow from each tank is pumped through two filters and then to the holding tank.

Filter Housing and Filters

The wash water is pumped through two filter housings and back to the main holding tank (figure 7). Each filter housing uses felt filter bags rated at 20, 10, 5, or 3 microns to remove particulate matter or seeds that are larger than the bag's rating. Any combination of bags can be used, depending on the size of seed or spores that are targeted. A 20-micron filter bag should catch all seed while the smaller bags can be used to trap spores.

Each housing is equipped with pressure gauges to determine when the filters are clogging. A pressure differential of 35 pounds per square inch indicates that the filters are becoming full. The filters can be stored for analysis or removed, backwashed to remove all the debris, and reused.

Figure 7—The filter housings are mounted on the trailer. Cloth or felt filters are used to remove particulate of different sizes, depending on the user's requirements. Typically, 20-micron filters will remove most noxious weed seeds while 3-micron filters can remove particles as small as fungal spores.

Electrical Power

A 1,000-watt gasoline generator provides electrical power to operate the two sump pumps and the motor that drives the oscillating underbody washer.

Mat Reel

A manually operated reel has been fabricated to help with the setup, transport, and storage of the mat (figure 8). The reel is designed so that the mat can be unrolled easily when setting up the washing station. An operator holds one end of the mat down, releases the locking mechanism, and pulls the trailer forward over the felt underlayment. Once the mat is in place, it can be unfolded for use.

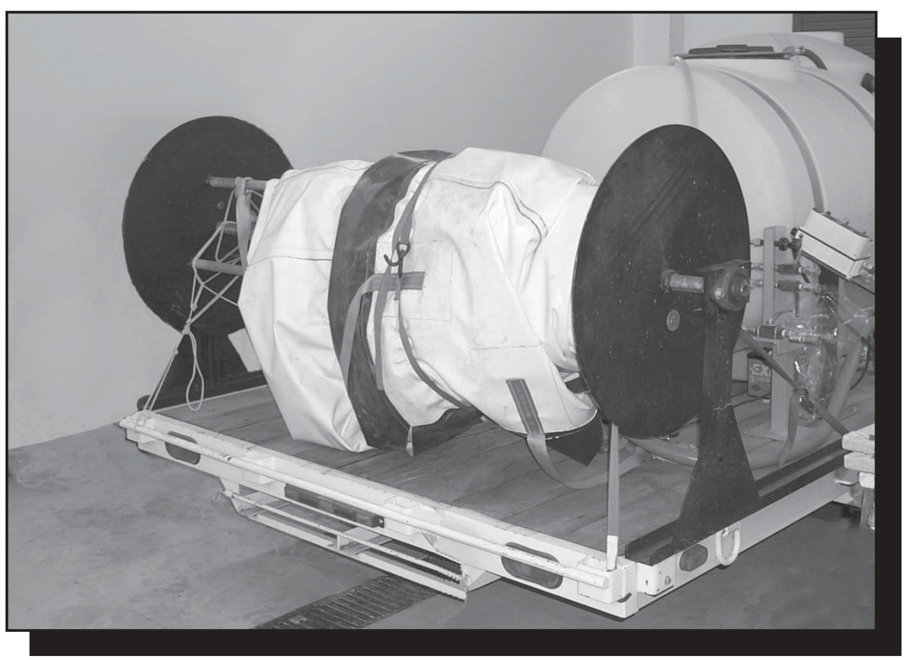

Figure 8—The mat reel is used to manually reel in the mat for transportation and storage

For 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 prevents the reel from unwinding. Tie-downs and straps hold the mat in place.

Initial Field Testing

From August 6 through 9, 2002, the prototype vehicle washer was set up and operated at the Cathedral Fire camp near Darby, MT. The vehicle washer was set up at the Deer Creek trailhead about 1½ miles from the fire camp on the Bitterroot National Forest. A contract vehicle-washing system was also set up and operating nearby.

The vehicle-washing system was set up on a level spot at the trailhead. All the used water ran down to one corner of the barrier and was pumped into the settling tanks (figure 4). The one drawback of the location 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 had not left enough room for the vehicles being washed to turn around and leave.

The camp philosophy was that all vehicles would be washed before entering the forest on the first day. Vehicles were not washed afterward so long as they were traveling between the fire and fire camp. All vehicles were to be washed before leaving camp during the fire camp's demobilization. The intent was to wash vehicles during the fire's demobilization, from August 7 to 9.

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. The wash-water supply tank had to be refilled three times (about 175 gallons per refill).

Results

The washing system did an excellent job. It took about 2 to 3 minutes to wash a standard pickup truck, sport utility vehicle, or car. Hotshot crew vehicles, fire engines, or tankers took about a minute or so longer. The contractor needed about 10 minutes per vehicle to wash them. The contractor had a very-high-pressure washing system (3,000 pounds per square inch) that used hot water. He had no containment system. All the used water and debris was left at the site.

The MTDC undercarriage washer did an excellent job, as evidenced by the amount of dirt and muddy water dropping from the vehicles.

During the 3 days of use, the water was not drained or flushed from the system. Although "dirty" water was being used to wash the vehicles, they appeared clean after drying and were mud free. After returning to the center, we found that the settling tanks had a lot of sediment in the bottom and it was difficult to drain them. It is recommended that tanks be partially drained daily to remove sediment, preferably early in the morning after the sediment has settled overnight.

Filter Analysis

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 (figure 9). This material was sent to the Montana State Seed Testing Laboratory in the Department of Plant Sciences at Montana State University, 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.

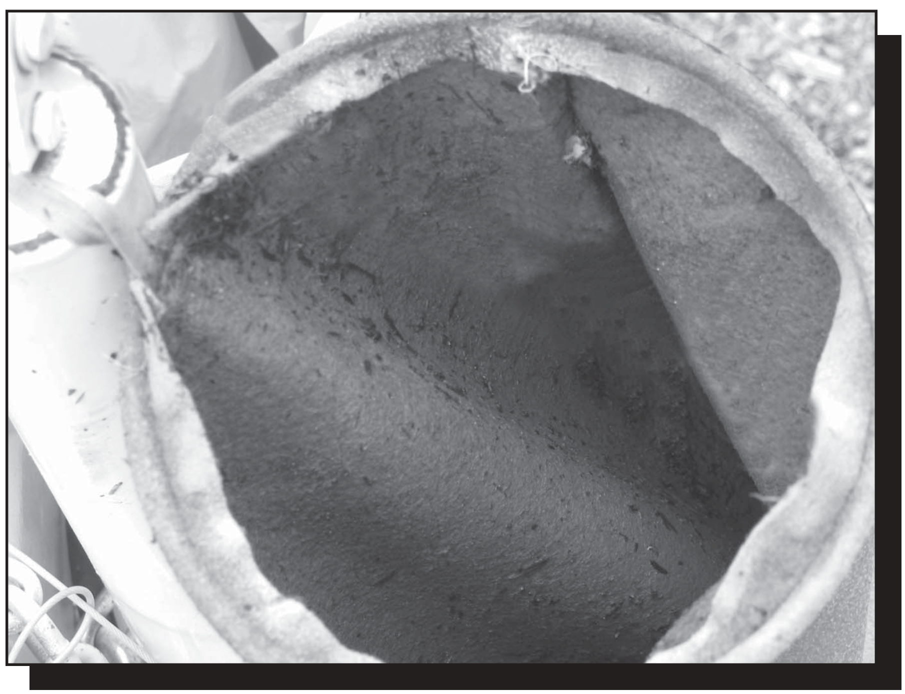

Figure 9—Filters collect noxious weed seeds and other debris from the wash water.

Recommendations

The initial testing of the vehicle washer proved that the overall concept of the prototype washer was sound. Vehicles were washed in about 2 to 3 minutes, depending on the vehicle's size and the amount of dirt on it. The undercarriage washer did a good job. All of the mechanical components (pumps, tanks, nozzles, and generators) performed as planned. The filters collected seeds of various sizes and species.

Some items need to be addressed before the design of the vehicle-washing system is completed.

Undercarriage Washer—The system's location at the test site required vehicles to drive over the undercarriage washer twice—once when driving onto and once when backing off of the mat. Two washings appeared to do a good job in removing dirt and debris underneath a vehicle. Ideally, the mat would be located where vehicles could "drive through." This would allow only one undercarriage washing, which may not be enough for a thorough cleaning. To address this issue, a second undercarriage washer could be placed on the opposite end of the mat to ensure that the underside would be washed twice.

The overall effectiveness of the undercarriage sprayer needs to be addressed. MTDC is developing a method to determine whether the undercarriage sprayer is providing complete coverage and whether the sprayer is effective in the areas it covers. One method could involve covering the bottom of a vehicle with a fluorescent dye and then driving the vehicle over the undercarriage washer. Photographs of the vehicle's undercarriage could be taken using a fluorescent light to show the location of any remaining dye.

The center is also investigating using water from the high-pressure pump rather than an electrical motor to drive the oscillating mechanism for the underbody washer. This change would eliminate the need for the electrical motor, flex shaft, and motor control, reducing the cost.

Sump Pumps—The sump pump used to pump the water from the mat clogged occasionally because of pine needles and other debris. To solve this problem, MTDC designed and fabricated a filter sock to be slipped over the sump pump, keeping any large debris from entering the pump (figure 10).

Ramp—A small piece of 2- by 6-inch steel channel was used to protect the hoses and flexible drive shaft when vehicles drove onto the mat. A piece of conveyor belting was placed over the channel to make it easier for vehicles to drive over it. However, a more permanent solution should be developed and fabricated before the next test.

Petroleum Products—Small amounts of petroleum products may come off vehicles during washing. Oil-absorbent pads may be placed in the settling tank overflow barrel to collect all petroleum products as they float to the surface. The pads can then be disposed of according to local regulations.

Drawings and Operator's Manual—Fabrication drawings and equipment specifications will be developed soon after the system's design is final. These materials will allow districts and contractors to build their own washers. An operator's manual will be developed that addresses setup, operations, maintenance, and cleanup.

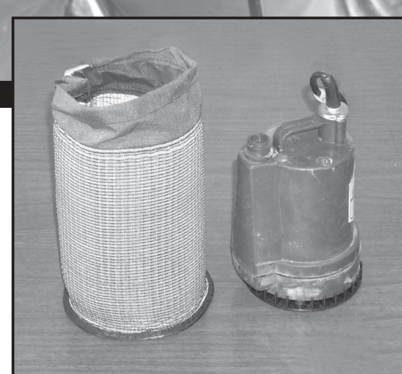

Figure 10—The sump pump that drew water from the mat clogged periodically with debris such as pine needles, twigs, and grass. A filter sock was fabricated to prevent debris from entering the sump pump.

Notes

Notes

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, Andy worked as a civilian engineer for the Department of the 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 of forest health protection since the fall of 1999. Dick has been a project leader at MTDC in the resource areas of GPS, 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.

Scott Gilmour has been a mechanical engineering technician in MTDC's shop since 2001. Scott worked as a submarine tender for the 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

Trent, Andy; Karsky, Dick; Gilmour, Scott. 2002. MTDC portable vehicle washer: interim report. Tech. Rep. 0234–2836–MTDC. Missoula, MT: U.S. Department of Agriculture, Forest Service, Missoula Technology and Development Center. 10 p.

Describes a prototype vehicle washer that is mounted on a flatbed trailer and can be towed by a ¾-ton pickup truck. The washer is designed to be used at fire camps where weed seeds need to be removed from the underbody and body of vehicles before and after the vehicles leave the area. Operators use two high-pressure wands to wash the vehicle's sides, wheels, and wheel wells. The vehicle's underbody is washed when the vehicle drives over an oscillating, high-pressure, underbody washer. An industrial rubber mat with foam-filled barriers on all sides confines the wash water, which is filtered before being reused. The prototype washer was tested from August 6 to 9 when a fire camp was being demobilized near Darby, MT. It took 2 to 3 minutes to wash a standard pickup truck, sport utility vehicle, or car. It took another minute or so to wash hotshot crew vehicles, fire engines, and a school bus. The wash water supply tank had to be refilled three times (about 175 gallons per refill) to wash 74 vehicles.

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

---

Additional single copies of this document may be ordered from:

USDA Forest Service, MTDC
5785 Hwy. 10 West
Missoula, MT 59808–9361
Phone: 406–329–3978
Fax: 406–329–3719
E-mail: *wo_mtdc_pubs@fs.fed.us*

Electronic copies of MTDC's documents are available on the Forest Service's FSWeb Intranet at:

http://fsweb.mtdc.wo.fs.fed.us

For further technical information, contact Andy Trent at MTDC.

Phone: 406–329–3912
Fax: 406–329–3719
E-mail: *atrent@fs.fed.us*