DECONTAMINATING FIREFIGHTING EQUIPMENT TO REDUCE THE SPREAD OF AQUATIC INVASIVE SPECIES

HOW TO GUIDE

OVERVIEW

This template protocol/How-To Guide serves as supplement to the National Wildfire Coordinating Group's Guide to Preventing AIS Transport by Wildfire Operations (PMS 444, January 2017).

June 2022

HOW TO GUIDE
for the Decontamination of Wildland Fire Equipment to Prevent the Spread of Aquatic Invasive Species (AIS)

Contents

Introduction

In the US, the National Invasive Species Management Plan defines an invasive species as “a species that is non-native to the ecosystem under consideration and whose introduction causes or is likely to cause economic or environmental harm or harm to human health.” Invasive species are one of the

largest threats to biodiversity, cited as second only to habitat destruction as a result of development. Invasive species are one of the most serious environmental threats of the 21st century.

Over the past 30 years, aquatic invasive species (AIS) have become a prominent concern and focus in managing North America's freshwaters. Many of these species, including plants, mussels, fish, amphibians, snails, and others, pose a significant threat to water management facilities, water supply infrastructure, and aquatic ecosystems across North America. This threat involves direct and indirect economic costs to the agriculture sector, industry, and municipalities. It affects aquatic ecosystem integrity and has social and economic impacts on recreation and tourism activities. In the United States, AIS cost the country an estimated $123 billion annually. For example, it is estimated that an infestation of invasive mussels (e.g., quagga or zebra) would create about $500 million in annual losses in the Columbia River Basin, up to $234 million in Montana, $95 million in Idaho, and $75 million in Alberta if they were to become established. The species of highest concern will depend on the location that the incident occurs.

Watercraft and water-conveyance equipment are the most likely source of an AIS introduction to western waters. This may include firefighting equipment and gear, construction equipment, agricultural implements, and seaplanes. In wildland fire management, AIS can be transported via firefighting equipment that contacts or transports untreated water, such as portable pumps (including floatable pumps), portable tanks, helicopter buckets, and internal tanks of fire engines, water tenders, helicopters, and fixed wing aircraft. By being conscious of drafting techniques and following Clean Drain Dry principles, the risk of many types of equipment inadvertently spreading AIS can be mitigated. The components that have the highest risk of introducing or spreading AIS include foot valves, drafting hoses and helicopter buckets.

This HOW TO GUIDE provides step-by-step instructions on drafting from a water source, setting up and using a decontamination station, and disposing of products once finished at a site. This Guide is intended to serve as a supplement to the National Wildfire Coordinating Group's *Guide to Preventing AIS Transport by Wildfire Operations* (PMS 444, January 2017). All protocols and practices in this *How To Guide* are supported by the science and literature in the PMS 444, and are mandatory in the Northern Rockies region per the Northern Rockies Coordinating Group AIS Directive (effective march 29, 2018). A training video (based on PMS 444) and training slides (based on template protocol) have also been developed to accompany the NRCG *How To Guide* and Directive (see resources in Appendix A). Every time you are working on a wildfire, it is essential that these principles are followed:

1. Ensure that your firefighting equipment is **CLEAN** and free of all plants, mud, and organic debris, **DRAINED** of all standing water, and as **DRY** as possible before it is used again. Removing all organic material prior to decontamination is essential as it increases the efficacy of the treatment.
2. **Recommended methods for decontamination include a hot water or chemical** (chlorine bleach) options. See point 5 below for other circumstances.
3. When priming pumps, **always use the water source (not the tank water) to reduce the chance of backflow from the engine tank into the water source**.
4. Whenever possible, **bring extra (clean) foot valves** to reduce risk of spreading AIS.
5. If the incident you're responding to requires special attention, has extenuating circumstances or special circumstances, or other species of AIS are of most concern, **ensure that the method you are using is supported by the PMS 444**.
6. Consider using a custom stamp or other means of documenting when/what equipment has been decontaminated (recommended).

7. Print off AIS field ID guides and have them available at the site (if possible).

Drafting from the Water Source

- Ensure foot valves and draft hoses are clean and free of AIS when arriving and departing a fire.
- If fish-friendly intake screens are used on site, ensure that they are decontaminated after use.
- When possible, top-fill engines from a municipal hydrant, a water tender, or from a pump assigned to a single drafting source. This negates the need to decontaminate engine drafting equipment.
- When spraying water to suppress a fire, avoid application of untreated water where it can run into local waterbodies (ponds, lakes, rivers, streams, wetlands, seeps, or springs), especially if the water in the tank came from a different watershed. Water delivery equipment and accessories (e.g., fire line hoses, wye valves, nozzles) that do not transfer tank water to waterbodies do not need to be decontaminated.
- Priming the engine pump for drafting —To minimize the potential for engine water leakage through the foot valve, ***prime with water from the drafting source rather than using water from the engine tank.***
- When priming by filling the drafting hose with a bucket, first make sure that the bucket is clean so that it does not transfer AIS. Additionally, don't leave the draft hose full, with foot valve engaged and submerged in water source when not pumping.
- To prevent leakage and to maintain the prime, be sure that foot valves are screwed snugly onto drafting hoses and are fully closing and not leaking before and during drafting. If foot valves are leaking, refrain from drafting and replace foot valve with one that is operating properly. Test all foot-valves prior to use. Do not assume new ones are closing properly.
- Elevate foot valves above the bottom of the waterbody for clean, sediment-free operation—for example, duct tape foot valve to a shovel or place the valve in a hard hat or bucket.
- Remove water drain plug/s from self-priming pumps (e.g., trash pumps) to empty pump housing before moving to a new waterbody.
- When filling the engine tank, avoid tank overflow into the water source.
- During the spawning season for native fish, pumping sites should be located away from spawning gravels.

**See PMS 444 page 6-7 for more information*

Ground-Based Water Handling Equipment Drafting Options

Best Management Practices for Fire Fill Sites

- Whenever possible, top-fill engines and tenders from a pump dedicated to a drafting source. This reduces the exposure of engines and tender drafting equipment to "raw" water and prevents the need to decontaminate it.
- If the above practice is not an option, use an approved pump into a porta tank for all apparatus to draft from (instead of all engines drafting raw water). See options below.

- These techniques greatly reduce the risk of contamination by limiting the number of equipment that must directly fill from the water source.
- This also protects the waterway by limiting the amount of traffic on the banks of the water source (streams, lakes, ponds, rivers, etc.)

Lowest Risk (preferred) – Engine and Tender Top-Fill

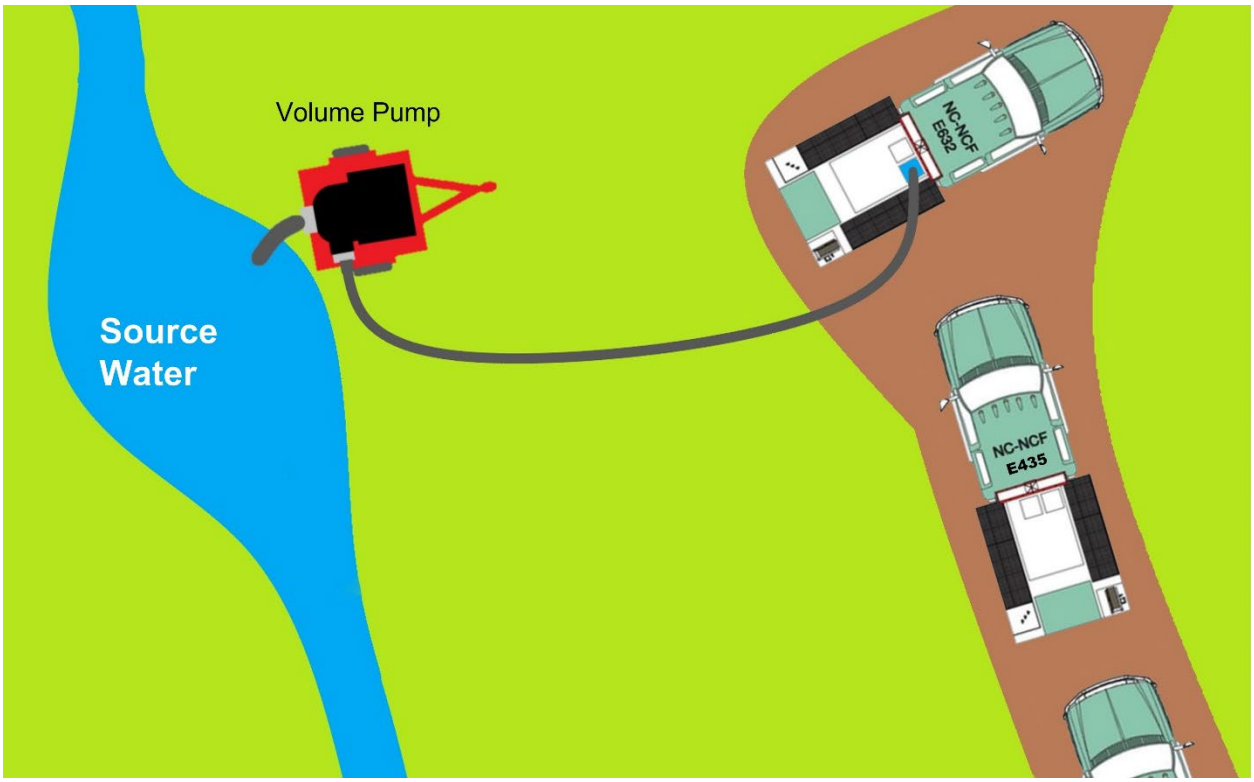


Figure 1: Preferred option for drafting - engine + tender top fill (graphic developed by Clint Sestrich, USFS)

This drafting option isolates the drafting source from engines and tenders so there is no risk of tank water backflowing into source. It does not require engine and tender draft hose decontamination.

Risk/Vectors (avoid)

- Fill hose coming in contact with contaminated engine tank water, then to uncontaminated tanks
- Tank overflow into drafting source
- Volume pump and / or drafting hose contaminated
- Volume pump sucking up AIS

Mitigations

- To prevent cross contamination of engine tank water, don't allow fill hose to contact internal surface of tank or tank water.
- To prevent tank overflow into the drafting source, don't over-fill tanks and don't fill where overflow could run into source.

- To prevent contamination of the drafting source, decontaminate volume pump and its draft hose before changing drafting sources.
- To reduce the potential for sucking up AIS, elevate the pump intake off of the stream or lake bottom with a shovel.

Moderate Risk - Engine and Tender Portable Tank Drafting

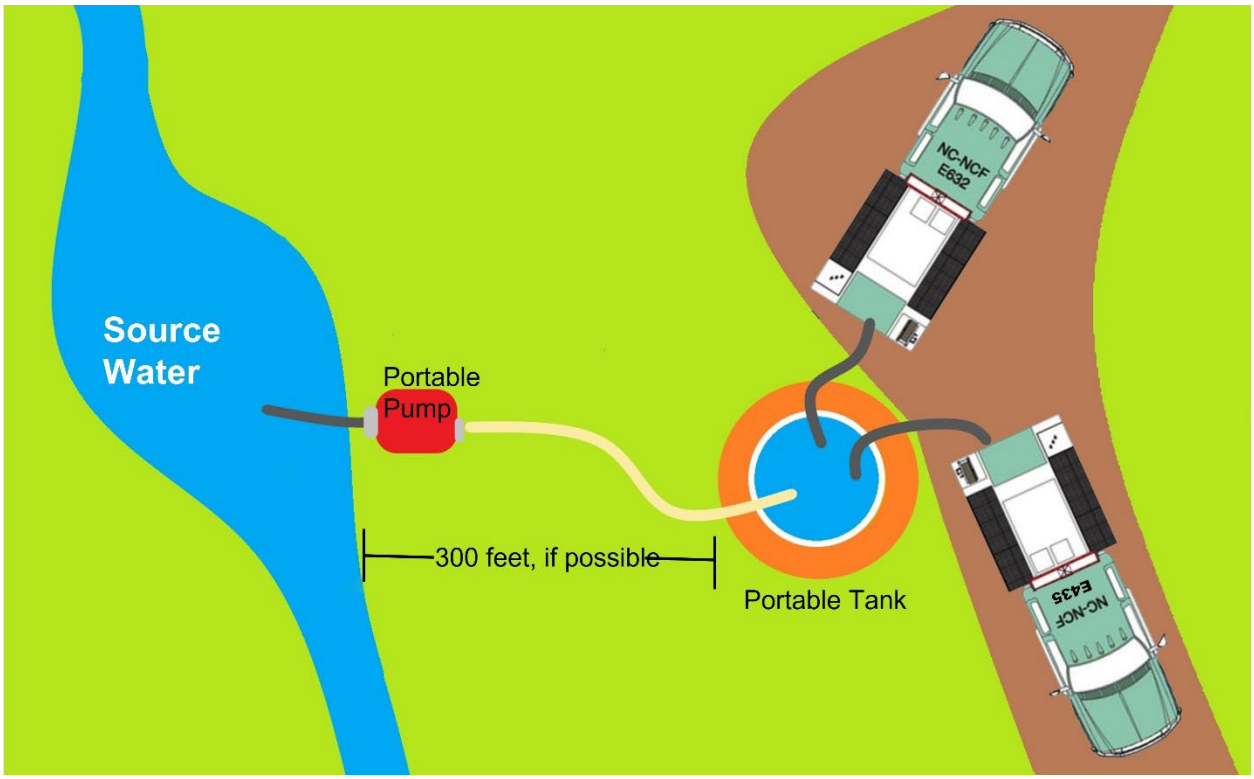


Figure 2: Engine + tender portable tank drafting (graphic developed by Clint Sestrich, USFS)

This drafting option isolates the drafting source from the engine, tender drafting equipment, and tank water. It reduces the risk of AIS spread to the source water from dirty drafting hoses and tank water back flow and reduces the amount of equipment coming into direct contact with waterbodies.

Risk/Vectors

- Portable tank water becoming contaminated from dirty draft hoses and/or tank water backflow through leaky foot valves.
- Contaminated portable tank water leaking into source water (tank rupture, siphon of tank water back through fill hose pump and drafting hose).
- Engine and tender drafting hoses contaminated by AIS in live water in portable tank.
- Portable pump drafting hose contaminated.
- Portable pump sucking up sediment and AIS into portable tank.

Mitigations

- To reduce potential for portable tank water becoming contaminated, adhere to AIS mitigations for drafting hose decontamination and foot valve function. Decontaminate portable tanks after each use.
- To prevent potentially contaminated portable tank water from leaking into water source, portable tanks should be set up a minimum of 300 feet from the source water.
- To prevent a back-siphon, the fill hose should not come in contact with portable tank water and should not be left in the portable tank when not in use.
- To prevent AIS spread, decontaminate drafting hoses before moving to next drafting source.
- To reduce the potential for sucking up AIS, elevate the pump intake off the stream or lake bottom with a shovel.

Highest Risk - Engine and Tender Drafting Directly from Source Water

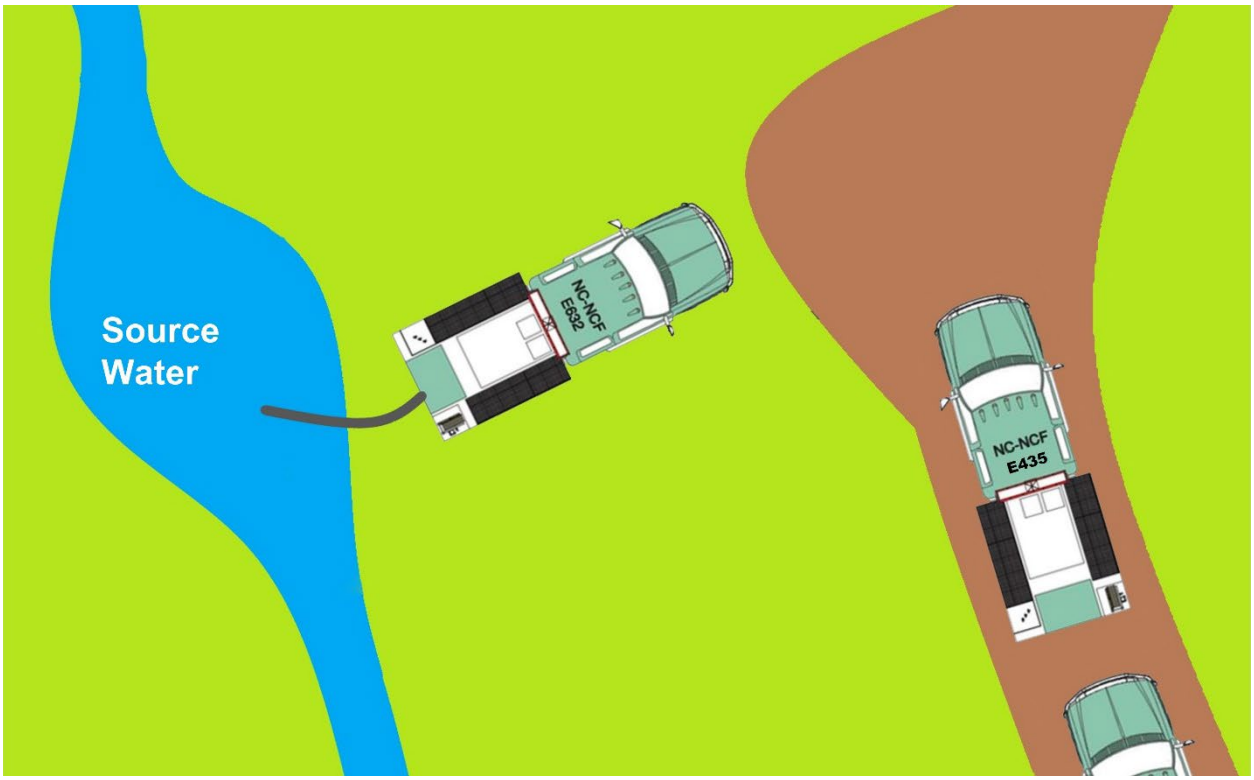


Figure 3: Drafting directly from source water (least favorable option). Graphic developed by Clint Sestrich, USFS

This drafting option has no isolation between the engine and tender drafting equipment. It relies entirely on drafting hoses being decontaminated prior to use and fully closing foot valves.

Risk/Vectors

- Contaminated drafting hose coming in contact with source water.
- Contaminated tank water back flowing into source water through drafting hose.
- Contaminated tank water running into water source when tank is overfilled.
- Drafting hose sucking up AIS and spreading to next water source.

Mitigations

- Decontaminate drafting hoses before changing water sources.
- Prime pumps with source water.
- Leak test all foot valves prior to use to ensure that they are fully closing.
- To reduce the potential for sucking up AIS, elevate the pump intake off the stream or lake bottom with a shovel.

Assembly, Use and Disassembly of Chemical Decontamination Station

Required Equipment	Quantity
30-gallon drum with lid (metal/plastic); 32-gallon trash can with lid; OR horse trough/larger tubs to accommodate wide/long hoses (*NFES001005, NFES001249*)	2
Ratchet straps 15’	2
Chlorine bleach (household, 6%) *	1 gallon
Clean water for bleach solution	15 gallons
Clean water for rinse tank	30 gallons
Pallet	1
Eye protection/safety glasses	1
Rubber gloves (common gauntlet style)	1 pair
Parachute cord (NFES00533) OR 2 laundry mesh bags with clip to secure	4x 6’
Document protectors (print SDS, Risk Assessment and Sign and put in protectors)	3
Safety Data Sheet (SDS) for chlorine bleach (see appendix A)	1
Risk Assessment – fill out and signed (see Appendix B & C for bleach and hot water)	1
AIS chemical decontamination station sign (see Appendix D)	1
Chlorine Test Strips - 2 per day needed. (See information on rec. product below)	2 (per day)

**If other products used, consult PMS 444 for ratios. Disposal will be site/jurisdiction specific.*

Figure 4: Chemical Decontamination Station Example

Figure 5: Ensure proper safety measures and signage are in place

Suggested Decontamination Station Assembly

1. Prior to decontamination assembly, review the Safety Data Sheets for Chlorine Bleach (*Appendix D*). Print out and tape onto drum that will contain the chlorine/water mixture.
2. Secure empty barrels to pallet with ratchet straps (one for bleach solution, one for rinse).
3. Print and fill out the instructions on the SDS, Risk Assessment and AIS Station sign to drum in a manner visible to all users of station. Sign should be visible from distance (consider multiple signs).
4. Wear both eye and hand protection when assembling, operating, or disassembling the Chemical Decontamination Station.
5. Fill first drum with 15 gallons of clean water, fill drum no more than half full. This reduces chances of splashing when putting item in drum.
6. Fill second drum with 30 gallons fresh water for rinse (after chemical bath).
7. Add 1 gallon of 6% bleach to the water in the first drum. Do so in a manner that avoids splashing. Dispose of bleach containers in the normal waste.
8. Tie 6' parachute cord sections to handles of trash can (to easily retrieve items from chemical bath). OR insert foot valves and hose into laundry mesh bag and secure with clip to barrel edge.
9. Place lid on drums when not actively placing or removing items from the decontamination solution. This will lessen evaporation and provide increased safety for people.

Figure 4: Example of a larger bath for longer/wider draft hoses

Decontaminating Items

1. Place item (e.g., foot valves, draft hose) in solution for 10 minutes to decontaminate foot valves and hose from potential AIS present. If possible, unscrew foot valve from drafting hose.
2. After 10 minutes carefully remove item (using parachute cord or laundry mesh bag), allowing solution to drain back into barrel.
3. When drained, remove item completely and rinse in clean water barrel (bleach is corrosive).
4. Place items back into service as a decontaminated item. *
5. Attach Safety Data Sheet for Chlorine to site.
6. Use chemical test strips to check bleach concentration each day at noon and 5 pm to ensure adequate treatment of equipment *(Recommended product: Cole Parmer High Level Chlorine Test Strips available here)*.

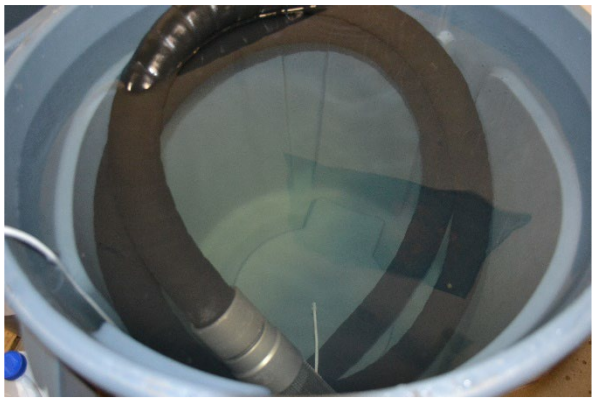


Figure 5: Draft hose fully submerged in chemical solution

**Consider the use of bright flagging tape or rubber band that can denote decontaminated items.*

Decontamination Station Disassembly

1. Add clean water to chemical solution to dilute (up to top of barrel or trash can). Solution is now neutralized and can be disposed of as tap water*.
2. See disposal requirements for rural and urban areas in section below.
3. No dilution required for clean water rinse barrel – dispose of on vegetated area.
4. Return other materials to source of supply.

**If using other products or circumstances, consult appropriate agencies/Resource Advisor on disposal technique and location*

Disposal Considerations

A discharge of wastewater containing chlorine or other approved oxidants used for disinfection may be subject to permitting requirements depending on the state in which you're operating. The most secure method of disposal in *urban areas* is at a sanitary wastewater treatment facility. This method will require reasonable access and a minimum service fee. In *rural areas*, Incident Management Teams should check with Resource Advisor, but general considerations for the disposal of chemical bath include dilation and disposal by on-site land application on porous roadways (dust abatement), parking areas, or similar land surfaces following the best management practices below:

- Land apply using tenders with aerating spray bars;
- Land apply using high pressure pumps and aerating nozzles (if available);
- Land apply in self-contained low areas like gravel pits;
- Prevent direct contact or runoff with surface water or natural drainages;
- Prevent discharge into municipal sewer systems;
- Prevent runoff from vegetated areas; and
- Further dilute disinfectant water with clean water prior to land application.

Hot Water Decontamination

Hot water decontamination is needed when chemical is not available, or on aviation equipment (and associated parts) that will corrode if decontaminated with chemicals. It is listed here as an option but understood that many incidents will not have access to hot water. If a vendor option or a mobile hot water unit can be obtained, this method can mitigate the risk of most AIS.

NOTE: the focus remains on equipment that comes in direct contact with raw water from lakes, rivers, streams, etc.

Aviation Protocol

- Obtain local unit information on known AIS locations, whenever possible.
- Avoid using bodies of water with known AIS infestations.
- Avoid dipping or scooping water from multiple water sources within the same operational period to minimize cross-contamination of water sources.
- Use deeper (blue) water whenever possible. Avoid areas that will intake mud or plants.
- Switch out contaminated helicopter buckets with clean buckets before moving to a new water source. All helicopters should carry a minimum of three buckets at all

times.

- Avoid transferring water between drainages or between unconnected waters within the same drainage.
- Do not dump water directly from one stream or lake into another. Avoid spraying suppression water into local waterbodies (ponds, lakes, rivers, streams, wetlands, seeps, or springs).
- If cross-contamination occurs or anyone believes it may have occurred report the incident to the on- site aviation manager (e.g. helicopter manager, helicopter crewmember, etc.) who will forward to their supervisor, incident management, or an agency administrator.

Recommended Equipment for decontamination of helicopter buckets, foot valves & draft hoses

- Hot water pressure washer capable of 140°F+ and 2,500 psi with water holding tank*
- Pumpkin (1,000 gal) to hold water or large vessel for hot water bath to decontaminate helicopter buckets, draft hoses, and foot valves
- Bucket
- Spare foot valve (if possible)
- Infrared thermometer
- Appropriate PPE including safety glasses, gloves, and an implement to retrieve the items inside the hot water bath.

**Check the temperature of the spray with a thermometer to ensure that it is at least 140 degrees at the end of the hose. This may mean setting the hot water pressure washer as high as 160 degrees.*

Preparation

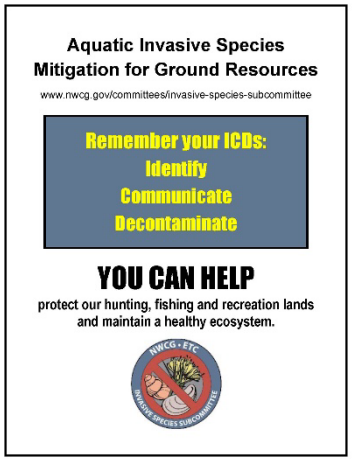
- Attach a low pressure (garden hose) attachment to decontamination unit or use the spray wand with the high-pressure nozzle removed.
- Start decontamination unit and turn on burner, adjust thermostat to 140°F. Test the temperature of the water using a digital thermometer by spraying water from decontamination unit into a bucket and verifying the temperature with a digital thermometer. Failure to do this can result in damage or ineffective decontamination.
    - Hot Water Bath: Set up a pumpkin or large vessel for hot water bath. Place items to be decontaminated inside.
    - Submerse items in hot water, ensuring that the water is at least 140°F at the end of the hose.
    - Soak items for ~10 minutes.
    - Let sit until dry to the touch (if possible).

**If a helicopter bucket has a butyl (rubber) valve seal, avoid prolonged application of hot water spray to the seal to prevent softening of this vulnerable material. Power washing greatly reduces the likelihood that any target AIS are present.*

APPENDIX A: Training and Educational Resources

- **Guide (PMS 444):** The National Wildfire Coordinating Group (NWCG) developed a science-based guide to prevent the introduction and spread of AIS via wildland fire equipment. This is the parent document for this protocol as well as many of the resources below. It can be found here.

- **R-130 Refresher video (PMS 444):** The intent of RT-130, Wildland Fire Safety Training Annual Refresher (WFSTAR) is to focus line-going personnel on operations and decision-making issues related to fireline safety in order to recognize and mitigate risk, maintain safe and effective practices, and reduce accidents and near misses. This 9:20 video was created to augment the PMS 444 guide and provide a short (30 min) training session. See video, discussion questions and other materials here.



- **NWSG poster and pocket card**: A poster and "pocket cards" were made for firefighters as a reminder to follow the PMS 444 guide. Available here.

- **USFS AIS Mitigation Information (Intermountain Region)**

- **Training slides for template protocol:** Training slides have been developed for this protocol. They can be found on the Western Regional Panel on Aquatic Nuisance Species Fire Working Group website.

- **Idaho AIS & Fire Information:** Model website for information on AIS mitigation related to wildland fire equipment – includes the PMS 444 guide, the training video, and the NRCG mandatory protocol.

Aquatic Invasive Species Mitigation for Ground Resources

Avoid the spread of aquatic invasive species by fire personnel and water delivery equipment by adhering to the procedures presented in this video.
Category: Operations
Core Component(s): Current Issues
Estimated Delivery Time: 30:00; **Video Length**: 9:20

Figure 9: R-130 Refresher Training on AIS now available

APPENDIX B: Aquatic Invasive Species of Concern in the West

Western states are concerned about numerous AIS that may pose a significant threat to the aquatic resources or water infrastructure of states. Although states have differing lists of what species are considered AIS, the species included here are most commonly considered invasive throughout the west and the highest concerns for introduction or spread via wildland firefighting equipment.

Resources for state AIS Programs within the Northern Rockies Region

Idaho: Idaho Dept of Agriculture manages the AIS Program. More information here (https://invasivespecies.idaho.gov/programs-overview). Call 1-877-336-8676 for information or to report suspicious AIS or associated activities.

Montana: Montana Fish, Wildlife & Parks manages the AIS Program. More information here (https://fwp.mt.gov/conservation/aquatic-invasive-species). Call (406) 444-2440 for information or 1-800-TIP-MONT to report suspicious AIS or associated activities.

North Dakota: North Dakota Game & Fish manages the AIS Program. More information here (https://gf.nd.gov/ans). Call 701-328-6300.

South Dakota: South Dakota Game, Fish & Parks manages the AIS Program. More information here (https://sdleastwanted.sd.gov/).

Wyoming: Wyoming manages the AIS Program. More information here. Call 1-877-WGFD-AIS.

Figure 9 & 10: Quagga & Zebra Mussel, USGS

Zebra/Quagga Mussels

ABOUT: Zebra and quagga mussels are freshwater mollusks native to the Russia and Ukraine. Larvae are microscopic whereas adults can reach up to two inches long.

IMPACTS: Unlike native North American freshwater mussels, adult zebra and quagga mussels can attach to surfaces, causing major economic and ecological impacts to hydropower structures, irrigation equipment, water intakes, agriculture, native habitat, and recreation access. Both species can live up to 30 days out of the water and survive cold waters; they are of utmost concern to western states and provinces, as the Columbia River Basin is the only major river drainage in North America believed to be free of zebra and quagga mussels; extensive prevention measures are in place to protect these waters. More information here.

New Zealand Mudsnail

ABOUT: The New Zealand mudsnail is native to New Zealand and was probably introduced into the United States through transoceanic ships or transported with live game fish. They are transported primarily by humans on gear and equipment.

IMPACTS: The mudsnail can clone itself (e.g., only takes one); densities have been recorded over 300,000 per square meter. They outcompete native species.

Figure 11: NZ Mudsnail (Dan Gustafson, MSU)

Asian clam

ABOUT: The Asian clam is native to Asia, Africa, the Mediterranean, and Australia and is believed to have been introduced intentionally as food or incidentally imported with the Pacific oyster. It was initially discovered in 1938 in the Columbia River and now occurs in 38 states. Asian clams are spread by boats and equipment, through bait bucket introductions, accidental introductions with aquaculture species, illegal introductions for food, and through water currents.
IMPACTS: Much like zebra and quagga mussels, the Asian clam can clog pipes at power generation and water supply facilities, causing millions of dollars in damage.

Figure 12: Asian clam (Noel Burkhead)

Hydrilla

ABOUT: Hydrilla is native to Asia and was introduced into the US in the early 1950's for use in aquariums. The species spread into open water through discarded fragments or by planting in canals. Since its initial introduction, hydrilla has spread to 27 states, most likely transported on trailered watercraft.

IMPACTS: Hydrilla displaces native vegetation, alters physical and chemical properties in lakes, reduces fish foraging efficiency, obstructs boating, fishing, and swimming, and impedes water delivery.

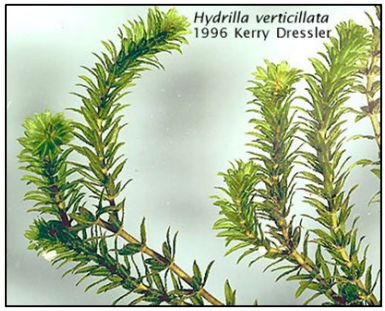


Figure 13: Hydrilla (Kerry Dressler)

Eurasian watermilfoil

ABOUT: Eurasian watermilfoil is native to Europe, Asia, and northern Africa and may have been intentionally introduced to the US. It was first documented in Washington D.C. in 1942, and now occurs in 45 states and Canada.
IMPACTS: The species is spread on trailered watercraft and fragments can spread naturally downstream; one stem or leaf fragment can start a new colony. Eurasian watermilfoil is an aggressive plant, displacing native plants leading to reduced diversity. Dense beds form canopies and reduce light penetration, invertebrate abundance, fish forage space, and fish predation efficiency. In addition, it degrades water quality and reduces oxygen levels. Dense beds can also hamper recreation by restricting swimming, fishing, and boating.


Figure 14: Eurasian watermilfoil (USGS)

Curlyleaf pondweed

ABOUT: Curlyleaf pondweed is native to Eurasia, Africa and Australia and was introduced into the United States in the mid 1800's. It is now found in almost every state in the continental U.S. Curlyleaf pondweed reproduces by seed (turion) which can be easily transferred in mud or water. It has been introduced into new areas by accidental introductions and as an ornamental plant.
IMPACTS: Curlyleaf pondweed competes with native plants reducing plant diversity and forms dense mats that impact water-based recreation.


Figure 15: Curlyleaf pondweed (Vic Ramey, University of Florida)

APPENDIX C: Field Testing for Footvalve Leaks

Background information

AIS can be found in the untreated water sources used in firefighting operations, either a natural source (a river or lake) or a human-made water body (a reservoir, canal, or stock tank). Untreated water sources may harbor a variety of AIS, including quagga and zebra mussels, New Zealand mudsnails, whirling disease, didymo (*rock snot)*, and many others.

Of great concern for ground equipment is the possibility that residual tank water contaminated with AIS could be transferred to uncontaminated waterbodies during the drafting process.

To be prepared, foot valves on engines and water tenders should be tested monthly during the fire season and whenever an apparatus is moved between waterbodies. The following protocol outlines a simple test method that can be implemented in the field. Because foot valves can leak at either low or high pressures, **testing at both pressure levels is required** to evaluate the potential for leakage during operational drafting conditions.

Equipment List

Some items may be part of an engine's supplied equipment. Other items may need to be purchased but are easily found at fire equipment vendors.

Items needed to perform the leak test include:

- Suction hose and ratchet straps
- Assorted male-to-female adapters, increasers, and reducers

If a pressure gauge is not present on equipment:

- 1 ½" Pump Test Kit with Gauge – CFE (Cascade Fire Equipment) P/N: 11495 or similar
- 1 ½" 90 Degree Elbow – CFE (Cascade Fire Equipment) P/N: 10251-90 or similar

Figure 10: Suction hose with foot valve attached to engine ladder

Low Pressure Test (3-5 psi)

To perform the low-pressure test, fasten a length of suction hose to the engine or water tender (Figure 16). Use ratchet straps

or another suitable method, as long as the suction hose is attached safely and securely to the ladder.

To adjust for size of the foot valve (e.g., 1½", 3", or other), use a combination of male-to-female adapters, increasers, and/or reducers to attach the foot valve to the suction hose (Figure 16). Fill the suction hose with 6 to 10 feet of water to obtain 3-5 psi (2' of hose = 1 psi).

Figure 11: Foot valve attached to suction line with various adapters as needed to adjust for foot valve size

The weight of the water provides the pressure on the foot valve. Check the foot valve for 3 to 5 minutes. There should be no leakage. If leakage occurs, replace the foot valve.

High Pressure Test (130 PSI)

To perform the high-pressure test, first attach a wye or other suitable shut-off valve to the rear discharge (Figure 10). If a pressure gauge is not available on the equipment, attach a pressure gauge to the wye, then attach the 90-degree elbow and next attach the foot valve. The test set-up should resemble the one shown in Figure 10. Using the engine's pump, increase the pressure to 130 psi. Check the foot valve for 3 to 5 minutes. There should be no leakage. If leakage occurs, replace the foot valve with one that does not leak.

**Thanks to Carl Schaefer at U.S. Forest Service, San Dimas Technology and Development Center, for development of this foot valve test protocol.*

Figure 12: Pressure valve attached to the foot valve

APPENDIX D: Decontamination Sign for Station

*__PRINT AND POST AT DECONTAMINATION STATION__ (multiple signs may be required)