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Guide to Preventing Aquatic Invasive Species Transport by Wildland Fire Operations

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The *Guide to Preventing Aquatic Invasive Species (AIS) Transport by Wildland Fire Operations* is a product of, and maintained by, the Invasive Species Subcommittee (ISSC), a component of the Equipment Technology Committee of the National Wildfire Coordinating Group (NWCG). The ISSC provides national leadership in the prevention of invasive species transport by wildland fire mobile equipment and related vehicles, and its primary objectives are to:

- Develop and disseminate practical standards, guidelines, best practices, and recommendations to prevent the spread of invasive species.
- Integrate new and evolving information from the natural resource management community into the invasive species control effort.
- Evaluate and recommend wildland fire and support vehicle utilization and/or decontamination techniques, equipment, or products to minimize invasive species transport.

Questions and comments may be emailed to: BLM_FA_NWCG_Products@blm.gov.

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Current Membership

Julie Laufmann – Chair; USDA Forest Service

Cynthia Tait – Co-chair; USDA Forest Service

Lou Ballard – Primary member; USDI Fish and Wildlife Service

Justin Boeck – Advisor; USDI Bureau of Land Management

Myron Chase – Primary member; USDI National Park Service

Matt Cnudde – Primary member; USDA Forest Service

Myron Hotinger – Primary member; previous chair; Bureau of Indian Affairs

Richard Schwab – Advisor; USDI National Park Service

Clint Sestrich – Advisor; USDA Forest Service

David Shy – CAL FIRE

Kristy Swartz – Primary member; USDI Bureau of Land Management

Previous Membership

Ryan Becker – Chair; USDA Forest Service

Tate Fischer – USDI Bureau of Land Management

Other Reviewers

NWCG National Interagency Aviation Committee (NIAC)

NWCG Equipment Technical Committee, Mobile Equipment Subcommittee

Sam Wu and Ralph Gonzales – USDA Forest Service, San Dimas Technology and Development Center

Todd Neel – USDA Forest Service

Cody Peel – USDA Forest Service

Terry Swinscoe – USDA Forest Service

Robert Button – SEI Industries Inc.

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Chapter 1 Purpose

The *Guide to Preventing Aquatic Invasive Species Transport by Wildland Fire Operations* is intended to help wildland firefighters avoid the spread of aquatic invasive species. The *Guide* includes:

- Best management practices (BMPs) to prevent contact with and spread of invasive species,
- The best procedures for decontaminating ground and aviation equipment,
- AIS prevention recommendations for resource advisors, and
- AIS of concern to firefighters nationwide and disinfection methods.

Chapter 2 Aquatic Invasive Species and Why We Care

WHAT ARE THEY?

Aquatic invasive species are harmful, non-native plants, animals, and microorganisms living in aquatic habitats that damage ecosystems or threaten commercial, agricultural, and recreational activities.

WHY DO WE CARE?

Firefighter and public safety is our first priority, but aquatic invasive plants and animals pose a risk to native species, hydropower facilities and water supplies, and to firefighting equipment. Avoidance and decontamination can prevent the spread of these organisms and help assure that firefighting equipment remains operational. See *Appendix D: Aquatic Invasive Species of Concern to Firefighters* for information on the species firefighting resources are most likely to encounter, including their distributions, disinfection methods, and references.

WHERE DO AIS COME FROM?

Aquatic invasive species 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) that has not been treated for municipal use or human consumption. Municipal water distributed via hydrants is not considered a reservoir of invasive species. Untreated water sources may harbor a variety of AIS, including quagga and zebra mussels, New Zealand mudsnails, whirling disease, didymo (or *rock snot)*, and plants such as hydrilla, Eurasian watermilfoil, and giant salvinia, as well as many vertebrate species. In some cases, the occurrence of aquatic invasive species in a water body is well documented, but for many western waters such information is incomplete or nonexistent.

HOW DO AIS GET MOVED AROUND?

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. Typically, components of the equipment that cannot be drained and dried completely are most likely to harbor invasive species and thus serve as vectors. Residual water left in incompletely drained tanks in equipment moved between fire incidents is of special concern: quagga mussel larvae are able to survive 5 days in summer and 28 days in autumn in residual water contained within undrained boats (*Appendix D*, Choi et al. 2013), a time interval which is well within the re-deployment period for most firefighting equipment.

There are many possible invasion pathways for AIS within the context of wildland fire incident response. During an incident, untreated water is routinely moved between watersheds and sometimes between basins. Typically, large water bodies, such as reservoirs, serve as primary sources to fill various types of firefighting equipment, which then transport and disperse that water to other parts of the fire. In many fire incidents, helicopters equipped with snorkels and internal tanks or buckets draft or dip from untreated water sources, then may draft from a new source with contaminated gear.

HOW IS FIRE EQUIPMENT AFFECTED BY AIS?

Invasives such as zebra mussels and New Zealand mudsnails may adhere to the surfaces of tanks, pumps, and hoses. They can be transmitted to uncontaminated water sources if this equipment is not drained and dried completely or decontaminated.

Chapter 3 Guidelines and Best Management Practices

GENERAL PREVENTION

Preventing exposure to AIS through best management practices is the easiest and simplest way to control their spread.

- Map the distribution of aquatic invasive organisms in watersheds where the operation will take place (Figure 1). See Chapter 6 for sources for maps or GIS layers showing locations of AIS infested waters. You can never be certain that invasives are NOT present, but at least you will know ahead of time where they ARE known to be present.
- Fill tanks from municipal water sources whenever possible.
- When possible, avoid drafting from waterbodies with known infestations of aquatic invasive species.
- Avoid transferring water between drainages or between unconnected waters within the same drainage. Do not dump water from one waterbody (e.g., stream, lake, or reservoir) into another waterbody. Do not allow water from fold-a-tanks or pumpkins to drain into nearby waterways if the fold-a-tank was filled with water from a different drainage. Dispose of excess water over uplands.
- Avoid sucking organic and bottom material into water intakes when drafting from shallow water. Use screens. If collapsible tanks can be filled with municipal water, draft from those tanks instead of untreated water sources.
- Avoid entering (driving through) water bodies or wet areas when possible.
- Remove all plant parts and mud from external surfaces of gear and equipment after an operational period.

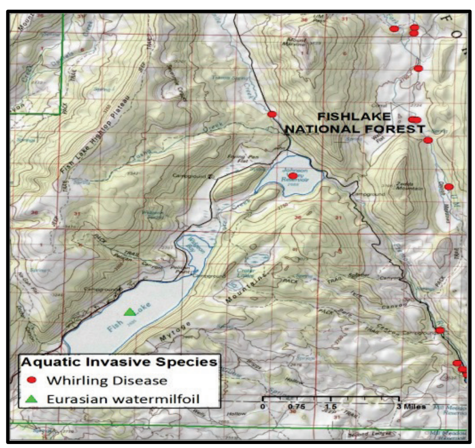

Figure 1. Map the distribution of aquatic invasive species on your unit. Aquatic plants and whirling disease are present in this watershed on Fishlake National Forest.

- Avoid obtaining water from multiple sources during a single operational period unless drafting/dipping equipment is decontaminated or changed out with clean equipment between sources.

- If contamination of equipment with untreated water or mud/plants is unavoidable, see “Decontaminating Ground Equipment” and “Decontaminating Aviation Equipment”, below.

Chapter 4 Ground Operations

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. However, if proper drafting and water handling BMPs are used and foot valves are working correctly, there is low risk that contaminated tank water could "seep" into the drafting water source.

WATER HANDLING OPERATIONS

- When possible, fill engines from a municipal hydrant, a water tender, or from a pump assigned to a single drafting source.
- When spraying water to suppress a fire, avoid application of untreated water into local water bodies (ponds, lakes, rivers, streams, wetlands, seeps, or springs), especially if the water in the tank came from a different watershed (Figure 2). Water delivery equipment and accessories (e.g., fireline hoses, wye valves, nozzles) that do not transfer tank water to waterbodies do not need to be decontaminated.
- 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 (Figure 3). If foot valves are leaking, refrain from drafting and replace foot valve with one that is operating properly. See *Appendix B* for methods to field test foot valves for leakage.

Figure 2. Water delivery equipment is low risk if contaminated water is pumped onto a fire and not applied to another waterbody.

Figure 3. Be sure foot valves are not leaking before and during drafting.

- 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* (Figure 4). 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 draft hose full with foot valve engaged and submerged in water source when not pumping.
- 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.

Figure 4. To minimize risk of engine water leakage through foot valve, prime with water from the drafting source rather than from the tank.

- 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.

DECONTAMINATING GROUND EQUIPMENT

- Before moving to a new water source (in a different watershed), decontaminate all external and internal surfaces of foot valve and draft hose. Three options are:
  - Power wash with hot water (140^{o} F, allow spray to contact surfaces for 2 minutes) using a hot pressure washer (e.g., a 'Hotsy').
    OR
  - Dry the gear in the hot sun until completely dry to the touch (sunlight intensifies the decontamination process).
    OR
  - Use a chemical solution (see *Appendix A: Decontaminating with Chemical Disinfectants*). Surfaces of the drafting hose and foot valve can be decontaminated by coiling and submerging in a bucket filled with disinfectant (Figure 5) or by spray application with a backpack pump or a large spray bottle.
- Consider carrying spare, clean, dry draft hoses and foot valves to switch out with used ones when moving to a new water source.

Figure 5. If drying or hot water are not options, draft hoses with foot valves can be decontaminated by submerging in a bucket filled with disinfectant. Alternatively, disinfectant can be sprayed on.

Chapter 5 Aviation Operations

Aircraft such as air tankers and single engine air tankers, which use water from municipal sources, are unlikely to encounter AIS and are not addressed here. All other aircraft utilize untreated water and have the potential to transfer AIS.

GENERAL PREVENTION

- Avoid dipping or scooping water from multiple water sources within the same operational period to minimize cross-contamination of water sources.
- If possible, use water dipped from the same drainage that it will be dropped in. This can be accomplished by setting up heliwells (portable tanks/pumpkins) filled from small streams with Mark III pumps.
- Use deeper (blue) water whenever possible. Avoid areas that will intake mud or plants.
- Switch out a contaminated helicopter bucket with a clean bucket before moving to a new water source. Alternating used (possibly contaminated) helicopter buckets with spare (clean) buckets can save time and increase efficiency, as the first bucket can be decontaminated while the second bucket is being used.

Figure 6. Helicopter snorkels, such as on this Sky Crane, do not need priming so no risk of tank water leakage during drafting. However, snorkel ends and foot valves that touch untreated water must still be decontaminated.

- Helicopter snorkels do not need to be primed with either source or tank water, so there is no risk of residual tank water entering a water source during drafting operations (Figure 6). However, snorkel ends and foot valves that encounter untreated water must be decontaminated between drainages (see below).

DECONTAMINATING AVIATION EQUIPMENT

Chemicals such as bleach and quaternary ammonium compounds do not meet corrosion requirements for aluminum and **shall not be used on aircraft fuselages or water delivery components such as helicopter buckets and footvalves**.

- Visually inspect water handling equipment (snorkel hoses, pumps, foot valves, screens, buckets, intakes and tanks) for mud, debris, or plant parts daily, during maintenance, and after every water dropping mission, when possible. Remove plants and mud from external surfaces.
- When contact with untreated water has occurred or is suspected, decontamination is needed. Thorough drying in the hot sun alone is an easy and effective decontaminating method, though required drying times can vary with equipment materials (e.g., metal, rubber, fabric). Dry gear in the sun until it's completely dry to the touch. Drying may not be possible for a quick turnaround, so carry spare, clean gear to switch out with wet gear.
- Alternatively, clean and decontaminate accessible, exposed surfaces by power washing with hot water (140°F) for 2 minutes before moving to new, unconnected water sources or new incidents. 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 aquatic invasives are present.

- When hot water (140°F) is not available or practical, use potable water to flush invasive species from the system. Ensure that run-off cannot reach a water source.

DECONTAMINATING ACCESSIBLE INTERNAL TANKS

Accessible tanks have doors or other openings that allow access for cleaning. Scooper aircraft (CL215 or CL415, and Fire Boss), Sky Crane helicopters (CH-54/S-64), and other tanked helicopters are examples of aircraft with accessible tanks.

- Decontaminate internal tanks by spraying the internal surface with hot water (140°F) from a hot pressure washer (e.g., a 'Hotsy'). Allow spray to contact surface for at least 2 minutes. This method is recommended for scooper and Fire Boss aircraft (Figure 7). Tanked helicopters have tank doors that open widely from below for easy tank access and draining.
  Hot water spray or thoroughly dry these surfaces.

Figure 7. A CL-415 scooper plane fills its belly tanks [inset]. Workers decontaminate belly tanks of CL-415 scooper plane by spraying hot water from a high pressure wand and a portable hot washer, or 'Hotsy'.

Chapter 6 AIS Prevention for Resource Advisors

During fire events, Resource Advisors (READs) and Resource Advisors, Fireline (REAFs) play an integral part in guidance, facilitation of decontamination actions, acquisition of equipment, and education. Whether the READs have local knowledge or have been assigned to a fire from outside the area, they are a critical factor in reducing the risk of AIS spread.

LOCATING AQUATIC INVASIVE SPECIES

Maps of known AIS infestations are a valuable tool for READs to communicate which waterbodies to avoid for drafting (Figure 1, pg. 6). Currently there is no nationwide, central repository of maps or geospatial data identifying AIS infested waters, but regional or local information may be available. Ideally, mapping occurrence of AIS would be done as a preseason activity involving local aquatic specialists and fire staff. At that time, maps could be prepared and distributed to local fire staff who could then provide a handoff packet (if needed) during large fire events or for incoming personnel unfamiliar with the area. Bear in mind that many waterways have not been surveyed and the presence of aquatic invasive species may be unknown, which is why any source of untreated water could harbor AIS.

Maps or GIS layers showing locations of AIS infested waters for resource advising on a fire might be obtained from the following sources:

- Local agency administrators or aquatic specialists may have information. Sometimes local land management offices maintain AIS data and prepare maps as part of preseason planning.
- A number of agencies or States may also have AIS location data. These include:
  - United States Geological Survey (USGS) Nonindigenous Aquatic Species database (nationwide, does not include pathogens): https://nas.er.usgs.gov/

- US Forest Service
    - Intermountain Region (UT, NV, ID, western WY) https://www.fs.usda.gov/detail/r4/landmanagement/resourcemanagement/?cid=fsbdev3_016100
    - Pacific Northwest Region (OR, WA) https://www.fs.fed.us/r6/fire/aquatic-invasive-species/
- Individual States' invasive species offices and Tribal fisheries offices
- IMapInvasives http://imapinvasives.org/ , a web-based, publicly accessible (but password protected) database of invasive species location information. To date, only 10 states participate, mostly in the east.

Ideally, mapping of AIS sites (as spatial data, if possible, or as hard-copy maps) should be done preseason, and made available to air tanker bases or as a packet to Incident Commander and Fire Ops at the beginning of an incident.

Mapped AIS waterways are not currently included in the Wildland Fire Decision Support System (WFDSS). If preseason AIS mapping has not be completed, it is the responsibility of the READs to use their local knowledge of AIS occurrences to advise fire operations during a fire.

IDENTIFYING HIGH PRIORITY AQUATIC RESOURCES AT RISK

In addition to locating known AIS infestations, READS should also take into consideration which waters have high resource values for protection from an unintended AIS transfer. These values include waterbodies with native fish populations, recreational fisheries, municipal and hydropower water sources, or pristine high elevation lakes. As with AIS positive waters, high priority aquatic resources should be mapped prior to the fire season, and included in AIS prevention communications to fire managers.

UNDERSTAND AIS AND HOW FIRE ACTIVITIES CAN SPREAD THEM

Educating yourself and others regarding AIS and their dangers is likely one of the best management tools available. AIS encompass many species, from mollusks to plants to pathogens, and can be transported and decontaminated in a variety of ways. (See *Appendix D: Aquatic Invasive Species of Concern to Firefighters and Disinfection Methods* for descriptions and disinfection methods for AIS that may be of concern during water handling fire operations.) In addition, AIS educational materials are available on State and federal agency invasive species websites.

AIS are most likely to be transported via firefighting equipment that contacts or conveys 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. Residual water left in incompletely drained tanks in equipment moved between fire incidents can harbor AIS, and quagga mussel larvae are able to survive for days in residual water contained within undrained boats. However, BMPs targeting drafting procedures greatly reduce AIS risk from residual tank water.

KNOW THE BMPS AND DECONTAMINATION PROTOCOLS

Study the General Prevention best management practices, which are simple operational techniques to prevent contact with AIS at the outset. For example, prudent prevention practices would be avoiding transferring water between drainages, or not sucking organic and bottom material into water intakes when drafting. Also, educate yourself on methods of decontamination, and emphasize flushing with pressurized hot water, drying of equipment, and use of spare gear over using chemical disinfectants. Note that for hot water decontamination, the recommended temperature is 140^{o}F with a contact time of 2 minutes. According to research studies, this combination of temperature and contact duration will kill the majority of AIS of concern to fire operations (See *Appendix D*). For the hardier species, such as whirling disease, the flushing action of pressurized hot water greatly decreases the likelihood of retention on equipment.

Refer people who do not know how to decontaminate their equipment to someone who can either do the work or train them how. Be knowledgeable of contract language associated with equipment cleaning and decontamination requirements (e.g., scooper aircraft and helicopters). Read the "Operational Guidelines for Aquatic Invasive Species" section of the Interagency Standards for Fire and Fire Aviation Operations (the Red Book) at: https://www.nifc.gov/policies/pol_ref_redbook.html. Talk to helicopter managers and air operations to see if they need additional information or equipment.

INTERNAL ENGINE TANKS AND DRAFTING METHODS

Of great concern in the past was the possibility that residual engine or helicopter tank water contaminated with AIS could be transferred to uncontaminated waterbodies during the drafting process. However, if proper drafting and water handling BMPs are used and foot valves are working correctly (see *Appendix B*), there is low risk that contaminated tank water could "seep" into the drafting water source.

By focusing on drafting techniques rather than the difficult decontamination of internal tanks, which may or may not contain AIS, we can abolish the use of large volumes of chemical disinfectants and instead rely on procedure. Priming the engine pump with source water and not using tank water to initiate the prime eliminates the possibility of residual tank water entering a new waterbody through a leaky footvalve. Offer to provide information or assist engine operators on how to perform a foot valve test for leakage. Ask them if they are able to prime their pumps with source, or stream, water rather than from the engine tank. (See *Appendix B* for methods to field test foot valves for leakage.)

Helicopter snorkels do not need to be primed with either source or tank water, so there is no risk of residual tank water entering a water source during helicopter drafting operations.

Minimal risk occurs when contaminated tank water is applied to fire and upland areas so long as it does not enter other waterbodies. Water delivery equipment and accessories (e.g., fireline hoses, wye valves, nozzles) that do not transfer tank water to waterbodies do not need to be disinfected.

Familiarize yourself with situations where risk of AIS transfer is highest, such as gear that contacts untreated water and later is moved to new watersheds or waterbodies. Or a helicopter bucket that has snagged water plants and mud. Be able to discuss these scenarios so that others understand that the objective is to reduce the possibility of moving AIS from one source to another.

Serve as a problem solver, not an enforcer of rules and practices! Use your expertise as a READ to explain the BMPs and why they are important for ecosystem health.

PREPAREDNESS: DECONTAMINATION PERSONNEL, EQUIPMENT, AND SUPPLIES

There is typically a lag time between the onset of a fire incident and the arrival of decontamination equipment, such as heated pressure washers. Once equipment arrives, there may not be personnel available that are trained in its safe operation. The following measures are recommended to ensure your unit is properly prepared to prevent the spread of AIS during fire operations:

- Secure heated pressure washing equipment for use on your unit or the larger area in which you work. If you are unable to purchase equipment, have contact information at the ready for local contractors, rental shops, and chemical supply houses.
- For ground operations, ensure access to disinfectants for instances where heated pressure washing equipment is not available or there is insufficient time to thoroughly dry equipment. Know which disinfectants to provide to engine operators (see *Appendix A*).
- Train personnel in the safe implementation of decontamination protocols and operation of equipment. Develop Risk Assessments or Job Hazard Analyses for each specific decontamination task or piece of equipment. See *Appendix C* for Risk Assessment templates for disinfecting fire equipment: "*Operating Hot Water Pressure Washers*"; "*Disinfecting Field Gear With Quaternary Ammonium Compounds*"; and "*Disinfecting Field Gear With Chlorine Bleach*". Modify these to fit your particular situation and field unit.
- Secure all necessary Personal Protective Equipment (PPE) for pressure washing and use of chemicals, if appropriate.

Appendix A: Decontaminating with Chemical Disinfectants

Chemical disinfectants, though effective, can be hazardous, corrosive, and difficult to dispose of. However, when other decontamination methods, such as hot water or drying, are not options, chemicals can be used for small gear items ONLY (e.g., footvalves, draft hoses, or screens) in volumes appropriate for small buckets. Bleach and quaternary ammonium compounds do not meet corrosion requirements for aluminum and **shall not be used on aircraft fuselages or aerial water delivery components such as helicopter buckets and snorkels.**

Quaternary ammonium compounds (quats), common cleaning agents used in homes and hospitals, are safe for MOST gear and equipment when used at recommended concentrations and rinsed. Chlorine products are not emphasized for use in these guidelines because of their corrosiveness to fabrics, plastics, rubber, and metal and their limited effectiveness against snails. However, bleaches are extremely effective against certain invasive organisms (e.g., chytrid fungus, Port Orford cedar root disease) and are relatively inexpensive. (See *Appendix D*: *Aquatic Invasive Species of Concern to Firefighters and Disinfection Methods*.)

TO DECONTAMINATE GEAR WITH QUAT DISINFECTANTS:

The quaternary ammonium formulations *Super HDQ®* and *Green Solutions High Dilution256®* (which replaces the discontinued *Sparquat* 256®) were recently (see *Appendix D,* Stout et al. 2016) found to be most effective against a variety of AIS. *Green Solutions Neutral Disinfectant®* is a less concentrated version of *Green Solutions 256®*. These formulations can be used at concentrations according to their labels (see below). Soak gear in a bucket for 10 minutes. Alternatively, gear may be disinfected by spraying with quat from a backpack weed sprayer or spray bottle. Afterwards, **rinse gear thoroughly in clean water**. Quat compounds are highly toxic to aquatic organisms but are immobile in soil. Keep effluent, containing this product, at least 100 feet from lakes, ponds, streams or other waters. Do NOT allow product to enter storm drains, lakes, streams, or other waterbodies.

Volume of Tap Water	***Super HDQ®***	***Green Solutions Neutral Disinfectant High Dilution 256®***	***Green Solutions Neutral Disinfectant®*** (this product is a lower concentration)	**Soak Time**	**Spray Time**
1 gallon water	½ oz	½ oz	2 oz	10 min	5 sec spray; let stand 10 minutes; rinse
1 gallon water	1 Tbsp.	1 Tbsp.	4 Tbsp.	10 min	5 sec spray; let stand 10 minutes; rinse

TO DECONTAMINATE GEAR WITH CHLORINE BLEACH:

Bleaches are corrosive to canvas, gaskets, and metal and have limited effectiveness against snails. However, bleaches are extremely effective against other invasive organisms, especially pathogens, and the bleach concentration below has been found to be effective for chytrid fungus and other AIS (*See Appendix D:* Johnson et al. 2003). Soak gear in a bucket for 10 minutes. Afterwards, **rinse gear thoroughly in clean water**.

Volume of Tap Water	"*Regular Clorox® Bleach*" (6% sodium hypochlorite)	Soak Time
1 gallon water	9 oz	10 min
1 gallon water	1 ⅛ Cup	10 min

CHEMICAL DISPOSAL

Small quantities of diluted quaternary ammonium products or bleach which have been used to disinfect foot valves or other firefighting equipment may be disposed of in a sanitary sewer **as allowed by the product label**. Alternatively, used solutions of quaternary ammonium products or bleach may be disposed of by any application specified on product label direction, such as:

- Cleaning vehicle exteriors and tires by spray application of diluted materials
- For the prevention of mildew on non-porous surfaces
- Disinfection of toilets (including portable)

Always consult the product label in determining the appropriate PPE necessary for the mixing and use of these chemicals, and for final direction on a given products use and disposal. Do NOT allow these products to enter storm drains, lakes, streams, or other waterbodies.

SUPPLY SOURCES

These recommended chemicals are available through the U.S. Government Services Administration (GSA) https://www.gsaadvantage.gov or through local janitorial chemical suppliers.

1) *Green Solutions Neutral Disinfectant*®

   GSA (NSN# 3502-04) = $32 per case (4 gal) = $8 per gal = $.06 per oz = $0.12 per gallon of mixed solution
   (Spartan Chemical Company; EPA registration #1839-169-5741)

2) *Green Solutions High Dilution 256®* (replaced *Sparquat 256*®)

   This formulation is **4X more concentrated** than *Green Solutions Neutral Disinfectant*® (see above)

Not carried by GSA, but can be purchased from local janitorial supply businesses. Distributor locations can be found at: http://www.spartanchemical.com/where-to-buy

Cost = ~$140 per case (4 gal) = $35 per gal = $0.27 per oz = $0.13 per 1 gallon of mixed solution
(Spartan Chemical Company; EPA registration #1839-169-5741)

3) *Super HDQ®* (twice as concentrated as *Sanicare Quat 128®*)

GSA (NSN# 1204-04) = $71 per case (4 gal) = $18 per gal = $0.14 per oz = $.07 per 1 gallon of mixed solution

(Spartan Chemical Company; EPA registration # 10324-141-5741)

4) *Liquid household bleach (*6% sodium hypochlorite) (e.g., Regular Clorox® Bleach)
Grocery stores, prices vary

Appendix B: Field Testing Foot Valves for 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.

Therefore, the following best management practices are recommended.

- Use a properly functioning and tested foot valve during drafting. Ensure the foot valve is screwed on snugly and not leaking.
- To minimize the potential for engine and water tender tank water leakage through the foot valve, *prime with water from the drafting source rather than water from the engine tank*. When priming using a bucket, first make sure that the bucket is clean prior to priming so the bucket does not transfer AIS. Additionally, during drafting and water tending operations don't leave draft hose full with foot valve engaged and submerged in water source when not pumping.
- Care should be taken when drafting to minimize any potential of tank water to come in contact with drafting source; e.g., pump priming or overflow of engine tank when filling.
- Untreated tank water obtained in one location should never be directly discharged into a waterbody at a different location.

In order 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.

<u>Items needed to perform the leak test include:</u>

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

<u>If a pressure gauge is not present on equipment:</u>

- 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

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 8). 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 9). Fill the suction hose with 6 to 10 feet of water to obtain 3-5 psi (2' of hose = 1 psi). 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 with one that does not leak.

Figure 8. Suction hose with foot valve attached to engine ladder.

Figure 9. Foot valve attached to suction line with various adapters as needed to adjust for foot valve size.

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.

Figure 10. Pressure valve attached to the footvalve.

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

Appendix C: Job Safety Risk Assessment Templates for Disinfecting Field Gear

- **OPERATING HOT WATER PRESSURE WASHERS**
- **DISINFECTING FIELD GEAR WITH QUATERNARY AMMONIUM COMPOUNDS**
- **DISINFECTING FIELD GEAR WITH CHLORINE BLEACH**

07-09-2009 R4 RSC	**Organizational and Operational Risk Assessment Worksheet** **Organizational Risk Management**	**Modified** **215_A**

1. Forest or Unit : **TEMPLATE EXAMPLE**	Location:	Prepared by *(Name / Duty Position)*:	2. Page ___________of**______________**
3. Work Project/ Activity **OPERATING HOT WATER PRESSURE WASHERS**	4. Initial Assessment Date:	5. Date of this assessment update:	6. Version___________of____________

7. Worksheet Instructions:

- For each hazard identified in box 8, the local district/unit is to complete boxes 12 and 13 with specific implementation controls and personnel assigned unique to the activity and location.
- Additional hazards unique to this location or unit may need to be documented in box 8 by the local district/unit.

8. Identified Hazards	9. Assess the Hazards: Initial Risk rating from risk matrix.				10. Initial Proposed Control Measures Developed for Identified Hazards/Risks:	11. Assess the Hazard's Residual Risk:				12. How to Implement the Controls: (To be completed on the local unit)	13. Assigned to: (To be completed on the local unit)
(Be Specific)	**L**	**M**	**H**	**E**	**(Be Specific)**	**L**	**M**	**H**	**E**	**(Be Specific)**	**(Be Specific)**
Unfamiliarity with Equipment			X		To reduce the risk of injury, read operating instructions carefully before using. Know how to stop the machine and bleed pressure quickly. Be thoroughly familiar with the controls.	X					
Physical Protection		X			High pressure spray can cause debris to become airborne and fly at high speeds. To avoid personal injury, wear eye, hand and foot safety devices. Keep operating area clear of all persons.	X					
Risk of fire			X		Do not add fuel when the product is operating or still hot.	X					
Handling Hazardous Fuels				X	Do not confuse gasoline and fuel oil tanks. Keep proper fuel in proper tank. Don't use oil containing gasoline, solvents or alcohol. A mix up can result in fire and/or explosion.	X					

CONTINUED

14. Identified Hazards	15. Assess the Hazards: Initial Risk from matrix.				16. Control Measures Developed for Identified Hazards*: (Specific measures taken to reduce the probability of a hazard/risks)*	17. Assess the Hazard's Residual Risk:				18. How to Implement the Controls:	19. Assigned to:
(Be Specific)	**L**	**M**	**H**	**E**	**(Be Specific)**	**L**	**M**	**H**	**E**	**(Be Specific)**	**(Be Specific)**
Refueling				X	Allow engine to cool for 1-2 minutes before refueling. If fuel is spilled, make sure area is dry before testing the spark plug or starting the engine. (Fire and/or explosion may occur if this is not done.) Refuel gasoline engines: outdoors; with the engine stopped; with no source of ignition within 10 feet of dispensing point; and with allowance for fuel expansion in hot weather.	X					
High Pressures			X		High pressure will cause personal injury or equipment damage. Keep clear of nozzle. Use caution when operating. Do not direct discharge stream at people, or severe injury or death will result. Before disconnecting discharge hose from water outlet, turn burner off and open spray gun to allow water to cool below 100° before stopping the machine. Then open spray gun to relieve pressure. Failure to properly cool down or maintain the heating coil may result in a steam explosion. Never run pump dry or leave spray gun closed longer than 1-2 minutes.	X					
High Pressure Nozzle		X			Grip cleaning wand securely with both hands before starting. Failure to do this could result in injury from a whipping wand.	X					

20. Remaining Risk Level After Control Measures Are Implemented: (CIRCLE HIGHEST REMAINING RISK LEVEL)	**LOW** (Supervisor)	**MEDIUM** (Program Manager	**HIGH** (District Ranger)	**EXTREME** (District Ranger or Forest Supervisor)

21. RISK DECISION AUTHORITY: **(Approval/Authority Signature Block)** (If Initial Risk Level is Medium, High or Extremely High, Brief Risk Decision Authority at that level on Controls and Control Measures used to reduce risks) (**Note**: if the person preparing the form signs this block, the signature indicates only that the appropriate risk decision authority was notified of the initial risk level, control measures taken and appropriate resources requested; and that the risk was accepted by the decision authority.)

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(Signature)

RISK ASSESSMENT MATRIX

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- Then the risks can be addressed from top right down to bottom left. High-probability/low-impact and high-impact/low-probability risk of equal risk exposure score will tend to be evaluated at around the same time.
- The process can be done on the wall with flipchart-paper, on a paper or computer format, or in many cases in your head.

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<tr><td rowspan="4">Severity

(Effect/impact)</td><td>Catastrophic:
Fatal, life threatening or permanent disability</td><td>I</td><td rowspan="2">Extreme
(4)</td><td>E</td><td colspan="2">H</td><td>M</td></tr>
<tr><td>Major:
Severe injury or illness. Long term disability and/or Lost time</td><td>II</td><td colspan="2">H</td><td>M</td><td rowspan="3">L</td></tr>
<tr><td>Moderate:
Medical treatment-no permanent injury or illness, and/or restricted duty</td><td>III</td><td>High
(3)</td><td colspan="2">M</td><td rowspan="2">L</td></tr>
<tr><td>Minor: First aid -
Minor cuts, bruises, or sickness. No lost time/restricted duty</td><td>IV</td><td>Medium
(2)</td><td colspan="2">Low
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</table>

Risk Tolerance Rating Criteria

Extreme - 4	High - 3	Medium - 2	Low - 1
Unacceptable: Likely harm from an event must not be accepted. Must be reduced with administrative barriers of protection and/or engineering controls. Eliminate or avoid risk to maintain sufficient safeguards.	**Intolerable:** Should be reduced with administrative and/or engineering controls. Risk should not be tolerated save in special/limited circumstances.	**Tolerable:** Tolerable if further risk reduction (cost, time, effort) would be grossly disproportionate to improvement gained.	**Acceptable:** Negligible given common safe job procedures are applied. Continual vigilance necessary to maintain assurance that risk remains at this level.

07-09-2009 R4 RSC	**Organizational Risk Management** **Organizational and Operational Risk Assessment Worksheet**	**Modified** **215_A**

1. Forest or Unit : **EXAMPLE TEMPLATE**	Location:	Prepared by *(Name / Duty Position)*:	2. Page ________of_________
3. Work Project/ Activity **DISINFECTING FIELD GEAR WITH QUATERNARY AMMONIUM COMPOUNDS (e.g., HDQ, Green Solutions)**	4. Initial Assessment Date:	5. Date of this assessment update:	6. Version______of _________

7. Worksheet Instructions:

- For each hazard identified in box 8, the local district/unit is to complete boxes **12 and 13** with specific implementation controls and personnel assigned unique to the activity and location.
- Additional hazards unique to this location or unit may need to be documented in box 8 by the local district/unit.

8. Identified Hazards	9. Assess the Hazards: Initial Risk rating from risk matrix				10. Initial Proposed Control Measures Developed for Identified Hazards/Risks:	11. Assess the Hazard's Residual Risk:				12. **How to Implement the Controls:** (To be completed on the local unit)	13. **Assigned to:** (To be completed on the local unit)
(Be Specific)	**L**	**M**	**H**	**E**	**(Be Specific)**	**L**	**M**	**H**	**E**	**(Be Specific)**	**(Be Specific)**
Chemical Contact			X		Concentrated quat compounds are corrosive and can cause irreversible eye damage and skin burns. Wear protective clothing including safety glasses or goggles and impervious gloves.	X					
Swallowed Chemical		X			If chemical is swallowed, drink a glassful of water and call a physician. Do not induce vomiting.	X					
Eye Contact			X		Wear PPE. Remove contact lenses if present. Flush eyes with copious amounts of water for at least 15 minutes. If irritation persists, see a doctor. When preparing quat solutions in the field each crew member should carry 1 quart of water at a minimum for use as an eye flush.	X					
Storage and Transport	X				Store in an air tight container upright in a cool, dry area, and avoid heat above 110° F. In case of spill, flood areas with large quantities of water. Do not reuse empty container. Do NOT allow product to enter storm drains, lakes, streams, or other bodies of water.	X					

CONTINUED											
14. Identified Hazards	15. Assess the Hazards: Initial Risk from matrix				16. Control Measures Developed for Identified Hazards: *(Specific measures taken to reduce the probability of a hazard/risks)*	17. Assess the Hazard's Residual Risk:				18. How to Implement the Controls:	19. Assigned to:
(Be Specific)	**L**	**M**	**H**	**E**	**(Be Specific)**	**L**	**M**	**H**	**E**	**(Be Specific)**	**(Be Specific)**
Inhalation of Fumes	X				Avoid inhalation of vapor or mist; normal room ventilation is adequate.	X					
Physical or Chemical Hazards				X	Do not mix with chlorine bleach. The combination may release hazardous or explosive gases.	X					
Environmental Hazards			X		Quat compounds are highly toxic to aquatic organisms but are immobile in soil. Keep effluent containing this product at least 100 ft from lakes, ponds, streams or other waters (EPA's Reregistration Eligibility Decision for Aliphatic Alkyl Quaternaries EPA739-R-06-008 at: https://archive.epa.gov/pesticides/reregistration/web/pdf/ddac_red.pdf. Flush to sanitary sewers if possible, but notify treatment facility if large volumes are involved.	X					

20. Remaining Risk Level After Control Measures Are Implemented: (CIRCLE HIGHEST REMAINING RISK LEVEL)	**LOW** (Supervisor)	**MEDIUM** (Program Manager Staff Officer)	**HIGH** (District Ranger)	**EXTREME** (District Ranger or Forest Supervisor)

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Likely harm from an event must not be accepted. Must be reduced with administrative barriers of protection and/or engineering controls. Eliminate or avoid risk to maintain sufficient safeguards.</td><td>**Intolerable:**
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07-09-2009 R4 RSC	**Organizational Risk Management** **Organizational and Operational Risk Assessment Worksheet**	Modified 215_A

1. Forest or Unit : **EXAMPLE TEMPLATE**	Location:	Prepared by *(Name / Duty Position)*:	2. Page__________ of____________
3. Work Project/ Activity **DISINFECTING FIELD GEAR WITH CHLORINE BLEACH**	4. Initial Assessment Date:	5. Date of this assessment update:	6. Version ________of_____________

7. Worksheet Instructions:

- For each hazard identified in box 8, the local district/unit is to complete boxes 12 and 13 with specific implementation controls and personnel assigned unique to the activity and location.
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(Be Specific)	**L**	**M**	**H**	**E**	**(Be Specific)**	**L**	**M**	**H**	**E**	**(Be Specific)**	**(Be Specific)**
Chemical Contact			X		Bleach can cause severe but temporary eye irritation and can be a skin irritant. Wear protective clothing including safety glasses or goggles and impervious gloves.	X					
Swallowed Chemical		X			If chemical is swallowed, drink a glassful of water and call a physician. Do not induce vomiting.	X					
Eye Contact			X		Wear PPE. Remove contact lenses if present. Flush eyes with copious amounts of water for at least 15 minutes. If irritation persists, see a doctor. When preparing bleach solutions in the field each crew member should carry 1 quart of water at a minimum for use as an eye flush.	X					
Storage and Transport	X				Store in an air tight container upright in a cool, dry area, and away from direct sunlight and heat to avoid deterioration. In case of spill, flood areas with large quantities of water. Do not reuse empty container. Do NOT allow product to enter storm drains, lakes, streams, or other bodies of water.	X					

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14. Identified Hazards	15. Assess the Hazards: Initial Risk from matrix				16. Control Measures Developed for Identified Hazards*: (Specific measures taken to reduce the probability of a hazard/risks)*	17. Assess the Hazard's Residual Risk:				18. How to Implement the Controls:	19. Assigned to:
(Be Specific)	**L**	**M**	**H**	**E**	**(Be Specific)**	**L**	**M**	**H**	**E**	**(Be Specific)**	**(Be Specific)**
Inhalation of Fumes	X				Avoid inhalation of vapor or mist and use only in a well-ventilated area.	X					
Physical or Chemical Hazard**s**			X		Product contains a strong oxidizer. Prolonged contact with metal may cause pitting or discoloration. Will damage fabrics and rubber. Do not add bleach directly to fire retardants containing ammonia, such as Phos-Chek, or with quaternary ammonium products. Mixing bleach with products containing ammonia may release hazardous or explosive gases.	X					
Environmental Hazards		X			Bleach is toxic to aquatic organisms but degrades rapidly. Do not discharge effluent containing this product into lakes, ponds, streams or other waters.	X					

20. Remaining Risk Level After Control Measures Are Implemented: (CIRCLE HIGHEST REMAINING RISK LEVEL)	**LOW** (Supervisor)	**MEDIUM** (Program Manager Staff Officer)	**HIGH** (District Ranger)	**EXTREME** (District Ranger or Forest Supervisor)

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Appendix D: AQUATIC INVASIVE SPECIES of Concern to Firefighters and Disinfection Methods

The species fire operations are most likely to encounter, their distributions, all disinfection methods, and references.

Zebra & Quagga Mussels

***Dreissena polymorpha* &**
Dreissena rostriformis bugensis

Photo credit: The Nature Conservancy

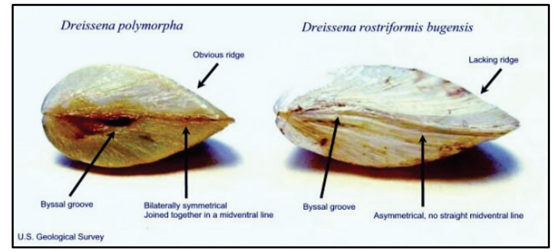

Photo credit: U.S. Geological Survey

GENERAL INFORMATION:

- **Quagga Mussel Distribution:** CA, NV, UT, AZ, CO, NM, OK, TX, midwest, Great Lakes region and NE US. For most up-to-date information on distribution, please see: https://nas.er.usgs.gov/taxgroup/mollusks/zebramussel/
- **Zebra Mussel Distribution:** CA, UT, CO, OK, KS, NE, SD, ND, LA, AR, MO, IA, MN, MS, TN, AL, KY, IN, other midwest and Great Lakes regions and NE US. For most up-to-date information on distribution, please see: https://nas.er.usgs.gov/taxgroup/mollusks/zebramussel/
- **Habitat:** Both mussels attach to hard surfaces in temperate lakes and slow rivers. Microscopic mussel larvae are released into open water where they swim about for several days before settling.
- **Fire Activities Posing Risk:** Most concern is with microscopic larvae present in water column. Larvae can survive for 5 days in internal tanks with residual water (summer months). Risks include: contact with untreated water; helicopter buckets, snorkels, and other drafting gear that capture bottom sediments, mud, or aquatic plants; internal tanks and hoses that retain residual untreated water.
- **Environmental Impacts:** Zebra and quagga mussels colonize water supply pipes and biofoul hydroelectric and nuclear power plants, public water plants, and industrial facilities. These species remove nutrients in aquatic ecosystems and litter beaches with sharp-edged shells.

DISINFECTION PROTOCOLS:

Methods of Control for Firefighters	Details of Method	References	Notes
Temperature	HOT WATER SPRAY To kill Quagga or Zebra mussel adults ≥ 140°F (60°C) for 5 to 10 seconds To kill Quagga/Zebra mussel free-swimming larvae ≥ 140°F (60°C) likely to be 'instantly lethal'	Comeau et al. 2011 (quagga adults); Morse 2009 (zebra adults) R. McMahon, pers. comm. (2014)	

Methods of Control for Firefighters	Details of Method	References	Notes
	HOT WATER IMMERSION: <u>To kill Quagga/Zebra mussel adults and free-swimming larvae</u> ≥ 120°F (50°C) for 1 minute FREEZING ≤ 32°F (0°C) for 48 hours or more for adults	Beyer et al. 2011 McMahon 1996	
Drying	In summer, 5 days survival time for larvae in internal tanks with residual water; in cooler months; 28 days	Choi et al. 2013	
Mechanical	Scraping, brushing, hot water pressure washing to flush larvae	Comeau et al. 2011 and multiple sources	
CHEMICALS			
Quaternary ammonium Compounds (e.g., alkyl dimethyl benzylammonium chloride [ADBAC]; diecyl dimethyl ammonium chloride [DDAC])	<u>To kill Quagga mussel larvae</u>: *3.1% Sparquat256®* solution Mixing instructions: 4.3 oz per 1 gallon water 3.4 gallons per 100 gallons water Contact time = 10 minutes **OR** *1.8% Green Solutions High Dilution 256® solution* Mixing instructions: 2.5 oz per 1 gallon water 1.9 gallons per 100 gallons water Contact time = 10 minutes	Britton and Dingman 2011 Britton and Dingman 2011	Quat compounds methods are specifically for larvae likely found in the water column. Quat Compounds can corrode aluminum; not for use on aircraft equipment.
Bleach (e.g., Clorox®) 6% sodium hypochlorite	*0.5% bleach solution* (250 ppm sodium hypochlorite) Mixing instruction: 0.6 oz bleach per 1 gallon water	Modovski 2011 (Based on Cope et al. 2003 which cited Gatenby 2000	Bleach is corrosive to gear and metals.

Methods of Control for Firefighters	Details of Method	References	Notes
	1.1 Tablespoons of bleach per gallon water ½ gallon bleach per 100 gallons water Contact time = rinse only, no time specified.		
Other Disinfectants	To kill Quagga mussel adults & larvae: 2% *Virkon Aquatic®* solution Mixing instructions: 20 g/liter 76g per 1 gallon of water 760g per 100 gallons water Contact time = 10 minutes To kill Quagga mussel larvae only: 0.5% *Virkon Aquatic®* solution Mixing instructions: 5 g/liter 19g per 1 gallon of water 190g per 100 gallons water Contact time = 10 minutes	Stockton 2011	Virkon is corrosive to soft metals. Although not specifically tested, may not be applicable for use on aircraft equipment.

Asian Clam

Corbicula fluminea

Photo credit: Noel M. Burkhead-USGS


Photo credit: Flyforums.co

General Information:

- **Distribution:** Almost all US states except MT, ND and ME. For most up-to-date information on distribution, please see: https://nas.er.usgs.gov//queries/FactSheet.aspx?speciesID=92.
- **Habitat:** Lakes and streams, buried in sediments or larvae and juveniles drifting in currents.
- **Fire Activities Posing Risk:** Most concern is with larvae and juvenile clams in swept into water column. Risks include: contact with untreated water; helicopter buckets, snorkels, and other drafting gear that capture bottom sediments, mud, or aquatic plants; internal tanks and hoses that retain residual untreated water.
- **Environmental Impacts**: Asian clams can biofoul power plant and industrial water systems. Juveniles secrete a mucousy dragline and can be easily transported in currents. The clams also clog irrigation canals and drinking water pipes.

Disinfection Protocols:

Methods of Control for Firefighters	Details of Method	References	Notes
Temperature	<u>To kill Asian clam larvae and small juveniles</u>: HOT WATER It is probable that a hot water spray ≥ 140°F (60°C) for a few seconds would be lethal. No scientific study reports effectiveness. Flushing equipment with hot water would remove larvae and juveniles, which are easily entrained in flowing water. <u>To kill Asian clam adults</u>: ≥ 109° F (43°C) for 30 minutes	R. McMahon, pers. comm. (2014) McMahon and Williams 1986 Mattice and Dye 1975	

Methods of Control for Firefighters	Details of Method	References	Notes
Drying	Dry gear in air for 14–27 days in cool weather; much shorter dry times in full sun	McMahon and Williams 1984	
Mechanical	Scraping, brushing, remove all plant material	Multiple sources	
CHEMICALS	Though chemicals are used in hydroelectric facilities, Asian clams are resistant to chemicals: decontamination times are lengthy and kill rates < 100%	For example, Barbour et al. 2013	

New Zealand Mudsnail

Potamopyrgus antipodarum

General Information:

- **Distribution:** WA, OR, CA, ID, MT, WY, UT, NV, AZ, CO, MN, IL, OH, PA, NY, and Canada. For most up-to-date information on distribution, please see: https://nas.er.usgs.gov/taxgroup/mollusks/newzealandmudsnaildistribution.aspx.
- **Habitat:** Streams and lakes, occurring on rocky substrates as well as aquatic plants.
- **Fire Activities posing risk:** Contact with untreated water; helicopter buckets, snorkels, and other drafting gear that capture bottom sediments, mud, or aquatic plants; internal tanks and hoses that retain residual untreated water.
- **Environmental impacts:** Mudsnails reproduce very quickly. It only takes a SINGLE snail can result in a colony of more than 40 million snails in just one year. New Zealand mudsnails can smother a streambed, crowding out the native aquatic species that provide food for fish.

Disinfection Protocols:

Methods of Control for Firefighters	Details of Method	References	Notes
Temperature	HOT WATER: ≥ 122°F (50°C) for 15 seconds FREEZING: ≤ 27°F (-3°C) for 1 to 2 hours	Dwyer et al. 2003 Richards et al. 2004	
Drying	Dry gear in full sunlight for ≥ 50 hours Dry gear at 86°F (30°C) for 24hours Dry gear at ≥ 104°F (40°C) for at least 2 hours	Alonso and Castro-Diez 2012 Richards et al. 2004	

Methods of Control for Firefighters	Details of Method	References	Notes
Mechanical	Scraping, brushing, washing and removing organics (e.g. mud)	Multiple sources	
CHEMICALS			
Quaternary ammonium compounds (e.g., alkyl dimethyl benzylammonium chloride [ADBAC]; diecyl dimethyl ammonium chloride [DDAC])	<u>0.8% *Green Solutions High Dilution* 256® solution</u> Mixing instructions: - ½ liquid oz. per 1 gallon water - 1 Tbsp. per 1 gallon water Contact time = 10 minutes <u>0.33% *Super HDQ*®</u> Mixing instructions: - ½ liquid oz. per 1 gallon water - 1 Tbsp. per 1 gallon water Contact time = 10 minutes	Stout et al. 2016	Quat Compounds can corrode aluminum; not for use on aircraft equipment .
Bleach (e.g., Clorox®) 6% sodium hypochlorite	Not effective	Hosea and Finlayson 2005	

Methods of Control for Firefighters	Details of Method	References	Notes
Other Agents	2% *Virkon Aquatic*® solution Mixing instructions: 77g per 1 gallon of water 770 g per 100 gallons water Contact time = 15-20 minutes	Stockton and Moffitt 2013	Virkon is corrosive to soft metals. Although not specifically tested, may not be applicable for use on aircraft equipment.

Malaysian Trumpet Snail

Melanoides tuberculata

Also called: Red Rimmed Melania, Red Lipped Melania

Photo credit: Alex Kawazaki

Photo credit: Flickriver.com

General Information:

- **Distribution:** AZ, CA, CO, FL, HI, LA, MT, NC, NV, OR, UT, TX (possible in SD, VA and WY). For most up-to-date information on distribution, please see: https://nas.er.usgs.gov/queries/FactSheet.aspx?SpeciesID=1037.
- **Habitat:** Slow moving rivers and lakes, on mud and plants
- **Fire Activities Posing Risk:** Risks include: helicopter buckets, snorkels, and other drafting gear that capture bottom sediments, mud, or aquatic plants; internal tanks and hoses that retain residual untreated water
- **Environmental Impact:** This trumpet snail can outcompete native snails and alter ecosystem functions

Disinfection Protocols:

Methods of Control for Firefighters	Details of Method	References	Notes
Temperature	HOT WATER: To kill snails of all sizes 122 °F (50°C) for 4-5 minutes FREEZING: Freezing in Ice water for 12-24 hours Freezing in salty ice water for 2 hours	Mitchell and Brandt 2005 Mitchell and Brandt 2009	
Drying	Very resistant to drying, >20 days	Mitchell and Brandt 2005	
Mechanical	Scraping, brushing, hot water pressure washing	Multiple sources	

Methods of Control for Firefighters	Details of Method	References	Notes
CHEMICALS			
Quaternary ammonium compounds	No known studies		
Bleach (e.g., Clorox®) 6% sodium hypochlorite	Not effective	Mitchell et al. 2007	

Oriental Mystery Snail

Cipangopaludina spp.

Also called: Chinese Mystery Snail

Photo credit: Cornell University

Photo credit: Oregon Dept of Fish and Wildlife

General Information:

- **Distribution:** WA, OR, CA, ID, UT, AZ, CO TX, NE, MO, GA, FL, NC, Great Lakes region, and northeastern US. For most up-to-date information on distribution, please see: https://nas.er.usgs.gov/queries/FactSheet.aspx?SpeciesID=1044.
- **Habitat:** Slow moving rivers and lakes, on mud and plants. Readily transported by equipment infested with snails hitchhiking on aquatic plants.
- **Fire Activities Posing Risk:** Helicopter buckets, snorkels, and other drafting gear that capture bottom sediments, mud, or aquatic plants; internal tanks and hoses that retain residual untreated water.
- **Environmental Impact:** These snails form dense populations and outcompete native species for food and habitat. They are intermediate hosts for parasitic worms and can transmit diseases that kill waterfowl. Some mystery snails prey on fish embryos. Snail shells often litter shorelines and clog screens of water intakes.

Disinfection Protocols:

Method of Control for Firefighters	Details of Method	References	Notes
Temperature	HOT WATER: 122 °F (50°C) for 4-5 minutes	J. Havel, pers. comm. (2014)	
Drying	14 to ≥28 days, depending on snail size. Larger snails very resistant to drying	Havel 2011	
Mechanical	Scraping, brushing, clean off all plant material	Multiple sources	

Method of Control for Firefighters	Details of Method	References	Notes
CHEMICALS			
Quaternary ammonium compounds	No known studies		
Bleach (e.g., Clorox®) 6% sodium hypochlorite	No known studies, but as with other snails with sealing flaps (e.g., New Zealand mudsnails, trumpet snails), likely not effective		

Faucet Snail

Bithynia tentaculata

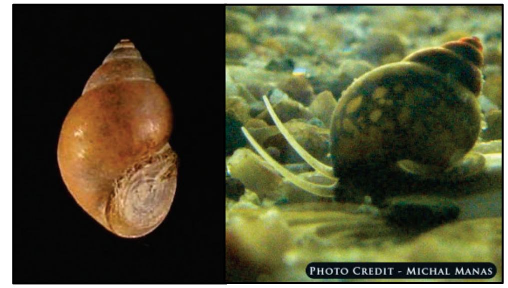

Photo credit: Amy Benson-USGS

General Information:

- **Distribution:** Great Lakes Region, WI, PA, NY, VT, VA, MD, and MT. For most up-to-date information on distribution, please see: https://nas.er.usgs.gov/queries/FactSheet.aspx?speciesID=987.
- **Habitat:** Slow moving rivers and lakes, on mud and plants. Readily transported by equipment infested with snails hitchhiking on aquatic plants.
- **Fire Activities Posing Risk:** Helicopter buckets, snorkels, and other drafting gear that capture bottom sediments, mud, or aquatic plants; internal tanks and hoses that retain residual untreated water.
- **Environmental Impact:** These snails outcompete native species for food and habitat in lakes and streams. They are intermediate hosts for parasitic worms and transmit diseases that kill waterfowl. Where abundant they infest municipal water supplies.

Disinfection Protocols:

Method of Control for Firefighters	Details of Method	References	Notes
Temperature	HOT WATER: 122 °F (50°C) for ≥1 minute	Mitchell and Cole 2008	
Drying	Dry gear for 14 to 21 days	Mitchell and Cole 2008	
Mechanical	Scraping, brushing, clean off all plant material	Multiple sources	
CHEMICALS			
Quaternary ammonium Compounds	No known studies		
Bleach (e.g., Clorox®) 6% sodium hypochlorite	Not effective	Mitchell and Cole 2008	
Other agents	*Virkon®* Not effective	Mitchell and Cole 2008	

Spiny Waterflea

Bythotrephes longimanus

Photo credit: Minnesota Department of Natural Resources

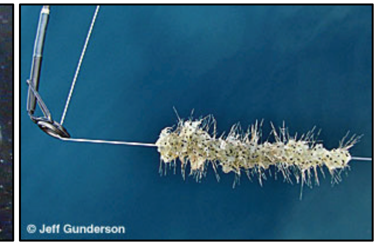

Photo credit: Jeff Gunderson

General Information:

- **Distribution:** Primarily in the Great Lakes Region of the US. For most up-to-date information on distribution, please see: https://nas.er.usgs.gov/queries/FactSheet.aspx?SpeciesID=162.
- **Habitat:** Waterflea plankton (adults and juveniles) are free-swimming in water column of ponds and lakes; dormant (resting) eggs are in mud or silt.
- **Fire Activities posing risk:** Contact with untreated water; helicopter buckets, snorkels, and other drafting gear that capture bottom sediments, mud, or aquatic plants; internal tanks and hoses that retain residual untreated water.
- **Environmental Impact:** The rapidly reproducing spiny waterflea competes with small fish and fouls fishing gear. Larger fish that feed on waterfleas may die due to punctures from spines.

Disinfection Protocols:

Methods of Control for Firefighters	Details of Method	References	Notes
Temperature	HOT WATER To kill adults, juveniles, and resting eggs: ≥ 122°F (50°C) for 5 minutes 140°F (60°C) for 1 minute	Branstrator et al. 2013 (resting eggs) Beyer et al. 2011 (plankton)	
Drying	Dry gear for ≥6 hours (planktonic adults and juveniles, and resting eggs)	Branstrator et al. 2013 (resting eggs) Branstrator, D.K., pers. comm. 2014; (plankton)	

Methods of Control for Firefighters	Details of Method	References	Notes
Mechanical	Scraping, brushing, removal of organic and plant materials.	Multiple sources	
CHEMICALS			
Quaternary ammonium compounds	No known studies		
Bleach (e.g., Clorox®) 6% sodium hypochlorite	Not effective	Branstrator et al. 2013	

Didymo

Didymosphenia geminata

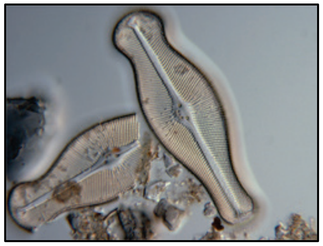

Photo credit: USGS

Photo credit: Biosecurity New Zealand

General Information:

- **Distribution:** WA, OR, CA, ID, MT, WY, CO SC, ND, AR, NC, VA WV PA, NY, NH, CT, AK, and Canada. For most up-to-date information on distribution, please see: https://www.invasivespeciesinfo.gov/aquatics/didymo.shtml.
- **Habitat:** Didymo is a single cell alga that attaches to submerged rocks in cold streams and rivers.
- **Fire Activities posing risk:** Contact with untreated water; helicopter buckets, snorkels, and other drafting gear that capture bottom sediments, mud, or aquatic plants; internal tanks and hoses that retain residual untreated water. Didymo can survive in residual tank water for <2 days in summer but up to 45 days in autumn (Kilroy et al. 2007).
- **Environmental Risk:** Didymo forms dense mats that trail downstream and can completely cover the substrate, smothering native plants, insects, and mollusks.

Disinfection Protocols:

Methods of Control for Firefighters	Details of Method	References	Notes
Temperature	HOT WATER: 113°F (45°C) for 20 minutes 140°F (60°C) for 1 minute FREEZING: 28°F (-2°C) for 4 hours ; 5°F (-15°C) for 2hours	Kilroy et al. 2007 Kilroy et al. 2007	
Drying	Dry external surfaces and internal tanks for 48 hours in summer	Kilroy et al. 2007	
Mechanical	Scraping, brushing, removal of organic and plant materials		
CHEMICALS			
Quaternary ammonium compounds (e.g., alkyl dimethyl	*2.0 % Sanicare Quat128*® solution Mixing instructions: 2.4 oz per 1 gallon water	Matthews 2007, derived from Kilroy et al. 2007	

Methods of Control for Firefighters	Details of Method	References	Notes
benzylammonium chloride [ADBAC]; diecyl dimethyl ammonium chloride [DDAC])	1.9 gallons per 100 gallons water Contact time = 1 minute **OR** *1.2% Sparquat256®* solution Mixing instructions: 1.7 oz per 1 gallon water 1.3 gallons per 100 gallons water Contact time = 1 minute **OR** *0.7% Green Solutions High Dilution 256®* solution Mixing instructions: 1.0 oz per 1 gallon water 0.8 gallons per 100 gallons water Contact time = 1 minute		
Bleach (e.g., Clorox®) 6% sodium hypochlorite	*2.0% bleach solution* (800 ppm sodium hypochlorite) Mixing instructions: 1.8 oz bleach per 1 gallon water 3.6 Tablespoons bleach per gallon water 1.4 gallon bleach per 100 gallons water Contact time = 1 minute	Root and O'Reilly 2012	≥90% effective in killing didymo; corrosive to fabric and metals
Other Disinfectants	1% *Virkon Aquatic®* 10 g/liter Contact time = 10 minutes *Greenworks* dish detergent: 5% solution for 1 minute *Dawn* dish detergent: 5% solution for 1 minute	Root and O'Reilly 2012	~80% effective ≥95% effective ≥95% effective

Chytrid fungus

Batrachochytrium dendrobatidis

Photo credit: Microbiologybytes

Photo credit: DPIW.tas.gov.au

General Information:

- **Distribution:** Chytrid fungus occurs on most continents.
- **Habitat:** Zoospores are free-swimming in water column and can survive in wet mud or silt.
- **Fire Activities posing risk:** Contact with untreated water; helicopter buckets, snorkels, and other drafting gear that capture bottom sediments, mud, or aquatic plants; internal tanks and hoses that retain residual untreated water.
- **Environmental Effects:** This aquatic fungus feeds on living vertebrates and primarily affects the skin of amphibians. Because amphibians breathe and take up water through their skin, the disease causes widespread amphibian declines.

Disinfection Protocols:

Methods of Control for Firefighters	Details of Method	References	Notes
Temperature	HEAT 140°F (60°C) for 5 minutes (tested in incubators)	Johnson et al. 2003	
Drying	Dry gear for ≥3 hours; in sunlight is best.	Johnson et al. 2003	
Mechanical	Scraping, brushing, removal of organic and plant materials.		
CHEMICALS			
Quaternary ammonium compounds (e.g., alkyl dimethyl benzylammonium chloride [ADBAC]; diecyl dimethyl ammonium	*0.15% Sanicare Quat128*® solution Mixing instructions: 0.02 oz per 1 gallon water ⅛ teaspoon per 1 gallon water Contact time = 30 seconds **OR** *0.04% Sparquat256*® solution	Johnson et al. 2003	

Methods of Control for Firefighters	Details of Method	References	Notes
chloride [DDAC])	Mixing instructions: 0.06 oz per 1 gallon water 0.36 teaspoon per gallon of water Contact time = 30 seconds **OR** *0.02% Green Solutions High Dilution 256®* solution Mixing instructions: - 0.03 oz per 1 gallon water - 0.2 teaspoon per 1 gallon water Contact Time = 30 seconds		
"Regular Clorox® Bleach" 6% sodium hypochlorite	*22% bleach solution* (1.2% sodium hypochlorite) Mixing instructions: 1 part bleach:4 parts water 26 oz bleach per 1 gallon water 20 gallons bleach per 100 gallons water Contact time = **5** minutes OR *7% bleach solution* (0.4% sodium hypochlorite) Mixing instructions: 9 oz bleach per 1 gallon water 7 gallons bleach per 100 gallons water Contact time = **10** minutes	Ultra Clorox® Label (EPA Reg #5813-50)	These mixing instructions are approved by EPA specifically for chytrid fungus. Johnson et al. 2003
"Clorox® Germicidal Bleach" 8.25% sodium hypochlorite	*22% bleach solution* (1.2% sodium hypochlorite) Mixing instructions: 1 part bleach:5.5 parts water 20 oz bleach per 1 gallon water 15.4 gallons bleach per 100 gallons water Contact time = 5 minutes	Germicidal Healthcare Clorox® label (EPA Reg. No. 5813-100)	These mixing instructions are approved by EPA specifically for chytrid fungus.

Methods of Control for Firefighters	Details of Method	References	Notes
Other Disinfectants	*0.1% Virkon®* 1 g/liter Contact time = ≥ 2 seconds	Johnson et al. 2003	

Whirling Disease

Myxobolus cerebralis

Photo credit: Colorado Parks and Wildlife

Photo credit: Colorado Parks and Wildlife

General Information:

- **Distribution:** WA, OR, CA, ID, NV,AZ, NM, UT, CO, NE, WY, ID, MT, MI, WI, OH, WV, VA, DE, MD, PA, NJ, CT, NY, MA, VT, NH, AK. For most up-to-date information on distribution, please see: https://www.invasivespeciesinfo.gov/microbes/whirling.shtml.
- **Habitat:** Free-swimming microscopic larvae occur in water column, resistant spores in mud and bottom sediments. Spores can remain viable in mud for 12 years.
- **Fire Activities Posing Risk:** Risks include: contact with untreated water; helicopter buckets, snorkels, and other drafting gear that capture bottom sediments, mud, or aquatic plants; internal tanks and hoses that retain residual untreated water.
- **Environmental Effects:** Whirling disease afflicts trout species, causing spinal distortions and population declines.

Disinfection Protocols:

Methods of Control for Firefighters	Details of Method	References	Notes
Temperature	HOT WATER: To kill spores 195°F (90°C) 10 minutes To kill free-swimming larvae ≥ 167°F (75°C) for 5 minutes	Hoffman and Markiw 1977 Wagner et al. 2003	
Drying	Dry gear for 24hours, drying in sunlight is best to kill spores and larvae	Hedrick et al. 2008	
Mechanical	Scraping, brushing, washing and removing organics (e.g., mud)	Multiple sources	

Methods of Control for Firefighters	Details of Method	References	Notes
CHEMICALS			
Quaternary ammonium compounds (e.g., alkyl dimethyl benzylammonium chloride [ADBAC]; diecyl dimethyl ammonium chloride [DDAC])	*4.6% Sanicare Quat128®* solution Mixing instructions: 6.4 oz per 1 gallon water 5 gallons per 100 gallons water Contact time = 10 minutes. OR *3.1% Sparquat256®* solution Mixing instructions: - 4.3 oz per 1 gallon water - 3.4 gallons per 100 gallons water Contact time = 10 minutes OR *1.8% Green Solutions High Dilution 256®* solution Mixing instructions: 2.5 oz per 1 gallon water 1.9 gallons per 100 gallons water Contact time = 10 minutes	Hedrick et al. 2008	
Bleach (e.g., Clorox®) 6% sodium hypochlorite	*1% bleach solution* (500 ppm sodium hypochlorite) Mixing instruction: 1.1 oz bleach per 1 gallon water 2.2 Tablespoons bleach per gallon water 0.9 gallon bleach per 100 gallons water Contact time = 15 minutes	Hedrick et al. 2008 (spores) Wagner et al. 2003 (larvae)	

Viral Hemorrhagic Septicemia

Novirhabdovirus sp.

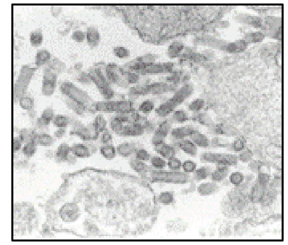

Photo credit: Seagrant.suny.edu

Photo credit: D. Kenyon Michigan DNR

General Information:

- **Distribution:** Great Lakes and St. Lawence River. For most up-to-date information on distribution, please see: https://www.invasivespeciesinfo.gov/microbes/vhs.shtml.
- **Habitat:** Viral Hemorrhagic Septicemia (VHS) is carried in the water column and in aquatic invertebrates, such as snails and crustaceans, as well as fish parts.
- **Fire Activities Posing Risk:** Most concern is with virus free floating in the water column. Risks include: contact with untreated water; helicopter buckets, snorkels, and other drafting gear that capture bottom sediments, mud, or aquatic plants; internal tanks and hoses that retain residual untreated water.
- **Environmental Effects**: Over 50 fish species are susceptible to this disease which causes significant fish die offs.

Disinfection Protocols:

Method of Control for Firefighters	Details of Method	References	Notes
Temperature	HOT WATER: 122°F (50°C) for 10 minutes 158°F (70°C) for 1 minute	Jørgensen 1974, cited in Bovo et al. 2005	
Drying	Dry gear for 4 days at 70°F (21°C)	Pietsch et al. 1977 (for IHNH virus). (Bovo et al. 2005)	IHNV and VHSV are closely related viruses. It is presumed that inactivation studies on one virus may pertain to the other.

Method of Control for Firefighters	Details of Method	References	Notes
Mechanical	Thoroughly wash and dry	Multiple sources	
CHEMICALS			
Quaternary ammonium compounds (e.g., alkyl dimethyl benzylammonium chloride [ADBAC]; diecyl dimethyl ammonium chloride [DDAC])	*0.4% Green Solutions High Dilution 256®* solution Mixing instructions: ½ oz per 1 gallon water 0.4 gallon per 100 gallons water Contact time = 10 minutes	EPA label Reg. No. 1839-167 (2010)	These mixing instructions are approved by EPA for closely related viruses in the same family, but not specifically for VHS.
Bleach (e.g., Clorox®) 6% sodium hypochlorite	*0.2% bleach solution* (98 ppm sodium hypochlorite) Mixing instructions: 0.26 oz/1 gallon water ~ ½ tablespoon/1 gallon water 26 oz/100 gallons water 0.2 gal/100 gallons water Contact time: 2 minutes	Ahne 1982, cited in Bovo et al. 2005	
Other Agents	0.5% - 1% *Virkon Aquatic®* 5 g/liter to 10 g/liter Contact time = 10 minutes	Yanong and Erlacher-Reid 2012	

Spring Viremia of Carp

Rhabdovirus carpio

Photo credit: ytponet

Photo credit: USGS

General Information:

- **Distribution:** NC, Il, WI OH,MN, MO, WA, Ontario. For most up-to-date information on distribution, please see: https://www.glerl.noaa.gov/res/Programs/glansis/nas_database.html.
- **Habitat:** Spring Viremia of Carp (SVC) is carried in the water column and survives long periods in wet mud.
- **Fire Activities posing risk:** Most concern is with virus free floating in the water column. Risks include: contact with untreated water; helicopter buckets, snorkels, and other drafting gear that capture bottom sediments, mud, or aquatic plants; internal tanks and hoses that retain residual untreated water.
- **Environmental Effects:** This virus is a major cause of disease and death in carp and 50 other fish species.

Disinfection Protocols:

Method of Control for Firefighters	Details of Method	References	Notes
Temperature	HOT WATER: 122°F (50°C) for 5 minutes	Ahne 1976, cited in Bovo et al. 2005	
Drying	>28 days at 70°F (21°C)	Ahne 1982	
Mechanical	Scraping, brushing, washing and removing organics (e.g., mud)	Multiple sources	
CHEMICALS			
Quaternary ammonium compounds (e.g., alkyl dimethyl benzylammonium chloride [ADBAC]; diecyl dimethyl ammonium chloride [DDAC])	*0.4% Green Solutions High Dilution 256*® solution Mixing instructions: ½ oz per 1 gallon water 0.4 gallon per 100 gallons water Contact time = 10 minutes	EPA label Reg. No. 1839-167 (2010)	These mixing instructions are approved by EPA for closely related viruses in the same family, but not specifically for SVC.

Method of Control for Firefighters	Details of Method	References	Notes
Bleach (e.g., Clorox®) 6% sodium hypochlorite	*0.1% bleach solution* (55 ppm sodium hypochlorite) Mixing instructions: ¼ teaspoon per 1 gallon water 11.5 oz per 100 gallons water Contact time: 2 minutes	Ahne 1982, cited in Bovo et al. 2005	
Other Agents	*0.5% to 1%Virkon Aquatic®* 5 g/liter to 10 g/liter for 10 minutes 0.1% *Virkon Aquatic®* 1 g/liter for 30 minutes	Bowker et al. 2012	

Port Orford Cedar Root Disease
(*Phytophthora lateralis*)

&

Sudden Oak Death (*Phytophthora ramorum*)

Photo credit: USDA Forest Service

Photo credit: phytophthoradb.org

General Information:

- **Port Orford Cedar Root Disease Distribution:** WA, OR, CA. For most up-to-date information on distribution, please see: http://www.issg.org/database/welcome/.
- **Sudden Oak Death Distribution:** CA, OR. For most up-to-date information on distribution, please see: http://www.issg.org/database/welcome/.
- **Habitat:** Spores swim in standing water and can be carried large distances in flowing water; they also occur in soil.
- **Fire Activities Posing Risk:** Most concern is with spores carried in untreated water. Risks include: contact with untreated water; helicopter buckets, snorkels, and other drafting gear that capture bottom sediments, mud, or aquatic plants; internal tanks and hoses that retain residual untreated water.
- **Environmental Effects:** Port Orford cedars of all sizes may be killed by the root disease. Sudden oak death affects other trees as well as oaks, leading to widespread forest destruction.

Disinfection Protocols:

Method of Control for Firefighters	Details of Method	References	Notes
"Regular Clorox® Bleach" 6% sodium hypochlorite	Add **1 gallon** bleach to 1000 gallons of drafted water (~50 ppm sodium hypochlorite). Prepare the mixture at least 5 minutes prior to application for dust abatement, fire suppression, and cleaning vehicles and logging, road building, and maintenance equipment.	Ultra Clorox® Label (EPA Reg. No. 5813-50) AND Southwest Oregon Interagency Fire Management Plan (USDA Forest Service 2013)	[1]See note below for application.

Method of Control for Firefighters	Details of Method	References	Notes
"Clorox® Germicidal Bleach" 8.25% sodium hypochlorite	Add **¾ gallon** bleach to 1000 gallons of drafted water (~50 ppm sodium hypochlorite). Prepare the mixture at least 5 minutes prior to application for dust abatement, fire suppression, and cleaning vehicles and logging, road building, and maintenance equipment.	Germicidal Healthcare Clorox® label (EPA Reg. No. 5813-100)	

[1] Locate vehicle washing stations (with chlorinated water) where water will not run into streams. When refilling tenders/engines, fill with water first, pull 150' away from the stream (or where overland flow will not run back into the stream), and then add the chlorine. Avoid dropping buckets of or directly releasing chlorine-treated water into streams or wetlands. Don't treat water from streams that are uninfected with the root rot disease, unless it is for use at washing stations (to avoid unnecessary use of chlorine). (Southwest Oregon Interagency Fire Management Plan 2013)

Aquatic Invasive Plants


Purple Loosestrife Photo credit:universityofconn.com


Parrot feather. Photo credit: Aquariussystems.com


Hydrilla. Photo credit: nwdistrict.ufl.edu

General Information:

- **Distribution:** Varies based on species. For most up-to-date information on distribution, please see: https://www.invasivespeciesinfo.gov/aquatics/main.shtml.
- **Habitat:** Aquatic plants are usually confined to shorelines and relatively shallow portions of waterbodies, though plant pieces can float throughout.
- **Fire Activities Posing Risk:** Contact with untreated water; helicopter buckets, snorkels, and other drafting gear that capture bottom sediments, mud, or aquatic plants; internal tanks and hoses that retain residual untreated water.
- **Environmental Effects**: Non-native aquatic plants clog waterways and threaten the diversity and survival of native species.

Disinfection Protocols:

Method of Control for Firefighters	Details of Method	References	Notes
Temperature	HOT WATER PRESSURE WASH: ≥140°F (60°C) for 2 minutes; inspect and re-treat as needed.	Blumer et al. 2009	This study is specific to Eurasian watermilfoil, but lethal temperatures likely comparable for other submerged species.
Mechanical	Scraping, brushing, high pressure washing and mud removal. Some seeds may remain viable after washing, so disposal or filtration of treated water is recommended.	Multiple sources	

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