BUREAU OF RECLAMATION

Inspection and Cleaning Manual for Equipment and Vehicles to Prevent the Spread of Invasive Species

Policy and Programs, Environmental Compliance Division

U.S. Department of the Interior

September 2021

Mission Statements

The Department of the Interior (DOI) conserves and manages the Nation's natural resources and cultural heritage for the benefit and enjoyment of the American people, provides scientific and other information about natural resources and natural hazards to address societal challenges and create opportunities for the American people, and honors the Nation's trust responsibilities or special commitments to American Indians, Alaska Natives, and affiliated island communities to help them prosper.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

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Notice of Availability

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Inspection and Cleaning Manual for Equipment and Vehicles to Prevent the Spread of Invasive Species

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Cover Photo: Pre-cleaning heavy soil accumulations from tractor tracks, quagga mussels covering a penstock gate at Davis Dam, and quagga mussels covering a rope from the Lower Colorado River (Reclamation/Fred Nibling/Dave Arend/Joe DiVittorio, respectively)

Contents

Authorities

Carson-Foley Act of 1968, P.L. 90-583 (Stat. 2671).

Executive Order 13112, entitled Invasive Species, issued February 3, 1999; revised as Executive Order 13751, entitled Safeguarding the Nation from the Impacts of Invasive Species, issued December 5, 2016

Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) of 1947, as amended

Fish and Wildlife Coordination Act of 1934, as amended (FWCA)

Reclamation Act of 1902, as amended

U.S. Department of the Interior's Departmental Manual

517 DM 1: Integrated Pest Management Policy.

https://www.doi.gov/sites/doi.gov/files/elips/documents/517-dm-1.pdf

Provides policy and requirements for Department of the Interior bureaus and offices to incorporate Integrated Pest Management (IPM) into their pest management activities.

524 DM 1: Invasive Species Management.

https://www.doi.gov/sites/doi.gov/files/elips/documents/524-dm-1_0.pdf

Establishes Department of the Interior policy that directs Bureaus/offices to manage the risk of invasive species in their activities, and minimize that risk where applicable and practicable, in cooperation with others as appropriate. This includes helping prevent the introduction, establishment, and spread of invasive species; promoting early detection and rapid response; and providing for eradication and control to minimize adverse impacts, such as impacts to the environment, human health and safety, cultural resources, recreation, infrastructure, and the economy.

Reclamation Manual

ENV PO2 (Policy), Integrated Pest Management and Invasive Species, May 12, 2020

https://www.usbr.gov/recman/env/env-p02.pdf

Reclamation is responsible for the identification and management of pests and invasive species on Reclamation lands and waters at Reclamation-owned facilities in accordance with the Federal, tribal, state and local laws and regulations as applicable. This responsibility is to be fully considered in the development of an IPM/Invasive Species Program

ENV 01-01 (Directives and Standards), Integrated Pest Management and Invasive Species Program, May 11, 2020

https://www.usbr.gov/recman/env/env01-01.pdf

Provides directives and standards (D&S) for the Bureau of Reclamation personnel involved with the implementation of a combined Integrated Pest and Invasive Species Management Program. The benefit of this D&S is to protect Reclamation from the harmful effects of pests and invasive species for the benefit of the American Public.

PEC 10-29 (Directives and Standards), Reclamation Standard Water-Related Contract Articles, Article 29: Pest Management, PEC 10-29, December 21, 2006

https://www.usbr.gov/recman/pec/pec10-29.pdf

This article requires contractors to effectively control undesirable plants and animals on Federal project lands, project waters, and project works for which they have operation and maintenance responsibilities.

Bureau of Reclamation's Acquisition Contract Guide Specifications

This page provides (Reclamation only) access to guide specifications and standard drawings used for preparing Reclamation construction and supply specifications. The guide specification adopts this Inspection and Cleaning Manual as the Reference Standard for equipment and vehicle inspection and cleaning.

intra.usbr.gov/tsc/guidespecs/

Coordination with National-Level Plans

National Invasive Species Management Plan, 2016-2018. National Invasive Species Council, 2016.

https://www.doi.gov/sites/doi.gov/files/uploads/2016-2018-nisc-management-plan.pdf

Aquatic Nuisance Species Task Force 2020-2025 Strategic Plan, Aquatic Nuisance Species Task Force. 2020.

https://www.fws.gov/anstaskforce/Documents/ANSTF-Strategic-Plan-2020-2025.pdf

Quagga-Zebra Mussel Action Plan (QZAP) for Western U.S. Waters, Aquatic Nuisance Species Task Force. 2010. Submitted to the Aquatic Nuisance Species Task Force by the Western Regional Panel on Aquatic Nuisance Species. Updated in 2020

https://www.fws.gov/anstaskforce/QZAP/QZAP_FINAL_Feb2010.pdf

Definition of Terms

Best Management Practice: A practice or combination of practices that is determined to be the most effective and practicable means of preventing or reducing undesirable results.

Cleaning: The physical removal of visible soil, mud, debris, invasive species and their propagules, or other substances that may contain invasive species materials.

Decontamination: The process of complete removal and/or killing all viable invasive species and their propagules from vehicles and equipment.

Desiccation: The state of extreme dryness or the process of extreme drying.

Exotic: Introduced from another country; not native to the place where found.

Flocculation: To cause to aggregate into a flocculent (loosely aggregated particles) mass.

Invasive species: Per 524 DM 1 With regard to a particular ecosystem, a non-native organism whose introduction causes or is likely to cause economic or environmental harm or harm to human, animal, or plant health. Invasive species may include plants, animals, pathogens, and other organisms in terrestrial and aquatic habitats

Invertebrate: Animals without a vertebral column.

Ion: An electrically charged atom or molecule due to the loss (a net positive charge) or gain (a net negative charge) of electrons. Metal ions such as copper and zinc have a net positive electrical charge.

Macrophyte: An aquatic emergent, submerged, or floating plant.

Mollusk (also spelled mollusc): A type of shellfish, such as a clam, scallop, or mussel. Mollusks having two hinged shells are referred to as a bivalve mollusk.

Non-Native Species (also Alien Species). With respect to a particular ecosystem, an organism, including its seeds, eggs, spores, or other biological material capable of propagating that species, that occurs outside of its natural range.

Noxious weed: Any living stage, such as seeds and reproductive parts, of any parasitic or other plant of a kind, which is of foreign origin, is new to or not widely prevalent in the United States, and can directly or indirectly injure crops, other useful plants, livestock, or poultry or other interests of agriculture, including irrigation, or navigation, or the fish or wildlife resources of the United States or the public health. The term is usually defined as part of law, statute, or regulation.

Organism: Any living thing.

Pest: Any organism - with the exception of viruses, bacteria, or other micro-organisms on or in living humans or other animals - which the Administrator (of the U.S. Environmental Protection Agency) declares to be a pest, which is injurious to health or the environment.

Propagate: The biological processes of reproduction; may be sexual or asexual.

Propagule: Any plant material used for the purpose of plant propagation.

Rhizome: A horizontal stem of a plant that is usually found underground, often sending out roots and shoots from its nodes.

Sanitation: Process in which pathogenic microorganisms are reduced in number where they are no longer harmful; usually indicates more than 99.99% of microbes be removed from surfaces.

Species: A group of related organisms capable of interbreeding and producing fertile offspring.

Sterilization: Process in which either inactivates or kills all microorganisms.

Stolon: A specialized type of horizontal above-ground shoot, a colonizing organ that arises from an axillary bud near the base of the plant.

Veliger: The free-swimming immature life stage of a mollusk.

Weed: A native or non-native plant that is unwanted in a particular place at a particular time.

Executive Summary

Procedures have been developed in this manual to address the transport of pest and invasive species through vehicle and equipment movement. This manual provides guidelines for inspecting and cleaning vehicles and equipment to help prevent the spread of pest and invasive species during Bureau of Reclamation (Reclamation) activities. The general types of vehicles and equipment described in this manual are:

- Rubber-tired land vehicles
- Tracked land vehicles
- Personal use equipment
- Construction equipment
- Diving equipment
- Watercraft

The spread of pests and invasive species from one location to another has been linked to the use and movement of contaminated vehicles and equipment. The introduction of the invasive zebra and quagga mussel from the Eastern watersheds of the United States into the Western watersheds is thought to be almost entirely by cross country movement of contaminated watercraft and other equipment, and highlights the importance of inspection and cleaning.

Preventing pest and invasive species spread can be a highly effective tool for limiting the impacts of invasive species to Reclamation's mission. Prevention is typically the most cost-effective management approach because once invasive species become established and widespread, control can require significant and sustained budget expenditures and labor for increased maintenance requirements.

The successful prevention of the spread of invasive species is the goal of all equipment and vehicle inspection and cleaning processes, and is the main purpose of this manual. Prevention actions deny the entry of pest and invasive species into un-infested locations. This factor underpins all vehicle and equipment inspection and cleaning methods to be discussed: through prevention, the spread of these species from one place to another can be limited or eliminated.

Before conducting any equipment inspection or cleaning action, first review the introductory sections at the beginning of this manual. In particular, the Overview of Inspection Procedures and the Overview of Cleaning Procedures sections provide valuable information. In addition, the Inspection-Cleaning Relationship flowchart (Figure 7) is an extremely helpful resource that illustrates the complex tasks of equipment inspection and cleaning. These two overview sections and Figure 7 references other sections of the manual for more in-depth discussion: appendix A for Inspection Standards and appendix B for Cleaning and Decontamination Procedures.

Introduction

This manual provides guidelines for inspection and cleaning of vehicles and equipment that come in contact with pest and invasive species. The information in this manual will help personnel to understand how pest and invasive plants and animals can be dispersed and will provide instructions and recommendations to reduce the risk of spread. Note that inspection and decontamination are only one type of preventative methods used under an integrated pest management (IPM) program. For more information on prevention of invasive species, as well as species-specific information see Reclamation's IPM manual.

Limiting the dispersal of pest and invasive species can be a significant challenge, as organisms can be spread in in numerous ways. For example, soil, mud or debris that may accumulate on undersides of vehicles can carry seeds or viable propagules of pest and invasive plants. Plant or animal propagules are often not easily recognizable by casual inspection, and can become lodged in areas of limited sight and access. Also, the use of watercraft, pumps, in-water tools or instruments, and even waders in waters infested with these species can easily become sources for new infestations. Therefore, it is vital that Reclamation personnel have sufficient training in inspecting and cleaning vehicles and equipment.

This Manual provides an effective self-help resource to personnel for inspection and cleaning of equipment as a primary tool for preventing the introduction of pest and invasive species into un-infested locations.

Spread of Invasive Species

Work and use of equipment or vehicles in natural environments, whether aquatic or terrestrial, presents opportunities for spreading aquatic invasive species. Mature organism or their propagules can become lodged in or on clothing or personal gear, watercraft, construction equipment, trailers, towing vehicles or any other piece of equipment that is used in the field. Since invasive plants can spread from fragments or other specialized vegetative structures as well as seed, special care must be taken to identify and address these issues before leaving a site or water body. Invasive aquatic species, such as the zebra and quagga mussel, can attach easily and survive for extended periods out of the water, requiring thorough inspection and cleaning methods to prevent them from being transported to an un-infested area.

Vehicles and Equipment

Pest and invasive species are often spread when humans move equipment to new areas. A comparison of Figures 1 and 2 illustrate that the most heavily populated traffic routes in the United States correlate with increased zebra and quagga mussel sightings throughout the West. For mussels, the general pattern of infestation is overland transport by watercraft and in-water equipment via the highway system to a water body, then to other connected systems by way of downstream water flow.

Watercraft, land-based vehicles, earth-moving equipment, pumps, trailers, and other equipment are particularly troublesome avenues of spread of invasive organisms. Clothing, shoes, waders, and diving gear can become vectors of spread when personnel leave infested areas that contain soil or mud laden with seed or plant fragments (Figure 3). Invasive species can also be deposited on fuel tanks, wheel wells, and behind the bumpers of vehicles. Pathogens, insects, and other animals can be transported in the same manner.

Watercraft can transport invasive organisms in ballast water or other areas where water is captured. Boat hulls and trailers may also become fouled with invasive mussels or aquatic weeds, which may be able to remain viable for several days or weeks out of water depending on weather conditions.

Land-based equipment can collect plant materials during operations in the field. Tracked vehicles are especially prone to picking up large amounts of soil, mud, and debris, making them more of a challenge to clean than rubber tired equipment. Heavy equipment that accumulates large amounts of soil and debris typically requires physical removal of foreign material before washing. Physical removal of accumulated material (pre-cleaning) before washing operations can help reduce water usage when cleaning certain equipment (Figure 4).

Equipment use might involve not only Reclamation-owned equipment, but also rented equipment and equipment used by contractors and subcontractors. Equipment brought in from other areas may inadvertently introduce contaminated equipment. All Reclamation-owned, managing partner, contractor, subcontractor, and rental equipment used at Reclamation worksites must be inspected, and cleaned if necessary, to ensure that equipment arrives and leaves clean to prevent introduction or spread of pest and invasive species.

Facility Equipment

Many facilities throughout Reclamation share common designs and components. In certain cases where these components are used interchangeably at facilities from one location to another, there is a pathway of invasive species spread, particularly for zebra or quagga mussels. Any parts, components, or equipment such as gates, valves, or pumps that contact raw water and may be used at another facility must be fully inspected and thoroughly decontaminated before transport.

Attention should also be given to testing equipment such as water bags used during crane calibration (Figure 4). Crane testing companies often fill water bags to the corresponding weight for the testing process from local raw water supplies. These bags are typically used at various locations across the country and could potentially be contaminated with invasive species from other locations. If not properly handled, water bags can become a pathway of aquatic invasive species spread.

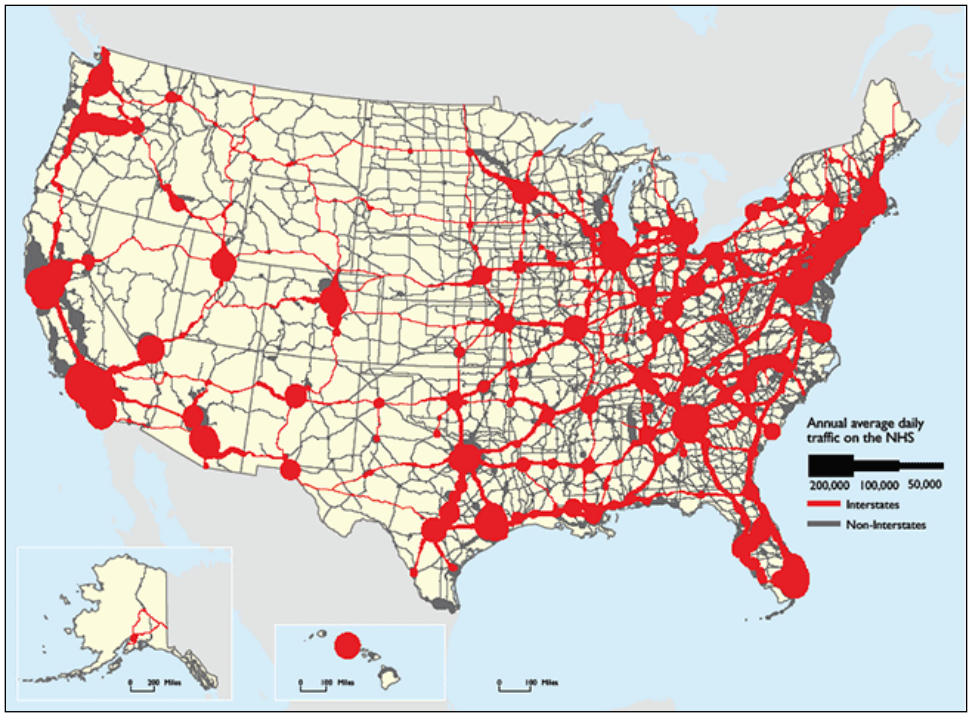

Figure 1. Annual average daily traffic on the National Highway System, 2012 (Bureau of Transportation Statistics).

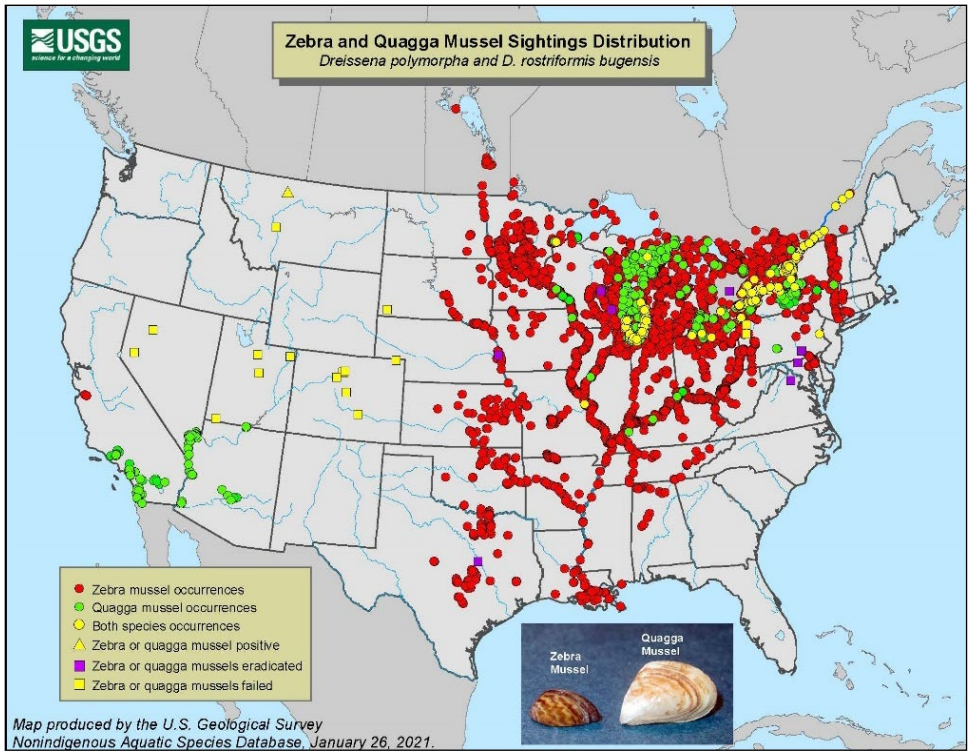

Figure 2. Zebra and Quagga Mussel Sightings Distribution, 2021 (U.S. Geological Survey).

Figure 3. Fragments of hydrilla (*Hydrilla verticillata*) a highly invasive aquatic weed on a boat trailer (Reclamation/Fred Nibling).

Figure 4. Pre-cleaning heavy accumulations of soil from tracked equipment (Reclamation/Fred Nibling).

Figure 5. Crane testing at Glen Canyon Dam using water bags (Imes Inc./Gerry Jarin)

Overview of Inspection and Cleaning Procedures

Prior to beginning any inspection or cleaning procedure, be sure to first review Appendices A and B; see the Inspection-Cleaning Relationship Flowchart for detailed inspection and cleaning pathway actions.

Inspection Overview

Inspection procedures are presented in this manual to systematically address transport of invasive species and pests through various types of vehicle and equipment movement. Personnel may require additional inspection training for specific invasive species and/or equipment types. Inspections should be conducted at multiple stages of the overall process, including prewashing, cleaning, and post-cleaning procedures.

Initial inspections of equipment, especially at field sites, have the potential to overlook enclosed, obscured, or otherwise difficult to access areas. After equipment is pre-cleaned, a more detailed inspection may reveal overlooked soil, mud or other debris potentially laden with invasive species and/or propagules. For example, on rubber-tired and tracked vehicles inspections should be conducted under wheel wells, behind bumpers, on radiators, on tracks, and above drivetrain belly pans.

Each specific piece of equipment may have its own particular requirements for inspection, although there are many common design features prone to accumulating foreign material. Vehicles may appear to be clean upon casual inspection, but closer examination may reveal hidden deposits (e.g. see Figure 6). Casual observation will not address hidden areas of concern.

Appendix A contains more detailed information on inspection standards and protocols, including watercraft, in-water equipment, and facility equipment that have specific inspection requirements.

Cleaning Overview

This section briefly discusses the procedure for cleaning vehicles and equipment which can be used in the field or other designated cleaning areas. Appendix B contains more detailed information on cleaning and decontamination, as well as recommendations for selecting a wash down location. Equipment of all types should be cleaned at the location of last use before being moved to a new location. Watercraft, other in-water equipment, and facility equipment have specific cleaning needs and will be covered more extensively in appendix B.

Mechanical pre-cleaning of heavy accumulations of debris with appropriate tools ("dry" cleaning) will save time and water usage during subsequent inspection and washing operations. After pre-cleaning is completed, effective cleaning to eliminate invasive species materials and prevent their spread can be accomplished by thoroughly removing soil and debris using pressurized water. In certain situations, cleaning with compressed air rather than water may be necessary to prevent damage to areas such as electrical equipment and vehicle cabs.

Figure 6. Invasive snails attached to the inside of a vehicle tire (U.S. Army Corps of Engineers/Al Cofrancesco).

Effective elimination of viable invasive species, including larvae and/or propagules may require heated water or chemical treatment in some cases. Use of chemical treatments may pose disposal

and wastewater concerns; local standards for waste disposal must be followed. In addition, states may require certification or licensing for personnel who use chemical treatments for these purposes.

Despite very careful efforts to capture and quarantine materials from cleaning operations, on-site spread of invasive species may occur. For example, perimeters of remote cleaning areas may benefit from silt fencing to filter wash water when cleaning certain kinds of equipment, which would cause invasive propagules to accumulate at the base of the fencing. Part of the cleaning process should involve inspecting such areas for new infestations and using appropriate control methods early to prevent additional spread.

Personal Protective Equipment

Using cleaning and disinfectant chemicals, power washers, air compressors, and other types of cleaning equipment may present unique working hazards. Personal protective equipment (PPE) items to protect such things as hearing, skin, eyes, and respiration may be required. For example, certain types of cleaning equipment may require electrical power and may present electrical hazards to the operator, and power washers that operate at very high pressures and are capable of causing serious bodily injury. Personnel who use equipment during cleaning operations are responsible for acquiring and properly using PPE.

- Users of all cleaning equipment must become completely familiar with operating the equipment before attempting its use.
- Not only must the user be familiar with inspection and cleaning equipment, but also with the equipment item to be inspected and cleaned.
- Consult all appropriate information sources and follow all manufacturers' guidelines and notices, as well as Reclamation Safety and Health Standards: https://usbr.gov/safety/rshs/index.html

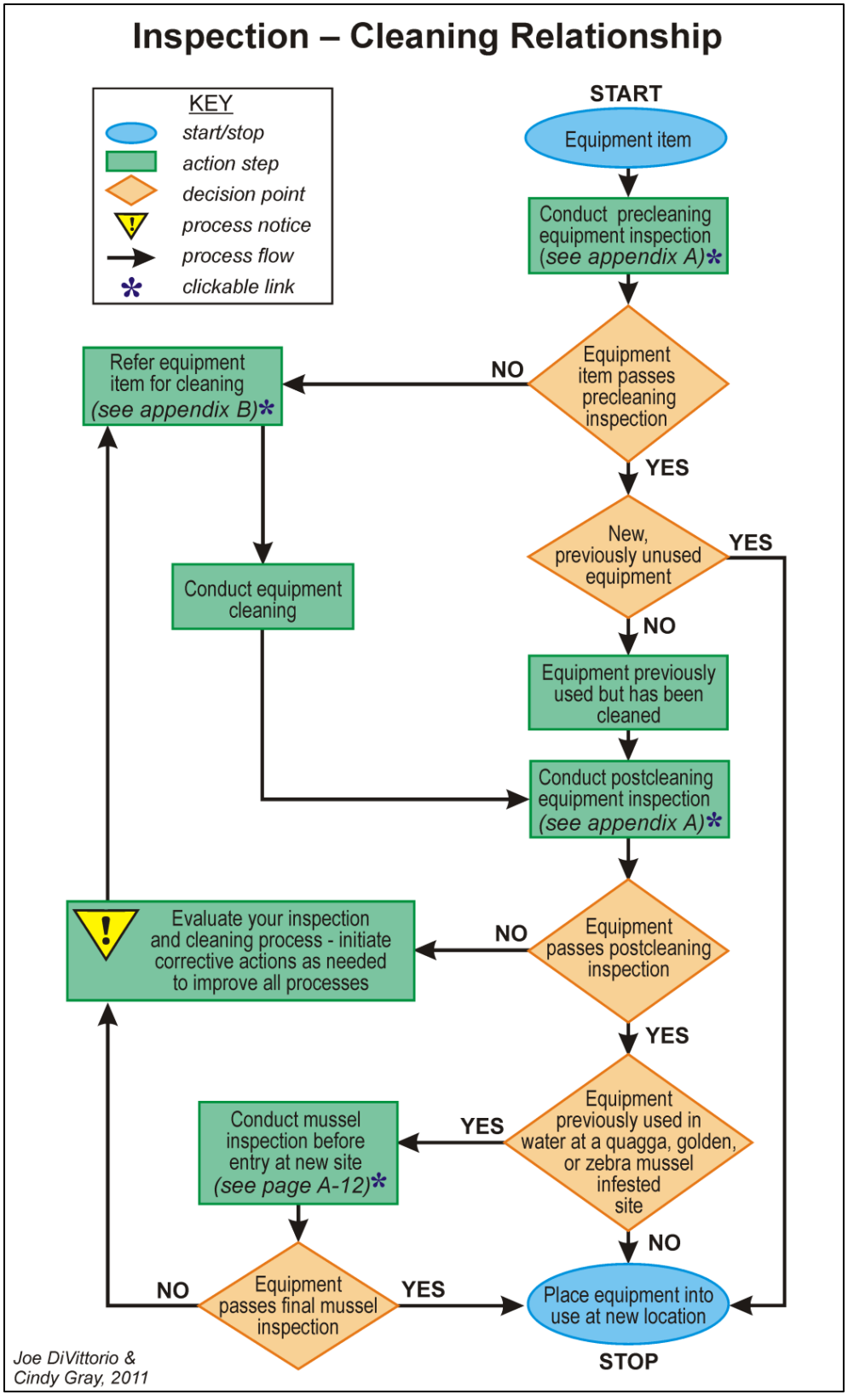

Figure 7. Inspection-cleaning relationship flowchart (Reclamation/Joe Divittorio and Cindy Gray).

Resources

Federal

Aquatic Nuisance Species Task Force

2020-2025 Strategic Plan, Aquatic Nuisance Species Task Force. 2020.
https://www.fws.gov/anstaskforce/Documents/ANSTF-Strategic-Plan-2020-2025.pdf

Bureau of Reclamation

Integrated Pest Management and Invasive Species Program, Reclamation Manual, Directives and Standards. ENV 01-01, 05/11/2020.
https://www.usbr.gov/recman/env/env01-01.pdf

Integrated Pest Management Manual, June 2009.
https://www.usbr.gov/mussels/docs/IPM_Manual_08_2019.pdf

National Invasive Species Council

National Invasive Species Management Plan, 2016-2018. National Invasive Species Council, 2016.
https://www.doi.gov/sites/doi.gov/files/uploads/2016-2018-nisc-management-plan.pdf

U.S. Army Corps of Engineers

Cofrancesco, Jr., A.F., D.R. Reaves, and D.E. Averett. 2007. Transfer of Invasive Species Associated with the Movement of Military Equipment and Personnel. U.S. Army Corps of Engineers – Engineer Research and Development Center.

State

Arizona Game and Fish Department

Pull the Plug on Mussels brochure
https://azgfd-portal-wordpress-pantheon.s3.us-west-2.amazonaws.com/wp-content/uploads/archive/PullThePlugOnMussels_Brochure11-2017.pdf

Watercraft Inspection Contacts
https://s3.amazonaws.com/azgfd-portal-wordpress/PortalImages/files/fishing/InvasiveSpecies/Rack%20Card%20Watercraft%20Inspection%20Contacts.pdf

California Department of Fish and Wildlife

Watercraft Inspection Programs in California Contact Information
https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=46843&inline

Check Station Map from CDFA
https://www.cdfa.ca.gov/plant/PE/ExteriorExclusion/borders_map.html

Guidance for Developing a Dreissenid Mussel Prevention Program
https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=140345&inline

Aquatic Invasive Species Decontamination Protocol
https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=43333&inline

Colorado Parks and Wildlife:

Boater's Guide to Aquatic Nuisance Species (ANS) Inspections
https://cpw.state.co.us/Documents/ANS/BoatersGuideToANS.pdf

ANS Program Fact Sheet
https://cpw.state.co.us/Documents/ANS/Fact-Sheet_ANS-Program.pdf

Boat Interdictions Fact Sheet
https://cpw.state.co.us/Documents/ANS/Fact-Sheet-ZQM-Boat-Interdictions.pdf

Idaho Invasive Species Council

Preparing to Meet the Challenge: An Assessment of Invasive Species Management in Idaho
https://idfg.idaho.gov/old-web/docs/wildlife/planInvasiveSpecies.pdf

Kansas Department of Wildlife and Parks

Aquatic Nuisance Species
https://ksoutdoors.com/Fishing/Aquatic-Nuisance-Species

Invasive Species in Kansas
https://defenders.org/sites/default/files/publications/kansas.pdf

Montana Fish, Wildlife and Parks

Clean Drain Dry
https://fwp.mt.gov/conservation/aquatic-invasive-species/what-you-can-do

Watercraft Inspections
https://fwp.mt.gov/conservation/aquatic-invasive-species/watercraft-inspection-stations

Nebraska Game and Parks

Invasive species info
http://outdoornebraska.gov/invasivespecies/

Nebraska Invasive Species Program
https://neinvasives.com/stop-aquatic-hitchhikers

Nevada Department of Wildlife

AIS Decal Brochure
http://www.ndow.org/uploadedFiles/ndoworg/Content/Wildlife_Education/Publications/AIS-Decal-Brochure.pdf

New Mexico Department of Game and Fish

Aquatic Invasive Species information
https://www.wildlife.state.nm.us/fishing/fishing-regulations/aquatic-invasive-species/

North Dakota Game and Fish

Aquatic Nuisance Species
https://gf.nd.gov/ans

North Dakota Aquatic Nuisance Species Management Plan
https://gf.nd.gov/gnf/fishing/docs/ndansmgmtplan.pdf

Dock and Boat Lift Cleaning Recommendations
https://gf.nd.gov/gnf/fishing/docs/ans-docks-boat-lifts.pdf

Oklahoma Department of Wildlife Conservation

Oklahoma Aquatic Nuisance Species Management Plan
https://www.wildlifedepartment.com/fishing-old/ans/ANS_plan.pdf

Oregon Invasive Species Council

Clean Drain Dry Aquatic Invasive Species Campaign
https://www.oregoninvasivespeciescouncil.org/clean-drain-dry

South Dakota Game, Fish and Parks

Aquatic Invasive Species Strategic Management Plan
https://sdleastwanted.sd.gov/docs/ais-management-plan.pdf

Texas Parks and Wildlife

Invasive Aquatic Species
https://tpwd.texas.gov/education/hunter-education/online-course/wildlife-conservation/invasive-aquatic-species

Utah Division of Wildlife Resources

Aquatic Invasive Species
https://wildlife.utah.gov/fishing/invasive-mussels.html

Washington Department of Fish and Wildlife

Preventing the Spread of Invasive Species
https://wdfw.wa.gov/species-habitats/invasive/prevention

Wyoming Game and Fish Department

Watercraft Inspection and Decontamination Frequently Asked Questions
https://wgfd.wyo.gov/FAQ/Watercraft-Inspection-FAQ

AIS Inspection Locations
https://wgfd.wyo.gov/Fishing-and-Boating/Aquatic-Invasive-Species-Prevention/AIS-Inspection-Locations

Non-Governmental Organizations

Stop Aquatic Hitchhikers

Clean Drain Dry Procedure
https://stopaquatichitchhikers.org/prevention/

Western Regional Panel

Quagga-Zebra Mussel Action Plan (QZAP) for Western U.S. Waters, Aquatic Nuisance Species Task Force. 2010. Submitted to the Aquatic Nuisance Species Task Force by the Western Regional Panel on Aquatic Nuisance Species.
https://www.fws.gov/anstaskforce/QZAP/QZAP_FINAL_Feb2010.pdf

Wildlife Forever

Clean Drain Dry Initiative
https://www.wildlifeforever.org/home/invasive-species/

Citations

Crystal-Ornelas, R., Hudgins, E.J., Cuthbert, R..N., Haubrock, P.J., Fantle-Lepczyk, J., Angulo, E., Kramer, A.M., Ballesteros-Mejia, L., Leroy, B., Leung, B., Lopez-Lopez, E., Diagne, C., and F. Courchamp. 2021. Economic costs of biological invasion within North America. NeoBiota. 67: 485-510.

Pimentel, D., L. Lach, R. Zuniga, and D. Morrison. 2000. Environmental and Economic Costs of Nonindigenous Species in the United States. Bioscience 50: 53-65.

Appendix A: Inspections

Prior to beginning any inspection or cleaning procedure, be sure to review the "Overview of Inspection Procedures" section, Figure 17, and applicable portions of Appendix

Equipment and vehicle inspections must include all areas, including areas difficult to reach and see. Effective inspections also require persons who have the task of inspecting vehicles, equipment, and personnel to be dedicated and accountable for their actions. Personnel must be trained to look for problem areas that are not apparent upon casual observation, and in the use systematic techniques and checklists to ensure thorough and inspections are conducted. This manual provides overview information, general guidelines, and some best practice information, but should not be considered a substitute for training specific to the equipment, vehicles, and species of interest.

Training for watercraft inspection is available from several sources, including:

Pacific States Marine Fisheries Commission
http://www.psmfc.org/

Western Aquatic Invasive Species Resource Center
https://www.westernais.org/overview-and-glossary-of-terms

Some states may also offer training programs for inspection and decontamination of invasive species.

How to Inspect

Inspections should be carried out on personal gear, equipment, and vehicles at a staging area dedicated to equipment and vehicle cleaning. Pre-cleaning inspections can identify problem areas and determine whether hand removal of large accumulations of soil and debris is necessary before washing. Post-cleaning inspections can verify that all materials deemed capable of spreading invasive species have been eliminated.

Include an inspection process for vehicles and equipment that arrive onsite from other areas. Equipment from rental agencies, outside contractors, and managing partners are subject to inspection as well.

Appropriate equipment needed for inspections may include flashlights, extendable and under-vehicle mirrors, magnifying glass, PPE, remote probe viewer or digital cameras, various hand tools, checklists of invasive species likely occurring at site of last equipment use, and portable lighting.

Inspection Sites

Contingencies should be made to deal with inspections in adverse site conditions, such as inclement weather, field emergencies, and other unknown factors which would hamper the ability to perform

rigorous inspections. Protocols for dealing with contingencies should be defined and included in the inspection process documentation.

Equipment Use

Equipment used at certain worksites may demand more, or sometimes less, stringent inspection attention than at other worksites, depending on site-specific conditions. Consider the following scenarios as examples:

Scenario 1. Since most weed plant reproductive structures are found in the topsoil, when working in a borrow site where topsoil is stripped and only subsoil or gravel remains, it would be less likely that vehicle movement out of such an area would be contributing significantly to the spread of weeds. Inspections or vehicles and equipment may not need to be as rigorous in such a situation as compared to Scenario 2, but should still be conducted in some manner.

Scenario 2. Equipment used at a location known to be infested with a high risk invasive species should undergo vigorous inspection, followed by thorough cleaning and a final inspection before being moved off the worksite. At the new worksite location, the equipment should be inspected again, preferably by someone other than the original inspector before the equipment is placed into service. This situation would be especially true for watercraft or in-water equipment previously used in zebra or quagga mussel infested waters.

The above scenarios are highly situational, as will be the decisions to be made by the individual in actual field locations. Careful review of the potential for spread should be conducted by knowledgeable personnel, and the level of inspection as well as the location of inspection staging areas should be determined on a case by case basis. Inspections may not be necessary when moving between nearby sites that are infested with the same invasive species, but should be performed before leaving the site.

Inspection Protocols for Personal Gear

Personal gear should be inspected for:

- Seeds, plant material, soil, mud, insects, and other invertebrates.
- Snails, mussels, algae, aquatic plant fragments, and other aquatic species.

For equipment in contact with raw water, inspect for zebra and quagga mussels. Look for presence of adult mussels and feel surfaces by hand for very small juvenile mussels.

Clothing, hats, socks, shoes, gloves, and jackets should be thoroughly inspected for above-listed materials. Pockets should be turned inside out to remove debris. Shoelaces and shoe tongues should be checked.

Upon inspection, pre-clean personal gear by physical removal of contaminated material with a stiff brush, lint remover, compressed air, or pressurized hot water.

Specific Areas of Concern

Particular attention must be given to places where foreign material could become accidentally trapped, such as in the cuffs and folds of clothing, treads of boots or waders, or closures such as zippers or ties.

Closures:
Zippers, belts, laces or ties, buckles, straps, Velcro grips, buttons/snaps/fasteners, and rivets.

Loose Particle Fabric:
Canvas, nylon, cotton, poly blend, wool, fleece, netting, and suede.

Other:
Socks and ankle grips, treads of footwear, cuffs and folds, seams, flaps, pockets, collars and hoods, and ventilation openings.

Inspection Protocols for Watercraft

Watercraft and trailers can be major contributors to the spread of invasive aquatic plants and animals. New infestations of exotic aquatic plants and animals are often first discovered near boat ramps and marinas. Detailed inspections must be made before watercraft, trailers, and facility equipment in contact with raw water are moved from one water body to another.

Zebra mussels and quagga mussels can be a difficult inspection problem. Plant materials are likely to be more easily visually identified; however, juvenile mussels can be as small as 1 millimeter or less and can be very difficult to visually identify. Do not rely on visual inspection alone for juvenile mussels; they can be detected by feel along all surfaces and inside holes and crevices. On a smooth surface, juvenile mussels will feel gritty, like sandpaper. As the juvenile ages and grows it may become more easily to visually identify, but may only appear as a nondescript speck. Adult mussels are much more easily seen (Figure A-1).

Step-by-step procedures for watercraft inspections have been developed by the Aquatic Nuisance Species Task Force (https://www.fws.gov/anstaskforce/default.php). The procedures are structured for staff at state inspection stations, and may not apply in their entirety to all situations, but provide best practices for watercraft inspection. General components of the inspection procedures are summarized here.

- Consider putting chocks under the wheels of the vehicle and the trailer to prevent boats or the trailer from rolling or moving during inspection.
- Look over (visual) and feel (tactile) the entire watercraft on both sides of hull and trailer.
- Physically inspect all through-hull fittings
- Check trailer bunks or rollers, tire wells, lights and electrical.
- Remove any plants or plant fragments that are present and dispose of properly.
- Check to see if the bilge plug(s) are installed. If it is installed, check for water in bilge prior to removing the plug.
- If it is installed, ask the boater to remove the bilge plug away from the water to allow draining.

- Physically and visually inspect the bilge area and use a flashlight to visually see if any AIS or standing water are present.
- If applicable, activate the bilge pump.
- If the watercraft has an inboard engine, be certain to carefully inspect the prop, prop shaft and rudder.
- Inspect intakes for ballasts, engines, and other interior compartments.
- Note: Through hull intakes and discharge ports will be a good indicator that more complicated systems may be on board.
- Visually and physically inspect the engine with a flashlight when it is in trailer mode (up).
- Lower the outboard or inboard/outboard.
- Visually and physically inspect the gimbal area of the outboard or inboard/outboard with a flashlight.
- Visually and physically inspect the transom or rear of the boat and any attached instruments including but not limited to pitot tubes, trim tabs, transducers, etc.
- Raise the drive unit to avoid damage during transport.
- Visually and physically inspect the anchor and rope or chain for mud, plants, and or ANS.
- Ensure all water related equipment is clean and dry including but not limited to bait buckets, water toys, fenders, auxiliary pumps, etc.

Drain and Check Interior Compartments

For larger craft, you will need to get into the watercraft to inspect interior compartments that could hold standing water (e.g. live wells). For smaller craft, you may be able to see without entering the watercraft. Ensure that the watercraft is drained to the best of your ability.

- Open up compartments so you can see all bait wells, live wells, equipment lockers and verifiable ballast tanks.
- If the watercraft has standing water in the bait well or in any container, remove standing water from the watercraft using a pump, sponge, or towel. If the watercraft can't be drained, it should be decontaminated.
- If the watercraft has a ballast system, inspect for standing water.
- Activate all discharge pumps and open any water restricting gates for the ballast system
- Inspect any accessible ballast tanks/bags through ballast ports
- If the watercraft has an inboard or inboard/outboard engine, inspect the engine compartment and its bilge. Run the bilge pump, if applicable. These engines do not drain fully and may require standing water decontamination prior to launching.
- Remove and inspect any sea strainers, re-install the strainers following inspection.
- Ensure the drive unit has been raised to avoid damages during transport.
- Ensure all inspectors are finished looking at the watercraft and that nothing was found.

Figure A-1. Adult quagga mussels covering a rope from the Lower Colorado River. It is likely this rope also contains unseen juvenile mussels (Reclamation/Joe DiVittorio).

Amphibious and Aquatic Vehicles

Inspection of amphibious and other aquatic vehicles should be conducted following guidelines for both watercraft and land based vehicles. Inspect bilge compartments, raw water holding tanks such as ballast water tanks, wet and live wells, propellers, trailers, anchors, chains, ropes and ties, tread mats, and traction grids.

Outboard Engine Watercraft

General Considerations:

- **LOOK** for attached adult mussels on all surfaces, especially at the bottom drain holes, propellers, cooling water intake ports, and motor mounts.
- **FEEL** by hand for attached juvenile mussels on all surfaces.
- **CHECK** all components, such as the hull, in live wells, motor, axle, dock line, trailer lights, rollers, runners, and any other parts in contact with water.

Inboard/Outboard Engine Watercraft

Look especially at propeller, steering components, cooling water intake ports, and under trim tabs.

Inboard Engine Watercraft

Look especially at trim tab, rudder, crevices, water intake ports, propeller, and input cap.

All Watercraft Engines

If the watercraft engine is not a closed cooling system configuration (if the engine intakes its cooling water from the environment), the following applies. Although it may seem counterintuitive, it is possible for zebra and quagga mussels to live inside the cooling system of watercraft engines and become a source of contamination when it is operated in un-infested waters. Mussel veligers can enter the engine cooling system through the cooling water intake, become attached inside the system, and grow into the adult (reproductive) life stage mussels. The mussels can survive on the "cool" side of the cooling system - that portion of the cooling system beginning at the water intake ports flowing to the engine's water jacket (heat exchanger - for the long term in between uses (Figures A-2 and A-3).

At the water jacket, engine heat is transferred to the cooling water. Now heated to at least 140 °F, the circulating cooling water is on the "hot" side of the cooling system - from the water jacket to the water outlet ports - where the heated cooling water will kill any mussels present (figure A-4). See appendix B for specific decontamination procedures for watercraft engines.

Figure A-2. Closeup view of outboard motor shaft housing with adult quagga mussels living inside the engine (Pacific States marine Fisheries Commission/Wen Baldwin).

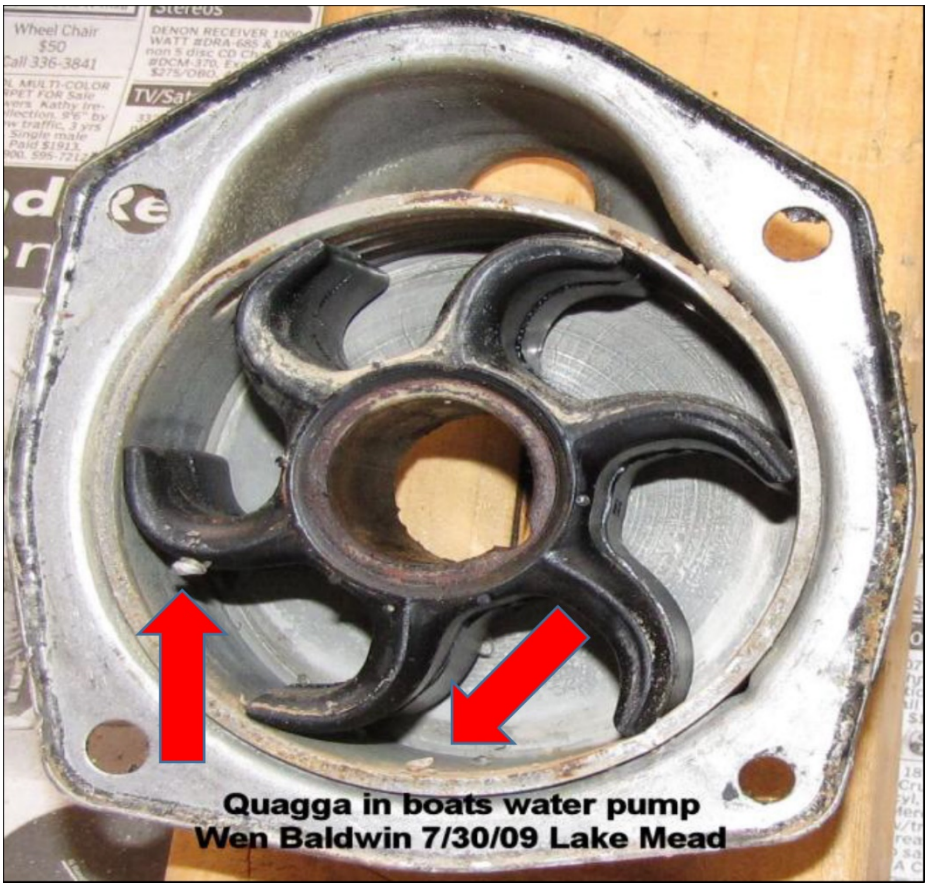

Figure A-3. Adult quagga mussels found living inside a disassembled watercraft engine water pump (Pacific States marine Fisheries Commission/Wen Baldwin).

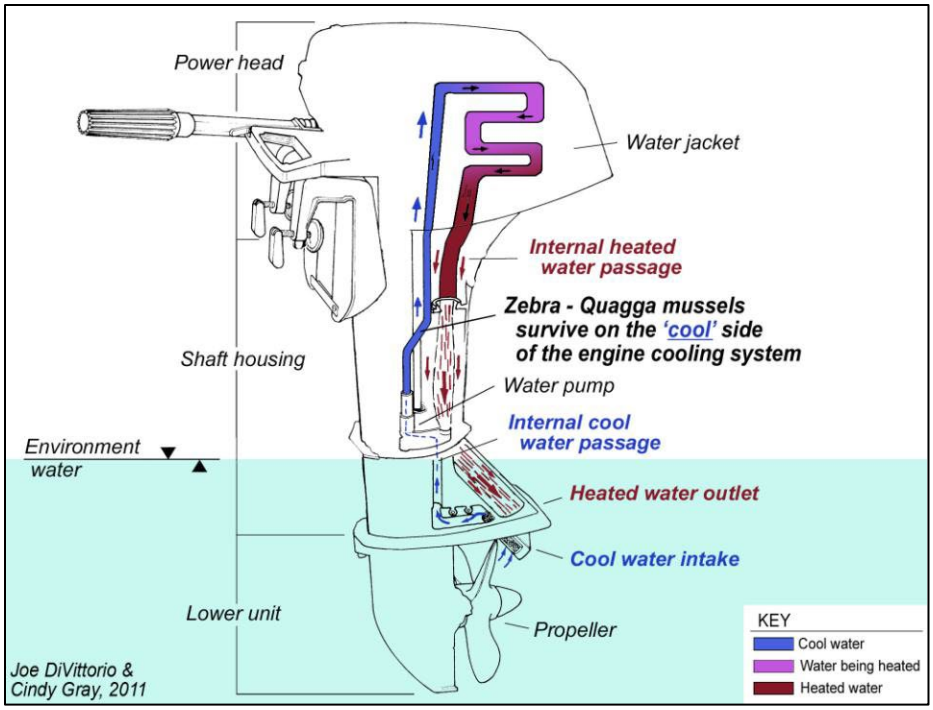

Figure A-4. Simplified cooling system of an outboard motor (Reclamation/Joe DiVittorio and Cindy Gray).

Inspection Protocols for Facility Equipment

Water Bags Used for Crane Testing, and In-Water Construction and Maintenance Equipment

Inspect facility equipment and in-water construction equipment in much the same way watercraft would be inspected.

Be sure to inspect all equipment that comes into contact with raw water. Any equipment item that has been in contact with raw water has the potential to become the source of contamination if it is placed into service at a new location. Remember that both adult and veliger life stages of mussels can hide in inconspicuous equipment recesses. A thorough inspection is necessary using the following points:

If equipment is used at a location known to be infested with an invasive species, the equipment should undergo a pre-inspection, followed by thorough cleaning and a post-cleaning inspection, before being moved off the worksite.

At the new location, the equipment should be inspected again, preferably by someone other than the original inspector before the equipment is placed into service.

If, on re-inspection, contamination is found on the equipment, do not allow the equipment entry on the new worksite; either return the equipment to the location of last use for additional cleaning or arrange for cleaning at a location that is specifically designed for equipment cleaning.

Inspect all waterway maintenance equipment (Figure A-5) in much the same way watercraft, or rubber-tired and tracked vehicles would be inspected. Look for any vegetation, soil, mud or water held in or on equipment after use. Follow the Clean, Drain, and Dry decontamination procedures detailed in appendix B.

Figure A-5. Equipment can become contaminated with pest and invasive species during field work. Contaminated equipment can spread these species to un-infested sites. Inspect and clean equipment before moving to a new work location.

Inspection Protocols for Rubber-Tired and Tracked Vehicles

The following is a suggested inspection protocol for vehicles that have been exposed to invasive weed material. In the field, all vehicles should be inspected and all visible material should be removed.

Specific Areas of Concern

Particular attention must be given to places where foreign material could become accidentally trapped, such as in cracks and crevices, in undercarriages, and in the treads of tracks or tires (Figure A-6). The following is a list of areas that warrant special attention and where plant material could most easily become lodged.

Figure A-6. A packrat nest constructed around the disk brake inside the front wheel of a vehicle. The major nest building material is straw, which was being used as a soil erosion control treatment at a nearby construction site (Reclamation/Joe DiVittorio).

Photos of specific types of vehicles illustrating potential problem areas for transporting invasive species are provided on the following pages (Figures A-7 through A-15).

Rubber Tired Land Vehicles

- Crevices in upper surface and panels
- Tires, rims, and fender wells
- Spare tire mounting area
- Bumpers
- Front and rear quarter panels
- Around and behind grills
- Bottom of radiator vent openings

- Brake mechanisms
- Transmission
- Stabilizer bar
- Shock absorbers
- Front and rear axles
- Beds
- Suspension units
- Exhaust systems
- Light casings and mirrors

Tracked Land Vehicles

- Crevices in upper surface and panels
- Top of axles and tensioners
- Support rollers
- Between rubber or gridded areas
- Beneath fenders
- Hatches
- Under casings
- Grills

Interiors of All Vehicles

- Beneath seats
- Beneath floor mats
- Upholstery
- Beneath foot pedals

Typical Rubber Tired Land Vehicle Problem Areas

- Inside the cab, underneath the edge of the floor mats
- Underneath the seat.
- On top or around the spare tire/spare tire compartment
- The rear bed.
- Hood vents
- Front of the grill and tray under the radiator.
- Rear bumper area, especially behind the U-shaped protective tail light plate, electrical wiring.
- Ledges underneath the bumpers, front and rear quarter panels.
- Above the plastic protective plate behind the vehicle‘s front tires.
- Fuel tank filler tube where it enters the vehicle body.
- On top of the fuel tank protector.
- Shackles on stabilizer bar.
- Bottom of the shock absorbers where they join the axles.
- Top of the brake calipers or between the brake drums and the rim of the wheel.
- On top of the front suspension components.
- On top of the transmission.

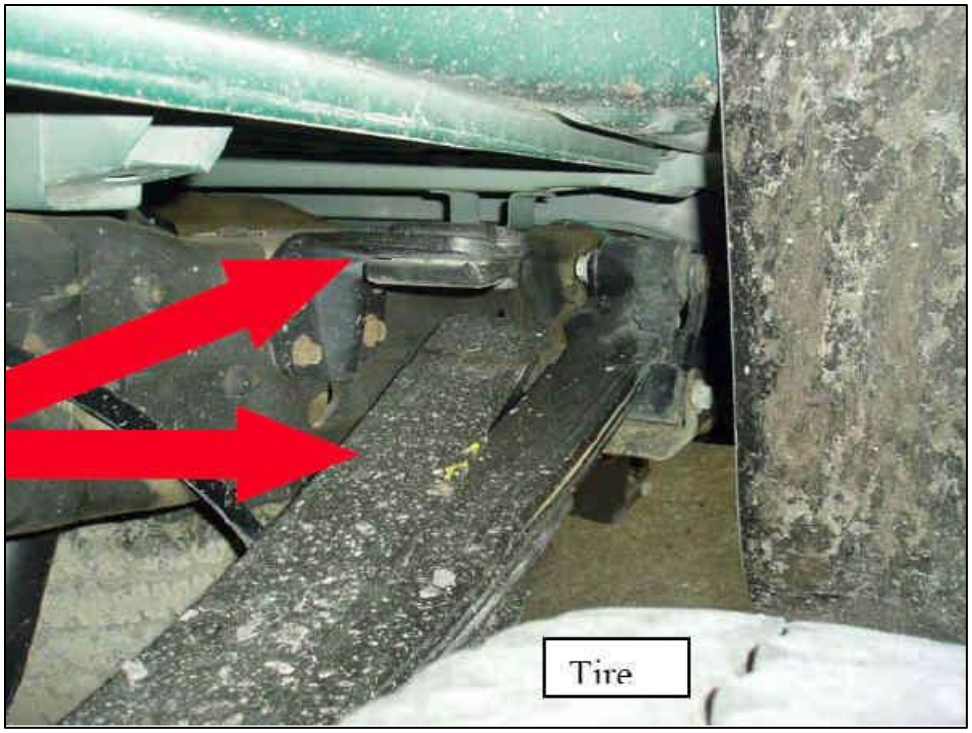

Figure A-7. Wheel well of a pickup (U.S. Department of Defense).

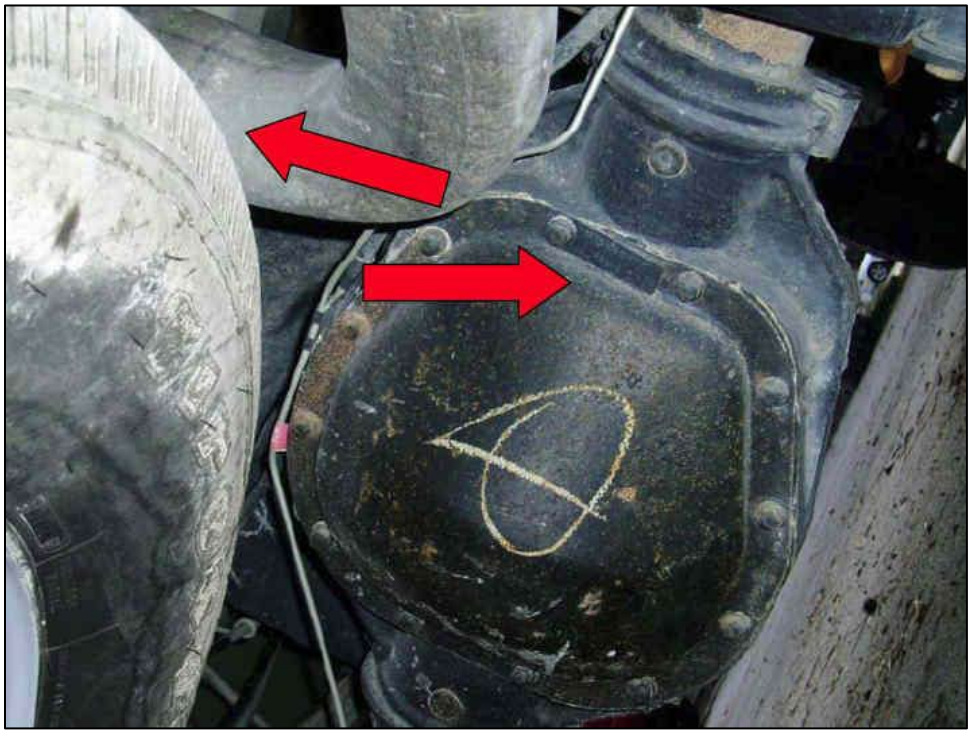
Figure A-8. Rear differential (undercarriage) and spare tire (U.S. Department of Defense).

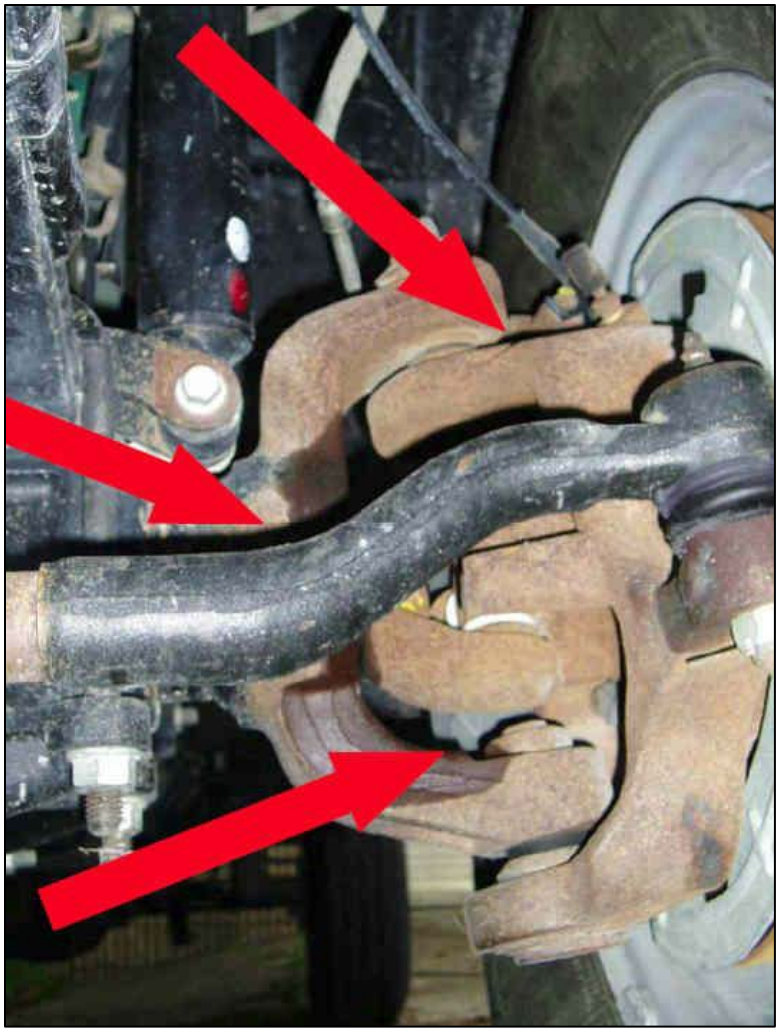

Figure A-9. Front wheel, spindle and kingpin (U.S. Department of Defense).

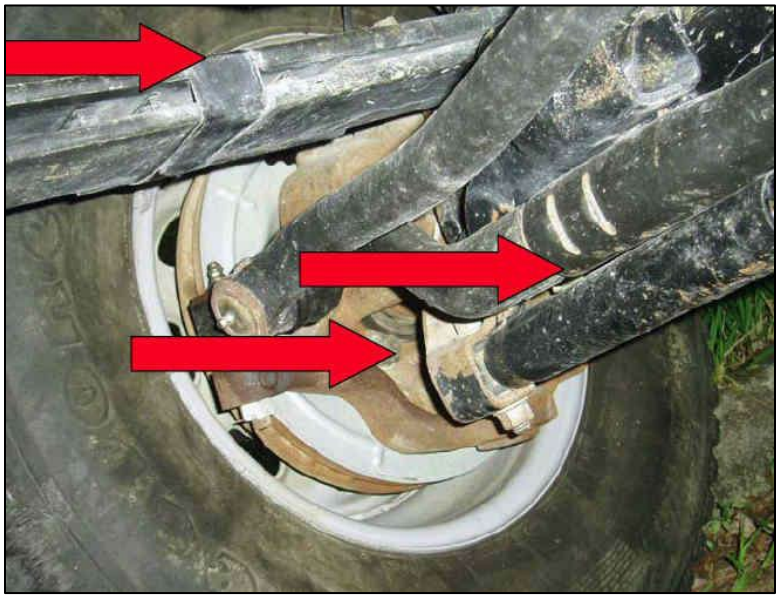

Figure A-10. Front spindle and steering cross tube (U.S. Department of Defense).

Figure A-11. Cowl under windshield and all engine compartment components (U.S. Department of Defense).

Tracked Land Vehicles

Figure A-12. All tracked land vehicles share many common components such as tracks, rollers, idlers, tensioners, and sprockets (U.S. Department of Defense).

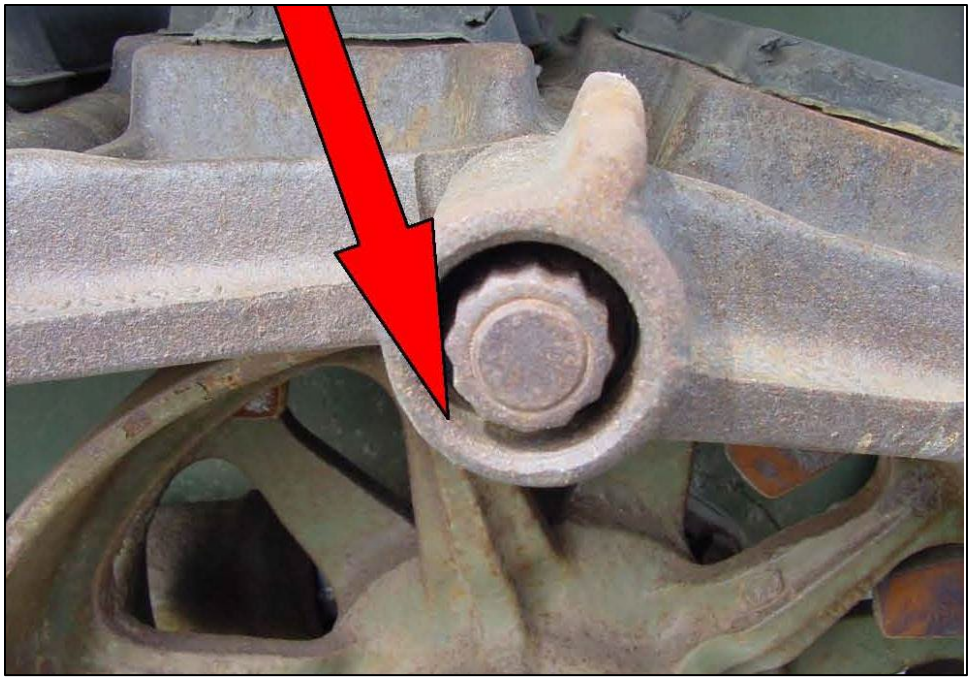

Figure A-13. Typical track plate link pin (U.S. Department of Defense).

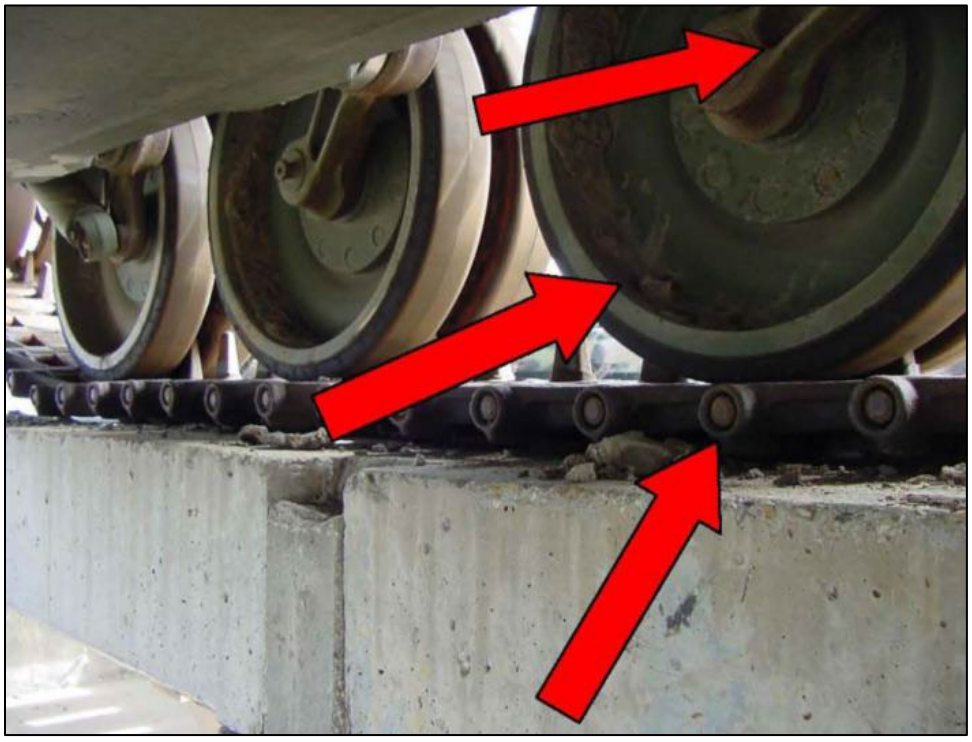

Figure A-14. Inner view of track roller, roller support, and track (U.S. Department of Defense).

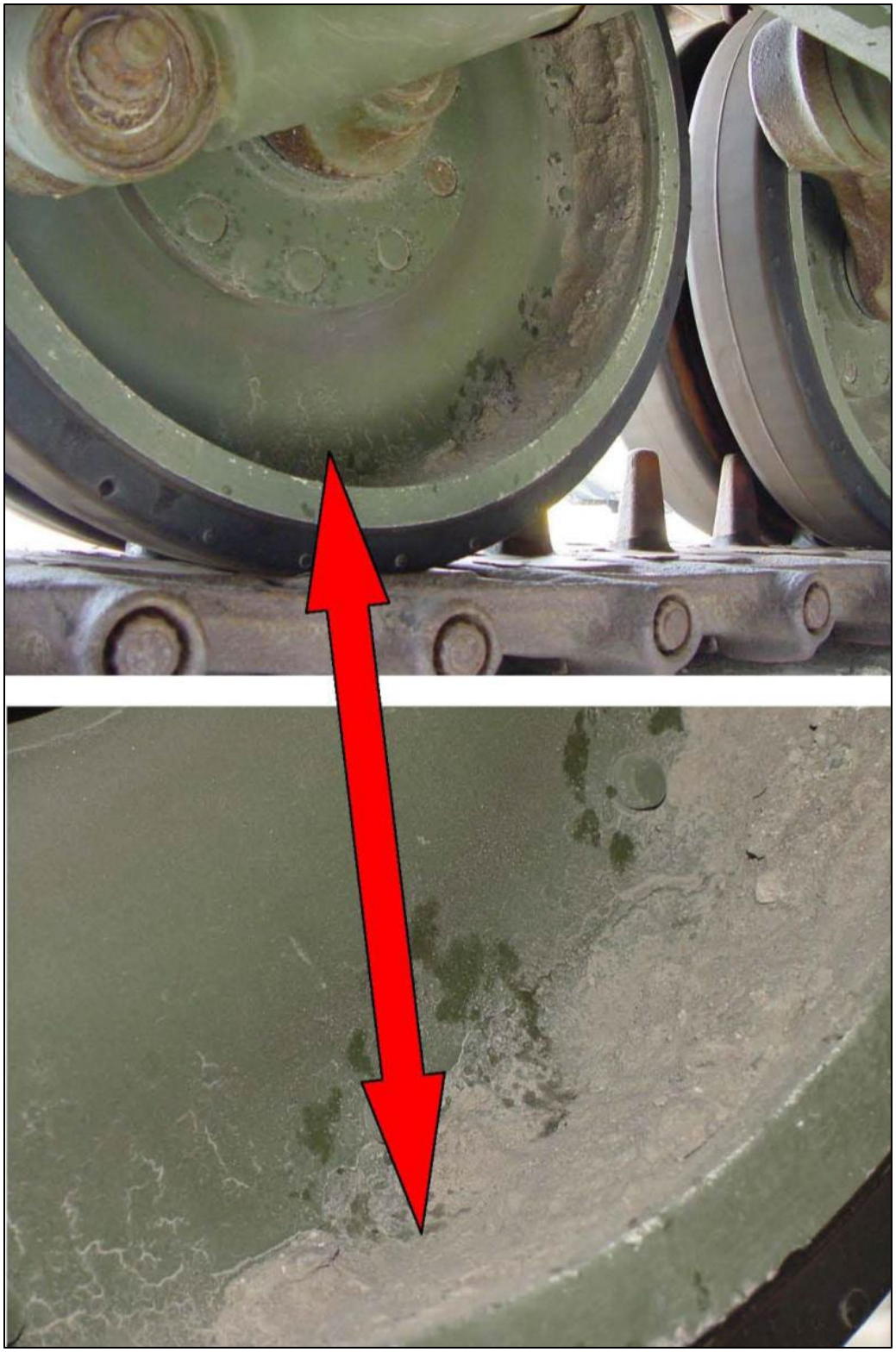

Figure A-15. Inner view of a track roller, post-cleaning inspection on a previously cleaned vehicle noted remaining mud accumulation (U.S. Department of Defense).

References

Colorado Parks and Wildlife, Official State Watercraft Inspection and Decontamination (WID) Protocols and Procedures. https://cpw.state.co.us/Documents/ANS/WIDStudentCurriculum.pdf

Pacific States Marine Fisheries Commission. 2008. Watercraft Inspection and Decontamination Training. Video presentation produced in conjunction with the U.S. Fish and Wildlife Service and Washington Department of Fish and Wildlife. http://www.aquaticnuisance.org/wordpress/wp-content/uploads/2014/06/Inspection_and_Decontamination.mp4,

Zook, Bill, and Stephen Phillips. 2009. Recommended Uniform Minimum Protocols and Standards for Watercraft Interception Programs for Dreissenid Mussels in the Western United States. Pacific States Marine Fisheries Commission, prepared for the Western Regional Panel on Aquatic Nuisance Species, September 2009.

Appendix B: Cleaning and Decontamination Procedures

Prior to conducting a cleaning or decontamination action, be sure to review the "Overview of Inspection Procedures" and the "Overview of Cleaning Procedures" sections, as well as Appendix A.

Cleaning and Decontaminating Personal Gear

Pre-cleaning Methods

Brushing

Used in conjunction with other physical removal methods such as vacuuming, or when in the field, this method is considered moderately effective in removing the majority of plant material from clothing, footwear, or other personnel gear. The use of a brush will remove most surface soil, plant material, and foreign matter from clothing. If there is a nap, brush with the nap rather than against it. Brushing against the nap could further embed small seeds into the weave of fabric. A combination of soft and stiff bristles of varying length is recommended for footwear and tread, while medium length and stiffness is desired for removal of soil and other matter from clothing. Follow brushing with a water wash.

Vacuuming

Vacuuming clothing with a brush attachment is suggested to remove most loose particle matter, but care should be given as small seeds may become embedded in materials. To prevent contained plant and soil matter from being redeposited or re-dispersed following the cleaning process, collected matter should be double bagged and disposed of in a sanitary landfill. Follow vacuuming with a water wash.

Adhesive Rollers

Used in conjunction with other physical removal methods such as brushing or vacuuming, or when in the field, this method is considered to be moderately effective in removing the majority of plant material from clothing, equipment, and gear. Proper attention and care given during removal is a direct reflection of the potential efficiency of this technique. Seed and fragment materials readily attach to the adhesive sheets and are effectively lifted out of seams and the weave of loose particle fabrics. Roller sheets should be double bagged and disposed of in a sanitary landfill.

Water Wash

General water washing or other cleaning methods can be used in conjunction with a physical removal technique such as brushing or vacuuming and is moderately effective in removing residual foreign materials, although small and embedded seeds are capable of persisting. In addition, seed may remain viable following a wash treatment. In extreme situations, where known invasive materials are present, wastewater can be treated or filtered and the waste materials double bagged and disposed of in a sanitary landfill.

Thermal Treatment

Thermal treatments involve the use of extremely hot temperatures in order to kill all invasive material. Applying steam, hot air, or hot water has proven to be especially effective at killing invasive species and propagules. Disadvantages to the use of thermal treatments, such as steam and hot water, are the risk of burns, labor intensity, and the initial investment cost of equipment. PPE is required when conducting thermal treatments.

Cleaning and Decontaminating Vehicles and Equipment

Pre-cleaning Methods

Brushing

Used in conjunction with other physical removal methods such as vacuuming, or when in the field, this method is considered moderately effective in removing the majority of plant material from vehicles and equipment. Brushing will remove most surface soil, plant material, and foreign matter. If there is a nap to fabric, such as upholstery or carpeting, brush with the nap rather than against it. Brushing against the nap could further embed small seeds into the material. A combination of soft and stiff bristles of varying length is recommended for use on carpeting or components made of rubber, nylon, or plastic. Bristles of medium length and stiffness are desired for removal of soil and other matter from fabrics and upholstery. Stiff bristles are recommended for the tread of wheels that become encrusted with soil and mud. Metal bristles may also be used to remove soil or in treads, but heavier wear and tear to the equipment will result. High-pressure compressed air blasting may be used to assist soil removal. Follow up with vacuuming, high-pressure air blasting, or high-pressure wash is recommended as applicable.

Vacuuming

Vacuuming equipment with a brush attachment is suggested to remove most loose particle matter, but care should be taken because small seed may become further embedded in materials. To prevent contained plant and soil matter from being redeposited or re-dispersed following the cleaning process, collected matter should be double bagged and disposed of in a sanitary landfill. Follow up with water wash, high-pressure air blasting, or high-pressure wash is recommended as applicable.

Water Wash

Water washing with high-pressure or thermal treatment is the most effective method for removing residual foreign materials, although small and embedded seeds are capable of persisting. Where known invasive materials are present, wastewater can be treated or filtered, and the waste materials double bagged and disposed of in a sanitary landfill. Improvement in the design of high-pressure washing makes it the most effective means of cleaning heavily soiled and contaminated items. Not all items are capable of withstanding the pressure of this treatment, and it should only be used where applicable. There are many models of high-pressure washers, from simple hand-held nozzles to laser guided, robotic control systems. In some cases, containment and operation sheds are portable. The water systems can be fresh or recycled and use hot or cold water. PPE is required when conducting high-pressure washes.

Thermal Treatment

Thermal treatments involve the use of extremely hot temperatures in order to kill all invasive material. Applying steam, hot air, or hot water has proven to be especially effective. Disadvantages to the use of thermal treatments, such as steam and hot water, are the apparent risk of burns, its labor-intensive nature, and the initial investment cost of equipment. PPE is required when thermal treatments are conducted.

Decontamination Sites and Equipment

To avoid re-accumulation of soil on cleaned vehicles a paved area for washing, offloading, and staging vehicle cleaning operations with paved roads between is recommended. This type of facility will often not be a viable option for activities in remote areas. Elevating the washing areas enables cleaning personnel to access the underside of vehicles and equipment, where contaminants are otherwise difficult to reach.

Water runoff carrying soil, seeds, animals, and petroleum contaminants must be managed with the use of berms or other containment (Figures B-1 and B-2). Silt fence installed along perimeters of work areas can also aid in preventing spread of contaminated materials outside of the wash down location. Do not locate the cleaning site adjacent to storm water drains that allow untreated effluent to enter surface water bodies.

Figure B-1. Bermed portable mat system with sump pump for water recycling (U.S. Department of Agriculture, Forest Service).

The area must be large enough to safely accommodate all vehicles and personnel before, during, and after cleaning operations. Considerations should include weather protection when necessary. An efficient site design should make it easy for vehicles to move into and out of the area.

Figure B-2. High-wall portable berm with wall supports in place. High-wall berms might offer better overflow protection when conducting equipment washing. Remove the wall supports on one side to move equipment onto the berm. All wall supports can be removed, and the entire berm rolled up for easy moving and storage. Bung openings can be positioned to fit specific need when ordering from the company (Reclamation/Joe DiVittorio).

Water availability is another major consideration for wash stations. Fresh water in a quantity suitable for all cleaning operations is necessary. When this is not possible, alternative options such as water recycling systems (figure B-1) or use of compressed air may be a more viable method to remove soil. The benefit of compressed air is that there is no contaminated cleaning water to process.

Raw water or even gray water is sometimes used for washing vehicles, but potential health issues may require precautions such as immunizations or specialized safety equipment for personnel (Figure B-3). When pumping water from field sources, unintentional movement of exotic plants, problematic algae, or other invasive aquatic species must be addressed. Proper placement of pump intakes away from aquatic or shoreline vegetation that is known to be invasive is a prudent first step. Heating field source water to 140 °F will prevent invasive mussel spread while washing with field source water.

Minimum water pressure for land vehicle cleaning should be at least 90 pounds per square inch (psi). Electricity for pressure sprayers must be made available, and adequate hoses (with repair and spare supplies) should be kept on hand.

Water can be supplied as high volume and low pressure or low volume and high pressure. Each option has advantages and disadvantages based on specific cleaning needs and water availability. Heavy accumulations of soil and debris on large land-use equipment can best be cleaned using high volumes of water, but it may create water treatment or disposal issues. Still, some currently available cleaning systems can effectively remove large accumulations of soil with relatively low-volume water

delivery. Cleaning watercraft and other in-water equipment usually requires lower volume, high-pressure washing systems.

Figure B-3. Water for vehicle cleaning was pumped from conveyance channel at Socorro, New Mexico field site (Reclamation).

Water storage tanks, filters, and recapture systems can offer adequate onsite water supplies with less water use than would otherwise be necessary without recycling. By using sand or cartridge filters, many contaminated substances can be captured during cleaning operations to be safely handled later. In addition to soil and invasive species, wash water and used wash water filters may also contain oily residues from cleaning certain types of equipment. Such items may require handling, treatment, and disposal according to State and local regulations.

Currently Available Systems

Some options available for paved surfaces currently in use by some agencies include portable runoff containment systems and elevated wash racks. Geotextile cloth, rubber flexible mats with berms and modular elevated wash racks that can be moved into position with a forklift are also available. Some suppliers of currently available equipment for designing a washing system are listed in the USDA Forest Service publication: *Vehicle Cleaning Technology for Controlling the Spread of Noxious Weeds and Invasive Species* (https://www.fs.fed.us/eng/pubs/pdf/05511203.pdf).

The Forest Service has also built and field tested a portable vehicle washer mounted on a flatbed trailer (figure B-4). That system includes two high-pressure wands to wash sides of vehicles, an underbody high-pressure nozzle system, portable rubber mat system with side berms, settling tanks, and filtration system coupled with a 550-gallon holding tank, powered by a 5,000-watt gasoline

generator. This portable system can wash at 800 psi, using 20 gallons of water per minute. Field tests demonstrated the ability to wash standard vehicles in 2 to 3 minutes. Further details about this portable vehicle washer can be found at:

https://www.fs.fed.us/t-d/pubs/htmlpubs/htm04712833/page08.php

Figure B-4. Trailer-mounted washing system field tested by Forest Service for cleaning land use vehicles and other equipment (U.S. Department of Agriculture, Forest Service photo).

Cleaning and Decontaminating Zebra/Quagga Mussels

General Considerations

- Set up the best staging area possible for cleaning operations:
    - A paved area with accommodations to elevate vehicles or otherwise allow easy access to the undersides of vehicles and equipment is the best setting.
    - A geotextile access and exit areas, bermed water recovery areas, and portable vehicle lifts is the next best option.
- Equipment of all types should be cleaned at the location of last use. If this is not possible, arrange for cleaning at a facility that is specially designed for equipment cleaning.
- Pre-clean equipment that contains heavy accumulations to reduce water usage.
- Make pressurized water available with pressure and nozzles capable of removing all soil and debris.
- Recapture invasive materials by using fine-mesh filters and dispose of invasive species material in a manner that ensures no spread.
- Do not allow wash waters to flow into storm drains because these drains often directly flow untreated into surface water bodies.
- At remote sites, install silt fence or otherwise contain materials left behind.
- Monitor sites closely and eradicate exotic species.

- Clean vehicles and equipment thoroughly, and ensure that they remain clean when leaving the site.
- Follow up cleaning operations with final inspections.
- After cleaning, drain and dry all equipment.

Acceptable Decontamination Methods

Chemical Decontamination

- Zebra and quagga mussel cleaning operations can be an involved and complex process.
- The life stage of the mussel will influence cleaning actions.
- The successful use of chemical decontamination also depends on the decontamination chemical used, the chemical concentration used, and contact time.
- Chemical decontamination as a means to kill adult mussels may require as long as 10 days contact time; chemical solutions are usually better suited for veliger (immature life stage) treatment.

Decontamination chemicals are somewhat difficult to use, and successful results can be difficult to achieve. Be aware that some of these solutions may cause corrosion on metal surfaces and electrical connections.

Generally, chemical decontamination materials are divided into two groups: oxidizing, and non-oxidizing. Any use of decontamination chemicals will involve disposal concerns and may pose user safety issues, PPE may be required.

Commonly used decontamination chemicals include:

- One percent solution of table salt (2/3 cups of salt into 5 gallons of water) for 24 hours of contact time.
- Undiluted white vinegar for 20 minutes of contact time.
- A diluted household bleach solution (less than five percent sodium hypochlorite at a concentration of 3 ounces of bleach into 5 gallons of water) for a minimum of 1 hour.
- Potassium permanganate solutions.
- Various quaternary ammonium and poly-quaternary ammonium compounds.

Thermal Treatment

Heating is generally regarded as the most effective and easy method for decontaminating equipment infested with invasive mussels. Temperature and exposure time determine the effectiveness of thermal treatments. Live steam, autoclaving, or boiling are all believed to be 100-percent effective against all zebra and quagga mussel life stages. Water temperature used during hot water washing or rinsing must be maintained at 140 ºF or greater at surface contact for 1-3 minutes exposure time to bring the surface temperature up to 140 °F for 30 seconds. Use a hand-held infrared temperature reader to verify 140 °F surface temperature. PPE is required when conducting thermal treatments.

Note that certain early literature references cited water temperatures at 104 °F as being an effective temperature to kill zebra and quagga mussels. However, most current authorities support using the

140 °F water temperature for greater lethal effect on mussels. Using 140 °F minimum temperature throughout for heat treatment is recommended unless otherwise specified.

Hot Water, High-Pressure Washing

Using hot water, high-pressure washing is the most widely accepted method of cleaning invasive mussels from surfaces. The combination of lethal temperature water (at least 140 °F), combined with the mechanical action of high pressure is most effective. PPE use required. The following measures are recommended:

- Use a power washer unit that is capable of applying a flow rate of at least 4 gallons per minute with a nozzle pressure of 3,000 psi, and that is able to supply water at 140 °F or hotter at the surface point of contact.
- To begin the cleaning process, reduce the nozzle water pressure by adjusting the power washer or using reduced pressure attachments.
- Do not attempt to remove or detach mussels from the surface using high water pressure at this point in the cleaning process; the goal is to kill adult mussels with hot water while they remain attached to the surface.
- Rinse the entire surface to be treated with heated water for at least 30 seconds exposure time at 140 °F to effectively kill all mussel life stages.
- To achieve this surface temperature, the operator may have to spray the surface for 1-3 minutes, depending on the size of the working area and the material composition of the surface.
- After rinsing the surface at reduced water pressure and achieving a surface temperature of 140 °F for 30 seconds, maintain a hot water temperature and increase the nozzle pressure high enough to detach the mussels from the surface.

Freezing

Adult zebra mussels have a relatively low tolerance to freezing. McMahon et al. (1993) reported 100-percent mortality when individual mussels were exposed to 14 °F for as little as 1.3 hours. However, clusters of mussels were more tolerant than individuals, and the corresponding freezing mortality exposure time at 14 ºF appears to be at least 4 hours.

Physical

Crushing is an effective way to kill individual adult mussels, but it is not effective against the attached veliger or juvenile life stage, nor is it practical for use over large surface areas. Any crushed adult remains should also be exposed to a hot water treatment prior to final disposal.

Desiccation

Desiccation is effective if sufficient time is allowed. In cool and highly humid settings it is estimated that mussels can survive for over 40 days out of water. Drying times necessary to kill mussels varies according to time of year, location, and relative humidity; therefore, no single drying time estimate can ensure a complete kill for all situations, unless a set maximum time is used.

Decontamination of Small In-Water Equipment

The following methods should be employed when decontaminating small in-water equipment such as nets, waders, boots, buckets, and field equipment used to collect samples. After contact with raw water, all equipment should be thoroughly cleaned before moving to another site. When possible,

use dedicated equipment at the same project area to prevent cross contamination. Whenever practical, the least infested (or least likely to be infested) sites should be visited first to reduce the risk of accidentally infesting a new area during field work. If sampling is being performed to determine whether invasive mussels are present at a given site, assume that they are present and thoroughly clean all sampling equipment before moving to another site.

All field equipment must be inspected, and all visible mussels must be removed and killed. However, since the mussel immature life stages are microscopic and cannot be seen without laboratory equipment, do not rely on visual inspection alone; feel by hand for surface roughness.

All field equipment can then be cleaned by soaking, dipping in, or scrubbing with hot water, or in one of the chemical decontamination solutions listed (see Acceptable Decontamination Methods, Chemical Decontamination) if chemical decontamination is permitted by the manufacturer. If adult mussels are found during inspection, the equipment should be steam cleaned, washed with hot, high-pressure water, or dipped treated in hot water, and allowed to dry completely before the next use. Particular attention must be given to places where the mussels could be accidentally trapped, such as the treads of boots and waders, items of clothing or other cloth materials, and hinges of benthic grabs.

Sampling equipment decontamination information can be found in the Reclamation Standard Operating Procedure: Field Sampling Methods for Invasive Mussel Early Detection.

https://www.usbr.gov/mussels/docs/FieldSOP_3.2021.pdf

Decontamination of Large In-Water Equipment

The following methods should be employed when decontaminating large in-water equipment; for example, watercraft, construction and facility equipment, and water bags used during crane testing.

Compartments

Bilge compartments, raw water holding tanks, such as ballast tanks, wet wells, live wells, and any other compartments that could hold water from an infested field site should be drained of water at the boat ramp before leaving the area. If it is not possible to drain all water held in holding tanks or compartments, a suction hose connected to a vacuum pump or a wet/dry shop vacuum can be used to remove remaining water. If a watercraft has carried water in these compartments from another location, remove all water into a container and heat it to at least 140 °F, or treat it with one of the decontamination solutions noted above. If adult mussels are found in these compartments, use the recommended hot water treatment.

After draining contained water, all water holding compartments should be filled with hot water for the appropriate contact time as noted above. If the compartment is too large to make filling practical, high pressure wash the compartment thoroughly with hot water as noted above.

Watercraft Hull Surfaces, Anchors, and Trailers

Wash down with hot, high-pressure water. Then, visually inspect and feel by hand to remove any remaining foreign material.

When using high-pressure, hot water washing, use a flushing attachment at reduced pressure to rinse all hard to reach areas and areas where high pressure may damage the equipment (such as the rubber

booted gimbal of an inboard/outboard unit). Maintain a hot water contact time of 2-3 minutes with these areas to ensure that mussels are killed on the surface, since it may not be possible to remove them from hidden or sensitive areas.

Advisory on Cleaning Watercraft and Other In-Water Equipment

There have been several anecdotal reports of boats that have been professionally cleaned, inspected, and certified as mussel free, then re-inspected days later only to find additional live mussels. More than likely, these boats had been harboring adult mussels in hidden recesses of the boat. During cleaning, the hidden surfaces did not reach the required 140 °F temperature for 30 seconds, which is needed for mussel kill. Instead, the hot water irritated the mussels, causing them to migrate out of these hidden recesses and onto visible areas of the boat surface. This finding reinforces the following points:

- If equipment is used at a location known to be infested with an invasive species, the equipment should undergo a pre-inspection, followed by thorough cleaning, and a final inspection before being moved offsite.
- At the new location, the equipment should be inspected again, preferably by someone other than the original inspector before the equipment is placed into service.
- If contamination is found on the equipment on re-inspection, do not allow the equipment entry on the new site; either return the equipment to the location of last use for additional cleaning or arrange for cleaning at a location that is specifically designed for equipment cleaning.

When inspecting and cleaning, special attention should be given to the following:

- Cracks and crevices in which mussels may become trapped.
- Aquatic plants harboring mussels that may be present on trailers or propellers.
- Trailer pads made of carpet and foam rubber, which could trap tiny mussels.
    - If possible, such material should be removed from trailers before use in invasive mussel-infested waters.

Watercraft Engines

Remember to use a flushing attachment at reduced pressure to rinse all hard to reach areas and those areas where high pressure may damage the equipment (such as the rubber booted gimbal of an inboard/outboard unit). Maintain a hot water contact time of 2 or 3 minutes with these areas to ensure that mussels are killed on the surface, since it may not be possible to remove them from hidden or sensitive areas.

If the watercraft engine is not a closed cooling system configuration (if the engine intakes its cooling water from the environment), the following applies:

- A hot water treatment is recommended for engine decontamination.
- Running a chemical solution, such as a bleach solution, through an engine to decontaminate it may violate the terms of the engine‘s warranty, or otherwise damage the engine, unless specified by the manufacturer.

- Chemical treatments are not well-suited for engine decontamination because the adult mussel is able to sense a toxic external environment and close up for extended periods of time.

Outboard Engines

All outer surfaces of the motor must be cleaned to remove any clinging foreign material by washing with hot, high-pressure water. Then, visually inspect, feel by hand, and remove any remaining foreign material. Finally, decontaminate the engine cooling system by either placing the outboard motor into a barrel filled with 140 º F to 160 º F water and operating the engine for 5 to 10 minutes, or using the appropriate flushing attachment, such as an "earmuff" attachment. Operate the engine according to the Engine Decontamination Instructions below.

Inboard/Outboard Engines

All outer surfaces of the outboard unit must be cleaned to remove any clinging foreign material by washing with hot, high-pressure water (figure B-5). Then, visually inspect, feel by hand, and remove any remaining foreign material. Finally, decontaminate the engine cooling system by using the appropriate flushing attachment, such as an "earmuff" attachment. Operate the engine according to the Engine Decontamination Instructions below.

Inboard Engines

All surfaces of the propeller, driveshaft and driveshaft bearing supports, rudder, and driveshaft bearings must be cleaned to remove any clinging foreign material by washing with hot, high-pressure water. Then visually inspect, feel by hand, and remove any remaining foreign material. Finally, decontaminate the engine cooling system by using the appropriate flushing attachment. Operate the engine according to the Engine Decontamination Instructions below.

Watercraft Engine Flushing Procedure

Use the appropriate attachment, such as an "ear muff" attachment, to flush the watercraft engine cooling system. Refer to the manufacturer's specific directions for flushing attachment hookup to the engine; PPE required.

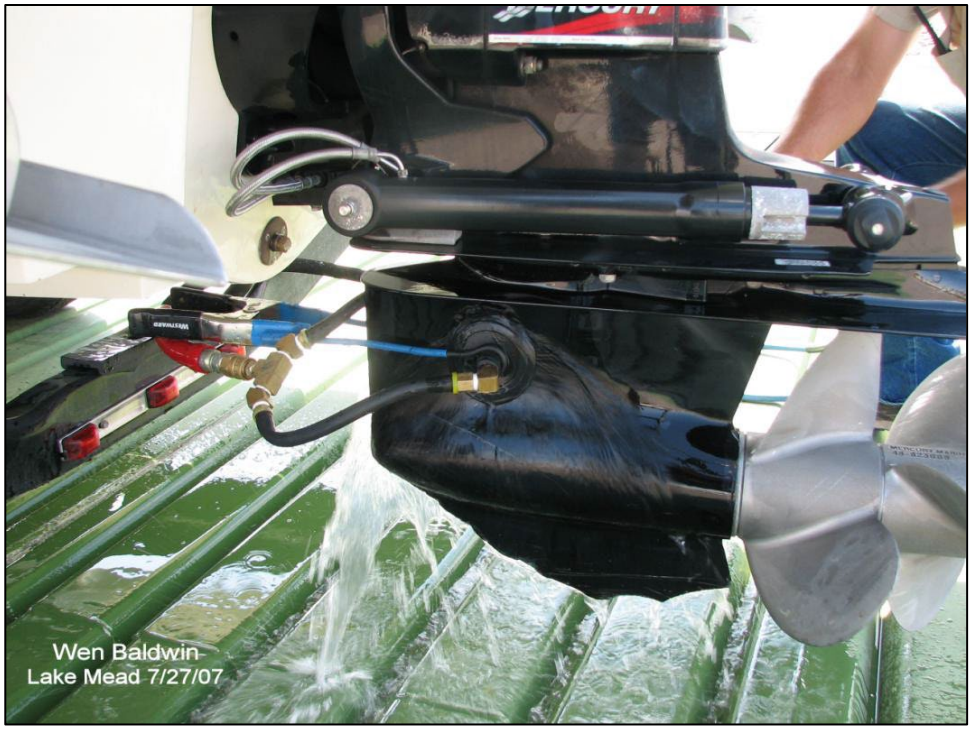

Figure B-5. Inboard/outboard engine flushing (Pacific States Marine Fisheries Commission/Wen Baldwin).

General watercraft engine flushing procedure is as follows:

- Stay clear of the propeller and keep other persons away during the flushing process.
- Set the watercraft transmission in neutral gear.
- Connect the flushing attachment to the power wash unit or other hot water source.
- Start hot water flowing through the engine and wait for water to exit from the cooling system outlet ports as a steady stream of water.
- If water does not flow as a strong, continuous stream from the outlet ports, there may be some debris or mussels already inside the cooling system that are blocking the free outflow of water.
- Examine the water intake ports closely and check the intake filter screens for any evidence of mussels or other blockage.
- Check the outflow water temperature with a handheld thermometer, or a handheld infrared temperature reader.
- If the engine is cold, the outflow water temperature maybe much cooler than the required 140 °F. required to kill mussels.
- If this occurs, heat is probably being transferred from the flushing water to the cold engine mass, wait for the outflow water to reach 140 °F. before proceeding.
- Some watercraft motor manufacturers allow engines to be operated during the flush procedure, while some do not.
- In addition, some manufacturers limit the input pressure of the flushing system; refer to the manufacturers' directions prior to attempting engine flushing.

If the manufacturer allows flushing with engine running: Start the engine and run at the lowest idle speed for 2 minutes. Make sure the required 140 °F temperature is maintained in the outflow water. Also make sure the engine does not reach an overheated condition. On certain engines, it is possible that a low coolant volume in the cooling system will not properly register an overheat condition on the engine temperature gauge; therefore, it is very important to monitor the temperature of the outflow water. When completed, shut down the engine first, and then shut off the water supply. Disconnect all flushing attachments.

Warning: Most hot water power washers have a flow rate of 4 gallons per minute or less. Be sure to check the flow rating of your washer, as using less than 5 gallons per minute flow rate when flushing the engine cooling system may cause engine damage if the 2-minute engine run time requirement is exceeded. Operate the engine at only low idle speed during flushing.

If the manufacturer does not allow flushing with engine running: Proceed according to the manufacturer‘s directions with engine shut down. Make sure the required 140 °F temperature is maintained in the flushing outflow water. When completed, shut off the water supply and disconnect all flushing attachments. Hot water flushing on an engine that is not running can usually exceed the 2-minute limit imposed for an engine that is running.

Decontamination of Water Bags Used During Crane Testing

As discussed previously, special attention must be given to inspecting and cleaning water bags used during crane testing. Crane testing companies often use water bags by filling the bag with water to the corresponding weight for the testing process. These bags can be used at various locations across the country. At the end of crane testing, the bag is drained and can be moved to a new location. Water bags used for crane testing generally cannot be easily inspected at the level required to find the mussel veliger life stage. If the water bag was filled with raw water during its prior use and was not decontaminated, assume it is contaminated. During the crane testing procedure, the water bag will be filled with water for only several hours, and then it will be drained. Therefore, the main risk factor is veliger mussel contamination in the bag’s residue water.

If the crane testing company can provide certification that the water bag was filled only with potable water at its last use location or was otherwise properly decontaminated, the bag can be assumed to be free of contamination.

Decontamination of a water bag may include the general treatment methods described below for all other equipment, provided the treatment complies with the water bag manufacturer‘s specifications. Treatments such as chemical decontamination, heat, freezing, physical, and desiccation may be considered for use based upon the bag‘s materials, construction, design, and specifications. All water bag decontamination treatments are the responsibility of the crane testing company.

Chemical Decontamination

If allowed by the manufacturer‘s specifications, the bag may be decontaminated for veliger mussels using the chemicals listed for the appropriate contact time. However, any chemical treatment would produce large quantities of wastewater and require special handling and disposal.

Heat Treatment

Heating a water bag directly is not a recommended treatment option unless specifically allowed by the water bag manufacturer. Hot water pressure washing may be an acceptable option as allowed by the manufacturer‘s specifications.

Freezing

Freezing a fully drained water bag is a promising treatment option when allowed by the manufacturer‘s specifications. Adult zebra mussels have a relatively low tolerance to freezing. Mussel veligers are thought to be more susceptible to freezing; however, more research is needed. Complete mortality was observed when individual adult mussels were exposed to 14 ºF for as little as 1.3 hours has been reported in recent scientific literature (McMahon et al., 1993). Clusters of adult mussels were more tolerant than individuals, and the corresponding freezing mortality exposure time at 14 ºF appears to be at least 4 hours.

Physical Removal

Water microfiltration, capable of removing immature mussel life stages is a physical treatment measure. If using a raw water source, a portable microfiltration unit, with associated connectors could be used for bag filling. Of course, all connections in contact with raw water would require decontamination prior to use in the next water body to prevent potential mussel transfer.

Desiccation

Desiccation as a treatment option might include air drying the bag assisted by fan circulation using room temperature or moderately heated air. Using dehumidified air will assist the desiccation process and shorten time requirements.

Decontamination of Dive Gear and Related Equipment

All diving gear exposed to water must be treated onsite after the completion of dive activities. Dive gear is often used in zebra or quagga mussel infested waters; therefore, it is vital that the equipment be properly treated using inspection and decontamination standards. Because dive gear is not typically exposed to zebra or quagga mussel infested waters over a long term, adult mussel infestation of dive gear is less of a concern. However, there is higher probability that mussel veligers could become trapped in or attached to dive gear during normal duration dives. Veligers would be invisible to the unaided human eye during visual inspection.

Any adult mussels found on dive gear should be easily spotted and removed during visual inspection. Exposed dive gear requiring inspection and decontamination includes equipment associated with scuba, remotely operated vehicle (ROV), and surface supplied air (SSA) activities. This protocol applies to all dive gear used in all water bodies, not just waters thought to be infested; do not assume any diving water is un-infested. When making dives at multiple sites, the known (or most likely) infested site should be the last dive of a multiple dive operation.

General procedure for inspecting and decontaminating dive equipment:

- Drain water from all equipment before leaving the dive site.
- Remove all mud and vegetation from your equipment.

- Visually inspect all gear for adult mussels attached to or trapped in equipment.
- Feel surfaces by hand for rough spots that may indicate attached juvenile mussels.
- Suggested dive gear decontamination methods are listed below for veliger decontamination.

Dive Gear Decontamination Methods

Saltwater Treatment

Of the methods for decontaminating dive gear, perhaps the most challenging involves a saltwater decontamination solution. While a saltwater solution is widely accepted in the literature as being very effective in killing zebra and quagga mussel veligers, and the solution is easy to prepare and use, disposal of the spent saltwater solution may be complicated by variable disposal requirements from State to State and among local governments.

What might be an acceptable disposal technique for the spent saltwater solution in one locale may not be acceptable in another. Therefore, it is not possible for the manual to discuss every saltwater disposal requirement that divers might encounter. If the saltwater decontamination method is selected, the dive team coordinator is advised to contact the environmental staff at the responsible field or area office. Advance contact with the environmental staff is highly recommended since discussion with other agencies may become necessary. It is preferable, when possible and if allowed by the local treatment plant authority, that the saltwater decontamination solution be disposed of into a domestic sewer drain. In remote locations with no reasonable access to domestic sewer drains, dispose of the spent saltwater solution on the ground near to the infested water body, or to another ground location recommended by the environmental staff or local facility manager.

Except for ROV, SSA, and other equipment as noted, the decontamination protocol below uses a decontamination water temperature of 104 ºF for greater efficacy. However, heated water may not be available at remote locations when decontamination of dive gear is necessary. Therefore, decontamination of dive gear in the field using a cold saltwater solution is the recommended minimum treatment option.

Zebra and quagga mussel veligers are far more susceptible to salinity than adult mussels. Mixing the saltwater decontamination solution at the rate of ½ cup of table salt per gallon of water approximates the salinity of seawater at 35 ppt (or 3.5 percent) salinity. The salinity of this solution is almost eight times more concentrated than the acute toxicity of 4.5 ppt noted.

Procedure for flashlights, weight belt, mask, snorkel, fins, notepad, hood, gloves, regulator, buoyancy control device (BCD), etc:

- Visually inspect everything inside and out, including any pockets and the inside of BCSs.
- Scrub all surfaces with a brush as required to remove foreign material.
- Use a salt concentration of ½ cup commercial table salt per gallon of water.
- Soak all dive gear in saltwater solution.
- If available onsite, use hot water (104 ºF) to prepare the decontamination saline solution.
- Note that water temperatures greater than 104 ºF may shorten the life of dive gear due to glue or plastic failure.
- Soak gear 30 minutes, rinse with non-infested fresh water.
- Allow gear to dry completely prior to next use.

Additional procedures for dry suits:

- Visually inspect inside of pockets and bottom of boots.
- Close off valve, wrist, and neck openings of dry suit.
- Prepare and use the saltwater solution as described above.
- Rinse with non-infested fresh water.
- Carefully inspect valves and zippers to prevent salt corrosion.
- Allow to dry completely prior to next use.

Procedures for ROV, SSA, umbilical cords, and scuba tanks

- Use a salt concentration of ½ cup of commercial table salt per gallon of cold water.
- Soak gear for 30 minutes, rinse with non-infested fresh water.
- Allow equipment to dry completely prior to next use.

Dedicated Equipment

Purchase and use a separate set of dive equipment dedicated for work in known infested water bodies is a good way to prevent spread of invasive mussels. Instead of purchasing extra dive equipment for all divers on a team, a more cost effective solution may be to select a limited number of divers with experience in performing zebra and quagga mussel inspection to use dedicated equipment.

Quarantine

All exposed dive equipment must be contained (kept separated from other dive gear in bags, etc.) and then thoroughly dried in storage before using again. This would prohibit diving with possibly contaminated dive equipment for a minimum quarantine period of time based on storage humidity. This is more easily accomplished when a separate dedicated set of dive gear is purchased for the diving only in infested waters.

Cold Temperature

Freezing is a possible option in some places because many Reclamation facility locations are at high altitude and dive operations are conducted year round. When outdoor air temperature is below freezing, drain excess water from dive equipment and leave it outside overnight, or use an electric freezer system. Freezing is appropriate for dive equipment that does not contain water and will not be damaged in the process such as dive suits, fins and gloves. Ensure that freeze time is adequate for a complete freeze. Use caution with dive gear that could hold water, such as valves or hoses, because expanding water may damage equipment. Make sure all components are completely free of water before freezing, or use an alternative treatment method.

Chlorine

Do not use a chlorine decontamination solution for dive gear, as there is a risk of residual chlorine gas inhalation through the regulator. It is also possible that chlorine could damage glue and other materials associated with diving gear from repeated chlorine washing. The use of normal chlorinated tap water (e.g., drinking water) to prepare the saline decontamination solution does not pose a risk to the diver.

Desiccation

Drying dive gear between dives is important, but dive teams are often tasked with dives at multiple locations over several days, making equipment drying difficult. Follow an accepted decontamination method and, whenever possible, allow dive gear to dry completely between dives. When used alone, drying is capable of killing mussels, but drying time effectiveness varies widely according to the mussel life stage, time of the year, location, and relative humidity; therefore, no single drying time estimate can ensure a complete kill for all situations, unless a set minimum time is used. Zebra and quagga mussel veligers are far more sensitive to desiccation than are adults.

Product Vendors

A list of vendors that provide products and services for cleaning equipment and vehicles follows. No endorsement of listed vendors or products is implied.

Spill containment berms and water tanks

Berg Containment Systems 16124 E. Euclid Avenue Spokane WA 99216 1-800-228-8277
http://bergco.com

Interstate Products, Inc. 3921 Sawyer Road Sarasota FL 34233 1-800-474-7294
http://www.interstateproducts.com

Polystar, Inc. 2030 Midway Drive Twinsburg OH 44087 330-963-5100 1-800-275-3453
http://www.polystarcontainment.com

Watercraft decontamination vendors:

Hydro Engineering, Inc. 865 W. 2600 S. Salt Lake City UT 84119 1-800-247-8424
http://www.hydroblaster.com

Hydro Tek Systems, Inc. 2353 Almond Avenue Redlands CA 92374 909-799-9222 1-800-274-9376
http://www.hydrotek.us

Industrial Equipment 830 Cherry Street Chico CA 95928 1-800-287-8306
http://www.industrial-equipment.biz/

S-K Environmental PO Box 4 Okanogan WA 98840 509-322-6909
http://s-k-enviro.com/

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