INVASIVE SPECIES
Impacts on
FEDERAL INFRASTRUCTURE





Michael Vissichelli · November 2018

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Note from the Executive Director

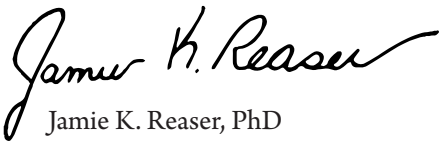
Because non-native species typically enter the United States through ports of entry in urban environments, some of the first observable impacts may be to infrastructure. In many cases, species that initially impacted infrastructure have had devastating impacts on ecological systems, agriculture, and/or fisheries when they spread into less modified landscapes and waterways. The United States currently lacks or has unclear comprehensive authority necessary to effectively prevent, eradicate, and control invasive species that impact the human-built environment ("infrastructure"). This prevents rapid response to some of the most damaging invasive species. It also limits the ability of agencies to prioritize and allocate the resources necessary to control invasive species that threaten public security (e.g., zebra mussels [*Dreissena polymorpha*] incapacitating power plants and irrigation systems), undermine costly federal programs (e.g., the Rasberry/tawny crazy ant [*Nylanderia fulva*], which has impacted electrical systems at the Port of Houston and NASA Johnson Space Center in Houston), and cause homeowners to incur substantial repair and maintenance costs (e.g., Formosan termite [*Coptotermes formosanu*]).

Recognizing the need to better understand and address invasive species impacts on infrastructure, the *2016-2018 National Invasive Species Council (NISC) Management Plan*[1] called for case studies of the invasive species impacts on U.S. infrastructure, as well as guidance that enables federal agencies to take the necessary action to prevent, eradicate, and control non-native species that harm or have the potential to harm infrastructure within the United States and its overseas territories. This report is one of the outputs produced in the response to these priority actions. It complements the Invasive Species Advisory Committee's (ISAC) white paper entitled, *Invasive Species Impacts on Infrastructure*.[2]

This report also supports the "best practices" tenant inherent in Executive Order 13807, *Establishing Discipline and Accountability in the Environmental Review and Permitting Process for Infrastructure Projects*.[3] In particular, this report highlights the need to include invasive species assessments as a best practice when conducting environmental reviews, not because of the potential impact of the project on invasive species, but because of the potential adverse impact of certain types of invasive species on the project. For example, burrowing species could put dams, levies, roads, canals, and similar structures at risk of collapse, especially during extreme weather events. Similarly, the presence of annual invasive grass or invasive species that cause tree mortality could increase fire risks to infrastructure.

Ultimately, this report is intended to inspire awareness of the substantial impacts that invasive species are having on infrastructure and concerted action to prevent and mitigate future impacts. We welcome your input at invasive_species@ios.doi.gov.

Together, we can do this…



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1 https://www.doi.gov/invasivespecies/management-plan-and-executive-order
2 https://www.doi.gov/sites/doi.gov/files/uploads/isac_infrastructure_white_paper.pdf
3 https://www.federalregister.gov/documents/2017/08/24/2017-18134/establishing-discipline-and-accountability-in-the-environmental-review-and-permitting-process-for

Abstract

To better understand the impacts of invasive species on infrastructure managed by the federal government an effort was undertaken by the National Invasive Species Council Secretariat (NISC Secretariat) to solicit feedback from those agencies. A questionnaire was sent out to the federal agencies that manage infrastructure to identify the impacts they have observed, how they are managing them, issues they have identified and resource needs. The research demonstrated that impacts from invasive species on federally managed infrastructure range from non-existent to significant. Identified gaps needing improvement include awareness and education of invasive species impacts, limited resources, insufficient policy, and lack of agency support.

Introduction

Impacts have been identified on various types of infrastructure managed by the federal government, including power, water, transportation and building systems. Specifically those facilities are impacted by invasive species in ways that effect their operational capabilities, capacity, efficiency, health, and safety. A number of gaps in federal infrastructure management on invasive species that have been identified are detailed in this review. This paper provides a comprehensive look at the ways invasive species are impacting federal infrastructure and how we can better approach future management to reduce their impacts.

Invasive species can cause significant damage and costs for repairs to damaged infrastructure, loss in value of assets, loss of efficiency, lost service time, and costs associated with controlling their spread. Services that facilitate the transportation of goods from ports of entry to inland distribution and storage facilities can provide a pathway for the movement and establishment of invasive species. Roads, rivers, and railways are major conduits for carrying commodities and possible invasive species, infrastructure surrounding these pathways are vulnerable to invasion and damage by these organisms.

A previous effort was undertaken by the Invasive Species Advisory Committee (ISAC) (ISAC 2016) that took a cursory look at the types of infrastructure that can be affected by invasive species. ISAC also looked at case studies of the life history and impacts to infrastructure of six specific invasive species.

To expand upon the work of ISAC, and in response to the 2016-2018 NISC Management Plan Action Items 4.2.1 and 4.2.2, it was determined that a more detailed investigation into the impacts invasive species are having on federal infrastructure was necessary. To collaborate with the various federal agencies that manage infrastructure, NISC Secretariat issued a questionnaire to get a better understanding of those impacts and to solicit additional case studies. The remainder of this document is a detailed review of the responses received from the federal agencies.

Methods

NISC Secretariat developed a questionnaire consisting of 22 questions regarding impacts of invasive species on federally managed infrastructure (See Appendix 1). The questionnaire was sent to 30 federal agencies (See Annex 1). The primary agencies selected to receive the questionnaire consisted of those that make up NISC.[1] In addition, other agencies were solicited either by one of the primary NISC agencies or because

1 NISC member agencies as defined by Executive Order 13751 can be found at https://www.doi.gov/invasivespecies/about-NISC Secretariat.

Agency Response/Infrastructure Managed

		Power	Water	Transportation	Buildings
United States Department of the Interior	United States Fish and Wildlife Service*	X	X	X	X
United States Department of the Interior	National Park Service*	X	X	X	X
United States Department of the Interior	United States Geological Survey*	X	X	X	X
United States Department of the Interior	Bureau of Land Management*	X	X	X	X
United States Department of the Interior	Bureau of Reclamation*	X	X	N/A	N/A
Environmental Protection Agency	Environmental Protection Agency*	X	X	X	X
Department of Defense	Department of Defense*	X	X	X	X
Department of Defense	United States Army Corps of Engineers*	X	X	X	X
General Services Administration	General Services Administration***+	X	X	N/A	X
United States Department of Homeland Security	Department of Homeland Security*	N/A	N/A	X	X
United States Department of Homeland Security	Customs and Border Protection*	N/A	N/A	N/A	N/A
United States Department of Homeland Security	United States Coast Guard*	X	X	X	X
United States Department of Agriculture	Natural Resources Conservation Service*	N/A	N/A	N/A	X
United States Department of Transportation	Department of Transportation*	N/A	N/A	X	N/A
Non-Federal Agency	Central Arizona Project**	X	X		
United States Department of Agriculture	Department of Transportation*	Agencies with infrastructure that did not respond to the data call.			
Department of Energy	Central Arizona Project**				
Department of Energy	Bonneville Power Authority***				
National Aeronautics and Space Administration	National Aeronautics and Space Administration*				
Health and Human Services	Center for Disease Control*				
Health and Human Services	Health and Human Services*				
United States Department of Commerce	National Oceanic and Atmospheric Administration*	Agencies that are not likely to have significant infrastructure that have not yet responded to the data call.			
Council on Environmental Quality	Council on Environmental Quality*				
Office of the United States Trade Representative	Office of the United States Trade Representative*				
U.S. Agency for International Development	U.S. Agency for International Development*				
White House Office of Science and Technology Policy	White House Office of Science and Technology Policy*				
White House Office of Management and Budget	White House Office of Management and Budget*				
United States Department of State	United States Department of State*				
United States Department of the Interior	Bureau of Environmental Management*				
United States Department of the Interior	Office of Insular Affairs*				

* NISC Member Agency (or associated agency within a NISC Member agency)

** This is a non-federal agency that received the questionnaire through a third party and provided a response.

*** Non-NISC Member Federal Agencies requested to provide a response

\+ Incomplete response received, did not provide useful data

2016-2018 NISC Management Plan Action Item 4.2.1

Compile case studies of the invasive species impacts on infrastructure in the United States and make them available through the NISC website or other public domain. The case studies should address: (a) biology of the organism in native and introduced ranges; (b) locality, date, and pathway of introduction; (c) documented impacts to infrastructure (including a timeline and economic costs); (d) documented non-infrastructure impacts (including a timeline and economic costs); (e) measures taken to eradicate/control the species and associated Federal costs; and (f) projected needs (including technologies and funding) to eradicate the species.

2016-2018 NISC Management Plan Action Item 4.2.2

Taking into consideration the output of Action 4.2.1, develop guidance that enables Federal agencies to take the necessary action to prevent, eradicate, and control non-native species that harm or have the potential to harm infrastructure within the United States and its overseas territories

they have closely coordinated with NISC Secretariat in the past on invasive species issues. All NISC member agencies were sent the questionnaire, but the expectation was that replies would be received from agencies that have a significant role in infrastructure management.

The questionnaire was developed to gain a better understanding of the management challenges tied to invasive species faced by federal agencies charged with oversight of infrastructure. Infrastructure was identified under four different systems: buildings, power, transportation and water as defined in Figure 2.

Infrastructure Type	Definition
Building Systems	Manmade facilities consisting of structures with a roof and wall, such as a house, school, store, office, historic and archeological buildings and landmarks.
Power Systems	Manmade facilities that generate, transmit, and distribute electric energy.
Transportation Systems	Manmade facilities that include highways, railroads, waterways, ports, and airways.
Water Systems	Manmade facilities that treat drinking water and waste water, control flood waters, divert storm water, impound water for a variety of purposes, and divert or convey water to agricultural and municipal users.

Figure 2 This table provides definitions used to define the four major infrastructure types.

These infrastructure types and definitions are similar to those identified in the ISAC white paper (ISAC 2016). The only difference is that this effort used buildings instead of housing since that more accurately captures the federal infrastructure inventory. In the questionnaire, a category for "other" was provided to determine if these four categories capture the federal inventory. Based on responses received it has been determined that the four categories accurately represent the federal infrastructure inventory.

Questions were targeted towards known problem areas such as policy, management, and budget to gain a better understanding of these areas as they relate to invasive species impacts on infrastructure across the entire federal government.

The questionnaire was developed with the intent to allow for effective evaluation of the responses (Diem 2004, NOAA 2015, OMB 2006, Walonick 2007, Willis 2014). The questionnaire was developed as a word document with a mix of multiple choice and essay type responses. No specific format for responses was provided. The questionnaire was sent out to a select audience prior to its broad distribution to make sure the content was understandable and would provide useful feedback.

To raise awareness and in an effort to encourage a higher response rate, a pre-notification e-mail was sent to the intended recipients two weeks prior to distribution of the questionnaire. Responses were requested to be provided 5 weeks after the questionnaire was sent out.

Two weeks after the questionnaire was sent out, follow up phone calls were scheduled with each of the recipients. In addition, a fact sheet (Annex 2) was provided to the recipients two weeks after the questionnaire was sent out to give further background on the topic and intended use of the information that would be provided in response to the questionnaire.

One week after the conclusion of the follow up phone calls, a Frequently Asked Questions document (Annex 3) was developed and shared with all of the questionnaire recipients to share answers to questions that were raised on those calls.

Follow up e-mails and phone calls were conducted with non-respondents after the deadline to try and solicit a response.

After responses were received they were reviewed, consolidated and evaluated by groupings and question type using Microsoft Word and Excel. Pertinent information was developed into the figures used throughout this document.

A template was developed to consistently capture Case Studies.

Results

The results of the questionnaire are not conducive to a direct summary of each question. As such, the discussion provides a detailed analysis of the categories to which responses were received. Although response to the data call was only 71%[2] out of the agencies expected to manage infrastructure, answers representing these categories were generally consistent across the various federal agencies who did respond.

Questionnaire responses were inconsistent in that some agencies provided a roll up for the entire agency, other agencies provided individual responses from project offices or regions and other agencies provided both.

Infrastructure

Responses varied in that some agencies were responsible for managing just one of the infrastructure types, but several were responsible for multiple or all of the infrastructure types (see Figure 3). It is assumed since no responses identified any other categories that the four categories of power, water, transportation and buildings accurately reflect the types of infrastructure managed by the federal government.

2 Of the 30 agencies solicited for response, only 21 were anticipated to have infrastructure that they manage. 15 of those agencies provided a response. The other 5 agencies are NISC members not anticipated to have infrastructure that they manage and therefore are not considered in this percentage even though they did not respond.

Infrastructure Managed By Agencies

	Power	Water	Transportation	Buildings
United States Fish and Wildlife Service	X	X	X	X
National Park Service	X	X	X	X
United States Geological Survey	X	X	X	X
Bureau of Land Management	X	X	X	X
Department of Defense	X	X	X	X
United States Army Corps of Engineers	X	X	X	X
Environmental Protection Agency	X	X	X	X
United States Coast Guard	X	X	X	X
General Services Administration	X	X	N/A	X
Bureau of Reclamation	X	X	N/A	N/A
Central Arizona Project	X	X	N/A	N/A
Department of Homeland Security	N/A	N/A	X	X
Natural Resources Conservation Service	N/A	N/A	N/A	X
Department of Transportation	N/A	N/A	X	N/A

Figure 3 *This table represents the infrastructure managed by agencies who responded to the questionnaire.*

Impacts

Over 130 specific types of invasive species that impact federal infrastructure were identified. The impacts from each species type is captured in Figures 4 and 5. Since the list of species was so large, they were grouped into 6 categories that capture the majority of the species types that impact infrastructure – mussels, aquatic weeds, terrestrial weeds, rooting and burrowing animals and other invertebrates. Invasive species types and control methods implemented by the federal agencies are detailed in Figure 6.

Infrastructure Types Impacted By Invasive Species

	Power	Water	Transportation	Buildings
Mussels	X	X	X	N/A
Aquatic Weeds	X	X	X	N/A
Terrestrial Weeds	X	N/A	X	X
Rooting and Burrowing Animals	X	X	X	X
Other Invertebrates	X	N/A	N/A	X
Other Vertebrates	X	N/A	N/A	N/A

Figure 4 This table represents a summary of the most common types of invasive species and the types of infrastructure they impact as detailed in the agency responses to the questionnaire. This list is consolidated and is not all inclusive.

Authorities

Figure 7 represents the Authorities that each agency provided that they follow for managing invasive species on infrastructure. The list is not intended to be all inclusive.

Case Studies

Case studies to provide further details of specific issues were requested from agencies. Several specific issues identified in the case studies and the responses to the questionnaire are detailed in Figure 5. Some of these

issues can be further developed into detailed case studies to better demonstrate the impacts invasive species have on federal infrastructure. One detailed case study was provided by the Bureau of Reclamation for mussel impacts at the Hoover dam. Two other case studies have been identified by the U.S. Army Corps of Engineers. These two case studies are under development and will focus on impacts to commercial navigation on the Arkansas River from water hyacinth (*Eichhornia crassipes*) and impacts to lock structures, flood control and water supply on Millwood Lake from alligator weed *(Alternanthera philoxeroides)* and hydrilla *(Hydrilla verticillata)*. The USFWS provided 26 case studies related to impacts from various invasive species on infrastructure they manage at their hatcheries and National Wildlife Refuges. See Annex 4 for all of the case studies.

Federal Infrastructure Impacts From Invasive Species

Water Systems	**Irrigation, Dams, Levees, Hatcheries** – potable/non potable water; conveyance systems; routine operations and maintenance; biofouling; cooling water systems; filtration; HVAC; fire suppression systems; potable water lines; service water lines; water flow capacity and speed; increased power demand; navigation; clogged components; pumps; pumping plants; turnouts; flow meters; intake structures; turbidity; waste; integrity of earthen structures such as access roads; dams; levees; grounds keeping; equipment; impacts to farming from herbicide application; intake/irrigation structures; crop failure; fallen trees, water level control structures, erosion, flooding.
Power Systems	**Hydropower, Power Plants, Transmission Lines** – penstock; gates; valves; scroll case; surge tank; service station pipelines; draft tube; raw water intake; strainers; cooling water heater; piping; air compressors; fire system; sump pumps; gate slots; trash rack; instrumentation; biofouling; water intakes; gratings; non-potable water systems; pumps; stop logs; sills; stop log structures; lock facilities; intakes; penstocks; screens; wooden power line posts; power outages; personnel safety; increased damage repairs; increased power costs; electrical switch gears; service wiring; arc flash; HVAC; grounds keeping; equipment; fallen trees, fire.
Transportation Systems	**Roads, Navigation Channels, Air Fields, Lock Chambers** – routine operations and maintenance; lake and river transportation; strike hazards to motorists, law enforcement and fire fighters; road beds; culverts; guard rails; fence posts; increased collisions; reduce lines of sight; blocked signs; roadway integrity; sedimentation; channel depth, channel passage, right of way clearance; aids to navigation; equipment; flight line; pumps; airstrip maintenance; aviation safety; pavement integrity at road/runway edges; road shoulders; loss of soil/gravel; consumer losses; fallen trees, fire, erosion, flooding.
Building Systems	**Offices, Outbuildings** – structural integrity; operations and maintenance; stucco; paint; plastic; pavement; cement; concrete; fencing; HVAC; landscaping; grounds keeping costs; mold remediation; equipment; fallen trees, appearance to historic structures, fire, flooding.

Figure 5 This figure details infrastructure types and the impacts agencies reported they have experienced as a direct or indirect result of invasive species.

Control Methods for Invasive Species Impacting Federal Infrastructure

Mussels	Terrestrial/Aquatic Weeds	Rooting and Burrowing Animals	Other Vertebrates	Other Invertebrates
• Chemical application (copper, chlorine) • Manual and mechanical removal • UV systems • Watercraft inspection and decontamination • Install/modify duplex strainers • Smaller filter baskets • Automated self-cleaning screens • Convert water sytems from raw water to treated water or closed loop systems • Cooling water temperature adjustments	• Chemical application (herbicides, copper) • Manual and mechanical removal • Prescribed burns • Goats • Biological control agents	• Chemical application (contraceptives, reproduction control, poison) • Traps • Exclusion • Shooting	• Traps • Exclusion • Biological control agents • Manual removal	• Chemical application (pesticides, rodenticides) • Traps • Exclusion • Biological control agents

Figure 6 This figure identifies control methods agencies have implemented for invasive species by type.

Agency Authorities for Management of Invasive Species on Federal Infrastructure

Authorities	Agency
Reclamation Act of 1902	BOR
Boulder Canyon Act of 1928 (P.L. 642)	BOR
Fish and Wildlife Coordination Act of 1934	BOR
Executive Order 13112 (Feb 1992)	BOR, USACE, DOD, USFWS
Executive Order 13751, Safeguarding the Nation from the Impacts of Invasive Species, issued December 5, 2016	BOR, USACE, NPS, DOD, USFWS
Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), 7 U.S.C. 136 et seq.	BOR
ENV P02 (https://www.usbr.gov/recman/env/env-p02.pdf)	BOR
ENV 01-01 (https://www.usbr.gov/recman/env/env01-01.pdf)	BOR
ENV 01-02 (https://www.usbr.gov/recman/env/env01-02.pdf)	BOR
PEC 10-29 (https://www.usbr.gov/recman/pec/pec10-29.pdf)	BOR
Power Equipment Bulletin No. 53 Information on Invasive Mussels for Reclamation, Power Facilities Advisory (Feb. 2014)	BOR

Technical Memorandum NO. 86-68220-07-05 Inspection and Cleaning Manual for Equipment and Vehicles to Prevent the Spread of Invasive Species (Sept. 2009)	BOR
Integrated Pest Management Manual for Effective Management on Reclamation Facilities (Nov. 2008)	BOR
ER 1130-2-540	USACE
USACE Policy letter on Invasive species 2009	USACE
The Invasive Species Leadership Team Program Management Plan	USACE
Removal of Aquatic Growth (RAG)	USACE
Aquatic Plant Control Program	USACE
River and Harbor Act of 1899	USACE
BLM's Collaborative Approach for Reducing Wildland Fire Risks to Communities and the Environment 10-Year Comprehensive Strategy Implementation Plan (WGA 2006)	BLM
Partners Against Weeds: An Action Plan for the Bureau of Land Management (BLM 1996)	BLM
Pulling Together: National Strategy for Invasive Plant Management (FICMNEW 1997)	BLM
The Public Rangelands Improvement Act of 1978 (Public Law 95-514; 43 U.S.C. 1901 et seq.)	BLM
Federal Land Policy and Management Act of 1976, as amended, (Public Law 94-579; 43 U.S.C. 1701 et seq.)	BLM
The Carson-Foley Act of 1968 (Public Law 90-583; 43 U.S.C. 1241 et seq.)	BLM
The Plant Protection Act of 2000 (Public Law 106-224;)	BLM
The Federal Noxious Weed Act of 1974 (Public Law 93-629) as amended by Section 15, Management of Undesirable Plants on Federal Lands, 1990, (7 U.S.C. 2801 et seq.) .	BLM
BLM Manual 9011 and Manual Handbook H-9011-1: Chemical Pest Control	BLM
BLM Manual 9014 – Use of Biological Control Agents of Pests on Public Lands	BLM
BLM Manual 9015: Integrated Weed Management, 1992	BLM
BLM Manual 9220: Integrated Pest Management	BLM
DM 517 Integrated Pest Management	BLM
BLM Manual 9177 - Maintenance and Safety of Dams	BLM
H-9177-1 Dam Condition Assessment Guidelines for Embankment Dams	BLM
H-9177-2 Dam Condition Assessments	BLM
23 U.S.C. §§319, 328, and 329	DOT
General Manual Title 190, Part 414 – Invasive Species	NRCS
Guiding Principles for Sustainable Existing Buildings	EPA
COMDTPUB P5090.1C, Dec. 2013,	USCG
All Coast Guard Message ALCOAST 074/14, 25 Feb 2014).	USCG
BENEFICIAL LANDSCAPING GUIDANCE - U. S. Coast Guard Environmental Management Division (G-SEC-3)	USCG
National Park Service Organic Act of 1916 (16 U.S.C. § 1 et seq., P.L. 113-287, 128 Stat. 3094.)	NPS
Animal Damage Control Act of 1931, as amended (7 U.S.C. § 426-426c)	NPS

Sikes Act of 1960, as amended (16 U.S.C. §670 et seq.)	NPS, USFWS, DOD
National Historic Preservation Act (NHPA) of 1966 (54 U.S.C. §§ 300101 et seq.)	NPS
National Environmental Policy Act of 1969 (42 U.S.C. § 4321-4370)	NPS
Sikes Act of 1960, as amended (16 U.S.C. §670 et seq.)	NPS
General Authorities Act, as amended by the Redwood National Park Act of 1978 (16 U.S.C. 1a-1; P.L. 113-296)	NPS
Clean Water Act of 1977 (33 U.S.C. § 1251 et seq., Public Law (P.L.) 95-217)	NPS
Cooperative Forestry Assistance Act of 1978, as amended (16 U.S.C. §2101 et seq.)	NPS
Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990	NPS, USFWS
Alien Species Prevention and Enforcement Act of 1992 (Pub.L. 102-393, 106 Stat. 1774)	NPS, USFWS
Hawaii Tropical Forest Recovery Act of 1992 (16 U.S.C. § 4502a, 4503a et seq.)	NPS, USFWS
Wild Bird Conservation Act of 1992 (16 U.S.C. § 4901 et seq., Pub.L. 102-440)	NPS
Government Performance and Results Act of 1993 (Pub.L. 103-62) as amended by the Government Performance Results Modernization Act of 2010 (Pub.L.111-352)	NPS
Violent Crime Control and Law Enforcement Act of 1994 (P.L. 103-322)	NPS
National Invasive Species Act of 1996	NPS
Wyden Amendment of 1998, as amended (Pub.L. 105-227 § 323; Pub.L. 109-54 § 434)	NPS
Nutria Eradication and Control Act of 2003 (P.L. 108-16)	NPS
Consolidated Natural Resources Act of 2008 (16 U.S.C. § 1j, P.L. 113-287, 128 Stat. 3094)	NPS
36 CFR § 1, 1.5, 1.7(b)	NPS
National Park Service Policies 2006	NPS
Defense Transportation Regulation (DTR) 4500.9R, Part V: DOD Customs and Border Clearance Policies and Procedures, Chapter 505-506	DOD
Agricultural Cleaning and Inspection Requiremements	DOD
DOD Pre-Clearance Program Customs and Agriculture	DOD
Technical Guide 31 - Guide for Agriculture. The Health Preparation of Military Gear and Equipment (Nov 2016)	DOD
DOD 4140.46M Issue Use and Disposal of Wood Packaging Material (WPM)	DOD
DOD Manual 4715.06 Vol 3 - "Regulations on Vessels owned or operated by the Department of Defense: Ballast Water, Well deck Sediment and Anchor Sediment Management	DOD
Department of Defense Instruction (DODI) 4715.03	DOD
DoDI 4150.07	DOD
DoDI 4715.06	DOD
MOU Continuation of the Cooperative Ecosystem Studies Units Network	DOD
MOU between DOD and USFWS to promote Conservation of Migratory Birds	DOD
MOU between DOD and The Nature Conservancy	DOD
MOU between the USDA, NRCS and the DOD	DOD
MOU between DOD and the Pollinator Partnership	DOD

MOU Animal Damage Assessment and Control	DOD
MOA Between USDA and DOD for cConduct of Forest Insect and Disease Suppression on Lands Administered by the US DOD	DOD
MOA between FAA, US Air Force, US Army, US EPA, USFWS and USDA to address Aircraft Wildlife Strikes.	DOD
National Wildlife Refuge System Administration Act of 1966 (16 USC §668dd-ee, regulated through 50 CFR)	USFWS
50 CFR § 27.52	USFWS
50 CFR § 27.21	USFWS
50 CFR Part 25	USFWS
National Wildlife Refuge System Improvement Act of 1997 (Public Law 105-57)	USFWS
Clean Vessel Act of 1992	USFWS
The North American Wetland Conservation Act of 1989 (16 USC § 4401 et seq., 16 USC § 669b (note))	USFWS
Refuge Manual - Chapter 7 RM 8	USFWS
Service Manual - 601 FW 3.16A	USFWS
Exotic Species Introduction and Management	USFWS
Service Manual - 750 FW 1	USFWS
Service Manual - 569 FW 1	USFWS
NISC Management Plan - 2008-2012	USFWS
Fish Health Policy	USFWS
Bio Security Protocols	USFWS
Broodstock Management Plan	USFWS

Figure 7 This figure represents the Authorities that each agency provided that they follow for managing invasive species on infrastructure. The list is not intended to be all inclusive.

Discussion

This section is broken out into several topics that were highlighted in the responses from the federal agencies. Independently, each of these sections has its own merit. When considered together, these topics illustrate a much more complex narrative that details the significance of the issue federal agencies face when managing invasive species on federal infrastructure.

Infrastructure

The responses strongly suggest that there is a significant amount of infrastructure managed by federal agencies. The extent of impacts by invasive species to this infrastructure is demonstrated in detail by some agencies while other agencies were not readily aware of problems. In many cases agencies were aware of the impacts invasive species can have, but reported that the infrastructure they manage did not have significant impacts from invasive species. One of the unique issues that came out of this questionnaire was that the responsibilities of who manages the infrastructure was often shared. The roles that each agency has for managing infrastructure and invasive species was often blurred because of responsibilities, awareness and lack of overlap in agency policies.

Impacts

Impacts from invasive species are numerous. The impacts range in significance from minor to levels that impact project operations such as mussels preventing hydropower generation or invasive grasses creating life safety risks along roadsides from increased fire risk or blocked sight lines. These impacts are glaring in some locations and discreet in others. Although many of the agencies responded that the impacts to their infrastructure was minimal; the overall impacts, where they exist, are significant. Many agencies also stated that awareness and education of invasive species were lacking, funding was limited, management needs were unknown, policy was not sufficient and agency support was not strong.

Agencies report that they have insufficient funding to address the challenges of invasive species. At the same time, agencies also struggle to fully capture or report the costs and impacts from invasive species. This problem is fueled by many different factors. Two primary factors are the level of prioritization that agencies give to managing invasive species and the financial resources needed to support their management needs. These shortfalls demonstrate the gaps in invasive species management across the federal government. The inability to consistently address these gaps and provide specific information to support these needs across the federal government inhibits the ability of federal agencies to successfully demonstrate the true extent of the impacts invasive species have on the infrastructure they manage.

Zebra Mussels on trash racks at Ray Roberts Lake. Photo Courtesy of Brandon Mobley, USACE.

For many agencies, attending to their backlog of deferred maintenance actions on their infrastructure places their preventative maintenance programs in a position where invasive species are not a priority. Ideally, these agencies would consider invasive species control in prioritizing their resources for asset maintenance. However, the agencies cannot document having impacts to their infrastructure that are significant enough to reach a threshold to prioritize that work. At the same time many other agencies are spending very large amounts of federal money to manage invasive species that have already impacted their infrastructure.

Agencies were inconsistent in capturing the extent of the issues invasive species have on their infrastructure. Their inability to better capture this is attributed to several factors. Awareness and resources were the two primary ones that were referenced.

Over 130 invasive species were mentioned by the agencies that they know are impacting federally managed infrastructure. This list is a random sampling provided in the agency responses to the questionnaire and is not inclusive of all species or impacts across the entire federal government. What this does show is the fact

that even with limited resources and awareness, there are a significant amount of species and associated impacts that when combined add up to a very large problem for the federal government both now and for the long term for management and operational costs and impacts.

Some specific examples of impacts that were discussed include increased operation and maintenance costs to federal agencies, excessive wear and tear on the equipment from over use and strain, consumer losses, costs due to lost man-hours, cost of repairs to damaged equipment, lost production and reduced reliability of asset operational readiness.

Highways require herbicide treatments to maintain visibility for safety, to reduce collisions, and to reduce snow drifting on the roadway.

Roads and power transmission are being impacted by increased wildfires that are melting pavement and burning wood poles supporting power lines. Roads and power line rights-of-way are becoming overgrown and hindering access for safety and maintenance. Brown Tree Snakes (*Boiga irregularis*) and tawny crazy ants (*Nylanderia fulva*) cause power outages and fire risks.

Watershed health is being impacted by excessive erosion, fires fueled by invasive vegetation and choking out of waterways and reduced water movement from invasive aquatic plants. Agriculture is experiencing failures in crops from irrigation systems not being able to supply a consistent and reliable source of water because of invasive mussels and plants. Endangered species are being impacted by inability to manage water levels in national fish hatcheries.

> "If a Tow has twelve barges then two separate lockages are necessary. It will turn a normal 2.5 hour lockage into an 8-12 hour lockage."
>
> *—Excerpt from Case Study on the impacts of invasive aquatic weeds on the Arkansas River.*

Aquatic weeds make it almost impossible to open miter gates affecting navigation lock facilities on major rivers transporting commerce, Gates have to open and close multiple times to remove water hyacinth from behind them. The gates have to be in the recess fully or the boats cannot get out of the lock chamber. The lock is not designed to accommodate large amounts of vegetation as well as the barges. The tow company struggles to get their tows back together because of the copious amounts of water hyacinth tangled between the barges. When there are no tows to lock through, the operators lock only water hyacinth, they will leave the lock gates open to let the vegetation drift in, then lock it down and let it drift out and start all over again. This cause's unnecessary strain on equipment; opening and closing lock gates to move debris is not the intended purpose of these locks. The problem is getting worse every year. A secondary impact from this is the loss of time and revenues from increased lockages to the barge industry.

Excessive mats of aquatic vegetation create friction below the surface and slow the flow of water in flood control, water supply impoundments and navigation systems. This creates a situation where more power is required to move the water. When dead, the vegetation detaches and floats to the surface, creating large mats. These mats clog critical components of the water conveyance system, including pumping plants, turnouts, and various critical flow meters and other structures and equipment. These mats also reduce flow capacity within licensed agricultural irrigation intake structures. These impacts cause increased costs to the agencies managing the infrastructure.

Rooting and burrowing from animals like iguanas, rats, hogs and nutria can impact the integrity of buildings and earthen structures such as access roads, levees and dams creating potential for catastrophic failures. Additionally they develop vulnerable areas for new invasive species to become established.

Water Hyacinth in a lock chamber along the Arkansas River. Photo Courtesy of Jeremy Crossland, USACE.

Giant African Snails (*Lissachatina fulica*) eat native vegetation and carry parasites that can cause diseases such as meningitis in humans. In addition, their appetites for materials like stucco, paint, and plastic can also be damaging to homes and infrastructure. The snails have been reported to dissolve bone, shells, cement and concrete to absorb the calcium for their shell.

One of the biggest impacts is the continued spread of new and existing invasive species through pathways that our federal infrastructure creates. Shipments moving upstream cause potential to transport invasives to upstream locations. Float Planes flying to remote National Wildlife refuges can transport invasives to new waters. All transportation infrastructure raises concern due to the possibility of spreading invasives along corridors such as highways.

Federal inspectors work diligently at major airports, seaports, and land border crossings where they monitor imports to protect the Nation from injurious invaders. The inspectors have broad authority to detain and inspect any international shipment, mail parcel, and vehicle or passenger baggage. These agencies continue their outreach and awareness programs to educate the traveling and trading public about the direct and indirect effects of invasive species. However, it is not just these major areas of import where invasives come from. Having eyes on the smaller ports of entry, private import companies, the pet trade and other avenues poses a serious challenge that is hard to overcome even with infinite resources. How we define and achieve success is a challenge that is only surmountable through a cohesive approach that starts with awareness and education. Many agencies stated that they were not aware of invasive species problems on the infrastructure they manage. In many cases their lack of awareness can be attributed to the agency's lack of education and/or lack of funding hindering their ability to look for those problems. While we have defined a number of areas to focus on impacts, the approach to addressing them still needs understanding, support, resources and a consolidated interagency team approach to have even the most minimal success.

Authorities

Numerous authorities exist relating to invasive species management and infrastructure. How all of these tie together is not very clear. The number of authorities listed by the agencies in response to the questionnaire is overwhelming (see Figure 7). The ability to oversee and manage the amount of authorities that some agencies have is a significant challenge.

Although agencies are limited via many avenues, including resources and leadership support to prioritize invasive species work, most appear to have policy or guidance for how each agency approaches invasive species management. Many agencies have developed their own specific invasive species policy or they have integrated invasive species awareness, management and control into their operational management plans and guidelines.

The list of Federal authorities that agencies reported that they use to manage invasive species is not comprehensive. Not only is the list not comprehensive, but the listing within individual agencies was not consistent in the responses to the questionnaire. These responses demonstrate that there is a need for agencies to follow a more definitive overarching interagency policy that addresses how federal agencies manage invasive species with regards to infrastructure. The importance of this is further demonstrated by the fact that many agencies seemed to have different levels of management responsibility on their infrastructure. In many cases, the infrastructure being occupied by one federal agency was managed by a different federal agency.

Although national and agency specific policy exist, it was evident from the responses to the questionnaires that awareness and implementation of these policies is not consistent within, and across individual agencies. Some agencies provided numerous responses from different individuals or offices spread out in different regions. The responses demonstrated an increased awareness or knowledge of certain authorities in some

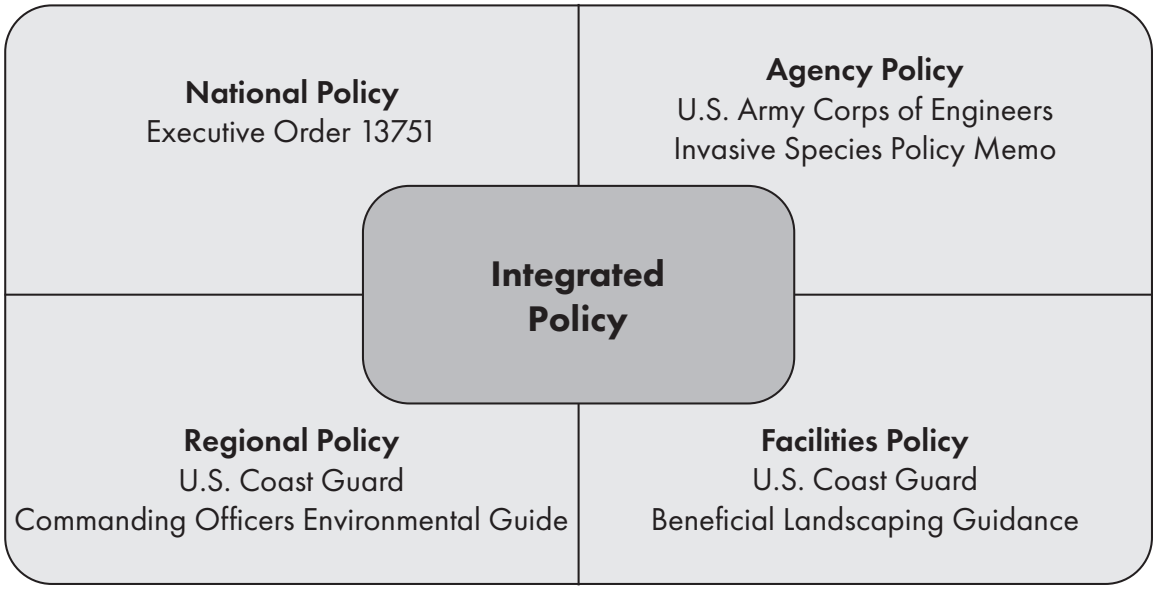

Figure 8 This graphic represents the considerations that should be included in development of integrated invasive species policy on federal infrastructure.

areas and no awareness or knowledge of them in other areas.

It would be beneficial to have an overarching integrated invasive species authority that applied across the federal government for management of infrastructure (see Figure 8). This would ensure that all aspects of invasive species management were consistent and would enhance the protection of valuable critical infrastructure from the harms of invasive species.

A streamlined process is necessary to allow agencies to more effectively manage invasive species. Without overarching authorities with clear implementing guidance that carries across all federal agencies the struggle of individual and isolated management will persist. For agencies to significantly impact invasive species management on infrastructure, they must unite under a common management approach. Doing so will provide consistency and allow a united and collaborative approach to all aspects of invasive species management on the various types of infrastructure managed by the federal government. In addition to interagency policy

and management, cooperation with stakeholders and partners (state and private groups) are essential. These groups should be an integral part of development of any streamlined integrated processes.

Case Studies

The 2016-2018 NISC Management Plan had a specific task to capture case studies of impacts from invasive species on infrastructure. These case studies, as provided by the BOR on the impacts of mussels on hydropower dams (see Annex 4), USACE on the impacts of aquatic weeds on navigation, hydropower and water supply and the numerous impacts to USFWS facilities provide very strong evidence of the severity of impacts that invasive species can have on infrastructure both financially and on the operations themselves. Development of case studies should be an ongoing effort to continue to demonstrate the true impacts of invasive species on infrastructure. These case studies will help demonstrate the need to prioritize invasive species work.

> "Funding and tracking of costs are two of the primary management challenges this project is faced with. We continue to try and document funding costs and needs to show the extent of this issue."
> *—Excerpt from Case Study on tracking costs of mussel related impacts at the Hoover Dam.*

Resource Needs

Responses to the questionnaire provided a range of gaps that affect the management of invasive species on infrastructure. Far above all other gaps identified by all of the agencies was funding. Funding is what provides the resources for invasive species management; it pays for personnel, research, contracts, materials, equipment, education, and much more. Resources for management of a program must be looked at from the past, present and future. Each of these plays an important role in comprehensive program management.

An agency needs to identify its requirements to implement an invasive species management program as demonstrated in Figure 9. This figure provides four essential elements for identifying resource needs. Both current and future resource needs must be considered for a successful management program. Typically historic expenditures are a good starting point. However, the current situation of invasive species management on federal infrastructure where agencies have limited budgets and have no way to clearly track their expenses does not provide a solid basis to start from. Agencies need to work together and understand the true needs

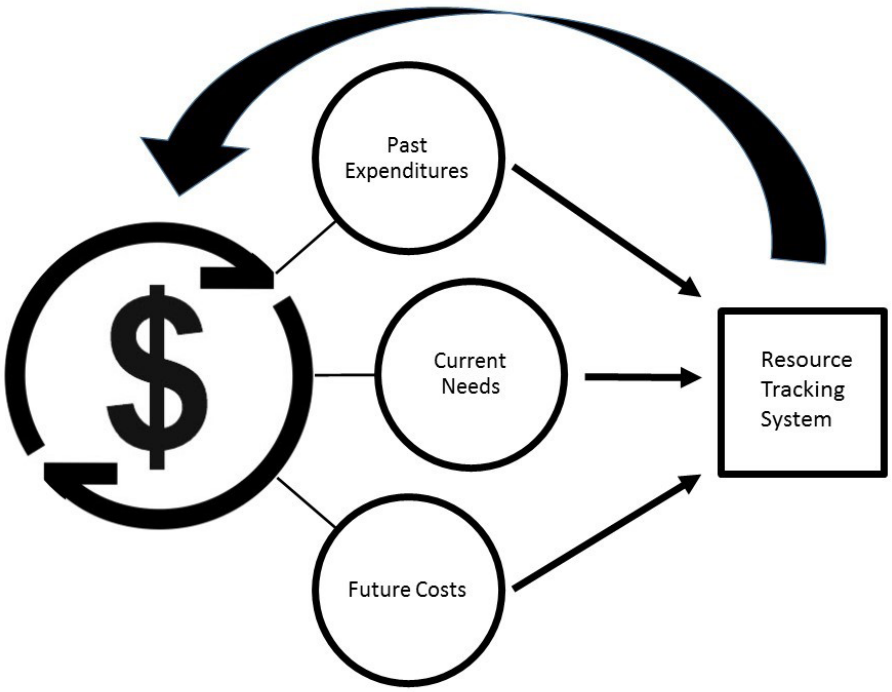

Figure 9 This graphic demonstrates the need to identify, capture and manage past, present and future costs to properly understand costs and to resource invasive species management on federal infrastructure.

and costs from those that have more rigorous programs that include planning and tracking mechanisms to identify resource needs.

It was clear from the responses that every agency is independent when it comes to their finances and management of invasive species. There is no clear process that bridges between or across agencies for budget development, allocation and tracking. No single agency demonstrated an agency wide process for capturing the costs of invasive species management or identifying the agency's needs. These are significant gaps that need to be addressed.

Some agencies are more advanced in certain areas of budget oversight for invasive species like BOR and USACE. However, each of these agencies only have detailed information in limited areas of the programs they manage. For example, the BOR has detailed information pertaining to mussel-related impacts and costs at Hoover, Davis, and Parker Dams. However, as an agency, they do not have a process to capture invasive species costs agency wide. Similarly, USACE has detailed information pertaining to certain costs for aquatic invasive plant management in their navigation program, however they do not capture and identify all of their needs for the 12 million acres of land and water that they oversee the management of.

It is evident that a clear process for budget development, allocation and expenditure tracking that transcends across all of the agencies is necessary. In discussions and correspondence with agency representatives, it was clear that the impacts from invasive species on infrastructure was noticed, but the ability to communicate those issues was lacking. Literature (USFWS 2012, USDA 2018) further supports this by providing numerous differing estimates for the cost of invasive species management. While all of these numbers are extremely high, it is apparent that the federal government does not have a handle on its costs for management of invasive species on federal infrastructure. A process needs to be established so all agencies have a consistent approach to their funding needs for the various aspects of invasive species management, in particular, as they apply to federally owned and managed infrastructure.

Program Support

Leadership support in all organizations from the top of the agency down is imperative to a successful invasive species management program. It is difficult for an agency to support expensive management or treatment for invasive species as a proactive approach to controlling invasive species because higher priorities typically out compete invasive species management. Responses stated that agency leadership typically need to see an impact before they are willing to spend money on prevention and management of that impact.

Mussel Related Costs at the Hoover, Davis and Parker Dams

- Through 2016 - $6,025,100
- Expected from 2017 to 2026 - $10,372,108

—As detailed in the 2016 BOR paper entitled Mussel-Related Costs at Hoover, Davis and Parker Dams

Budgeting and actually receiving money is another issue. Currently, across federal agencies invasive species packages do not compete well in the budget process. Most agency budgets run two years behind, allowing species to expand and increase their impacts, while waiting for funding. Unfortunately by the time funding is received, it can be too late to eliminate an infestation. Without a vigorous early detection and rapid response (EDRR) program in place, costs and the extent of the impacts escalate rapidly over time (DOI 2016). Figure 10 details the exponential impacts of the types of management discussed in this section.

Management

There are countless techniques to manage and control specific invasive species impacts to infrastructure.

"…reports recommended that each site should fully assess their facility and make pro-active changes to minimize the impacts of the quagga mussels."

—Excerpt from Case Study on tracking costs of mussel related impacts at the Hoover Dam

Based on the responses to the questionnaire, management styles of the federal agencies can be lumped into two categories, proactive management and reactive management.

Proactive management is generally an aggressive management style where early measures are implemented to identify and respond to invasive species issues. This management style is typically more effective and efficient over the long term (Bond et. al. 2010, Deal et. al. 2006, Simonsen et. al. 2015). This is not the typical management style implemented by the federal agencies, primarily due to limited funding and current workload priorities.

Interestingly, agencies provided several proactive management efforts that they implement. The ability to carry out these management efforts varied significantly within and across agencies. The primary factors that determined the use of these techniques was driven by resources and workload prioritization. While the agencies seem to be aware of the efforts needed to carry out early detection and rapid response through proactive management, in many cases they are not able to because of other factors. Resources and workload prioritization are essential to the success of identifying and responding to invasive species issues through EDRR.

Reactive management is a style where issues are addressed after they have already started to impact infrastructure and their operational readiness. This management style is generally less efficient and more costly (Bond et. al. 2010, Deal et. al. 2006, Simonsen et. al. 2015). This seems to be the more common management style implemented by federal agencies.

While each of these management styles has their pros and cons, this is one place where agencies responding to the questionnaire unanimously agreed. Generally, agencies stated that they lack the funding to carry out a robust proactive management campaign for invasive species on the infrastructure they manage. While they might implement some aspects, an overall proactive management approach is lacking in most agencies. This appears to be because of limited funding. Immediate priorities are where the funding is directed and

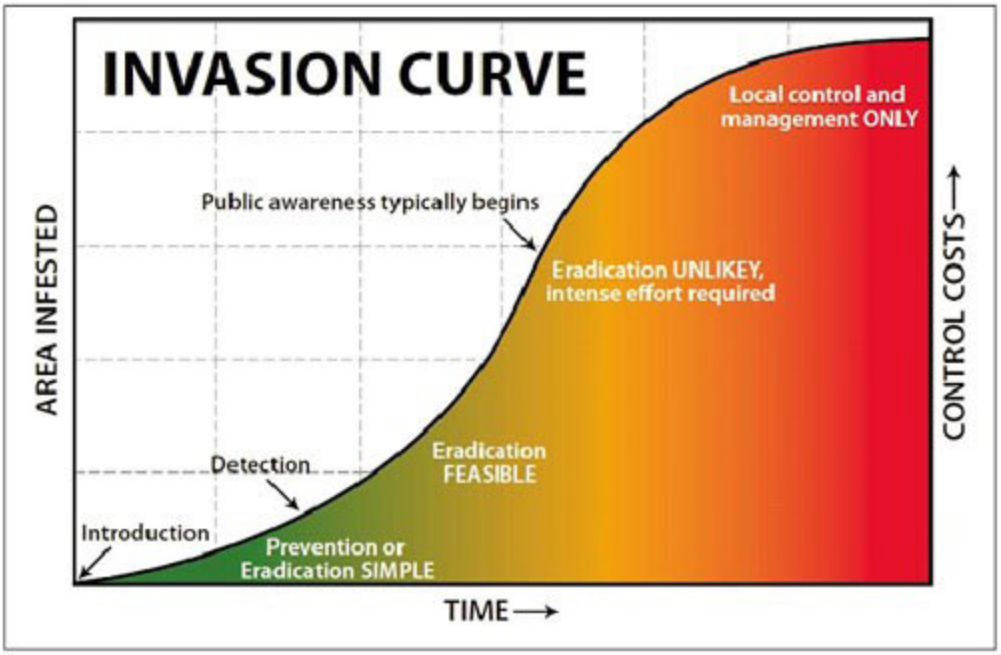

Figure 10 This graphic demonstrates that cost, size of infestations and the inability to control infestations increases significantly over time if invasive species are left unmanaged at the early stages of their establishment.

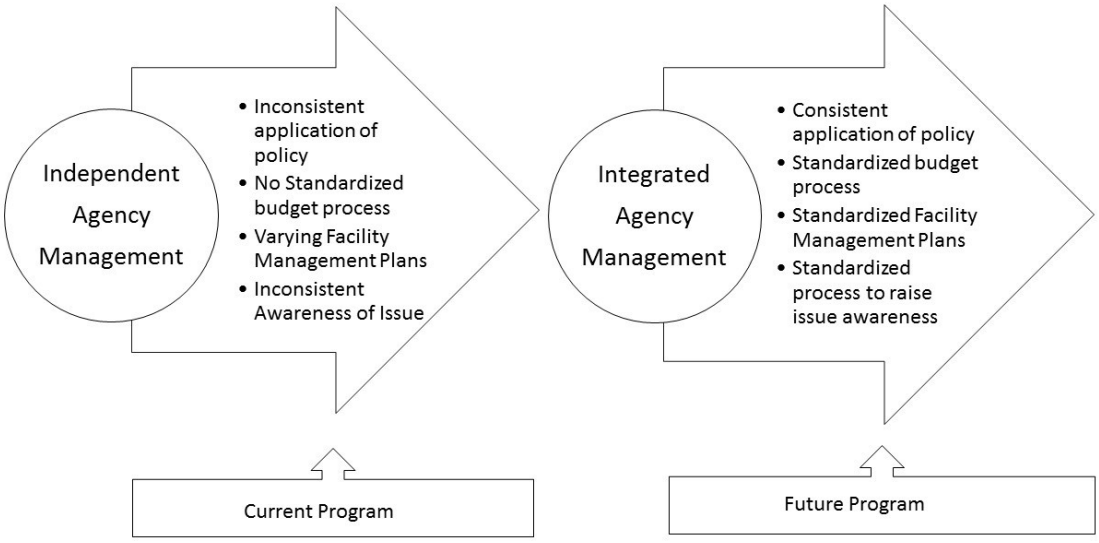

Figure 11 This graphic demonstrates the differences from the existing inconsistent independent management program and the benefits of a consistent integrated management program.

there is not usually much left for proactive management of invasive species. As such, federal agencies usually implement a reactive management program that results in delayed response time and increased costs as detailed in Figure 10.

Not only is management primarily reactive, but it is in most cases independent. Independent management in this case refers to isolated management within particular agencies, specific offices, regions or locations within agencies. These isolated management efforts do not allow for consistent application of policy. They provide no standardized process for all facets of budget management from planning through execution. They work off of varying interpretations and use of inter and intra-agency policies. They do not provide for consistent awareness of the management issues invasive species cause within or across each agency.

To successfully manage invasive species, the federal government needs to develop an integrated process that provides standardization and consistency across all of the agencies, offices, regions and locations (See Figure 11).

To achieve this, it starts with policy. Although agencies have numerous agency specific policies, they did not consistently reference any broad overarching policy. Broad policy already exists. Executive Order 13751 is the overarching policy at the national level that calls upon executive departments and agencies to take steps to prevent the introduction and spread of invasive species, and to support efforts to eradicate and control invasive species that are established. There is also the National Invasive Species Act (NISA 1996) which is a national level policy intended to prevent invasive species from entering inland waters through ballast water carried by ships. While NISA does not have a direct link to how federal agencies should manage invasive species, EO 13571 does. Most federal agencies were aware of EO 13571, however, agencies do not appear to aggressively pursue its implementation or use it as a cornerstone to invasive species management as it is intended. Based on responses to the questionnaire this seems to stem primarily from a lack of funding and leadership support. Without support you do not receive funding and without funding you do not have a successful management program. Those two need to be the first step with regard to implementing these authorities as intended.

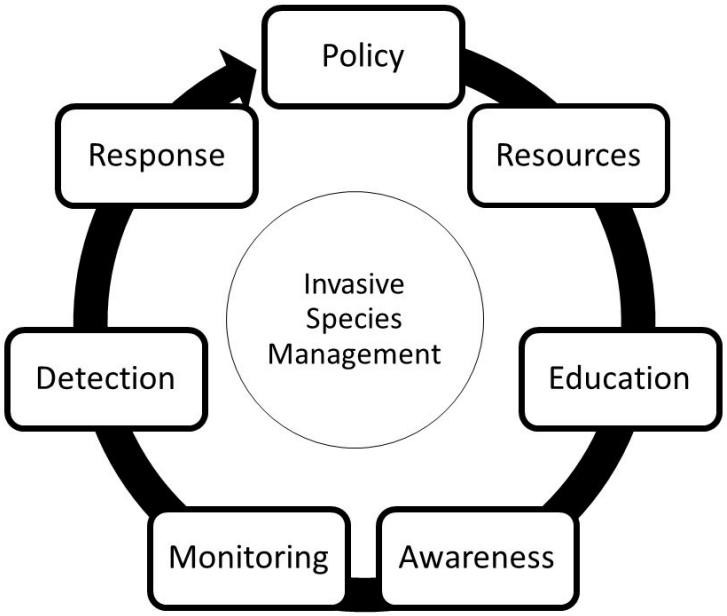

Figure 12 This graphic represents the various elements of an invasive species management program.

A multipronged approach is necessary for successful invasive species management as demonstrated in Figure 12.

This figure demonstrates the lifecycle of the necessary steps for successful invasive species management. If any of these steps are missing, gaps exist that will affect the success of the management program. Each step of the process has inherent issues that can break the chain. If each agency continues to implement independent programs without a consistent approach driven by policy and supported by resources the end results of successful management will not be achieved.

As discussed above, across agency policies are inconsistent. While some agencies have a lot of policies, others have more inclusive policies and others lack policy. An integrated management approach would provide each agency with similar level policy to provide consistency across the federal government to support its approach to invasive species management on federally managed infrastructure.

Agencies are also missing consistent tools. Numerous agencies manage the same type of infrastructure, but there is no consistent approach to how these agencies respond to invasive species impacts on a specific type of infrastructure. This stems from the same shortfalls as mentioned earlier (resources, agency support, policy), but it also misses an opportunity to unite, consolidate resources and proactively work to develop additional tools to help the agencies manage invasive species together. Things like standard operating procedures, education, outreach, training, invasive species management plans, EDRR monitoring plans and techniques, operation and maintenance protocols, facilities management plans, plans and specs for new construction, adaptive management and baseline inventories are just some of the things that it appears agencies can better work on together to have a united approach to invasive species management on federally owned infrastructure.

Priority Action Recommendations

1) Agency Support – The federal government acknowledges the implications invasive species have on federally managed infrastructure. Agencies need to embrace the issue and unite across agency boundaries to address ongoing impacts and reduce future infestations.

2) Integrated Policy – Agencies need to use EO 13751 as the cornerstone it was intended to be for managing invasive species. Further development of integrated policy that resonates across agency boundaries should be developed to provide standard practices for managing invasive species impacts to federally managed infrastructure.
3) Increased Appropriations – Agency support, integrated policy and tracking mechanisms should be developed and used to justify resource needs to manage invasive species impacts to federally managed infrastructure.
4) Synchronized Management Efforts – Agencies should work together to identify issues, consolidate resources and share knowledge to address invasive species impacts to federally managed infrastructure.
5) Proactive Management – Agencies should identify proactive management approaches to long term invasive species management with the intention of minimizing reactive management needs.
6) Develop Tracking mechanisms
   a. Budget – Agencies should develop a process to track budget needs and expenditures within and across federal agencies to be used to better show the disparity of needs and actual funding to manage invasive species on federally managed infrastructure.
   b. Impacts – An interagency database should be developed to capture invasive species types and their impacts to federally managed infrastructure.
7) Case Studies – Agencies should continue to identify and provide detailed case studies to the NISC Secretariat to further demonstrate the extent of impacts various invasive species are having to federally managed infrastructure.

Conclusion

This effort gathered information that was never consolidated before and gives a detailed look at the current state of invasive species management on infrastructure by the federal government. While they are not always directly evident and clearly visible or understood, invasive species impacts to federally managed infrastructure are significant. They cost the federal government a staggering amount of money each year and those numbers will continue to grow. While the federal government does the best it can with its limited resources to manage invasive species, it must do better.

The information provided by the agencies themselves demonstrates that there remains a significant need for management support, consistent policy, increased appropriations and synchronized management efforts across the federal government. The benefits of integrated proactive management need to be recognized and supported by agencies. Advancing science and technology to better understand, track and reinforce the issues across the federal government is essential to successful long term invasive species management. Continued development of case studies specific to invasive species and their impacts on infrastructure will help support and further progress the understanding of their impacts.

> "The United States currently lacks the comprehensive authority, or clarity of authority, necessary to effectively prevent, eradicate, and control invasive species that impact the human-built environment ("infrastructure")."
> —*Excerpt from the 2016-2018 NISC Management Plan.*

Invasive species is a complex and evolving battle. To keep up, the federal government needs to change its management paradigm. Specifically, there needs to be a comprehensive approach that is embraced by leadership across all federal agencies with the necessary resources to sustain the work needed to successfully manage invasive species impacts to infrastructure. Without this type of an approach, impacts and costs will continue to rise exponentially.

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Appendix 1

NISC

NATIONAL INVASIVE SPECIES COUNCIL

SECRETARIAT

Invasive Species Impacts on Federal Infrastructure

OVERVIEW

The *2016–2018 National Invasive Species Council* (NISC) *Management Plan* action items 4.2.1 and 4.2.2 call for the compilation of case studies of invasive species impacts on infrastructure in the United States, as well as the development of guidance that enables federal agencies to prevent the impacts of invasive species on US infrastructure assets. This data call advances these action items.

The impacts of invasive species on our infrastructure are not always obvious, but they are widespread and costly. Examples of control measures include:

- Spraying and physical removal of weeds on a dam, around roadways, airports, or other public facilities to protect power, water, and transportation systems.[1]
- Trapping to remove nutria (*Myocaster coypus*) and other burrowing aquatic species to protect power and water systems. Entire communities are at risk if compromised roads, levees, and bridges give way during storm events.
- Trapping and pesticide application for rats (*Rattus norvegicus*) and other species that chew on or otherwise short out electrical systems.
- Physical, chemical, and mechanical controls, manipulation of water flow rates, or antifouling coatings on dams and intake structures to control mussels (*Dreissenid rostriformis bugensis* and *Dreissena polymorpha*) to protect power and water systems.
- Repairs to fix structures and pesticides to control damage from Formosan termites (*Coptotermes formosanus*) to protect building systems.

Impacts from invasive species on federal infrastructure are poorly understood and are often overlooked. These impacts are frequently rolled in with other work (e.g., roadside or facilities maintenance) as a cost of doing business, go unfunded because they are not a priority, or they are simply not recognized as an "invasive species issue." These impacts are undoubtedly much bigger than are accounted for and thus challenging to "bring to light" so that they can be addressed in a timely and effective manner. We thus need your help in putting together the most accurate accounting feasible of the impacts that invasive species are having on our inventory of federal infrastructure. Specifically, we need you to provide us with the case studies and

[1] See page 5 for a glossary of terms and references.

statistics necessary for the development of useful federal guidance (per action item 4.2.2). With this information we can help provide much needed recognition to assist in supporting a more coordinated and comprehensive approach to the management of invasive species impacting our inventory of federal infrastructure.

In 2016, the Invasive Species Advisory Committee (ISAC) took the first steps in advancing Management Plan action item 4.2.1 by adopting a white paper on the impacts of invasive species to infrastructure. The paper highlights some case studies and corroborates the belief that gaps exist in understanding the physical and economic impacts of invasive species on infrastructure and that current policy is not sufficient to properly address invasive species issues.

The intent of this data call is to ground ISAC's work in the federal context. The data call will enable us to gather the necessary information to: 1) generally demonstrate that invasive species are having impacts on our federal infrastructure and 2) identify the species that are impacting our infrastructure, the type of infrastructure that is being impacted, the specific types and extent of impacts that we are managing, and the cost of those impacts to the federal government. This information will also enable us to identify gaps in regulatory authority and management capacity so we can make the changes necessary to protect our infrastructure against invasive species in the future.

We are requesting your cooperation in gathering the necessary information. The responses you provide are essential to inform future budget and policy decisions. Please provide as comprehensive and detailed a response to the data call as possible; your contributions will help remove barriers and create new opportunities for federal cost-efficiencies and programmatic effectiveness.

Although this data call is intended to gather information at the agency level, additional project specific responses are welcome. **Please respond to Mike Vissichelli of the NISC Secretariat no later than COB Friday, October 27, 2017.**

Questions and communications can be directed to:
Mike Vissichelli, Project Director for Invasive Species Impacts on Federal Infrastructure
National Invasive Species Council Secretariat
Telephone: 718-775-5571
E-Mail: michael.g.vissichelli@usace.army.mil

Thank you for your support!

NISC

NATIONAL INVASIVE SPECIES COUNCIL

SECRETARIAT

Invasive Species Impacts on Federal Infrastructure

Address of facility (if you are responding for a specific project or location):

POC for additional details (Name, Title, Agency, Phone Number, E-mail Address):

Detailed Information

1. What kind of infrastructure does your agency manage (circle all that apply)? [2]
   - Power Systems
   - Water Systems
   - Transportation Systems
   - Building Systems
   - Other – please describe

2. For facilities impacted or threatened directly by invasive species, provide their names and locations as well as genus and species name for the invasive species.
   - 2.1. How is that infrastructure impacted and what risks does that present to mission objectives?
   - 2.2. What are the broader costs from those impacts on infrastructure (e.g., to the economy, human health, natural and cultural resources)? Provide details (e.g., losses due to lower power generation).
   - 2.3. For infrastructure that is threatened by invasive species, how have you identified and assessed those risks?
   - 2.4. What management measures are being taken to prevent or control invasive species and their impacts?

3. Do you have any secondary impacts that you can associate with invasive species on your infrastructure (e.g., increased wildfire risks from invasive grasses that may threaten federal infrastructure such as roads or airports)?
   - 3.1. What other potential secondary impacts should be considered regarding invasive species on federal infrastructure?

[2] See page 5 for a glossary of terms and references.

4. What authorities does your agency have for managing invasive species that impact the infrastructure you manage?
   4.1. Do you have any written documentation or guidance you are following that specifically addresses management of invasive species impacts on federal infrastructure (i.e. EO, MOU, agency policies, management plans, etc.)? Please provide details and copies of any documents reference.

5. How does your agency identify needs for managing invasive species impacts on its infrastructure?
   5.1. What processes does your agency use to detect invasive species early, before they become a problem (e.g., baseline inventories, surveys)?
   5.2. Does your agency proactively manage its infrastructure to protect it from invasive species impacts or does it only respond when they cause significant harm?
   5.3. How does your agency prioritize highest risk assets and allocate resources accordingly?
   5.4. How does your agency measure its management success on invasive species?

Gaps

6. What are the gaps or other obstacles preventing you from being able to successfully manage the invasive species impacts on your infrastructure (circle all that apply)? Please provide a detailed explanation for each that apply.
   - Funding
   - People
   - Agency support
   - Policy
   - Science
   - Other

7. What resources do you need to successfully manage invasive species impacts on your agency's infrastructure (budgetary and non-budgetary)?

Funding

8. Do you have detailed information on costs associated with invasive species impacts on federally managed infrastructure?
   8.1. How much do you expend annually on invasive species control on your agencies infrastructure? Provide detailed annual budgetary expenditures by activity type from FY2014 through to the President's proposed budget for FY2018.
   8.2. How does your agency break out invasive species costs for infrastructure within its normal maintenance and repair budget?

Follow up

9. Would you be interested in serving on an interdepartmental task team related to this project? Is there anyone else you would recommend that would be interested in serving on an interdepartmental task team related to this project?
10. Does your agency have any issues that would serve as good case studies to help document impacts of invasive species on infrastructure? If so, please provide details and attach additional documentation as appropriate.

Appendix I: Glossary of Terms

Building Systems: manmade facilities consisting of structures with a roof and walls, such as a house, school, store, office, historic and archeological buildings and landmarks.

Control: containing, suppressing, or reducing populations of invasive species.

Early Detection: a process of surveying for, reporting, and verifying the presence of a non-native species before the population becomes established or spreads so widely that eradication is no longer feasible.

Eradication: the removal or destruction of an entire population of invasive species.

Infrastructure: systems of manmade physical structures.

Invasive species: 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 Advisory Committee **(ISAC):** a FACA committee whose primary duty is to provide information and advice for consideration by the Council on invasive-species related issues.

National Invasive Species Council **(NISC or Council):** the Secretaries and Administrators of 13 federal departments and the directors and chairs of three White House offices directed to work together in accordance with Executive Order 13751.

National Invasive Species Council **(NISC)** ***Secretariat:*** the team of federal employees whose function is to support and guide the work of the Council.

Non-native species **(Alien Species, Exotic 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.

Power Systems: manmade facilities that generate, transmit, and distribute electric energy.

Prevention: the action of stopping invasive species from being introduced or spreading into a new ecosystem.

Rapid Response: a process that is employed to eradicate the founding population of a non-native species from a specific location.

Transportation Systems: manmade facilities that include highways, railroads, waterways, ports, and airways.

Water systems: manmade facilities that treat drinking water and wastewater, control floodwaters, divert storm water, impound water for a variety of purposes and divert or convey water to agricultural and municipal users.

Appendix 2

NISC
NATIONAL INVASIVE SPECIES COUNCIL
SECRETARIAT

INVASIVE SPECIES

Impacts on Infrastructure

THE ISSUE

Because non-native species typically enter the United States (U.S.) through ports of entry in urban environments, some of the first observable impacts may be to infrastructure. In many cases, species that initially impacted infrastructure have had devastating impacts on ecological systems, agriculture, and/or fisheries when they spread into less modified landscapes and waterways. The U.S. currently lacks the comprehensive authority, or clarity of authority, necessary to effectively prevent, eradicate, and control invasive species that impact the human-built environment ("infrastructure"). We are thus unable to rapidly respond to some of the most damaging invasive species. We cannot effectively allocate the resources necessary to address invasive species that threaten public security, undermine federal infrastructure investments, or cause homeowners to incur substantial repair and maintenance costs.

(Right) Cheatgrass (*Bromus tectorum*) fuels fires that can destroy homes and businesses. (Left) Dreissenid mussels clog pipes and intake valves, costing agriculture and energy facilities millions of dollars in economic losses.

CALL FOR ACTION

The *2016–2018 National Invasive Species Council (NISC) Management Plan* action items 4.2.1 and 4.2.2 call for the compilation of case studies of invasive species impacts on infrastructure in the United States, as well as the development of guidance that enables federal agencies to prevent the impacts of invasive species on U.S. infrastructure assets.

Download the NISC Management Plan: on.doi.gov/2xh8h7m

INFRASTRUCTURE

The human built environment.

ISAC WHITE PAPER RECOMMENDATIONS

1. Work with relevant federal agencies to help them assess the physical and economic impacts of invasive species on the infrastructure projects that they manage.
2. Work with relevant federal agencies to quantify the actual cost of invasive species management to federally owned or supported infrastructure.
3. Adopt innovative construction practices that will prevent future impacts from invasive species.

Read the Infrastructure White Paper: on.doi.gov/2y14WNR

EXAMPLES

- As of 2016, more than $6 million has been spent at the Hoover, Davis, and Parker Dams collectively to manage quagga mussels (*Dreissena rostriformis bugensis*). An additional $10.3 million is anticipated to be spent at those three dams to manage quagga mussels during the next 10 years.[1]
- Raspberry/tawny crazy ants (*Nylanderia fulva*) short out electrical systems in private homes, businesses, and at federal facilities, including at the Port of Houston and NASA's Johnson Space Center. These power outages can be costly and create safety risks.
- Formosan termites (*Coptotermes formosanu*) impact residential, commercial, and federal buildings, including historical landmarks. A 1998 study concluded that Formosan termites exist in more than a dozen southern states, costing an estimated $1 billion a year in property damages, repairs, and control measures ($300 million in New Orleans, LA).[2] The total cost of impacts has likely increased substantially over the last 20 years.
- Aquatic weeds, such as water hyacinth (*Eichhornia crassipes*) and hydrilla (*Hydrilla verticillata*), choke navigation, dams, and water supply lines. These infrastructure impacts can have substantial financial implications, and also adversely impact food production and human health.
- Invasive grasses, such as buffelgrass (*Pennisetum ciliare*) and cheatgrass (*Bromus tectorum*), literally fuel fires that burn down buildings and damage transportation infrastructure.
- Nutria (*Myocaster coypus*), sucker mouth catfish (Subfamily *Hypostominae*), and other burrowing invasive species are known to compromise the structural integrity of roads, dams, levees, and bridges - thereby jeopardizing the safety of entire communities. Nutria contributed to a recent levee failure resulting in flood damage in excess of $500 million.[3]

1 Bureau of Reclamation Research and Development Office of Science and Technology Program (2016) Mussel-Related Impacts and Costs at LCDO Facilities (Hoover, Davis, and Parker Dams). Final Report ST-2016-1608. September 2016.

2 Brown, PL (2000) A plague in New Orleans, with jaws of steel. *New York Times,* May 14; Suszkiw J (1998) The Formosan termite: a formidable foe! Agricultural Research 46(10): 4–9.

3 Orlandini S, Moretti G, Albertson JD (2015) Evidence of an emerging levee failure mechanism causing disastrous floods in Italy. Water Resour. Res. 51: 7995–8011. doi:10.1002/2015WR017426.

PROGRESS

In December 2016, the Invasive Species Advisory Committee (ISAC) adopted a white paper entitled, "Invasive Species Impacts on Infrastructure." Among other things, ISAC recommended that NISC guide a process to assess invasive species impacts on federal infrastructure and, as feasible, to quantify the federal expenditures for managing invasive species that impact federal infrastructure.

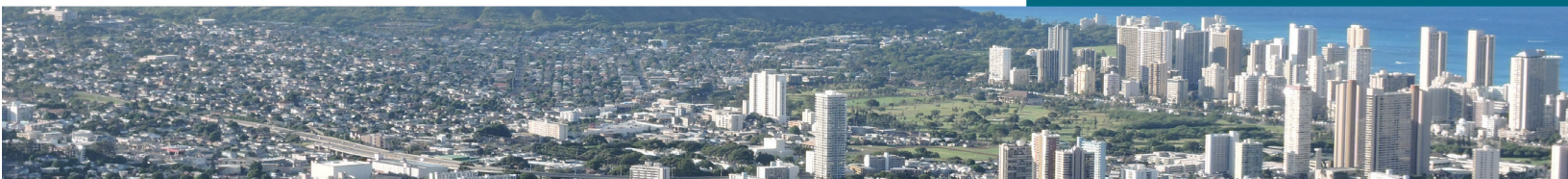
Read the Infrastructure White Paper: on.doi.gov/2y14WNR

NEXT STEPS

The NISC Secretariat is working with federal agencies to identify the breadth of impacts invasive species are having on federally managed infrastructure. For example, the NISC Secretariat is engaging a task team of interagency experts to analyze the information available on invasive species impacts to federal infrastructure, as well as to identify the priority actions that the federal government needs to take to effectively prevent, eradicate, and control invasive species that impact infrastructure. A report is anticipated in early 2018.

Questions and communications can be directed to:

Mike Vissichelli
Project Director for Invasive Species Impacts on Federal Infrastructure
NISC Secretariat
718-775-5571
michael.g.vissichelli@usace.army.mil



Appendix 3

NISC

NATIONAL INVASIVE SPECIES COUNCIL

SECRETARIAT

FREQUENTLY ASKED QUESTIONS

Invasive Species Impacts on Infrastructure

DRAFT GUIDANCE

NISC Secretariat Data Call

CONTACT

Mike Vissichelli
michael.g.vissichelli@usace.army.mil
718-775-5571

Question: How will this information be used?

Answer: The intent of this data call is to gather information to be used to inform the direction of future policy and management decisions for how the federal government approaches invasive species management on infrastructure. The NISC Secretariat will be engaging a task team of interagency experts to analyze the information available on invasive species impacts to federal infrastructure, as well as to identify the priority actions that the federal government needs to take to effectively prevent, eradicate, and control invasive species that impact infrastructure. A report is anticipated in early 2018.

Question: Will the agencies be able to see the results of this data call?

Answer: Yes, the results will be compiled and shared with the agencies in a final report that will be developed for this effort in early 2018.

Question: Should we include boats or vehicles in this response?

Answer: For the sake of this data call we do not want to include conveyances as they are the subject of other work. The exception would be when conveyances become fixed structures on federal properties and take on other functions (e.g. housing or ships maintained by Navy that are now secured in a mothball fleet or dockside for tourist access).

Question: What other perspectives should be addressed in our agency response to this data call whether we own and manage infrastructure or we do not?

Answer: If your agency does not directly manage or own infrastructure, providing details on the work you do that affects invasive species and infrastructure is still helpful. Identifying gaps and missing information in current policy and processes from your agency's standpoint can provide

important perspective. Detailing the potential effects invasive species can have on infrastructure affecting your agency's mission is very important to include in your response. Identifying your agency's role in infrastructure facilities management with regard to invasive species can provide very important information. For example, health risks such as rodent impacts on human health, pooling and flushing issues that affect mosquito populations and cyanobacteria, or bio-security associated with holding/quarantine facilities. These are just a few examples of some indirect issues that involve invasive species and infrastructure that we need your help in better understanding.

Question: What is the role and time commitment of the Interdepartmental Task Team?

Answer: The interdepartmental task team is intended to be a time-limited effort to solidify recommendations and possible guidance derived from the data call. Detailed terms of reference will be developed and circulated.

Question: Is there a standard format that should be used to respond to the data call?

Answer: No standard format has been developed for response to the data call. Simply filling in the answers after each question in the Word document provided with the questions is sufficient. Please make sure to provide thorough answers with as much detail as possible. Additional documentation and references to support your response should be provided, as appropriate.

Question: Do you want just one response for the agency or do you want specific case studies?

Answer: Ideally each agency would provide both. Our primary goal is to have at a minimum an enterprise-wide response for each agency. However, specific case studies often help to better portray the issues we are trying to highlight at a more detailed level. If possible it is requested that each agency provide specific case studies in addition to their agency wide response.

Question: Do you want pictures?

Answer: Yes. If available, good pictures of invasive species impacts on infrastructure would be greatly appreciated. Please make sure you provide photo credits.

Question: We are going to need more time, can we get an extension?

Answer: While it is preferred that you do your best to meet the October 27, 2017 deadline, we understand that delays are often inevitable. If this timeline is not feasible, please coordinate with project director listed below.

The NISC Secretariat thanks you for your time and effort in providing a complete and thorough response to this data call. If you feel that there are additional federal agencies representatives that we should contact with regard to the data call, please let us know.

If you have additional questions or comments, please direct them to Mike Vissichelli, Project Director for Invasive Species Impacts on Federal Infrastructure, NISC Secretariat – 718-775-5571, michael.g.vissichelli@usace.army.mil.

Appendix 4

Mussel-Related Impacts and Costs at Hoover Dam

Agency: Bureau of Reclamation
Project Name: Hoover Dam
Location: Boulder City, NV, Lower Colorado River
POC/E-mail/Phone Number: David Boyd, Civil Engineer, dboyd@usbr.gov, 702-293-8137
Invasive Species Type: Zebra and Quagga Mussels
Infrastructure Type: Dams

History
Quagga mussels were discovered at Lake Mead on January 6, 2007. This was the first sighting of this mussel west of the Rocky Mountains, although it has been in North America since the late 1980s. Scientists believe it may have arrived at Lake Mead on a boat trailered from infested Midwestern or Eastern water bodies. This introduction of the invasive species may have occurred sometime between 2003 and 2005.

Federal, state and local natural resources and water management agencies immediately conducted inspections of facilities along the lower Colorado River. Mussels were found in extremely low densities at external locations on Hoover, Davis and Parker Dams, but were not found in the water supply or other piping systems inside the dams. Mussels were also found at two fish hatcheries, at marinas on Lakes Mead and Mohave, and at the major Arizona and California diversion points in Lake Havasu. Since January 2007, the mussels also have been found in canals and lakes in southern California, in Arizona, and in the Colorado River as far south as the Imperial Diversion Dam, 20 miles north of Yuma, Arizona.

Mussels can form massive colonies, potentially causing a shift in native species and disrupting the ecological balance of the water body. The colonies also can block water intakes, affecting municipal water supply, irrigation and power-plant operations.

Quagga mussels can survive in waters with temperatures near freezing or as warm as 86 °F. They can also survive at great depths as long as the water is moving and has oxygen, nutrients, and a high level of calcium. The ideal spawning seasons occur in the Spring and Fall when the water temperature is between 60 and 70 °F. Mussel-Related Impacts and Costs at Hoover, Davis, and Parker Dams

The reproductive rate of mature adult quagga mussels compensates for the low survival rates of quagga mussels at larval stage (veliger). Less than 1% of veligers survive to become reproductive adults. An adult quagga mussel may:

- Have a lifespan of 3 to 5 years
- Spawn all year long if conditions are favorable (potentially 6 cycles per year)
- Produce 30,000 to 40,000 eggs and sperm per cycle

Therefore, significant resources have been expended by state, federal and local agencies on public outreach, monitoring, and some localized eradication programs to try to prevent their further spread.

Since January 2007, Reclamation has undertaken numerous actions to address the discovery of quagga mussels in the lower Colorado River system. The Lower Colorado Region has:

- Conducted an extensive literature search to learn more about the mussels' potential impact on hydroelectric and other infrastructure;
- Conducted research on mussel control/eradication methods;
- Hired a consulting firm experienced in mussel control to perform an in-depth assessment of Hoover, Davis and Parker Dams to:
  - Determine areas most at risk of colonization at each Dam, and
  - Determine preventative or control methods;
- Increased mussel detection strategies and preventative maintenance activities at Hoover, Davis and Parker Dams; and
- Participated in outreach efforts with other regions/facilities to share information, such as:
  - Possible control or preventative methods,
  - Newly available biological information about the invasive species.

The following systems and equipment at the Lower Colorado Dams Facilities (Hoover Dam, Davis Dam, and Parker Dam and their respective powerplants) have the potential to be adversely impacted by invasive mussels.

- Intake structures and trash racks
- Penstocks
- Gates and valves
- Cooling water systems
- Raw water fire protection systems
- Service and domestic water systems
- Instrumentation

Impacts from invasive species on the Hoover Dam project
Intake Structures – The four intake towers at Hoover Dam each supply water to a separate penstock. The towers are over 300 feet tall and the surface area of trash racks on each tower is approximately 44,000 square feet. During a Site Assessment Survey, remote cameras indicated that quagga mussel colonies are attached to the trash racks and to the concrete structures, but only at the upper portion. Water intake occurs at the lower cylindrical gate, which is well below the level at which quagga mussel colonies occur in the range of water levels at which Lake Mead has been operated since 2007; so the impact of quagga mussels at the Hoover Dam intake towers has been negligible to date.

Penstocks – One of the four 30-foot diameter penstocks is taken out of service for inspection each year on a rotating basis. Typically, the invert of the penstocks and the drain valves have been found to be covered with shell debris from dead quagga mussels. Colonies of live quagga mussels inside the penstocks are negligible and do not affect operation of the facilities. After the last turnout to the generators, the penstock decreases to 25-feet diameter and the water becomes still (non-flowing). With no significant movement of the water and a lack of nutrients, survival of the veligers (quagga larvae) and settlement of quagga mussel colonies has not been possible.

Valves – Hoover Dam has hundreds of valves of a variety of sizes and types. In the raw water (untreated) systems, all valves, regardless of size, are affected adversely by the quagga mussels and must be monitored and inspected regularly. Mussel colonies can restrict flow rates and shell debris can make it difficult and sometimes impossible to fully close the valves.

Cooling Water Systems – Each of the 17 generators has two separate water cooling systems. One system of piping and cooling tubes cools the lubricating oil in the oil tub. Failure to sufficiently cool the oil will set off alarms and implement unit shut-down procedures. The second cooling system runs raw water through finned tubes in eight large air coolers. Forced air passes through the air cooler and is used to cool

components of the generator. Similarly, failure to sufficiently cool the generator components will set off alarms and implement unit shut-down procedures.

Historically, the raw water used for cooling was taken directly from the penstock laterals. The water was approximately 53 °F and clean. With the quagga infestation of Lake Mead, the cooling water now has a large number of veligers Mussel-Related Impacts and Costs at Hoover, Davis, and Parker Dams (quagga larvae) searching for a hard surface to attach to and colonize. Also, the amount of shell debris can plug valves and cooling tubes and jeopardize the cooling systems. Hoover Dam is in the process of modifying the entire cooling water system, which will greatly reduce these risks. These "system changes" will be identified later in the report.

Raw Water Fire Protection Systems – Fire protection system water inside the powerplant and for the transformer deluge system is raw water taken directly from the penstock laterals. With the quagga infestation of Lake Mead, the raw water now has a large number of veligers (quagga larvae) searching for a hard surface to attach to and colonize. Also, the shell debris can plug valves, sprinkler heads, and deluge nozzles (jets, sprayers, and foggers) and jeopardize the fire protection systems. Failure of sprinkler heads and nozzles reduces the efficiency of the fire protection system and is unacceptable. Since the water in the fire lines is non-moving and there is no food source, the veligers do not survive long enough to colonize. However, the issue of shell debris is a significant concern and the risk is great. Therefore, Hoover Dam is in the process of modifying the fire water system, which will greatly reduce these risks. Potential "system changes" were identified in the Value Planning Report (Value Study completed in December 2015).

Service/Domestic Water Systems – The water treatment plant at Hoover Dam has not yet had issues with quagga mussels. Raw water is taken from the downstream tailrace and is screened and pumped up to the water treatment facility in the Arizona Valve House. The flow rate in the intake pipeline exceeds the velocity at which veliger can settle and attach to the pipeline to form quagga mussel colonies. At the treatment facility, the raw water is treated with the necessary chemicals (primarily chlorine) to kill micro-organisms, including but not limited to bacteria and veligers. The treated water is continually monitored, sampled, and tested to ensure that it meets "Safe Drinking Standards". The intake system and water treatment facility are inspected regularly as "preventative maintenance" to reduce the risks of potential damage caused by the invasive species.

Although the following agencies and facilities are not part of this study, they are also impacted by the quagga mussels. The potential costs of responding are staggering and many are seeking Federal funding to offset these previously unforeseen costs.

- Southern Nevada Water Authority (SNWA)
- Lake Mead National Fish Hatchery
- Willow Beach National Fish Hatchery
- National Park Service recreational facilities
- The Metropolitan Water District of Southern California (MWD)
- Central Arizona Project (CAP)
- Headgate Rock Dam and Powerplant (Bureau of Indian Affairs facility)
- Palo Verde Diversion Dam
- Imperial Dam
- Gila Aqueduct
- All-American Canal System
- Coachella Canal System

Each of these agencies has incurred new construction costs and increased operating and maintenance costs. The agencies that are likely affected the most are MWD and CAP, because they take their allotments

of Colorado River water from Lake Havasu and because of the extensive and intricate system of tunnels, canals, siphons, pumping plants, and storage reservoirs/lakes necessary to draw, transport and store their allotments serving California and Arizona. In reviewing various documents published by MWD, they have spent at least $20M since 2007 in upgrading their facilities and they anticipate annual costs directly associated with quagga mussels of $10M to maintain, operate, and continue to improve their facilities.

Management Approach (past, present and future)

A Site Assessment Report prepared by RNT Consulting Inc. in 2007 concluded that control or elimination of quagga mussels is not possible. The report also Mussel-Related Impacts and Costs at Hoover, Davis, and Parker Dams made clear that the circumstances are different at each facility on the lower Colorado River. These reports recommended that each site should fully assess their facility and make pro-active changes to minimize the impacts of the quagga mussels.

Recommended methods included:

- Cleaning and chemically treating pipelines and valves;
- Installing duplex strainers;
- Modifying existing duplex strainers to use filter baskets with smaller opening size;
- Installing automated self-cleaning screens;
- Installing UV light systems immediately downstream of the duplex strainers and/or automated self-cleaning screens; or
- Converting cooling water systems from raw water to treated water;
- Converting cooling water systems to closed loop system:
  - Using treated water, or
  - Using cooling oils;
- Adjusting the temperature of the raw water above or below the threshold that veliger can survive and/or spawn (reproduce).

Considerations associated with these options include the following:

- If chemicals are used, chemical monitoring and testing would be required. Disposal of chemicals into the water body may require special permits or the chemically treated water must be contained and disposed of legally.
- Automated self-cleaning screens have a large initial cost but maintenance costs are extremely low.
- If duplex strainers are used, the upfront cost is reduced but there are continual maintenance costs to change filter baskets and periodically empty/clean the baskets. The rate of maintenance is exponential based on the opening size of the filter screen/basket. The risk of shells and debris passing through the filter screen/basket is reduced if the openings are small (less than 1/16th of an inch) but the strainer requires more frequent cleaning and maintenance.
- UV light systems have a high initial cost and there is typically an annual service fee to the manufacturer for replacement of bulbs and routine service. In addition, it is imperative that strainers or self-cleaning screens are located upstream of the UV light system.
- Converting a raw water cooling system to a treated water system is the ideal solution, if it is feasible and economically viable. However, this alternative is not viable for the generator cooling (air coolers with finned-tubing) units at Hoover Dam, Davis Dam, or Parker Dam.
- Selecting and implementing a method to minimize the impacts of quagga mussels in pipelines and valves can be time consuming and costly.
- Adjusting the temperature of the raw water may work in theory. However, this is not a practical option and would not be cost effective. Mussel-Related Impacts and Costs at Hoover, Davis, and Parker

Management Challenges

Funding and tracking of costs are two of the primary management challenges this project is faced with. We continue to try and document funding costs and needs to show the extent of this issue. To do a better

job of this, a system for tracking mussel-related costs is being developed to coordinate with Acquisitions at the end of each fiscal year to identify all construction contracts, supply contracts, and service contracts issued by the Lower Colorado Dams Office (LCDO) that are related to control of quagga mussels. A computer-generated spreadsheet will summarize each type of contract and the site (Hoover, Davis, or Parker). This information will be provided to LCDO management. In addition, a system is in place with Hoover Dam to track costs for "in-house" work for quagga-related maintenance.

- Job-Specific Tasks – A separate and unique Work Order number will be established.
- General Tasks – A Work Order number has been established for quagga related tasks
- Work Order Reports – At the completion of work, the employee is to add a short summary. If the task was not previously identified as "quagga-related" work but should have been, this will be identified in the summary.
- Educate employees on the importance of documenting any work or task that is "quagga-related". An annual summary of Work Orders will be compiled at the end of the fiscal year and provided to LCDO management. A system to track "in-house" work for quagga-related maintenance at Davis Dam and Parker Dam will be developed in 2017 using information gained at Hoover Dam as a proto-type.

Costs for Quagga-Related Work
Contract costs incurred or planned at Hoover Dam for quagga-related work include the following:

Construction through 2016:
☐ Install UV Light System (Unit A2) $ 150,000
☐ Cooling Water Piping; Units A1- A9; N1-N8 $ 1,500,000 (Includes pumps, motors, and electrical work)
Subtotal $ 1,650,000

Construction, future:
☐ Install UV Lights for Remaining 16 Units $ 2,500,000
- $ 1,800,000 (UV Lights + Mechanical)
- $ 700,000 (Electrical)

☐ Replace pipe and modify fire protection system $ 5,000,000 ($ 500,000/year for 10 years)
Subtotal $ 7,500,000

Supply (Materials only, not including "in-house" installation by Reclamation):
☐ Misc. pipe, fittings, and valves $ unknown
☐ Duplex strainers; 2016 $ 78,000
☐ Duplex strainers; 2017 through 2020 $ 277,000

Service:
☐ Contract w/ Atlantium to service UV Lights $ 180,000 (Cost per year after 2018 when installation is complete)

In-house O&M costs for quagga related work include the following:

Through 2016:
☐ W.O. 1320719 Replace duplex strainer $ 2,405
☐ W.O. 2242621 N2 Cooling; Inst duplex strainer $ 7,762
☐ W.O. 1607741 AO Cooling Water Piping $ 8,623
☐ W.O. 3466910 General quagga related work $ 7,300
☐ Multiple W.O. Install duplex strainers $ 16,801
☐ Multiple W.O. Install duplex strainer $ 5,338

☐ W.O. 3870648 Order more duplex strainers $ 2,968
☐ W.O. 3946674 Order more duplex strainers $ 1,330
☐ W.O. 3957998 Order more duplex strainers $ 1,173
Subtotal $ 53,700

Future (2017 through 2020):
☐ W.O., NO Cooling Water Piping $ 10,000
☐ Multiple W.O. Order more duplex strainers $ 7,508
☐ Multiple W.O.; Install duplex strainers $ 436,000
Subtotal $ 453,508

Future (yearly/repetitive tasks):
☐ W.O. 3466910 General quagga related work $ 39,000
(Clean existing/new duplex strainers each week)

* This case study is a compilation of excerpts from the Bureau of Reclamations Research and Development Office Science and Technology Program Final Report, ST-2016-1608, Mussel-Related Impacts and Costs at Hoover, Davis, and Parker Dams (Lower Colorado Dams Office Facilities), September 2016.

CONTRACTOR'S REPORT

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