

Commonwealth of Pennsylvania

Pennsylvania Invasive Species Council

Aquatic Invasive Species Management Plan

October 2006

Acknowledgements

This plan was created by the Aquatic Invasive Species Management Plan Committee (AISMP), for the Pennsylvania Invasive Species Council (PISC). The AISMP included 13 representatives of state agencies, academic institutions, and nongovernmental organizations. Additional agency representatives, PISC members and stakeholders provided valuable technical input and reviews. This plan could not have been written without the hard work of the AISMP members and the support of the members and agencies of PISC. In addition, we drew heavily on, and are indebted to, the work of others who have developed aquatic and terrestrial invasive species management plans before us.

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Executive Summary

Invasive species are alien species whose introduction does or is likely to cause economic or environmental harm or harm to human health. Alien species are, with respect to a particular ecosystem, any species, including its seeds, eggs, spores or other biological material capable of propagating that species, that is not native to that ecosystem (Office of the President of the United States, 1999). Aquatic invasive species are a sub-set of invasive species that impact aquatic ecosystems. Based on the definition from the federal Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990, aquatic invasive species are defined in this document as non-native species that threaten the diversity or abundance of native species, the ecological stability of infested waters, human health and safety, or commercial, agricultural, aquacultural, or recreational activities dependent on such waters.

Article 1, Section 27 of the Pennsylvania Constitution states that *the people have a right to clean air, pure water, and to the preservation of the natural, scenic, historic and esthetic values of the environment. Pennsylvania's public natural resources are the common property of all the people, including generations yet to come. As trustee of these resources, the Commonwealth shall conserve and maintain them for the benefit of all the people.* The value of Pennsylvania's aquatic resources demands a comprehensive response to the threat posed by aquatic invasive species. The Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990, amended by the National Invasive Species Act of 1996, calls for the development of state and regional AIS management plans. Gathering input from Pennsylvania representatives of state and federal agencies, industry, nongovernmental organizations and other stakeholders, and using guidance from the federal Aquatic Nuisance Species Task Force, this plan has been developed to coherently address AIS issues across Pennsylvania. This plan is to be implemented under the auspices of the Governor's Pennsylvania Invasive Species Council (PISC).

The Commonwealth hosts more than 84,000 miles of streams and shares five major watersheds with other states and Canada, which has potential AIS management implications. In order for Pennsylvania to be effective in addressing AIS issues impacting the Commonwealth, it is critical that agencies and organizations collaborate and coordinate on all aspects of AIS prevention and management with neighboring states in the Great Lakes and Mid-Atlantic regions.

The goal for the Pennsylvania Aquatic Invasive Species Management Plan is to minimize the harmful ecological, economic and human health impacts of aquatic invasive species through the prevention and management of their introduction, expansion and dispersal into, within and from Pennsylvania.

Objectives

Given the magnitude of the problem and the variety of activities pertaining to aquatic invasive species in Pennsylvania, the following management objectives are proposed to help achieve this goal:

1. Provide leadership and coordination for AIS issues in Pennsylvania among local, state and federal agencies and organizations, and ensure that state policy effectively promotes the prevention, early detection and control of aquatic invasive species in Pennsylvania. Establish coordination and provide leadership within the Mid-Atlantic and Great Lakes

regions in order to address AIS issues more effectively, including prevention, advanced warning and concerted efforts in drainage basins shared across state lines.

2. Identify vectors and mechanisms and minimize the introduction and spread of aquatic invasive species into and throughout Pennsylvania.
3. Detect new introductions of aquatic invasive species in Pennsylvania before they have a chance to become established in the ecosystem.
4. Develop a system for early response to eradicate or contain target species before the species can become permanently established.
5. Monitor and inventory existing infestations of aquatic invasive species in Pennsylvania.
6. When feasible, control and eradicate established aquatic invasive species that have significant impacts in Pennsylvania. Reduce the harmful effects resulting from AIS infestations by managing those that cannot be eradicated.
7. Increase research efforts on AIS species, issues and impacts to support AIS management, control and eradication in Pennsylvania.
8. Educate the general public and people involved in the business, trade, research and government sectors about AIS issues so that they do not facilitate the introduction or spread of AIS species.

Priority Strategies

The plan identifies a number of strategies necessary to meet the above objectives. The highest priority strategies are:

- Create and fund an AIS coordinator position (Strategy 1B).
- Develop a permanent funding mechanism for AIS management in Pennsylvania (Strategy 1D).
- Increase public awareness about the problems associated with AIS introductions and educate the public and key constituencies about actions that can be taken to reduce the possibility of these species becoming established in Pennsylvania waters (Strategy 2E).
- Implement a coordinated system for rapid response efforts to contain or eradicate newly detected aquatic invasive species (Strategy 4A).
- Coordinate all AIS management programs and activities within Pennsylvania and establish multi-state cooperation and coordination within the Mid-Atlantic and Great Lakes regions and with national AIS programs (Strategy 1C).

- Prioritize organisms on which to focus control efforts and develop and implement specific control plans to address these (Strategy 6B).
- Establish a simple, coordinated reporting system(s) for AIS detection and monitoring in Pennsylvania (Strategy 3D and Strategy 5B).
- Explore and utilize the various methods available to control priority aquatic invasive species. Assess the efficacy of control and management interventions and adapt efforts as necessary to achieve management needs (Strategy 6C).
- Establish a comprehensive process to identify the aquatic invasive species of greatest concern that are not yet present in Pennsylvania waters (Strategy 2A).
- Develop a system to evaluate aquatic invasive species pathways and potential prevention strategies addressing these pathways (Strategy 2B).
- Limit the spread of established aquatic invasive species into new areas and control and eradicate established aquatic invasive species (Strategy 6A).

Priority Actions

The plan also identifies a number of actions necessary to meet the strategies. The highest priority actions are:

- Hire a coordinator (Coordinator) (1.0 FTE) for the Pennsylvania Aquatic Invasive Species Program. Responsibilities of the AIS Program Coordinator will include coordinating PISC AIS subcommittee and interagency activities and reporting progress on implementing the plan on an annual basis. The Aquatic Invasive Species Program Coordinator will work with subcommittees and other agencies and partners to review functional roles, gaps in authority, and develop an integrated annual work plan and budget (Action 1B1).
- Develop a model aquatic rapid response plan for Pennsylvania. The Plan should address such components as organizational structure and communication, authority, outreach, decision support and rapid scientific assessment, and management options for control/eradication, implementation, adaptive management, and funding. The process for planning efforts should include identifying and involving stakeholders (Action 4A1).
- Develop monitoring programs specific to pathways and geography for high priority aquatic invasive species using agency, stakeholder and/or volunteer resources (Action 5D1).
- Through PISC, work with the Governor's Office, Legislature and other Council members and partners to establish a permanent funding mechanism for AIS management activities (Action 1D1).

- Target outreach efforts and prioritize key audiences to promote understanding of invasive species dispersal pathways and current risk assessments (Action 2E1).
- Engage those conducting field work to be aware of key invasive species that they may come across. Conduct training for field staff to ensure that they can easily identify aquatic invasive species. Implement a statewide monitoring network to assist in the early detection and monitoring of aquatic invasive species (Action 3B1).
- Use scientific methods and procedures to facilitate the conduct of research-based risk analysis to determine the level of risk associated with introductions of certain potentially invasive aquatic species, with respect to the probability of entry through multiple pathways, potential to establish, ability to spread once established, and associated economic and ecological values, benefits and/or impacts (Action 2A1).
- Implement cost-benefit analyses to prioritize control efforts for both species and sites. Weigh all proposed actions against the “no-action” alternative (Action 6B1).
- Partner with AIS management programs in nearby states to share data and coordinate management activities. Pay special attention to “upstream” and “downstream” neighboring states to prevent AIS introduction and spread (Action 1C1).
- Develop a common AIS list(s) using a defined process and standards. The process should utilize scientific methods and procedures and should address such topics as the method for adding and deleting species from the list over time, the criteria to be used for making listing decisions, the status the list has, if any, in regulatory proceedings, and the trade-offs between a legislatively generated list and one maintained by agency discretion and rule-making (Action 1C2).

Various efforts are already underway across the Commonwealth to address AIS issues, and this document is not intended to duplicate efforts. Instead, it is a tool to provide a framework for identifying additional activities and tasks needed for effective AIS management in Pennsylvania, and to provide opportunities for further coordination of the efforts that are already underway.

To ensure that the goals of this plan are effectively addressed, a process for monitoring and evaluating the implementation of strategies and tasks will be initiated. This evaluation will focus on the feasibility and effectiveness of management activities. At a minimum, the Pennsylvania AIS management plan should be reviewed and updated every two years or more frequently if needed. Improvements in AIS management techniques could require alterations in proposed management strategies. The specific tasks employed to accomplish the goals and objectives of the plan must remain flexible to assure efficiency and effectiveness. While this version of the plan is a good starting point for identifying and integrating existing AIS programs and implementing new programs, the plan is a working document and will be updated and expanded based upon the experience gained from implementation, scientific research, and new tools as they become available

**Pennsylvania Invasive Species Council
Pennsylvania Aquatic Invasive Species (AIS) Management Plan**

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A. Introduction

A1. Definitions

Invasive species are alien species whose introduction does or is likely to cause economic or environmental harm or harm to human health. Alien species are, with respect to a particular ecosystem, any species, including its seeds, eggs, spores or other biological material capable of propagating that species, that is not native to that ecosystem (Office of the President of the United States, 1999). The definition for “alien species” can also be applied to the terms “non-native”, “nonindigenous”, or “exotic.”

Aquatic invasive species (AIS) are a sub-set of invasive species that impact aquatic ecosystems. Aquatic invasive species are defined in this document as non-native species that threaten the diversity or abundance of native species, the ecological stability of infested waters, human health and safety, or commercial, agricultural, aquacultural, or recreational activities dependent on such waters. Aquatic invasive species are introduced to new areas by many means, including intentional trade, release of ships’ ballast water, and as unintended hitchhikers in products or on clothing, vehicles and equipment. Aquatic and estuarine invasive species within Pennsylvania interfere with water uses (drinking water, water intakes, recreation), affect the ability of our lakes and streams to support native fisheries and wildlife, lower water quality, and alter riparian (streamside and shoreline) conditions. Aquatic invasive species are responsible for significant annual financial losses to the Commonwealth’s economy.

A2. Process for this Plan’s Development

The Pennsylvania Invasive Species Council (PISC) was created by Governor Rendell in 2004 through Executive Order #2004-1 (as amended September 2006). According to the executive order, PISC is responsible for advising the governor on and directing the development and implementation of a comprehensive invasive species management plan for the Commonwealth of Pennsylvania; providing guidance on prevention and control of invasive species and rapid response to new infestations; and facilitating coordination among federal, regional, state, and local efforts.

PISC is comprised of seven agencies and up to ten members of the public representing agriculture and natural resource organizations and educational institutions conducting invasive species research and outreach. PISC currently includes representatives from the following agencies and organizations (listed in alphabetical order):

- Penn Ag Industries
- Pennsylvania Biodiversity Partnership
- Pennsylvania Department of Agriculture (Chairperson)
- Pennsylvania Department of Conservation and Natural Resources
- Pennsylvania Department of Environmental Protection
- Pennsylvania Department of Health
- Pennsylvania Department of Transportation
- Pennsylvania Farm Bureau
- Pennsylvania Fish and Boat Commission
- Pennsylvania Forest Products Association

- Pennsylvania Game Commission
- Pennsylvania Landscape and Nursery Association
- Pennsylvania State University, Department of Entomology
- Pennsylvania State University, Pennsylvania Sea Grant
- The Nature Conservancy
- University of Pennsylvania, New Bolton Center
- Western Pennsylvania Conservancy

The first PISC meeting was held in October 2005. In April 2006, the AIS management plan committee (AISMPC) was created and charged with developing an AIS management plan for Pennsylvania. The AISMPC membership list is included in Appendix II. Drawing on guidance developed by the federal ANS Task Force, the AISMPC developed an outline for the plan and began writing. The AISMPC used two methods for gathering stakeholder input. The first method drew upon the proceedings of *Setting the Road Map: A Workshop for Developing Pennsylvania's Invasive Species Management Plan*, which was held October 26-27, 2005 in State College, Pa. This event, which was organized by Pennsylvania Sea Grant and the Great Lakes Commission, gathered input from 65 participants, representing state and federal agencies, environmental non-profits and commercial industries. The proceedings were presented to PISC for consideration during invasive species management planning efforts for the Commonwealth. The second method of gathering input began in the summer of 2006 when a larger group of stakeholders were identified by PISC members. These stakeholders and PISC members were asked to brainstorm and prioritize potential strategies and tasks for inclusion in the plan. PISC members and the stakeholders were also asked to comment on the draft AIS management plan. Comments were considered, and revisions made to the plan.

It should be noted that as of July 2006, PISC has begun the process of writing a terrestrial invasive species management plan, and eventually the aquatic and terrestrial plans will be joined to form the invasive species management plan for Pennsylvania.

A3. Relationship of this Plan to Other Plans

In developing this plan, many invasive species and natural resource plans were consulted. In implementing Pennsylvania's plan, PISC will coordinate with the Great Lakes and Mid-Atlantic Panels for AIS, as well as work with regional commissions and other entities involved with use and protection of Pennsylvania's major water bodies. Pertinent plans and activities with which to coordinate include:

- Water Resources Plan for the Delaware River Basin, 2004 (Delaware River Basin Commission)
- Plans and activities of the Great Lakes ANS Panel and the Mid-Atlantic AIS Panel
- EPA's Chesapeake Bay Program and species-specific AIS management plans
- Lower Susquehanna Comprehensive Water Resources planning (Susquehanna River Basin Commission)
- Rivers Conservation Program plans (Pennsylvania Department of Conservation and Natural Resources (DCNR) and local organizations)
- DCNR's Invasive Species Management Plan

- Pennsylvania's Coastal Zone Management Program (Pennsylvania Department of Environmental Protection (DEP))
- Pennsylvania Clean Lakes Plan (DEP)
- Pennsylvania Nonpoint Source Pollution Program (DEP)
- Neighboring states with AIS plans (currently New York, Ohio, Virginia and Delaware)
- Great Lakes Regional Collaboration Strategy (2005)

B. Existing Authorities and Programs

There is no single state statute that deals specifically with the management and control of aquatic invasive species in Pennsylvania. Agencies do have general statutory authorities in areas such as protection of waterways, and specific authorities over areas such as nuisance fish, or noxious weeds. There are also several non-governmental entities working on statewide and regional AIS issues. In addition, there are federal agencies with potential responsibility and authority for AIS management in Pennsylvania, and identifying this information is a task identified in the management actions.

BI. State Agencies

Pennsylvania Department of Agriculture (PDA)

PDA provides services to maintain and protect Pennsylvania agriculture through consumer protection and product regulation. This includes detection, identification and control of destructive plant pests (diseases, insects and weeds, both native and exotic). PDA Bureau of Plant Industry administers the State's *Noxious Weed Control Law*, the *Plant Pest Act*, and the *Seed Act*. Under the Pennsylvania Seed Act, prohibited noxious weed seeds cannot be present in seed sold in Pennsylvania. PDA has the authority to enter public and private property, collect specimens for study, issue stop sale notices to prevent movement of infected plants, and issue quarantines to contain serious plant pests. The agency provides pest-free certifications for nurseries, greenhouses, garden centers, Christmas tree plantations, etc. PDA, in cooperation with Pennsylvania Fish and Boat Commission (PFBC), has regulatory authority for aquaculture facilities and issues permits for the artificial propagation and sale and distribution of live aquatic animals. PDA also is responsible for addressing noxious weeds; it prohibits the propagation, sale and movement of any plant on the Pennsylvania Noxious Weed Control List (currently 13 species). Although the list deals primarily with agricultural pests, aquatic species are eligible to be added to the list. PDA has several action plans for the management of plant pests, noxious weeds and animal diseases and pathogens, including a giant hogweed eradication program and a biological control program for purple loosestrife. PDA provides public outreach and education on certain invasive plants (e.g., giant hogweed, purple loosestrife) and has provided training opportunities on aquatic invasive species for bait dealers and hatchery operators in cooperation with Pennsylvania Sea Grant.

Pennsylvania Department of Conservation and Natural Resources (DCNR)

DCNR actively manages State Parks and State Forests and controls invasive species in these locations if the feature for which an area is designated is in jeopardy. DCNR also has responsibility for protecting vulnerable and endangered native wild plants.

DCNR controls invasive plant species on the lands and in the associated waters it manages with systemic herbicides, mechanical and biological controls. As a result of its stewardship responsibilities for state forest and state park lands, DCNR has developed a comprehensive, agency-wide invasive species strategy. In addition, DCNR has developed and distributed a variety of educational materials on invasive plants.

Pennsylvania Department of Environmental Protection (DEP)

DEP is the state agency largely responsible for administering Pennsylvania's environmental laws and regulations. Its purview includes reducing air pollution; making sure drinking water is safe;

protecting water quality in rivers and streams; making sure waste is handled properly; supporting community renewal and revitalization; promoting advanced energy technology; and helping citizens prevent pollution and comply with the Commonwealth's environmental regulations.

Related to AIS, DEP has the authority to develop guidance and address sources of nonpoint pollution; provide funding or staff support for the Clean Lakes Program and riparian buffer Stream ReLeaf initiatives; protect water supplies for consumption, recreational use, and aquatic life; protect state waters by prohibiting pollution that alters biological properties; control (jointly with PFBC) aquatic plants and manage fish populations with approved algacides, herbicides, and pesticides; work with other agencies to assist in preventing AIS from being introduced into, spread within, or transferred out of the coastal zones to other waters/watersheds, and facilitate eradication where environmentally appropriate; provide funding and technical assistance for the Coastal Zone Management program (CZM). CZM and DEP's Office of the Great Lakes are involved in multiple regional initiatives, including the Great Lakes and Mid-Atlantic regional panels and the Council of Great Lakes Governors Ballast Water Initiative. DEP, through CZM, has funded grants for invasive species research and outreach since 1998. The Growing Greener Grant Program has also funded grants for restoration, including education, removal and control of invasives. DEP, working with Pennsylvania Sea Grant, is operating the Zebra Mussel Monitoring Network--a statewide, volunteer-based monitoring program. The Bureau of Watershed Management administers the Lakes Management Program, which works to control and mitigate exotic species that directly affect lake uses. DEP also provides public education and information on the identification and management of aquatic invasive plants and animals.

Pennsylvania Department of Health (DOH)

DOH was created by the Act of April 27, 1905, P.L. 312, and modified subsequently through the Administrative Code of 1929. Over the past 100 years, no issue has had more impact upon the lives of Pennsylvanians, and Americans as a whole, than the issue of public health. Over the years, the Department's mission has been adapted to meet the needs and demands of the dynamic nature of Public Health, but one thing has not changed – the commitment, dedication and professionalism of Department of Health staff to provide top-quality programs and services that benefit the health, safety and well-being of all Pennsylvanians.

The Department's mission is to promote healthy lifestyles, prevent injury and disease, and to assure the safe delivery of quality health care for all Commonwealth citizens. This mission interacts with any invasive species that either causes human disease or may be a vector that will transmit human disease. DOH oversees the West Nile Virus Surveillance program in Pennsylvania.

Pennsylvania Department of Transportation (PennDOT)

PennDOT controls the spread of invasive plants along highway rights-of-way. The department has actively researched the control and replacement of numerous invasive plants along the roadside for the safety of the traveling public and pavement preservation. The agency uses seed mixes that are void of noxious weeds and certified for purity and germination. PennDOT also develops invasive species control plans required for Army Corps permits, e.g. multiflora rose in bog turtle habitat. PennDOT engages in control of purple loosestrife, *Phragmites*, and multiflora rose in all wetland mitigation sites and certain stream projects, using biological control or

herbicide application. PennDOT has annual herbicide maintenance programs and cycled schedules to cover invasive weed control over the complete road system every three years. The agency also employs spot application controls (backpack sprayers) to target certain types of weed infestations for safety and drainage concerns, e.g., Japanese knotweed, *Ailanthus* and mile-a-minute.

Pennsylvania Fish and Boat Commission (PFBC)

PFBC is charged with ensuring the protection, propagation, and distribution of game fish, fish bait, baitfish, amphibians, reptiles, and aquatic organisms and managing recreational boating in the Commonwealth. PFBC has the authority to do the following: promulgate regulations to manage fish species and fishing; issue lists of species approved for propagation, live bait operations, and transportation; prohibit transfer of fish into state or non-native watersheds; inspect for species composition and disease; permit tropical fish imports unless there is a perceived threat to native species; prohibit introduction of non-native reptiles and amphibians into the environment; issue a list of species (jointly with PDA) approved for open-system propagation and to license unlisted species if there is no threat of water discharge or release of live fish or eggs; issue permits (jointly with DEP) for use of algaecides, herbicides, and fish control chemicals that may cause disturbances to waterways and watersheds.

PFBC also has developed regulations to address the potential risk of species introductions from bait and bait fish. In addition, PFBC has conducted educational and public information programs on aquatic invasive species in Pennsylvania, including surveys and outreach to boaters in cooperation with DEP and PASG.

Pennsylvania Game Commission (PGC)

PGC is authorized to prohibit the introduction, sale and release of any wildlife species of birds or mammals which are considered harmful to the public or wildlife. PGC has implemented a program for the control of Mute Swans in important wetland areas. PGC also engages in monitoring and management of invasive plants on State Game Lands, including the control of purple loosestrife, *phragmites*, and reed canary grass.

B2. Non-Governmental Entities

Delaware River Invasive Plant Partnership (DRIPP)

DRIPP is a multi-state non-profit organization focusing on invasive plant management in the Delaware River watershed. Its objectives are to reduce the number and extent of the invasive plant infestations, restore or rehabilitate lands which have been degraded by weed invasions, set priorities, coordinate or redirect current invasive plant management efforts, and direct the implementation of new practices.

Pennsylvania Sea Grant (PASG)

Pennsylvania Sea Grant provides grants for research projects involving aquatic invasive species, develops and disseminates education and training materials for use by the general public and key private sector audiences, promotes technology transfer to public sector, and encourages coordination and dialogue on statewide and regional AIS issues.

C. Aquatic Invasive Species in Pennsylvania

C1. Geography of Pennsylvania

The Commonwealth of Pennsylvania is located in the mid-Atlantic region, with New York State to the north, New Jersey to the east, Delaware, Maryland and West Virginia to the south, and West Virginia and Ohio to the west. The Commonwealth's varied geology and topography contribute to the large variety of aquatic and estuarine habitats. Pennsylvania encompasses six different landforms, ranging from coastal plain to the Appalachian Mountains, whose water bodies have correspondingly different characteristics and biota. The Commonwealth hosts more than 84,000 miles of streams and shares five major watersheds with other states and Canada, which has potential AIS management implications.

The Delaware River begins in New York and forms the Commonwealth's eastern boundary, draining about 6,422 square miles of eastern Pennsylvania. Roughly 50 miles of the river in Pennsylvania are freshwater tidal. The river's main stem in Pennsylvania contains no dams impassable to fish. Philadelphia, located at the southeastern corner of the state where the Schuylkill River flows into the Delaware Estuary, is a major port city.

The Susquehanna River begins in New York and flows into Pennsylvania, draining 21,000 square miles of Pennsylvania to the Chesapeake Bay, which is roughly 20 miles downstream of the Pennsylvania/Maryland border. The river's main stem contains four hydroelectric dams, three of which are located in Pennsylvania.

The Potomac River watershed's 1,570 square mile area within Pennsylvania consists mostly of first to third order headwaters streams in the south central region.

The Monongahela and Allegheny Rivers join at Pittsburgh to form the Ohio River. Together, these rivers drain 15,614 square miles of western Pennsylvania. The Ohio River system supports extensive commercial barge traffic. The Allegheny, which flows through the Allegheny National Forest, has eight locks and dams in Pennsylvania; the Monongahela has six, and the Ohio three.

The Lake Erie watershed has a six hundred and ten square mile area, and the Commonwealth owns approximately 740 square miles of submerged lands to the middle of the lake and the border with Canada. The port city of Erie is located in Presque Isle Bay, which is formed by a major sand spit peninsula. Lake Erie's tributary streams are relatively small and steep-banked owing to the glaciated geology of the watershed. The headwaters of the Genesee River watershed encompass 94 square miles in north central Pennsylvania along the New York border and are a tributary to Lake Ontario.

Pennsylvania has more than 1,200 lakes, many of which are impoundments, although this number does not include run-of-river impoundments (Lathrop, 2006). Major lakes and impoundments include Pymatuning Lake in the northwest (shared with Ohio), Allegheny Reservoir (an impoundment on the Pennsylvania/New York line) in the northwestern part of the state, Raystown Lake (an impoundment) in the south central part of the state, and Lake Wallenpaupack (an impoundment) in the northeast. Glacial lakes located across the northern part of the state are of special ecological interest because of the rare species they support.

Pennsylvania has a large variety and number of wetlands (Pennsylvania Game Commission, 2005). According to the National Wetland Inventory, there are a total of 729,535 wetland acres found in more than 160,000 wetlands across the state. Of this, 146,816 acres are lacustrine (lakes and ponds primarily) and 410,009 acres are palustrine habitat (marshes, etc.). An additional 643 acres of estuarine habitat are located in the southeastern region along the Delaware River. The majority of Pennsylvania's wetlands are palustrine (bogs, fens, swamps, shallow pools). Emergent wetlands (marshes, meadows) and shrub swamps comprise 10 to 20 percent of state wetlands.

C2. Known Problems and Concerns

Invasive species in the United States cause annual economic losses exceeding \$137 billion (Pimentel et. al. 2000). No comprehensive economic, environmental or health impact study has been done for AIS in Pennsylvania; however, some regional economic information for particular species is available. In the Great Lakes region, zebra mussel control alone costs:

- Approximately \$360,000 per year by affected municipalities and industries using large volumes of Great Lakes water;
- An average of \$20,000 per year on control efforts by small municipalities; and
- An average \$825,000 in additional costs per year by nuclear power plants (Stop Aquatic Hitchhikers).

Fisheries in Pennsylvania support both recreational activities and commercial enterprises, and represent one sector that could be impacted economically by aquatic invasive species. The 2001 National Hunting and Fishing Survey reported that 1.3 million state residents and nonresidents 16 years old and older fished in Pennsylvania, spending \$580 million on fishing. In 2005, the Pennsylvania Fish and Boat Commission sold 817,894 fishing stamps and licenses, generating \$18,581,999.00 in revenue.

The extent of the AIS issue within the Commonwealth is reflected in Pennsylvania's participation in AIS-related activities in its interstate watersheds. PASG and DEP are members of the Great Lakes Panel on ANS and the Mid-Atlantic AIS Regional Panel. PASG and DEP helped establish the Mid-Atlantic AIS Regional Panel and to develop species-specific management plans for Chesapeake Bay. Additionally, research is being conducted on selected AIS species, and personnel and limited funding are being directed by both state agencies and non-governmental organizations toward AIS prevention and control.

Ongoing and potential effects of aquatic invasive species are recognized in Pennsylvania legislation that is administered by Commonwealth agencies. For example, PFBC regulations prohibit the "sale, purchase or barter, possession, introduction, importation and transportation of certain injurious, non-native species." There are currently eleven species listed, including:

- Bighead carp (*Hypophthalmichthys nobilis*)
- Black carp (*Mylopharyngodon piceus*)
- European rudd (*Scardinius erythrophthalmus*)
- Quagga mussel (*Dreissena rostriformis bugensis*)
- Round goby (*Apollonia (Neogobius) melanostomus*)

- Ruffe (*Gymnocephalus cernuus*)
- Rusty crayfish (*Orconectes rusticus*)
- Silver carp (*Hypophthalmichthys molitrix*)
- Snakehead (*Channa* spp.)
- Tubenose goby (*Proterorhinus semilunaris*)
- Zebra mussel (*Dreissena polymorpha*)

Aquatic invasive species represent a challenge to state agencies in how they manage lands and waters to meet a stated mission. For example, DCNR has the mission of providing recreational uses in state parks and forests while demonstrating good natural resource stewardship. The Bureau of State Parks spends \$40,000 to \$50,000 annually on herbicides, which are mainly used for AIS treatment in park lakes in order to maintain recreational activities. Pennsylvania has 117 state parks and 20 forest districts that together manage about 2.5 million acres of state lands. DCNR park and forest district managers spent approximately \$215,000 in fiscal year 2004-2005 for invasive plant control efforts statewide. Current available funding, which comes mostly from operating budgets, is inadequate to meet the challenge of aquatic invasive species.

Since 2000, Pennsylvania has invested over \$30 million in the West Nile Virus Surveillance Program. In 2005, the program detected the mosquito-spread virus in 33 of Pennsylvania's 67 counties, and 25 humans tested positive (Pennsylvania West Nile Surveillance Program).

The spread of purple loosestrife in Pennsylvania illustrates the impact that emergent wetland and shoreline invasive species have on wildlife habitat. Total impacted acreage in Pennsylvania is unknown, but certainly runs to the thousands of acres. Purple loosestrife has become a monoculture in areas, replacing high habitat value native plants with habitat of limited value for wildlife including endangered species such as the bog turtle (*Clemmys muhlenbergii*) (Chesapeake Bay Program Office, 2004).

Pennsylvania and federal agencies fund numerous projects related to aquatic invasive species, including riparian buffer and stream bank restoration, aquatic habitat restoration, research on species biology and control, and management and restoration projects. For example, the PFBC, in cooperation with PASG, the DCNR Wild Conservation Resources Conservation Program, and the State Wildlife Grant Program, is funding comprehensive research to ascertain the effects of the invasive red-eared slider turtle (*Trachemys scripta elegans*) on native turtles.

Pennsylvania uses and participates in regional studies of some aquatic invasive species. For example, Pennsylvania Game Commission has based its approach to mute swan management on studies that demonstrate several ecological problems caused by feral mute swans. Several studies have documented large reductions in aquatic vegetation, and even the complete disappearance of certain plant species in some locals, because of heavy grazing by mute swans (Gregg, 2006).

C3. Pathways of Entry and Spread

There are a number of ways that aquatic invasive species can make their way into Pennsylvania's aquatic ecosystems. Pathways are the means by which species are transported from one location to another. Natural pathways include wind, water, and other forms of dispersal where a specific

species has developed morphological and behavioral characteristics enabling movement. Human pathways are those pathways which are enhanced or created by human activity, generally falling into categories of intentional or unintentional introductions.

As mentioned previously, many intentional non-native species introductions are beneficial. Species escaping cultivation or that are accidentally introduced most often have no negative impact in their new landscape. However, there are relatively small numbers of alien species that do become invasive and cause significant ecological and economic harm. For the purposes of the National Invasive Species Council, the term "vector" is viewed as a biological pathway for a disease or parasite (i.e. an organism that transmits pathogens to various hosts) and is not completely synonymous with the much broader definition of a pathway. The following are descriptions of potential human pathways for AIS introduction and spread in Pennsylvania.

Ship ballast: This is a primary pathway for long distance movement of non-native aquatic organisms. Aquatic organisms ranging from microscopic (plankton) to large fish can be transported to new areas through release of ballast water. According to the U.S. Coast Guard, U.S. harbors receive approx. 2 million gallons of ballast water every hour.

Hull fouling: Aquatic organisms can attach to ships' hulls or become entangled in submerged components of ships and be transported long distances, creating the potential to become dislodged in a new area.

Movement of equipment, gear, etc.: Various organisms can easily be moved, by attachment or containment in water or mud, between aquatic habitats by a number of devices including vehicles and trailers, watercraft, aircraft, water sports gear, construction equipment, and fishing and hunting gear.

Escapes from intentional introductions: Non-native species introduced for economic benefits may escape containment and eventually harm native species and their habitats, or natural enemies/pathogens associated with the introduced species may not be detected, escape and then pose a threat to native species. This pathway may include escape from containment or escape from scientific studies.

Discarded live fish bait: The movement and eventual discarding of live fish bait (fish and various invertebrates) can introduce these organisms, and possible pathogens that they may harbor, into new bodies of water.

Intentional release of aquatic pets and plants: Releasing pets and/or plants, rather than disposing of them in a proper manner, can lead to the establishment of non-native organisms.

Sales of organisms: A largely unregulated trade, this activity poses a major threat for long distance movement of organisms. Major sources include mail order and internet sales, flea markets and farmers markets.

Trading of aquatic invasive species: Hobbyists and collectors often have an opportunity to trade specimens (both plants and animals), and such activity can result in long distance movement of exotic organisms.

Smuggling activities: When entering another country, people may conceal organisms in baggage, vehicles, etc.

Contamination of products in channels of trade: Shipments of organisms may contain other organisms, included intentionally (for example, as packing material) or accidentally. Improper disposal of packing material has the potential to introduce invasive species into new environments. Shipments of approved organisms also may contain similar species that are difficult to distinguish with the naked eye, and accurate identification becomes critical.

Canal activities: Construction of canals opens pathways between water bodies. For instance, the opening of the St. Lawrence Seaway and Welland Canal increased exposure of the Great Lakes to AIS invasion and allowed sea lamprey to invade the Great Lakes from the Atlantic Ocean.

C4. Case Studies

Pennsylvania hosts a growing number of aquatic invasive species. The following examples are included as case studies because these species are regulated in Pennsylvania or because there are formal efforts by state agencies and organizations to control them. This is not a complete list of aquatic invasive species in Pennsylvania, nor is the AIS management plan limited to coverage of these species. The case studies below are included because they are representative of the problem. Several vascular plants normally considered terrestrial are included because of their deleterious effects on riparian habitats, which in turn negatively impact aquatic ecosystems.

The process of identifying these species also served to highlight some policy and management challenges based on the large geographic scope and range of ecosystems and riverine basins in Pennsylvania. For example, several species are native in one portion of the Commonwealth but have become invasive in another ecosystem. An extreme example of this is a species that is listed as threatened and endangered in one region, but may be invasive in another area. This may be the result of the species being introduced to a new location and finding the required habitat and absence of predators, or it may be result from a change in genetics and adaptive capabilities allowing it to become invasive, or some combination of the two. In addition, species may have beneficial uses in some situations but may be invasive under other conditions. One way this issue may be addressed is through the development of criteria and risk analyses to evaluate the impact of species, both of which are actions called for in the AIS management plan. A few case studies of species highlighting policy and management challenges are described in Section C5.

Asian Clam (*Corbicula fluminea*) was first reported in the United States in Washington's Columbia River in the 1930s. It was likely introduced intentionally for harvest and consumption purposes (Counts, 1986). The most prominent economic impacts of the Asian clam introduction in the United States have been related to biofouling of power plant water intakes and other municipal and industrial water intake and supply systems (Isom et al. 1986, Williams and

McMahon, 1986). Ecological impacts result from competition with native species for space and other limited resources. The Asian clam has been blamed for the decline and local extinctions of several native freshwater mussel species (Williams, 1997). The Asian clam is now found in all of the major river drainages in Pennsylvania, including the Allegheny and Susquehanna.

Asian carp is a term that actually refers to four carp species – bighead, black, grass, and silver. Bighead, black and silver carp are a high risk fish species currently not known to occur in Pennsylvania, but they are prohibited from sale, possession, transport, and release into Pennsylvania waters. Triploid grass carp, which has three sets of chromosomes and is sterile, is regulated in Pennsylvania by a permitting process through PFBC. Presently there is an electrical barrier on the Chicago Sanitary and Ship Canal, which connects the Illinois River to Lake Michigan, keeping silver and bighead carp from entering the Great Lakes from the Mississippi River. If silver and bighead carp become established in Great Lakes, it is possible that the current fishing industry of \$6.89 billion would be lost.

Bighead Carp (*Hypophthalmichthys nobilis*) were first captured in the wild in the 1980s and have spread to most of the Mississippi River drainage, including the Missouri and Ohio Rivers and their tributaries. Bighead carp are known to reach 90 pounds and in some of the large pools along the Mississippi River, they have multiplied so quickly in less than a decade that they make up 90 percent or more of the fish life. Bighead carp compete directly with native fish for food and space, and may feed on native fish larvae. Presently there is an electrical barrier on the Chicago Sanitary and Ship Canal, which connects the Illinois River to Lake Michigan, preventing the dispersal of Asian carp into the Great Lakes (USGS – “carp”; White et. al. 2004).

Black carp (*Mylopharyngodon piceus*) entered the United State in the 1970s in imported grass carp stocks. They have also been used by fish farmers for yellow grub control and as a fish food. Black carp are currently maintained in research and fish production facilities in the southern United States. There is concern about black carp because they typically grow to more than three feet in length and weigh over 30 pounds, but can reach five feet in length and weigh up to 150 pounds. Black carp feed primarily on mussels and snails but also eat freshwater shrimp, crawfish, and insects. Once introduced they are likely to have a considerable impact on native mussel and snail populations (USFWS, 2002).

Grass carp (*Ctenopharyngodon idella*) is an herbivorous fish that is native to China. In the 1960s, the United States cultured the grass carp for biological control of rooted aquatic vegetation. Since then, the fish has escaped from containment facilities to invade surrounding aquatic habitats. The grass carp is now found in all 48 contiguous states of the United States. Though the grass carp has successfully decreased populations of certain aquatic invasive macrophytes, it is not selective in its feeding and is capable of destroying all of the plant life where it has been introduced, including native species. Introduction of the grass carp may also be responsible for the presence of nonindigenous parasites in waters of the United States, such as the Asian tapeworm (Ganzhorn et al., 1992). Triploid grass carp, which has three sets of chromosomes and is sterile, can be stocked in Pennsylvania waters but is regulated by a permitting process through PFBC.

Silver carp (*Hypophthalmichthys molitrix*) were first captured in the wild in the 1980s and have spread to most of the Mississippi River drainage, including the Missouri and Ohio Rivers and their tributaries. Silver carp can reach 60 pounds and have become known for their tendency to panic when they hear a boat motor, hurling themselves out of the water and into the path or onto the deck of passing boats and personal watercraft. They are in direct competition with native fish for food, may feed on larvae of native fish, and feed year round (USGS, 2000 and National Wildlife Foundation, 2004).

Common Reed (*Phragmites australis*) is a tall grass that inhabits wet areas like brackish and freshwater marshes, riverbanks, lakeshores, ditches and dredge spoil areas. Native and introduced forms of *Phragmites* occur in the United States. Researchers believe that introduced European forms are the aggressive invasives that have replaced much of the native reed populations. Common reed threatens biodiversity by displacing native plants and forming monocultures in otherwise biologically diverse natural wetlands. It spreads by seed and strong vegetative growth and is very difficult to control once established (The Nature Conservancy, 2005). In Pennsylvania, the highest concentrations of common reed occur in the southeast corner of the Commonwealth along the Delaware River watershed. Efforts to control common reed include work by the Pennsylvania State Parks to treat limited acreage with herbicide, and the John Heinz National Wildlife Refuge near Philadelphia has expended considerable effort to control common reed for the past few years. In addition, the DCNR Presque Isle State Park in the Lake Erie area has an ongoing applied research program on control management strategies (Maryland Sea Grant, 2002).

Curly-leaf pondweed (*Potamogeton crispus*) is a perennial, rooted, submerged aquatic vascular plant native to Eurasia, Africa, and Australia. By 1950, curly-leaf pondweed had infested most of the United States. In the spring it forms dense mats that interfere with recreation and limit the growth of native aquatic plants. The reproductive ecology of this species is poorly known. By the end of the growing season curly-leaf pondweed senesces and forms vegetative propagules called turions. Turions are dispersed by water movement throughout a water body and may also be transferred to uninfested waters. The turions germinate in the fall, beginning a new life cycle (Sastroutomo, 1981). Curly-leaf pondweed is widely distributed across a majority of counties in Pennsylvania (USDA Plants Profile, 2006).

Eurasian watermilfoil (*Myriophyllum spicatum*), a submerged aquatic plant from Europe, Asia, and northern Africa, is spreading rapidly throughout the United States. Eurasian watermilfoil is capable of growing under a wide range of environmental conditions and on a variety of bottom substrates. It typically grows in shallow water, but in clear water conditions it can inhabit water up to 30 feet deep. Eurasian watermilfoil's surface canopy can outcompete and eliminate native aquatic vegetation, as well as threaten native fish and wildlife populations (Smith and Barko, 1990; Valley and Bremigan, 2002). The plant disperses primarily by vegetative propagation through stem fragmentation. Boat propellers and trailers are a major source of long-distance spread of Eurasian watermilfoil (Westbrooks, 1998). Eurasian watermilfoil has spread throughout the Chesapeake Bay watershed and to at least 33 states east of the Mississippi since it was first detected on the Potomac River in 1942 (Newswire, 2005).

European rudd (*Scardinius erythrophthalmus*) is medium-sized fish that are native to Europe and Western Asia, where they are popular as a food and game species. They were introduced to the United States in the late nineteenth or early twentieth century, and can now be found in at least twenty states. Although the impact of Rudd is mostly unknown, it is suspected that they compete with native fishes for invertebrate food sources and impact the population dynamics of various ecosystems. A study showed that rudd could be expected to compete with native fishes for invertebrate food sources. In addition, being omnivorous, the rudd can shift its diet to plants, unlike most native fishes. Because rudd are fairly hardy, they fare better than many native fishes in waters that are eutrophic or polluted. The European rudd has an established population in Pennsylvania, having been found in Lake Erie in 2003 and in Presque Isle Bay in May of 2005 (National Sea Grant, USGS - "rudd"). It is illegal in Pennsylvania to sell, purchase, barter, possess, introduce, import, or transport European rudd.

Hydrilla (*Hydrilla verticillata*) is a submerged, perennial plant native to Asia, but has spread into Europe, Australia, New Zealand, the Pacific Islands, Africa, South America and North America. This plant was first introduced into Florida waters in the early 1960s and now occurs in almost all of the Gulf and Atlantic coast states and on the west coast in California and Washington (Westbrooks, 1998). A highly prolific aquatic plant, hydrilla can outcompete native vegetation by photosynthesizing under low light conditions and can form a thick free-floating mat (Tate et al., 2003). Hydrilla causes major problems with water use. In drainage and irrigation canals, it greatly reduces flow and causes clogging, which can result in flooding and damage to canal banks, structures, and pumps. Hydrilla also has negative effects on fish populations in addition to decreased recreational opportunities. Excessive vegetation decreases growth and condition of adult fish (Colle and Shireman, 1980), and extremely high amounts of hydrilla (>80 percent coverage) may decrease angler harvest and effort (Colle et al., 1987). Hydrilla is most likely to spread when plant fragments are carried along with recreational boats into new habitat. According to the U.S. Geological Survey, hydrilla currently infests three water bodies in Pennsylvania. It is found in scattered stands in the Schuylkill River near Philadelphia; at Highland Lake, a 28 acre impoundment on Southwick Creek; and at Lake Nockamixon, where plants are abundant in a portion of Haycock Creek (USGS Nonindigenous Aquatic Species Database, 2006).

Japanese hops (*Humulus japonicus*) can be found in pastures, hayfields, roadsides, forest edges, and other non-crop areas. It reproduces by seeds, which are dispersed by wind and water. Japanese hops can form dense stands in floodplains and along stream banks and lakeshores, and can also thrive in disturbed areas. It can be found in full sun or shade (Rice, 1999; Hager and Nordby, 2004). In Pennsylvania, most of the infestations are found in the southeastern and south-central region.

Knotweed (*Polygonum* sp.) includes two plant species, giant and Japanese, which were introduced from Asia as garden ornamentals. The knotweeds are similar in their appearance, invasiveness, habitat choices, and their impacts to riparian areas. They both have extensive rhizomes, which make established populations very difficult to control. The knotweeds grow into thickets that can completely clog small waterways and displace streamside vegetation, increasing bank erosion and lowering the quality of riparian habitat for fish and wildlife. Giant knotweed hybridizes with Japanese knotweed. Once established, knotweeds spread by rhizomes,

enabling them to dominate and outcompete native or beneficial plants. Knotweed spreads to new locations from the fragmentation and movement of rhizomes by water or human activity and the dispersal of seeds by wind and water.

Giant knotweed (*Polygonum sachalinense*) releases chemicals from its roots which prevents other plants from growing and aids in the Giant knotweed's rapid colonization strategy. Once established, giant knotweed dominates and outcompetes native or beneficial plants. Lateral expansion rates of 6 to 8 feet per year are not uncommon. (King County DNRP; Washington State Noxious Weed Control Board; Penn State School of Forest Resources, 2000).

Japanese knotweed (*Polygonum cuspidatum*) is distributed in 36 states in the lower 48 from Maine to Wisconsin south to Louisiana, and scattered throughout midwestern and western states. Japanese knotweed is a very aggressive species (Hitchcock and Cronquist, 1964) that is capable of crowding out all other vegetation (Ahrens, 1975; Hickman, 1993). In addition, the plant can create a fire hazard in the dormant season (Ahrens, 1975). Japanese knotweed is an escaped ornamental that is becoming increasingly common along stream corridors and rights-of-way in Pennsylvania. This perennial plant is difficult to control because it has extremely vigorous rhizomes that form a deep, dense mat. In addition, the plant can sprout from fragments and along streams; plant parts may fall into the water and create new infestations downstream (Washington State Department of Ecology).

Mute swans (*Cygnus olor*) were transported to North America from Eurasia for their beauty and grace. Mute swans utilize a variety of aquatic habitats, including ponds and lagoons and fresh to salt water marshes. In the warmer months, mute swans spend most of their time in shallow water. As shallow water freezes, the birds move to deeper water, but will utilize deeper water throughout the year. Of primary concern to Chesapeake Bay ecologists is its presence year-round and its preference for feeding on submerged aquatic vegetation (SAV). A large, resident mute swan population feeding on SAV all year could jeopardize the ability of SAV to recover from winter waterfowl grazing and make it less available for native waterfowl the following winter. Declines in SAV abundance appear to correlate with declines in local native waterfowl populations. In closed waterways in Europe, mute swans have been documented as removing entire species of SAV (Maryland Sea Grant, 2002).

Northern snakehead (*Channa argus*) is a predatory fish that will compete with other fish for forage and habitat. Northern snakehead was first confirmed in Pennsylvania in July 2004 after an angler caught and preserved two from the 17-acre Meadow Lake near Philadelphia. PFBC biologists confirmed they were indeed northern snakeheads and captured additional ones from the lake. The lake is part of a maze of interconnected embayments and tidal sloughs and the Commission believes additional snakeheads are likely present elsewhere in the system, including the nearby lower Schuylkill and Delaware Rivers. It is too early to say what impact the presence of snakeheads will have on other species already in Meadow Lake and other waters (PA FBC – “snakehead”). It is illegal in Pennsylvania to sell, purchase, barter, possess, introduce, import, or transport any of the *Channa* species.

Purple loosestrife (*Lythrum salicaria*) is a perennial wetland plant from Europe and Asia that was introduced to the east coast of North America in the 1800's. Purple loosestrife is an extremely adaptive invader of marshes and lakeshores as it outcompetes native cattails and other wetland plants. Highly prolific, a single plant can produce over two million seeds and is also capable of sprouting from plant fragments. Purple loosestrife does not provide cover, food, or nesting sites for a wide range of native wetland animals including ducks, geese, rails, bitterns, muskrats, frogs, toads, and turtles (Thompson et al., 1992). Development of wetland areas and disturbance of these moist soils increases the chances of invasion of purple loosestrife (Aulwes, 1999). Purple loosestrife is on the Pennsylvania noxious weed list, and therefore it is illegal to propagate, sell or transport it, including all cultivars, in Pennsylvania.

Quagga mussel (*Dreissena rostriformis bugensis*) is small, finger-nail sized bivalve related to the zebra mussel but is a distinct species. It prefers deeper, colder waters which is consistent with laboratory studies indicating that the quagga has a lower temperature tolerance than the zebra mussel. In addition, it has byssal threads which allow it to attach to solid objects and so has the same potential as the zebra mussel to clog water intakes. In Lake Erie, the quagga mussel is now present in higher numbers than the zebra mussel. The discovery of the quagga mussel increases the probability that other species of Dreissenidae have already been introduced into the Great Lakes (Michigan's Office of the Great Lakes, 2002). Botulism in the Great Lakes may be concentrated by quagga mussels, which are then consumed and moved up the food chain by round gobies, leading to fish and bird death. It is illegal in Pennsylvania to sell, purchase, barter, possess, introduce, import, or transport quagga mussels.

Red-eared slider (*Trachemys scripta elegans*) is an omnivorous turtle that will eat insects, crayfish, shrimp, worms, snails, amphibians and small fish as well as aquatic plants. It is believed that native turtles in the southeastern part of Pennsylvania are now facing competition from the red-eared sliders that are released from captivity when pet owners no longer want them. Sliders are likely to compete for food, nesting sites and basking sites with many species of native aquatic and terrestrial turtles. Particularly at risk is the state threatened red-bellied turtle (*Pseudemys rubriventris*), which has virtually identical foraging, nesting and food requirements. Despite a 1975 ban by the US FDA on the sale of red-eared sliders under 4 inches, hatchlings are readily available for sale from mail order or the internet and are still considered popular pets (Urban et. al.).

Resident Canada Goose includes two subspecies, the giant Canada goose (*Branta canadensis maxima*) and the western Canada goose (*B. c. moffitti*), and possible hybrids between these and other subspecies. By the early 1900s, migratory Canada geese populations that breed in the Hudson Bay region of Canada and winter in the Chesapeake Bay area were in sharp decline due to over-harvesting. Beginning in the 1930s, state and federal wildlife agencies throughout the Northern Flyway stocked geese captured in other places to establish breeding populations and restore recreational opportunities. In Pennsylvania, a race of geese from Minnesota and Wisconsin called giant Canadas were released. Those birds were bigger than the Atlantic migrant geese (average 12 pounds compared to 8.8 pounds for migrants) and never migrated much from their homes in the Midwest, and they did not migrate in Pennsylvania either (Brittingham, 2006). Large flocks of resident Canada geese can devastate grassy areas, including parks, pastures, golf courses, lawns, and other landscaped areas where there are ponds, lakes, and

other bodies of water nearby. At airports, resident Canada geese have become a significant safety threat, resulting in dangerous takeoff and landing conditions and costly repairs to aircraft. Excessive goose droppings are also a health concern, and have contributed to the temporary closure of public beaches by local health departments in several states. In addition, agricultural and natural resource damage, including depredation of grain crops, overgrazed pastures, and degraded water quality have increased as resident Canada goose populations have grown (Penn State University, 2001).

Round goby (*Apollonia (Neogobius) melanostomus*) is an abundant species with origins in the Black and Caspian Seas. First reported in the St. Clair River in 1990, they quickly spread and now inhabit all five Great lakes (Michigan's Office of the Great Lakes, 2002). They are a small fish that feed chiefly on bivalves, amphipod crustaceans, small fish, and fish eggs. It is believed this fish was introduced into the Great Lakes from discharged ballast water. Field studies of fish suggest round gobies have a detrimental impact on native species through competition for food and habitat and predation on eggs and young fish. Round gobies have been implicated as a vector of botulism in the Great Lakes and round gobies have been recently discovered to be infected with Viral Hemorrhagic Septicemia (VHS) and may pose an additional concern as a vector to spread this viral disease to native species. It is illegal in Pennsylvania to sell, purchase, barter, possess, introduce, import, or transport round gobies.

Rusty crayfish (*Orconectes rusticus*) are native to waters in the Ohio, Kentucky and Tennessee region. Although they are indigenous to parts of the Ohio River basin, they are not considered native to Pennsylvania. Rusty crayfish were first found in the Commonwealth in 1976. Recent survey work funded by the PFBC to assess native crayfish distribution and abundance has documented additional rusty crayfish populations, mainly in south central Pennsylvania (PA FBC, 2005). Rusty crayfish are more aggressive than other native crayfish, better able to avoid fish predation, and can harm native fish populations by eating their eggs and young. They can displace native crayfish, hybridize with them, and graze on and eliminate beneficial aquatic plants. They have likely spread by releases from bait buckets and aquariums, activities of commercial bait harvesters, and live study of specimens purchased from biological supply houses. Females can carry fertilized eggs or a male's sperm, so even the release of a single female could establish a new population (Indiana DNR, 2003). It is illegal in Pennsylvania to sell, purchase, barter, possess, introduce, import, or transport rusty crayfish.

Sea lamprey (*Petromyzon marinus*) are native to the Atlantic Ocean, but they head to freshwater rivers to spawn. Sea lampreys kill prey by attaching to the fish and feeding on the fish's body fluids. Sea lamprey gained access to the Great Lakes after the opening of the St. Lawrence Seaway and the Welland Canal. The invasion of the sea lamprey into the Great Lakes in the 1940s resulted in substantial economic losses to recreational and commercial fisheries, and has required annual expenditures of millions of dollars to control sea lamprey populations. During the 1940s and 1950s the sea lamprey devastated populations of whitefish and lake trout and significantly contributed to the collapse of the Great Lakes fishery (Great Lakes Fishery Commission). For example, before sea lampreys entered the Great Lakes, Canada and the United States harvested about 15 million pounds of lake trout in lakes Huron and Superior annually. By the early 1960s, the catch was only about 300,000 pounds. In 1992, approximately \$10 million per year was spent on sea lamprey control costs and research to reduce its predation.

Ongoing control efforts in the Great Lakes have resulted in a 90 percent reduction of sea lamprey populations in most areas. The total value of the lost fishing opportunities plus indirect economic impacts in the Great Lakes could exceed \$500 million annually (Office of Technology Assessment, 1993). Sea lamprey is a possible vector in spread of disease as well – Bacterial Kidney Disease is a significant bacterial disease of salmonids. In Pennsylvania, sea lamprey are native in the Delaware River but invasive in Lake Erie.

Spring Viremia of Carp (SVC) is a viral disease mainly of common carp (*Cyprinus carpio*). The causative agent spring viremia of carp virus (SVCV) or *Rhadovirus carpio* was first described in 1971 but there is evidence that it was present in Europe since the Middle Ages. Historically, SVC has been reported in many countries in Europe, the Middle East, and Asia but more recently, it has been reported both in South and North America, the latter in both wild and cultured fish. It has been reported in North Carolina, Wisconsin, Illinois, Missouri and Washington, and Hamilton Harbor, Ontario. In Europe, the disease has substantial impact on carp production with estimated losses of 10-15 percent of yearling carp and mortality rates as high as 70 percent. It is an Office International des Epizooties (OIE) notifiable disease. Although common carp which includes Koi carp is the main species that is affected by SVC, several other susceptible species (under natural conditions) includes the crucian carp (*Carassius carassius*), grass carp (*Ctenopharyngodon idella*), silver carp (*Hypophthalmichthys molitrix*), bighead carp (*Hypophthalmichthys nobilis*), goldfish (*Carassius auratus*), tench (*Tinca tinca*), and sheatfish (*Silurus glanis*). Roach (*Rutilus rutilus*), pike (*Esox lucius*), guppy (*Lebistes reticulatus*), pumpkinseed (*Lepomis gibbosus*), zebra danios (*Brachydanio rerio*) and golden shiners (*Notemigonus crysoleucas*) have been found to be experimentally susceptible to the disease. Horizontal transmission of the disease from infected fish is via feces and possibly in the urine and gill mucus. Reservoir host include sick fish and fish that have survived outbreaks of the disease. In addition to carp, other cultured and wild fish may serve as reservoir hosts. Vertical transmission is thought to be possible as the virus has been found in ovarian fluids but lack of outbreaks in fry and fingerlings suggest that this might not be an important route of transmission. Parasites like the carp louse (*Argulus foliaceus*) and the leech (*Pisciola geometra*) have been shown to be passive vectors while mechanical vectors (birds or mechanical equipment) can also cause problems since the SVCV can maintain infectivity for a long time in water or mud. Currently, no antiviral treatment or commercial vaccines are available although some vaccine studies show potential (Illinois DNR, 2005).

Tubenose goby (*Proterorhinus semilunaris*) are a fish thought to have crossed the Atlantic in the ballast tanks of transoceanic ships. Although both the tubenose goby and the round goby were first identified in the Great Lakes in 1990, the round goby has become extremely abundant in the area while the tubenose goby has yet to become widespread. Because the tubenose goby is a smaller, less aggressive species, its effect on the community is expected to be minimal. Individuals live about five years and tend to spawn on vegetation. Aquatic insects are their main prey but they also eat round goby fry. Ironically, because of habitat destruction, the tubenose goby is endangered in parts of its native range around the Black and Caspian seas of Eurasia. Tubenose gobies lay eggs on vegetation, and so one potential pathway for transport is via plants attached to boats and trailers that have been in infested waters (Moen, 2002). It is illegal in Pennsylvania to sell, purchase, barter, possess, introduce, import, or transport tubenose goby.

Viral Hemorrhagic Septicemia (VHS)

Historically, this disease has been considered the most serious viral disease of salmonids reared in freshwater in Europe. It however was recently associated with marine species and even more recently (2005), it has become an emerging disease of freshwater fish in the Great Lakes region of the US and Canada. VHS is caused by rhabdovirus and in Europe is known as Egtved virus. It is highly virulent causing high mortality and is listed as a reported disease by the World Organization for Animal Health. Related strains from a variety of marine species have been isolated in the North Pacific, North Atlantic, and seas around northern Europe and Japan. Susceptible species to the North American genotype include 40 different species, both freshwater and marine. These are Salmoniformes (salmon, trout), Esociformes (pike), Clupeiformes (herring, anchovy), Gadiformes (cod), Pleuronectiformes (flounders, soles, other flatfishes), Osmeriformes (smelt), Perciformes (perch, drum), Scorpaeniformes (rockfishes, sculpins), Anguilliformes (eels, cyprinodontiformes (mummichog), and Gasterosteiformes (sticklebacks). Current control methods include eradication and fallowing. All VHS viruses can be isolated from internal organs, sex products and urine but not the feces of infected fish. Piscivorous birds may be mechanical vectors (the virus appears to be unable to survive the gastrointestinal tract of the birds) and it appears that there are no parasitic vectors. The Great Lakes isolate may be a new substrain of the North American genotype and has been shown to cause moderate mortality in Lake Trout, Chinook salmon and Steelhead trout. These are recreationally important species that were introduced and have become established in the upper portions of the Great Lakes where VHS has not yet been detected. Cage culture of salmonids also occurs on the Canadian side of the Great Lakes. Baitfish represent a concern as a potential introduction and/or spread of VHS. Several species of baitfish are collected in the Great Lakes and are used as bait around the United States. Baitfish is also imported from Canada. Baitfish broodstock is also sometimes collected from the Great Lakes for baitfish production. Aquaculture food fish production in the 4 states that border the lower Great Lakes where VHSV has been isolated comprised just over 1 percent of total value of US production based on the 1998 Census of Agriculture. These states also contribute approximately 1-2 percent of the total value of baitfish and sport/gamefish in the United States. The 1998 Census of Agriculture listed 43 foodfish farms, 8 baitfish farms and 5 sport/game fish farms in Pennsylvania. Of the VHS-susceptible foodfish species in Pennsylvania, the trout production based on the 1998 census had a value of approximately \$5.5 million. The value of the other foodfish and sport/gamefish in Pennsylvania were not available (USDA APHIS, 2006).

Water Chestnut (*Trapa natans*) is an annual aquatic plant, with both surfacing and submersed leaves. Fruit are nut-like and "woody" with typically four barbed spines that are sharp enough to penetrate shoes. Long cord-like stems can attain lengths of up to 16 feet, forming dense floating mats and making the waters inaccessible to recreational activities. This plant also severely limits the passage of light into the water, reduces oxygen levels in the water, outcompetes native vegetation, and is of little value to wildfowl. Water chestnut grows in freshwater lakes and ponds and slow-moving streams and rivers. It prefers calm, shallow, nutrient-rich waters. Water chestnut reproduces by overwintering seeds, and ungerminated seeds may remain viable for up to 12 years. However, most seeds probably germinate in the first two years (Vermont DEC, 2004; Washington Department of Fish and Wildlife, 2001). Water chestnut currently infests six water bodies in Pennsylvania.

West Nile virus (WNV), first isolated in 1937, has been known to cause asymptomatic infection and fevers in humans in Africa, West Asia, and the Middle East. Human and animal infections were not documented in the Western Hemisphere until 1999. In 1999 and 2000, outbreaks of WNV encephalitis (inflammation of the brain) were reported in persons living in the New York City metropolitan area, New Jersey, and Connecticut. The Centers for Disease Control and Prevention reported that the disease epidemic grew rapidly from an initial United States outbreak of 62 cases of human disease in 1999 to 49 states reporting 3000 cases in 2005. Pennsylvania reported 25 human cases in 2005. West Nile virus may be transmitted when an infected mosquito bites a human to take in blood. Mosquitoes become infected when they feed on infected birds, which may circulate the virus in their blood for a few days. In addition, recent investigations confirmed WNV transmission through transplanted organs and transfused blood. The recent introduction of routine WNV screening of blood donations should greatly reduce the risk of spread of WNV through transfused blood. Only about two persons of every 10 who are bitten by an infected mosquito will experience any illness. Although illness from WNV is usually mild, serious illness and death are possible, particularly for persons over the age of 50. West Nile virus is spread by a “filth mosquito,” referred to as such because it prefers to reproduce in stagnant standing water. Three simple actions can help prevent infection: avoiding mosquito bites by using insect repellants with DEET and wearing light, long-sleeved clothing, mosquito-proofing properties by emptying standing water and installing screens, and reporting dead birds to local health authorities (Indiana DNR; Rankin, 2006).

Zebra mussel (*Dreissena polymorpha*) is a small fingernail-sized bivalve native to Eastern Europe and Western Asia. It is one of the best known invaders of the Great Lakes region and other areas of the country where it has spread. The zebra mussel is a highly opportunistic mollusk that reproduces rapidly, consumes microscopic aquatic plants and animals from the water column in large quantities, and colonizes on hard surfaces. The potential impact on the fishery can be profound due to changes in food availability and spawning areas. Economic impacts are as pervasive as the ecosystem impacts. Due to infestations of zebra mussel in their intake and discharge pipes, Great Lakes municipalities, utilities, and industries have significant costs associated with monitoring, cleaning, and controlling infestations. According to a recent economic impact study, each of 84 Great Lakes water users reported average total expenditures of \$513,600 over the five-year period from 1989 to 1994 (Hushak et al., 1995). Commercial and recreational vessels and beach areas also are vulnerable to the negative impacts of the zebra mussel. Zebra mussels can colonize on native mussels, and have extirpated most of the native mussels found in Lake Erie. They can also attach to docks, buoys, boats, and beaches. Their shells are sharp which makes it painful to walk barefoot on a beach. Zebra mussels are established in several water bodies in northwestern Pennsylvania, including Lake Erie, Edinboro Lake, Conneauttee Creek, Sandy Lake, Conewango Creek, and in the upper Allegheny River. Zebra mussels are also present in the lower Allegheny, Monoghahela and upper Ohio rivers near Pittsburgh and in a diving quarry near Bethlehem. It is illegal in Pennsylvania to sell, purchase, barter, possess, introduce, import, or transport zebra mussels.

C5. Case Studies Highlighting Policy and Management Challenges

As mentioned previously, there are some species that highlight policy and management challenges for Pennsylvania. These challenges will have to be addressed as AIS management in

Pennsylvania moves forward. Examples of three species that highlight a few of these challenges are described below, but more policy and management challenges may become apparent as Pennsylvania moves forward with implementation of the AIS management plan.

Broad-leaved watermilfoil (*Myriophyllum heterophyllum*) is an aquatic plant that poses significant policy and management challenges. The few long-enduring, clearly native populations such as those at Presque Isle are tracked by the Pennsylvania Natural Heritage Program as Pennsylvania Endangered, but the plant also behaves like an invasive in several Pennsylvania lakes and impoundments, as has been reported in several northeastern states. Broad-leaved watermilfoil, also known as variable-leaf milfoil or two-leaf milfoil, is a submersed, perennial aquatic plant usually found rooted in up to 6 feet of water. It grows in a variety of habitats including ponds, swamps, and rivers. Although the plant is largely submersed, the flowering/fruitlet portion may extend four to six inches above the surface. The plants are thick and have robust stems which are usually dark red, branched, and up to 1/3 inch in diameter. Leaves are in whorls of four to six, up to two inches in length. Reproduction occurs both vegetatively and by seed production. *Myriophyllum heterophyllum* is considered an exotic in several New England states (NatureServe, 2004; New Hampshire DES, 1999; Stratford and Hoyle, 1999).

Flathead Catfish (*Pylodictis olivaris*) is an example of a species that is native in one portion of Pennsylvania, but has become invasive in another ecosystem. Flathead catfish, which are native to western Pennsylvania waters, have been caught in the Susquehanna and Schuylkill River drainages in recent years in increasing numbers. Flathead catfish grow longer and heavier than other Pennsylvania catfish. Flatheads grow fairly rapidly and mature sexually at about 15 inches and five years old. They can live to at least 19 years old. Juvenile flatheads live in riffle areas and feed on larvae and nymphs of aquatic insects. As the flathead grows it switches to crayfish and fishes, although many items are on its menu. One concern about flathead catfish in the eastern drainages is excessive predation on sunfishes (PA FBC –“catfish”).

Narrow-leaved and Hybrid Cattail (*Typha angustifolia*, *T. x glauca*) are species with both useful and detrimental impacts. Narrow-leaved cattail is useful in wetland restoration projects as it takes up water and nutrients, but without control it will form dense stands that eventually out-compete other valuable wildlife food and cover species. Narrow-leaved cattails are believed to have been introduced to the Atlantic seaboard from the dry ballast of European ships. This plant has since spread westward and occurs throughout much of the United States. Narrow-leaved cattail is a non-native, invasive plant that hybridizes with the native broad-leaved cattail (*T. latifolia*) to produce the invasive *T. x glauca*. All three aquatic perennials may grow up to a height of 10 feet and produce a velvety brown spike of flowers. These plants establish dense monocultures that enable them to shade out native vegetation. They are also thought to be allelopathic, producing chemicals that discourage growth of other plant species. Cattails reproduce both vegetatively by rhizomes and sexually through massive amounts of seed (Ohio DNR, 2005).

D. Management Objectives, Strategies and Actions Proposed

The objectives, strategies and actions proposed here are to be implemented under the auspices of the Pennsylvania Invasive Species Council.

The goal for the Pennsylvania Aquatic Invasive Species Management Plan is to minimize the harmful ecological, economic and human health impacts of aquatic invasive species through the prevention and management of their introduction, expansion and dispersal into, within and from Pennsylvania.

Given the magnitude of the problem and the variety of activities pertaining to aquatic invasive species in Pennsylvania, eight management objectives have been identified to achieve this goal:

1. Provide leadership and coordination for AIS issues in Pennsylvania among local, state and federal agencies and organizations, and ensure that state policy effectively promotes the prevention, early detection and control of aquatic invasive species in Pennsylvania. Establish coordination and provide leadership within the Mid-Atlantic and Great Lakes regions in order to address AIS issues more effectively, including prevention, advanced warning and concerted efforts in drainage basins shared across state lines.
2. Identify vectors and mechanisms and minimize the introduction and spread of aquatic invasive species into and throughout Pennsylvania.
3. Detect new introductions of aquatic invasive species in Pennsylvania before they have a chance to become established in the ecosystem.
4. Develop a system for early response to eradicate or contain target species before the species can become permanently established.
5. Monitor and inventory existing infestations of aquatic invasive species in Pennsylvania.
6. When feasible, control and eradicate established aquatic invasive species that have significant impacts in Pennsylvania. Reduce the harmful effects resulting from AIS infestations by managing those that cannot be eradicated.
7. Increase research efforts on AIS species, issues and impacts to support AIS management, control and eradication in Pennsylvania.
8. Educate the general public and people involved in the business, trade, research and government sectors about AIS issues so that they do not facilitate the introduction or spread of AIS species.

Associated strategies and specific actions pertaining to each of the above objectives are presented in this chapter. These actions have been identified as being critical action items in managing the issues of aquatic invasive species more effectively, before many of these species cause further damage to the Commonwealth.

Many of the suggested actions in the following pages will require additional funding sources in order to be implemented. The actions identified here are what "should" happen in order to have an effective statewide AIS management program for Pennsylvania. It is understood that due to funding issues, it may take several years for some of these actions to be undertaken.

Objective 1. Leadership, Coordination and Policy

Provide leadership and coordination for AIS issues in Pennsylvania among local, state and federal agencies and organizations, and ensure that state policy effectively promotes the prevention, early detection and control of aquatic invasive species in Pennsylvania.

Establish coordination and provide leadership within the Mid-Atlantic and Great Lakes regions in order to address AIS issues more effectively, including prevention, advanced warning and concerted efforts in drainage basins shared across state lines.

Strategy 1A. Develop and implement a Pennsylvania AIS management program.

Action 1A1. Implement the Pennsylvania AIS Management Plan as signed by the Governor and approved by the ANS Task Force.

Strategy 1B. Create and fund an AIS coordination position.

Action 1B1. Hire a coordinator (Coordinator) (1.0 FTE) for the Pennsylvania Aquatic Invasive Species Program. Responsibilities of the AIS Program Coordinator will include coordinating PISC AIS subcommittee and interagency activities and reporting progress on implementing the plan on an annual basis. The Aquatic Invasive Species Program Coordinator will work with subcommittees and other agencies and partners to review functional roles, gaps in authority, and develop an integrated annual work plan and budget.

Strategy 1C. Coordinate all AIS management programs and activities within Pennsylvania and establish multi-state cooperation and coordination within the Mid-Atlantic and Great Lakes regions and with national AIS programs (Strategy 1C).

Action IC1. Partner with AIS management programs in nearby states to share data and coordinate management activities. Pay special attention to “upstream” and “downstream” neighboring states to prevent AIS introduction and spread.

Action IC2. Develop a common AIS list(s) using a defined process and standards. The process should utilize scientific methods and procedures and should address such topics as the method for adding and deleting species from the list over time, the criteria to be used for making listing decisions, the status the list has, if any, in regulatory proceedings, and the trade-offs between a legislatively generated list and one maintained by agency discretion and rule-making.

Action IC3. Identify key personnel in state and federal agencies and private organizations and their AIS responsibilities and authorities.

Action IC4. Establish a process for PISC, through the Chair and Coordinator, to communicate progress, emerging issues and needs to the Governor’s Office. Upon direction by or approval from the Governor’s Office, work with Pennsylvania’s established Federal advocacy process to address national issues and needs to help states prevent and control aquatic invasive species threats.

Action IC5. Compile existing regulatory authorities and requirements by agency (state and federal) with regards to AIS management and address gaps in legal authority.

Action IC6. Participate in regional and national forums, such as the Great Lakes and Mid-Atlantic Regional Panels, to ensure that AIS efforts in Pennsylvania remain current, based in effective science, and coordinated with regional and national programs.

Action IC7. Conduct periodic forums focused on AIS impacts in Pennsylvania and potential management alternatives.

Strategy 1D. Develop a permanent funding mechanism for AIS management in Pennsylvania.

Action 1D1. Through PISC, work with the Governor's Office, Legislature and other Council members and partners to establish a permanent funding mechanism for AIS management activities.

Strategy 1E. Establish a process for revising and updating the AIS management plan.

Action 1E1. As part of the overall Pennsylvania Invasive Species Management Plan, review, update and submit the Aquatic Invasive Species Management Plan for the Governor's approval on a five-year basis, with biennial status reports to the Governor. Establish a process for more frequent review if necessary.

Objective 2. Prevention

Identify vectors and mechanisms and minimize the introduction and spread of aquatic invasive species into and throughout Pennsylvania.

Strategy 2A. Establish a comprehensive process to identify the aquatic invasive species of greatest concern that are not yet present in Pennsylvania waters.

Action 2A1. Use scientific methods and procedures to facilitate the conduct of research-based risk analysis to determine the level of risk associated with introductions of certain potentially invasive aquatic species, with respect to the probability of entry through multiple pathways, potential to establish, ability to spread once established, and associated economic and ecological values, benefits and/or impacts.

Action 2A2. For aquatic invasive species with the greatest potential to infest Pennsylvania waters, identify existing and potential pathways that facilitate new introductions of these species.

Strategy 2B. Develop a system to evaluate AIS pathways and identify potential prevention strategies addressing these pathways.

Action 2B1. Identify and prioritize highest-risk pathways for the introduction of harmful aquatic species into Pennsylvania waters

Action 2B2. Develop and implement specific actions and plans to reduce the likelihood of introduction of harmful non-indigenous aquatic species from both intentional and unintentional high-risk pathways.

Action 2B3. Identify "ecologically sensitive" aquatic resource areas that are relatively free of aquatic invasive species, and identify potential pathways and additional precautionary protocols, including additional outreach and enforcement, to implement for those areas.

Strategy 2C. For priority aquatic invasive species identified through predictive screening and/or risk assessment processes, develop and implement appropriate management actions required to prevent their introduction into Pennsylvania.

Action 2C1. Identify best management practices, codes-of-conduct and potential certification options for key industry and user groups (e.g., pet and aquarium trades, water gardens, aquaculture industry, research community, commercial shipping, recreational boating, transportation industry, bait retailers and suppliers, etc.) to keep the priority AIS out of Pennsylvania. Work with appropriate agencies, industry representatives and user groups who may represent potential pathways to ensure awareness of the threats of aquatic invasive species and to develop methods to better assist in preventing the introduction and transfer of aquatic invasive species.

Action 2C2. Evaluate the need for new and/or strengthened tools to prevent the introduction of priority non-indigenous aquatic invasive species (e.g., enhanced inspection programs, a "watch" list of species deemed to have a high potential to cause significant harm in Pennsylvania, new import/trade restrictions and/or review and approval processes for certain species, etc.).

Action 2C3. Incorporating pathway analysis, evaluate the potential effectiveness of existing management and regulatory tools in preventing the introduction of these priority aquatic invasive species into Pennsylvania.

Action 2C4. Encourage state agencies to serve as role models by adopting sound aquatic invasive species prevention practices for their own operations.

Action 2C5. Encourage greater cooperation between federal and state agencies in the development and implementation of aquatic invasive species risk management partnerships at all ports of entry and other suitable pathway points. Coordinate efforts with the Pennsylvania Department of Agriculture Bureau of Plant Industry on the Pennsylvania Noxious Weed list.

Action 2C6. Explore opportunities to cooperate with adjoining or nearby states to identify opportunities for interrupting pathways for priority aquatic invasive species.

Strategy 2D. Review existing programs and policies which address the prevention of new aquatic invasive species in Pennsylvania and identify opportunities for improving their effectiveness.

Action 2D1. Identify set of best prevention practices and “model” aquatic invasive species laws and programs to prevent new infestations, and conduct benchmark comparison with Pennsylvania’s current statutory/regulatory framework.

Action 2D2. Identify opportunities to enhance cooperation between the public and private sectors in preventing new introductions of aquatic invasive species in Pennsylvania.

Action 2D3. Review and assess existing federal and state programs and authorities (laws, regulations, policies, etc.) which deal with the prevention of aquatic invasive species in Pennsylvania, and identify potential gaps and recommendations for improvement.

Action 2D4. Identify and pursue opportunities for improving inter- and intra-agency cooperation and coordination in the administration and implementation of aquatic invasive species prevention programs in Pennsylvania.

Action 2D5. Evaluate the current capacity (funding, staffing, technical support, etc.) of existing federal and state programs designed to prevent the introduction of new aquatic invasive species in Pennsylvania, and identify list of priority resource needs and new funding opportunities.

Strategy 2E. Increase public awareness about the problems associated with aquatic invasive species introductions and educate the public and key constituencies about actions that can be taken to reduce the possibility of these species becoming established in Pennsylvania waters. (Strategy and Tasks repeated in Education/Outreach Section).

Action 2E1. Target outreach efforts and prioritize key audiences to promote understanding of invasive species dispersal pathways and current risk assessments

Strategy 2F. Prioritize and promote research to reduce the threat of aquatic invasive species introductions into Pennsylvania waters. (Strategy and Tasks repeated in Research Section).

Action 2F1. Develop technical partnerships with key industries and universities to promote applied research.

Action 2F2. Prioritize AIS research needs. Coordinate research activities and maintain an inventory of these activities to ensure the use and application of research products.

Objective 3. Early Detection

Detect new introductions of aquatic invasive species in Pennsylvania before they have a chance to become established in the ecosystem.

Strategy 3A. Identify gaps in existing efforts

Action 3A1. Survey and evaluate current early detection programs/networks, including volunteer networks, identify geographic gaps, and make recommendations to improve detection efforts across institutional and jurisdictional boundaries.

Strategy 3B. Increase the knowledge and expertise available to enhance early detection efforts.

Action 3B1. Engage those already in the field to be aware of key invasive species that they may come across. Conduct training for field staff to ensure that they can easily identify aquatic invasive species. Implement a statewide monitoring network to assist in AIS early detection and monitoring.

Action 3B2. Develop expert list (within agencies, academia and contractors) that can help with hard-to-identify species, and develop contract arrangements if necessary.

Action 3B3. Support taxonomic research and the establishment of new taxonomic expertise to support early detection efforts (Task repeated in Research Section).

Strategy 3C. Prioritize early detection efforts by location and species

Action 3C1. Create a regional species “watch” list (likely invaders currently not documented in Pennsylvania) of species for which to be on the lookout.

Action 3C2. Identify high hazard areas for targeted early detection surveying.

Strategy 3D. Establish simple, coordinated reporting system(s) for AIS detection and monitoring in Pennsylvania (Strategy and Tasks Repeated in Monitoring and Inventory Section).

Action 3D1. Develop an Aquatic Invasive Species Tracking Program for Pennsylvania, which would include an online interactive GIS interface and a QA/QC system for confirming identification. Establish simple reporting procedures and publicize information to state and local monitoring groups.

Strategy 3E. Facilitate regional cooperation for AIS early detection efforts.

Action 3E1. Establish cooperative policies with states sharing watersheds for early detection efforts to limit the spread of AIS populations.

Objective 4. Rapid Response

Develop a system for early response to eradicate or contain target species before the species can become permanently established.

Strategy 4A. Implement a coordinated system for rapid response efforts to contain or eradicate newly detected aquatic invasive species.

Action 4A1. Develop a model aquatic rapid response plan for Pennsylvania. Plan should address such components as organizational structure and communication, authority, outreach, decision support and rapid scientific assessment, management options for control/eradication, implementation, adaptive management, and funding. Process for planning efforts should include identifying and involving stakeholders.

Action 4A2. Explore the establishment and administration of permanent funding to implement emergency response plans.

Action 4A3. Identify and support personnel training and equipment needs and interagency partnerships for successful rapid response operations. Have the licenses and permits necessary for specified control techniques: mechanical and biological; chemical), contract authority necessary for purchased services; and agreements necessary for mutual aid with other states and federal agencies

Action 4A4. Create an inventory/database of available resources across the state, such as equipment and labor, which could be shared so that resource managers can easily determine who to contact to borrow various types of equipment or gather additional personnel or volunteers.

Strategy 4B. Develop specific rapid response plans for priority organisms.

Action 4B1. Establish a prioritization process to focus rapid response resources.

Action 4B2. Using model plan created above, develop rapid response plans for specific, high priority aquatic invasive species. Establish rapid response teams capable of executing safe, effective species-specific response efforts.

Objective 5. Monitoring and Inventory

Monitor and inventory existing infestations of AIS in Pennsylvania.

Strategy 5A. Create a master inventory of Pennsylvania aquatic invasive species.

Action 5A1. Create a compilation of inventories of aquatic invasive species in Pennsylvania held by various local, county, state, and federal agencies, and private organizations such as land trusts, conservancies, etc. Explore the feasibility of making the master inventory an electronic geographic database accessible through the Internet and investigate the option of combining inventories into one master inventory, with common nomenclature and data elements. Explore the feasibility of allowing agencies and other stakeholders to update the electronic master inventory. Address QA/QC concerns with this process.

Action 5A2. Identify inventory gaps and develop strategies to address them.

Strategy 5B. Establish simple, coordinated reporting system(s) for AIS detection and monitoring in Pennsylvania (Strategy and Tasks Repeated in Early Detection Section).

Action 5B1. Develop an Aquatic Invasive Species Tracking Program for Pennsylvania, which would include an online interactive GIS interface and a QA/QC system for confirming identification.

Action 5B2. Establish simple reporting procedures and publicize information to state and local monitoring groups.

Strategy 5C. Develop a cadre of field associates to monitor priority aquatic invasive species.

Action 5C1. Assess feasibility of using local, state and federal field staff, stakeholder organizations and volunteers to monitor priority aquatic invasive species.

Action 5C2. Develop training program to certify agency field staff, stakeholder organizations and volunteers in AIS identification and use of the electronic master inventory system.

Strategy 5D. Prioritize monitoring efforts for existing AIS populations in Pennsylvania.

Action 5D1. Develop monitoring programs specific to pathways and geography for high priority AIS using agency, stakeholder and/or volunteer resources.

Objective 6. Control and Management

When feasible, control and eradicate established aquatic invasive species that have significant impacts in Pennsylvania. Reduce the harmful effects resulting from AIS infestations by managing those that cannot be eradicated.

Strategy 6A. Limit the spread of established aquatic invasive species into new areas and control and eradicate established AIS.

Action 6A1. Identify what has already been done for control and management to avoid duplication and identify management needs; clarify management responsibility especially among agencies and organizations. Identify and publicize “success stories” to reinforce the importance of these actions and sustain momentum and support for addressing AIS.

Action 6A2. Identify information, staff, research, and budget needs to improve invasive species management in Pennsylvania.

Strategy 6B. Prioritize organisms on which to focus control efforts and develop and implement specific control plans to address these.

Action 6B1. Implement cost-benefit analyses to prioritize control efforts for both species and sites. Weigh all proposed actions against the “no-action” alternative.

Action 6B2. Develop species-specific or location-specific action plans, as appropriate. Integrate knowledge from efforts throughout Pennsylvania, nationally, and internationally when dealing with specific species to determine appropriate control actions.

Action 6B3. Develop a procedure for determining when to apply limited-duration surface use restrictions on infested waters. This procedure will take into account the state’s need to balance the provision of public access with other resource and recreational values. As part of this effort, they will work with the PFBC, municipalities and lake associations to determine when and how non-state entities could be responsible for plan enforcement and buoy deployment.

Action 6B4. Research and summarize effective control and management measures in Pennsylvania and elsewhere regarding specific species. (Task repeated in Research Section).

Action 6B5. Develop means of adapting human activities in response to AIS infestations.

Strategy 6C. Explore and utilize the various methods available to control priority AIS. Assess the efficacy of control and management interventions and adapt efforts as necessary to achieve management needs.

Action 6C1. Implement control strategies that are based on the best available scientific information and conducted in an environmentally sound manner. Coordinate control strategies with federal agencies, local governments, interjurisdictional organizations and other appropriate entities. Continue ongoing chemical treatment methods at existing sites and use these methods to treat new infestations as appropriate.

Action 6C2. Establish protocols that will provide guidance in designing and implementing control and eradication strategies.

Action 6C3. Support cooperative scientific research by state and federal agencies and academic institutions to investigate potential control strategies and associated environmental impacts.

Action 6C4. Develop a common volunteer training program and help volunteers optimize control and management activities

Action 6C5. Support the development of special use permits for chemicals in situations that are not currently labeled for use in Pennsylvania.

Action 6C6. Continue to prudently explore the utilization of biocontrol options for plant species.

Action 6C7. Work with a local community(s) and lake and game associations to develop model infestation control plans for the water body that is best suited as a “demonstration” project to model the kind of components such a plan should contain, e.g., strategies for containment, eradication and restoration (if eradication is successful), surface use, boating access, and measuring results.

Action 6C8. Evaluate potential incentive programs or assistance for private landowners for the control of invasive species and restoration of ecosystems vulnerable to invasion and make recommendations to the Governor’s Office and Pennsylvania Legislature to establish or enhance these programs.

Objective 7. Research and Risk Assessment

Increase research efforts on AIS species, issues and impacts to support AIS management, control and eradication in Pennsylvania.

Strategy 7A. Establish and coordinate a Pennsylvania AIS research network by building on existing state, federal and university programs. This network will develop research capacity and communicate AIS research needs to other institutions.

Action 7A1. Identify priority research needs. These priorities should address aquatic invasive species research, monitoring, and risk assessment needs specific to Pennsylvania's diverse freshwater and estuarine habitats. Areas of research will include prevention, early detection, distribution and populations, control and management, and restoration of affected habitats.

Action 7A2. Research and summarize effective control and management measures in Pennsylvania and elsewhere regarding specific species. (Task repeated in Research Section).

Action 7A3. Support priority research needs with adequate staff and funding in appropriate Pennsylvania agencies and other institutions. Gather and disseminate funding source information to research entities. Facilitate the collection and dispersal of information, research, and data about Pennsylvania aquatic invasive species among research institutions.

Action 7A4. Support taxonomic research and the establishment of new taxonomic expertise to support early detection efforts (Task repeated in Early Detection Section).

Strategy 7B. Increase aquatic invasive species risk assessment capacity.

Action 7B1. Compile available risk assessments completed for aquatic invasive species already established in Pennsylvania and identify needs for further analysis. This process should result in a list of "established high priority aquatic invasive species," which are 1) currently established in Pennsylvania, or 2) widely recognized as a threat to human health, ecological or economic resources.

Action 7B2. Develop human health, environmental, and economic indicators for evaluating impacts of AIS.

Action 7B3. Implement a process for assessing risks associated with potential AIS that are likely to be introduced unintentionally or are known to be moving toward Pennsylvania and for which rapid response tools are necessary.

Action 7B4. Work with governmental and non-governmental stakeholders to develop a science-based, comprehensive screening system for evaluating risks associated with the initial introduction of non-native aquatic species.

Strategy 7C. Prioritize and promote research to reduce the threat of aquatic invasive species introductions into Pennsylvania waters. (Strategy and Tasks repeated in Prevention Section).

Action 7C1. Develop technical partnerships with key industries and universities to promote applied research.

Action 7C2. Prioritize AIS research needs. Coordinate research activities and maintain an inventory of these activities to ensure the use and application of research products.

Objective 8. Education and Outreach

Educate the general public and people involved in the business, trade, research and government sectors about AIS issues so that they do not facilitate the introduction or spread of aquatic invasive species.

Strategy 8A. Increase public awareness about the problems associated with aquatic invasive species introductions and educate the public and key constituencies about actions that can be taken to reduce the possibility of these species becoming established in Pennsylvania waters. (Strategy and Tasks repeated in Prevention Section).

Action 8A1. Target outreach efforts and prioritize key audiences to promote understanding of invasive species dispersal pathways and current risk assessments

Strategy 8B. Develop and distribute AIS educational materials to increase awareness of the AIS problem.

Action 8B1. Develop new or maintain and upgrade any currently existing state websites on AIS.

Action 8B2. Develop and distribute AIS fact sheets and identification materials describing the methods to prevent their spread. Materials may include a contact number of where to report potential sightings.

Action 8B3. Identify available materials to educate the public about what aquatic invasive species are, the problems they cause, and the avenues available for citizens to help address the issue. Modify existing materials or develop new materials to meet any identified gaps.

Action 8B4. Produce periodic press releases and public service announcements on specific AIS threats.

Action 8B5. Review AIS curriculum materials available for teachers to use in classrooms. Modify existing materials or develop new materials to meet any identified gaps. Use existing teacher-training entities as vehicle for distributing materials.

Action 8B6. Develop materials for presentations on AIS issues to aquatic resource user groups.

Action 8B7. Develop common materials and messages (for example, slogans or logos) that all agencies can use to promote public participation in AIS prevention and control.

Action 8B8. Incorporate AIS information into boater safety classes.

Action 8B9. Continue to include AIS information in state hunting, fishing, and boating regulations.

Strategy 8C. Develop and distribute AIS educational materials targeted at specific, public pathways of introductions.

Action 8C1. Install appropriate signage at all infested water bodies to raise public awareness of AIS.

Action 8C2. Create outreach materials about AIS impacts via the release of aquarium animals and aquatic ornamental plants. Use the materials to raise awareness about aquatic invasive species, the laws regulating them, their harmful effects in natural systems, and steps to take to prevent AIS introduction and spread. Distribute the materials to pet stores, garden centers, distributors, and bait dealers for distribution to customers.

Action 8C3. Develop and distribute AIS educational materials to aquaculture industry, aquatic user groups (i.e. dive clubs, angling clubs, sailing clubs, etc.), aquaria industry, recreational boating industry (i.e. marinas and boat dealers), and the horticultural industry (aquatic plant distributors, water garden dealers, etc.).

Strategy 8D. Develop and distribute AIS identification and management information to resource agency staff.

Action 8D1. Organize and facilitate AIS identification workshops for state aquatic resource managers. Distribute AIS educational materials to all resource agency field staff, municipalities using surface water supplies, city park departments, county conservation boards, Coast Guard Auxiliary groups, and other entities with aquatic resource management responsibilities.

Strategy 8E. Target policy makers and legislative staff for outreach effects.

Action 8E1. Identify sponsors at the State legislature and county governments who will support policy issues regarding aquatic invasive species.

Action 8E2. Provide educational briefings on the threats, economic impacts, and solutions to AIS invasions for decision-makers and legislators and keep legislators and decision-makers abreast of the progress of AIS management efforts. Encourage community groups to address policy makers regarding their concerns about aquatic invasive species in Pennsylvania.

E. Program Implementation and Evaluation

E1. Priorities for Action

Though all actions identified in this plan are considered important for the effective management of aquatic invasive species in Pennsylvania, the identification of priority actions is a key step to begin plan implementation. PISC and associated subcommittees, and the Aquatic Invasive Species Coordinator position (Task 1B1), will provide key entities to help determine these priorities, as well as play key roles in task implementation.

Based on stakeholder input, a preliminary demarcation of priority strategies and tasks needed to successfully implement the Pennsylvania AIS Management Plan is presented here. It is emphasized that this section should truly be considered an ongoing effort. It is expected to be updated not only in future drafts and versions of this plan, but also throughout the year as discussions continue.

Priority Strategies

Based on stakeholder input, the following strategies were identified as highest priority:

- Create and fund an AIS coordinator position (Strategy 1B).
- Develop a permanent funding mechanism for AIS management in Pennsylvania (Strategy 1D).
- Increase public awareness about the problems associated with AIS introductions and educate the public and key constituencies about actions that can be taken to reduce the possibility of these species becoming established in Pennsylvania waters (Strategy 2E).
- Implement a coordinated system for rapid response efforts to contain or eradicate newly detected aquatic invasive species (Strategy 4A).
- Coordinate all AIS management programs and activities within Pennsylvania and establish multi-state cooperation and coordination within the Mid-Atlantic and Great Lakes regions and with national AIS programs (Strategy 1C).
- Prioritize organisms on which to focus control efforts and develop and implement specific control plans to address these (Strategy 6B).
- Establish simple, coordinated reporting system(s) for AIS detection and monitoring in Pennsylvania (Strategy 3D and Strategy 5B).
- Explore and utilize the various methods available to control priority aquatic invasive species. Assess the efficacy of control and management interventions and adapt efforts as necessary to achieve management needs (Strategy 6C).
- Establish a comprehensive process to identify the aquatic invasive species of greatest concern that are not yet present in Pennsylvania waters (Strategy 2A).

- Develop a system to evaluate aquatic invasive species pathways and potential prevention strategies addressing these pathways (Strategy 2B).
- Limit the spread of established aquatic invasive species into new areas and control and eradicate established aquatic invasive species (Strategy 6A).

Priority Actions

In addition, stakeholders identified the following action items as highest priority:

- Hire a coordinator (Coordinator) (1.0 FTE) for the Pennsylvania Aquatic Invasive Species Program. Responsibilities of the AIS Program Coordinator will include coordinating PISC AIS subcommittee and interagency activities and reporting progress on implementing the plan on an annual basis. The Aquatic Invasive Species Program Coordinator will work with subcommittees and other agencies and partners to review functional roles, gaps in authority, and develop an integrated annual work plan and budget (Action 1B1).
- Develop a model aquatic rapid response plan for Pennsylvania. Plan should address such components as organizational structure and communication, authority, outreach, decision support and rapid scientific assessment, management options for control/eradication, implementation, adaptive management, and funding. Process for planning efforts should include identifying and involving stakeholders (Action 4A1).
- Develop monitoring programs specific to pathways and geography for high priority aquatic invasive species using agency, stakeholder and/or volunteer resources (Action 5D1).
- Work with the Governor's Office, Legislature and other Council members and partners to establish a permanent funding mechanism for AIS management activities (Action 1D1).
- Target outreach efforts and prioritize key audiences to promote understanding of invasive species dispersal pathways and current risk assessments (Action 2E1).
- Engage those already in the field to be aware of key invasive species that they may come across. Conduct training for field staff to ensure that they can easily identify aquatic invasive species. Implement a statewide monitoring network to assist in the early detection and monitoring of aquatic invasive species (Action 3B1).
- Facilitate the development and use of science-based risk assessments to determine the level of risk associated with introductions of certain potentially invasive aquatic species, with respect to the probability of entry through multiple pathways, potential to establish, ability to spread once established, and associated economic and ecological values, benefits and/or impacts (Action 2A1).

- Implement cost-benefit analyses to prioritize control efforts for both species and sites. Weigh all proposed actions against the “no-action” alternative (Action 6B1).
- Partner with AIS management programs in nearby states to share data and coordinate management activities. Pay special attention to “upstream” and “downstream” neighboring states to prevent AIS introduction and spread (Action 1C1).
- Develop a common AIS list(s) using a defined process and standards. The process should address such topics as the process for adding and deleting species from the list over time, the criteria to be used for making listing decisions, the status the list has, if any, in regulatory proceedings, and the trade-offs between a legislatively generated list and one maintained by agency discretion and rule-making (Action 1C2).

E2. Program Evaluation

To ensure that the goals of this plan are being effectively addressed, a procedure for monitoring and evaluating the implementation of strategies and tasks will be developed and initiated. It is recommended that this evaluation process is conducted at least every two years for the first four years, beginning after an AIS coordinator is hired. Systematic monitoring and evaluation of the progress made toward implementation of actions and their effectiveness will be undertaken by the agencies designated as leads on the implementation table. This evaluation will focus on the feasibility and cost-effectiveness of management activities. The plan is a working document and will be periodically updated and expanded based upon the experience gained from implementation, scientific research, and new tools as they become available. It is anticipated that an annual or biannual report will be completed by the AIS coordinator and include recommendations for updating and modifying the relevant management activities.

E3. Implementation Table

Objectives, Strategies and Tasks	Current Status	Fund Source	Lead Entity	Cooperating Entities	Recent Efforts				Requested Efforts		Future Needs
					FY-05-06		FY06-07		FY07-08		
					\$0	FTE	\$0	FTE	\$0	FTE	
Objective 1. Leadership, Coordination and Policy Provide leadership and coordination for AIS issues in Pennsylvania among local, state and federal agencies and organizations, and ensure that state policy effectively promotes the prevention, early detection and control of AIS in Pennsylvania. Establish coordination and provide leadership within the Mid-Atlantic and Great Lakes regions in order to address AIS issues more effectively, including prevention, advanced warning and concerted efforts in drainage basins shared across state lines.											
Strategy 1A. Develop and implement a Pennsylvania AIS management program.											
Action 1A1. Implement the Pennsylvania AIS Plan as signed by the Governor and approved by the ANS Task Force											
Strategy 1B. Create and fund an AIS coordination position.											
Action 1B1. Hire a coordinator (Coordinator) (1.0 FTE) for the Pennsylvania Aquatic Invasive Species Program. Responsibilities of the AIS Program Coordinator will include coordinating PISC AIS subcommittee and interagency activities and reporting progress on implementing the plan on an annual basis. The Aquatic Invasive Species Program Coordinator will work with subcommittees and other agencies and partners to review functional roles, gaps in authority, and develop an integrated annual work plan and budget.	DEP CZM program provided grant to Dept. of Agriculture for halftime coordinator position.						34,000	.5			
Strategy 1C. Coordinate all AIS management programs and activities within Pennsylvania and establish multi-state cooperation and coordination within the Mid-Atlantic and Great Lakes regions and with national AIS programs.											
Action 1C1. Partner with AIS management programs in nearby states to share data and coordinate management activities. Pay special attention to “upstream” and “downstream” neighboring states to prevent AIS introduction and spread.	DCNR Need – attend AIS coordinating conferences		DCNR BSP						1,000		1,000 per year
Action 1C2. Develop a common AIS list(s) using a defined process and standards. The process should utilize scientific methods and procedures and should address such topics as the											

Objectives, Strategies and Tasks	Current Status	Fund Source	Lead Entity	Cooperating Entities	Recent Efforts				Requested Efforts		Future Needs
					FY-05-06		FY06-07		FY07-08		
					\$0	FTE	\$0	FTE	\$0	FTE	
method for adding and deleting species from the list over time, the criteria to be used for making listing decisions, the status the list has, if any, in regulatory proceedings, and the trade-offs between a legislatively generated list and one maintained by agency discretion and rule-making.											
Action IC3. Identify key personnel in state and federal agencies and private organizations and their AIS responsibilities and authorities.	DCNR - Work with aquatic vegetation management consultants for private organizations		DCNR BSP	Nonprofits, landowner organizations							
Action IC4. Establish a process for PISC, through the Chair and Coordinator, to communicate progress, emerging issues and needs to the Governor's Office. Upon direction by or approval from the Governor's Office, work with Pennsylvania's established Federal advocacy process to address national issues and needs to help states prevent and control aquatic invasive species threats.											
Action IC5. Compile existing regulatory authorities and requirements by agency (state and federal) with regards to AIS management and address gaps in legal authority.											
Action IC6. Participate in regional and national forums, such as the Great Lakes and Mid-Atlantic Regional Panels, to ensure that AIS efforts in Pennsylvania remain current, based in effective science, and coordinated with regional and national programs.	DEP and PASG participate in Great Lakes and Mid Atlantic AIS Regional Panels. DEP participates in Council of Great Lakes Governors AIS Task Force										
Action IC7. Conduct periodic forums focused on AIS impacts in Pennsylvania and potential management alternatives.											
Strategy 1D. Develop a permanent funding mechanism for AIS management in Pennsylvania.											

Objectives, Strategies and Tasks	Current Status	Fund Source	Lead Entity	Cooperating Entities	Recent Efforts				Requested Efforts		Future Needs
					FY-05-06		FY06-07		FY07-08		
					\$0	FTE	\$0	FTE	\$0	FTE	
Action 1D1. Through PISC, work with the Governor’s Office, Legislature and other Council members and partners to establish a permanent funding mechanism for AIS management activities.											
Strategy 1E. Establish a process for revising and updating the AIS management plan.											
Action 1E1. As part of the overall Pennsylvania Invasive Species Management Plan, review, update and submit the Aquatic Invasive Species Management Plan for the Governor’s approval on a five-year basis, with annual or biennial status reports. Establish a process for more frequent review if necessary.											
Objective 2. Prevention Identify vectors and mechanisms and minimize the introduction and spread of AIS into and throughout Pennsylvania.											
Strategy 2A. Establish a comprehensive process to identify the aquatic invasive species of greatest concern that are not yet present in Pennsylvania waters.	Need – develop better reporting guidelines to include specifics of reported occurrences, including location (county, watershed)			All entities that report new occurrences							
Action 2A1. Use scientific methods and procedures to facilitate the conduct of research-based risk analysis to determine the level of risk associated with introductions of certain potentially invasive aquatic species, with respect to the probability of entry through multiple pathways, potential to establish, ability to spread once established, and associated economic and ecological values, benefits and/or impacts.											
Action 2A2. For aquatic invasive species with the greatest potential to infest Pennsylvania waters, identify existing and potential pathways that facilitate new introductions of these species.											
Strategy 2B. Develop a system to evaluate aquatic invasive											

Objectives, Strategies and Tasks	Current Status	Fund Source	Lead Entity	Cooperating Entities	Recent Efforts				Requested Efforts		Future Needs
					FY-05-06		FY06-07		FY07-08		
					\$0	FTE	\$0	FTE	\$0	FTE	
species pathways and identify potential prevention strategies addressing these pathways.											
Action 2B1. Identify and prioritize highest-risk pathways for the introduction of harmful aquatic species into Pennsylvania waters											
Action 2B2. Develop and implement specific actions and plans to reduce the likelihood of introduction of harmful non-indigenous aquatic species from both intentional and unintentional high-risk pathways.											
Action 2B3. Identify "ecologically sensitive" aquatic resource areas that are relatively free of aquatic invasive species, and identify potential pathways and additional precautionary protocols, including additional outreach and enforcement, to implement for those areas.											
Strategy 2C. For priority aquatic invasive species identified through predictive screening and/or risk assessment processes, develop and implement appropriate management actions required to prevent their introduction into Pennsylvania.											
Action 2C1. Identify best management practices, codes-of-conduct and potential certification options for key industry and user groups (e.g., pet and aquarium trades, water gardens, aquaculture industry, research community, commercial shipping, recreational boating, transportation industry, bait retailers and suppliers, etc.) to keep the priority AIS out of Pennsylvania. Work with appropriate agencies, industry representatives and user groups who may represent potential pathways to ensure awareness of the threats of aquatic invasive species and to develop methods to better assist in preventing the introduction and transfer of aquatic invasive species.											
Action 2C2. Evaluate the need for new and/or strengthened tools to prevent the introduction of priority non-indigenous aquatic invasive species (e.g., enhanced inspection programs, a "watch" list of species deemed to have a high potential to cause significant harm in Pennsylvania, new import/trade restrictions and/or review and approval processes for certain species, etc.).											
Action 2C3. Incorporating pathway analysis, evaluate the											

Objectives, Strategies and Tasks	Current Status	Fund Source	Lead Entity	Cooperating Entities	Recent Efforts				Requested Efforts		Future Needs
					FY-05-06		FY06-07		FY07-08		
					\$0	FTE	\$0	FTE	\$0	FTE	
potential effectiveness of existing management and regulatory tools in preventing the introduction of these priority aquatic invasive species into Pennsylvania.											
Action 2C4. Encourage state agencies to serve as role models by adopting sound aquatic invasive species prevention practices for their own operations.											
Action 2C5. Encourage greater cooperation between federal and state agencies in the development and implementation of invasive species risk management partnerships at all ports of entry and other suitable pathway points. Coordinate efforts with the Pennsylvania Department of Agriculture Bureau of Plant Industry on the Pennsylvania Noxious Weed list.											
Action 2C6. Explore opportunities to cooperate with adjoining or nearby states to identify opportunities for interrupting pathways for priority aquatic invasive species.											
Strategy 2D. Review existing programs and policies which address the prevention of new aquatic invasive species in Pennsylvania and identify opportunities for improving their effectiveness.											
Action 2D1. Identify set of best prevention practices and “model” aquatic invasive species laws and programs to prevent new infestations, and conduct benchmark comparison with Pennsylvania’s current statutory/regulatory framework.											
Action 2D2. Identify opportunities to enhance cooperation between the public and private sectors in preventing new introductions of aquatic invasive species in Pennsylvania.											
Action 2D3. Review and assess existing federal and state programs and authorities (laws, regulations, policies, etc.) which deal with the prevention of aquatic invasive species in Pennsylvania, and identify potential gaps and recommendations for improvement.											
Action 2D4. Identify and pursue opportunities for improving inter- and intra-agency cooperation and coordination in the administration and implementation of aquatic invasive species prevention programs in Pennsylvania.											
Action 2D5. Evaluate the current capacity (funding, staffing,											

Objectives, Strategies and Tasks	Current Status	Fund Source	Lead Entity	Cooperating Entities	Recent Efforts				Requested Efforts		Future Needs
					FY-05-06		FY06-07		FY07-08		
					\$0	FTE	\$0	FTE	\$0	FTE	
technical support, etc.) of existing federal and state programs designed to prevent the introduction of new aquatic invasive species in Pennsylvania, and identify list of priority resource needs and new funding opportunities.											
Strategy 2E. Increase public awareness about the problems associated with aquatic invasive species introductions and educate the public and key constituencies about actions that can be taken to reduce the possibility of these species becoming established in Pennsylvania waters. (Strategy and Tasks repeated in Education/Outreach Section).	DCNR Need – signs and brochures at state parks		BSP								20,000
Action 2E1. Target outreach efforts and prioritize key audiences to promote understanding of invasive species dispersal pathways and current risk assessments.											
Strategy 2F. Prioritize and promote research to reduce the threat of aquatic invasive species introductions into Pennsylvania waters. (Strategy and Tasks repeated in Research Section).											
Action 2F1. Develop technical partnerships with key industries and universities to promote applied research.											
Action 2F2. Prioritize AIS research needs. Coordinate research activities and maintain an inventory of these activities to ensure the use and application of research products.											
Objective 3. Early Detection Detect new introductions of AIS in Pennsylvania before they have a chance to become established in the ecosystem.											
Strategy 3A. Identify gaps in existing efforts											
Action 3A1. Survey and evaluate current early detection programs/networks, including volunteer networks, identify geographic gaps, and make recommendations to improve detection efforts across institutional and jurisdictional boundaries.	DCNR Need – develop better reporting protocol										10,000
Strategy 3B. Increase the knowledge and expertise available to enhance early detection efforts.											
Action 3B1. Engage those already in the field to be aware of key invasive species that they may come across. Conduct training for field staff to ensure that they can easily identify AIS. Implement	DCNR Need Staff training workshop	WRCP, C2P2, Oil and gas lease	DCNR Wild Resource	Local governments, nonprofits, universities	40,000				20,000		40,000

Objectives, Strategies and Tasks	Current Status	Fund Source	Lead Entity	Cooperating Entities	Recent Efforts				Requested Efforts		Future Needs
					FY-05-06		FY06-07		FY07-08		
					\$0	FTE	\$0	FTE	\$0	FTE	
a statewide monitoring network to assist in the early detection and monitoring of AIS.		funds	Conservation Program, Community Conservation Partnership Program								
Action 3B2. Develop expert list (within agencies, academia and contractors) that can help with hard-to-identify species, and develop contract arrangements if necessary.	DCNR Need – engage field consultants										30,000
Action 3B3. Support taxonomic research and the establishment of new taxonomic expertise to support early detection efforts (Task repeated in Research Section).											
Strategy 3C. Prioritize early detection efforts by location and species											
Action 3C1. Create a regional species “watch” list (likely invaders currently not documented in Pennsylvania) of species for which to be on the lookout.											
Action 3C2. Identify high hazard areas for targeted early detection surveying.											
Strategy 3D. Establish simple, coordinated reporting system(s) for AIS detection and monitoring in Pennsylvania (Strategy and Tasks Repeated in Monitoring and Inventory Section).											
Action 3D1. Develop an Aquatic Invasive Species Tracking Program for Pennsylvania, which would include an online interactive GIS interface and a QA/QC system for confirming identification. Establish simple reporting procedures and publicize information to state and local monitoring groups.											
Strategy 3E. Facilitate regional cooperation											
Action 3E1. Establish cooperative policies with states sharing watersheds for early detection efforts to limit the spread of AIS populations.											

Objectives, Strategies and Tasks	Current Status	Fund Source	Lead Entity	Cooperating Entities	Recent Efforts				Requested Efforts		Future Needs
					FY-05-06		FY06-07		FY07-08		
					\$0	FTE	\$0	FTE	\$0	FTE	
Objective 4. Rapid Response Develop a system for early response to eradicate or contain target species before the species can become permanently established.											
Strategy 4A. Implement a coordinated system for rapid response efforts to contain or eradicate newly detected AIS.											
Action 4A1. Develop a model aquatic rapid response plan for Pennsylvania. Plan should address such components as organizational structure and communication, authority, outreach, decision support and rapid scientific assessment, management options for control/eradication, implementation, adaptive management, and funding. Process for planning efforts should include identifying and involving stakeholders.											
Action 4A2. Explore the establishment and administration of permanent funding to implement emergency response plans.											
Action 4A3. Identify and support personnel training and equipment needs and interagency partnerships for successful rapid response operations. Have the licenses and permits necessary for specified control techniques: mechanical and biological; chemical), contract authority necessary for purchased services; and agreements necessary for mutual aid with other states and federal agencies	DCNR - 4 people pesticide-certified; renew yearly	BSP operating funds	BSP		1,400		1,400		1,400		1,400 yearly
Action 4A4. Create an inventory/database of available resources across the state, such as equipment and labor, which could be shared so that resource managers can easily determine who to contact to borrow various types of equipment or gather additional personnel or volunteers.											
Strategy 4B. Develop specific rapid response plans for priority organisms.											
Action 4B1. Establish a prioritization process to focus rapid response resources.											
Action 4B2. Using model plan created above, develop rapid response plans for specific, high priority AIS. Establish rapid response teams capable of executing safe, effective species-specific response efforts.											

Objectives, Strategies and Tasks	Current Status	Fund Source	Lead Entity	Cooperating Entities	Recent Efforts				Requested Efforts		Future Needs
					FY-05-06		FY06-07		FY07-08		
					\$0	FTE	\$0	FTE	\$0	FTE	
Objective 5. Monitoring and Inventory Monitor and inventory existing infestations of AIS in Pennsylvania.											
Strategy 5A. Create a master inventory of Pennsylvania AIS.											
Action 5A1. Create a compilation of inventories of AIS in Pennsylvania held by various local, county, state, and federal agencies, and private organizations such as land trusts, conservancies, etc. Explore the feasibility of making the master inventory an electronic geographic database accessible through the Internet and investigate the option of combining inventories into one master inventory, with common nomenclature and data elements. Explore the feasibility of allowing agencies and other stakeholders to update the electronic master inventory. Address QA/QC concerns with this process.											
Action 5A2. Identify inventory gaps and develop strategies to address them.											
Strategy 5B. Establish simple, coordinated reporting system(s) for AIS detection and monitoring in Pennsylvania (Strategy and Tasks Repeated in Early Detection Section).											
Action 5B1. Develop an Aquatic Invasive Species Tracking Program for Pennsylvania, which would include an online interactive GIS interface and a QA/QC system for confirming identification.											
Action 5B2. Establish simple reporting procedures and publicize information to state and local monitoring groups.											
Strategy 5C. Develop a cadre of field associates to monitor priority AIS.											
Action 5C1. Assess feasibility of using local, state and federal field staff, stakeholder organizations and volunteers to monitor priority AIS											
Action 5C2. Develop training program to certify agency field staff, stakeholder organizations and volunteers in AIS identification and use of the electronic master inventory system											
Strategy 5D. Prioritize monitoring efforts for existing AIS populations in Pennsylvania.											
Action 5D1. Develop monitoring programs specific to pathways	DEP and PASG zebra						20,000				

Objectives, Strategies and Tasks	Current Status	Fund Source	Lead Entity	Cooperating Entities	Recent Efforts				Requested Efforts		Future Needs
					FY-05-06		FY06-07		FY07-08		
					\$0	FTE	\$0	FTE	\$0	FTE	
and geography for high priority AIS using agency, stakeholder and/or volunteer resources	mussel monitoring program, future efforts to target Susquehanna River watershed. PDA could monitor Butomus umbellatus, yellow iris, Uruguay seedbox, reed mannagrass, mud mat, european frogbit, waterchestnut, Hydrilla,										11,000
Objective 6. Control and Management When feasible, control and eradicate established AIS that have significant impacts in Pennsylvania. Reduce the harmful effects resulting from AIS infestations by managing those that cannot be eradicated.											
Strategy 6A. Limit the spread of established AIS into new areas and control and eradicate established AIS.											
Action 6A1. Identify what has already been done for control and management to avoid duplication and identify management needs; clarify management responsibility especially among agencies and organizations. Identify and publicize “success stories” to reinforce the importance of these actions and sustain momentum and support for addressing AIS.											
Action 6A2. Identify information, staff, research, and budget needs to improve invasive species management in Pennsylvania.											
Strategy 6B. Prioritize organisms on which to focus control efforts and develop and implement specific control plans to											

Objectives, Strategies and Tasks	Current Status	Fund Source	Lead Entity	Cooperating Entities	Recent Efforts				Requested Efforts		Future Needs
					FY-05-06		FY06-07		FY07-08		
					\$0	FTE	\$0	FTE	\$0	FTE	
address these.											
Action 6B1. Implement cost-benefit analyses to prioritize control efforts for both species and sites. Weigh all proposed actions against the “no-action” alternative.											
Action 6B2. Develop species-specific or location-specific action plans, as appropriate. Integrate knowledge from efforts throughout Pennsylvania, nationally, and internationally when dealing with specific species to determine appropriate control actions.	USFWS – Sea Lamprey control program for select Lake Erie tributaries. Funding amounts unknown.										
Action 6B3. Develop a procedure for determining when to apply limited-duration surface use restrictions on infested waters. This procedure will take into account the state’s need to balance the provision of public access with other resource and recreational values. As part of this effort, they will work with the PFBC, municipalities and lake associations to determine when and how non-state entities could be responsible for plan enforcement and buoy deployment.											
Action 6B4. Research and summarize effective control and management measures in Pennsylvania and elsewhere regarding specific species. (Task repeated in Research Section).											
Action 6B5. Develop means of adapting human activities in response to infestations of AIS.											
Strategy 6C. Explore and utilize the various methods available to control priority AIS. Assess the efficacy of control and management interventions and adapt efforts as necessary to achieve management needs.											
Action 6C1. Implement control strategies that are based on the best available scientific information and conducted in an environmentally sound manner. Coordinate control strategies with federal agencies, local governments, interjurisdictional organizations and other appropriate entities. Continue ongoing chemical treatment methods at existing sites and use these methods to treat new infestations as appropriate.	DCNR - \$50,000/year for treating 30 lakes	BSP operating funds	BSP		50,000		50,000		50,000		50,000 per year

Objectives, Strategies and Tasks	Current Status	Fund Source	Lead Entity	Cooperating Entities	Recent Efforts				Requested Efforts		Future Needs
					FY-05-06		FY06-07		FY07-08		
					\$0	FTE	\$0	FTE	\$0	FTE	
Action 6C2. Establish protocols that will provide guidance in designing and implementing control and eradication strategies.											
Action 6C3. Support cooperative scientific research by state and federal agencies and academic institutions to investigate potential control strategies and associated environmental impacts.											
Action 6C4. Develop a common volunteer training program and help volunteers optimize control and management activities											
Action 6C5. Support the development of special use permits for chemicals in situations that are not currently labeled for use in Pennsylvania.											
Action 6C6. Continue to prudently explore the utilization of biocontrol options for plant species.	DCNR cooperates with APHIS on experimental releases. Need – begin more widespread use with successful species.										100,000
Action 6C7. Work with a local community(s) and lake and game associations to develop model infestation control plans for the water body that is best suited as a “demonstration” project to model the kind of components such a plan should contain, e.g., strategies for containment, eradication and restoration (if eradication is successful), surface use, boating access, and measuring results.											
Action 6C8. Evaluate potential incentive programs or assistance for private landowners for the control of invasive species and restoration of ecosystems vulnerable to invasion and make recommendations to the Governor’s Office and Pennsylvania Legislature to establish or enhance these programs.											
Objective 7. Research and Risk Assessment Increase research efforts on AIS species, issues and impacts to support AIS management, control and eradication in Pennsylvania.											

Objectives, Strategies and Tasks	Current Status	Fund Source	Lead Entity	Cooperating Entities	Recent Efforts				Requested Efforts		Future Needs
					FY-05-06		FY06-07		FY07-08		
					\$0	FTE	\$0	FTE	\$0	FTE	
Strategy 7A. Establish and coordinate a Pennsylvania AIS research network by building on existing state, federal and university programs. This network will develop research capacity and communicate AIS research needs to other institutions.											
Action 7A1. Identify priority research needs. These priorities should address aquatic invasive species research, monitoring, and risk assessment needs specific to Pennsylvania’s diverse freshwater and estuarine habitats. Areas of research will include prevention, early detection, distribution and populations, control and management, and restoration of affected habitats.	PFBC: Red-eared slider population and distribution studies	PA Sea Grant Wild Resource Conservation Fund grant State Wildlife Grant program			PASG \$10,000 WRCF \$35,000 SWG 76,000						
Action 7A2. Research and summarize effective control and management measures in Pennsylvania and elsewhere regarding specific species. (Task repeated in Control section).											
Action 7A3. Support priority research needs with adequate staff and funding in appropriate Pennsylvania agencies and other institutions. Gather and disseminate funding source information to research entities. Facilitate the collection and dispersal of information, research, and data about Pennsylvania AIS among research institutions.											
Action 7A4. Support taxonomic research and the establishment of new taxonomic expertise to support early detection efforts (Task repeated in Early Detection Section).											
Strategy 7B. Increase aquatic invasive species risk assessment capacity.											
Action 7B1. Compile available risk assessments completed for aquatic invasive species already established in Pennsylvania and identify needs for further analysis. This process should result in a list of “established high priority aquatic invasive species,” which are 1) currently established in Pennsylvania, or 2) widely recognized as a threat to human health, ecological or economic resources.											

Objectives, Strategies and Tasks	Current Status	Fund Source	Lead Entity	Cooperating Entities	Recent Efforts				Requested Efforts		Future Needs
					FY-05-06		FY06-07		FY07-08		
					\$0	FTE	\$0	FTE	\$0	FTE	
Action 7B2. Develop human health, environmental, and economic indicators for evaluating impacts of AIS.											
Action 7B3. Implement a process for assessing risks associated with potential AIS that are likely to be introduced unintentionally or are known to be moving toward Pennsylvania and for which rapid response tools are necessary.											
Action 7B4. Work with governmental and non-governmental stakeholders to develop a science-based, comprehensive screening system for evaluating risks associated with the initial introduction of non-native aquatic species.											
Strategy 7C. Prioritize and promote research to reduce the threat of aquatic invasive species introductions into Pennsylvania waters. (Strategy and Tasks repeated in Prevention Section).											
Action 7C1. Develop technical partnerships with key industries and universities to promote applied research.											
Action 7C2. Prioritize AIS research needs. Coordinate research activities and maintain an inventory of these activities to ensure the use and application of research products.											
Objective 8. Education and Outreach Educate the general public and people involved in the business, trade, research and government sectors about AIS issues so that they do not facilitate the introduction or spread of AIS species.											
Strategy 8A. Increase public awareness about the problems associated with aquatic invasive species introductions and educate the public and key constituencies about actions that can be taken to reduce the possibility of these species becoming established in Pennsylvania waters. (Strategy and Tasks repeated in Prevention Section).											
Action 8A1. Target outreach efforts and prioritize key audiences to promote understanding of invasive species dispersal pathways and current risk assessments	AIS-HACCP programs conducted for aquaculture industry and DEP										

Objectives, Strategies and Tasks	Current Status	Fund Source	Lead Entity	Cooperating Entities	Recent Efforts				Requested Efforts		Future Needs
					FY-05-06		FY06-07		FY07-08		
					\$0	FTE	\$0	FTE	\$0	FTE	
	biologists.										
Strategy 8B. Develop and distribute AIS educational materials to increase awareness of the AIS problem.											
Action 8B1. Develop new or maintain and upgrade any currently existing state websites on AIS.											
Action 8B2. Develop and distribute AIS fact sheets and identification materials describing the methods to prevent their spread. Materials may include a contact number of where to report potential sightings.											
Action 8B3. Identify available materials to educate the public about what AIS are, the problems they cause, and the avenues available for citizens to help address the issue. Modify existing materials or develop new materials to meet any identified gaps.	DCNR Video	WRCP	DCNR Wild Resources Conservation Program		50,000						10,000
Action 8B4. Produce periodic press releases and public service announcements on specific AIS threats.											30,000
Action 8B5. Review AIS curriculum materials available for teachers to use in classrooms. Modify existing materials or develop new materials to meet any identified gaps. Use existing teacher-training entities as vehicle for distributing materials.											
Action 8B6. Develop materials for presentations on AIS issues to aquatic resource user groups.											
Action 8B7. Develop common materials and messages (for example, slogans or logos) that all agencies can use to promote public participation in AIS prevention and control.											
Action 8B8. Incorporate AIS information into boater safety classes.											
Action 8B9. Continue to include information on AIS in state hunting, fishing, and boating regulations.											
Strategy 8C. Develop and distribute AIS educational materials targeted at specific, public pathways of introductions.											
Action 8C1. Install appropriate signage at all infested water bodies to raise public awareness of AIS.											
Action 8C2. Create outreach materials about the impact of AIS											

Objectives, Strategies and Tasks	Current Status	Fund Source	Lead Entity	Cooperating Entities	Recent Efforts				Requested Efforts		Future Needs
					FY-05-06		FY06-07		FY07-08		
					\$0	FTE	\$0	FTE	\$0	FTE	
via the release of aquarium animals and aquatic ornamental plants. Use the materials to raise awareness about AIS, the laws regulating them, their harmful effects in natural systems, and steps to take to prevent AIS introduction and spread. Distribute the materials to pet stores, garden centers, distributors, and bait dealers for distribution to customers.											
Action 8C3. Develop and distribute AIS educational materials to aquaculture industry, aquatic user groups (i.e. dive clubs, angling clubs, sailing clubs, etc.), aquaria industry, recreational boating industry (i.e. marinas and boat dealers), and the horticultural industry (aquatic plant distributors, water garden dealers, etc.).											
Strategy 8D. Develop and distribute AIS identification and management information to resource agency staff.											
Action 8D1. Organize and facilitate AIS identification workshops for state aquatic resource managers. Distribute AIS educational materials to all resource agency field staff, municipalities using surface water supplies, city park departments, county conservation boards, Coast Guard Auxiliary groups, and other entities with aquatic resource management responsibilities.											
Strategy 8E. Target policy makers and legislative staff for outreach effects.											
Action 8E1. Identify sponsors at the State legislature and county governments who will support policy issues regarding AIS.											
Action 8E2. Provide educational briefings on the threats, economic impacts, and solutions to AIS invasions for decision-makers and legislators and keep legislators and decision-makers abreast of the progress of AIS management efforts. Encourage community groups to address policy makers regarding their concerns about AIS in Pennsylvania.											

F. Glossary

Alien species: with respect to a particular ecosystem, any species, including its seeds, eggs, spores, or other biological material capable of propagating that species, that is not native to that ecosystem.

Aquatic invasive species: non-native species that threaten the diversity or abundance of native species, the ecological stability of infested waters, human health and safety, or commercial, agricultural, aquacultural, or recreational activities dependent on such waters.

Baitfish: fish species commonly sold for use as bait for recreational fishing.

Ballast water: any water and associated sediments used onboard a ship to manipulate the trim and stability of a vessel.

Biocontrol: the use of living organisms, such as predators, parasites, and pathogens to control invasive species.

Control: as appropriate, eradicating, suppressing, reducing, or managing invasive species populations, preventing spread of invasive species from areas where they are present, and taking steps such as restoration of native species and habitats to reduce the effects of invasive species and to prevent further invasions.

Ecosystem: the complex of a community of organisms and its environment.

Eradicate: the act or process of eliminating an aquatic invasive species.

Federal agency: an executive department or agency, but does not include independent establishments as defined by 5 U.S.C. 104.

Great Lakes: Lake Ontario, Lake Erie, Lake Huron (including Lake St. Clair), Lake Michigan, Lake Superior, and the connecting channels (Saint Mary's River, Saint Clair River, Detroit River, Niagara River, and Saint Lawrence River to the Canadian Border), and includes all other bodies of water within the drainage basin of such lakes and connecting channels.

Infested: any water body where an aquatic nuisance species is known to occur.

Introduction: the intentional or unintentional escape, release, dissemination, or placement of a species into an ecosystem as a result of human activity.

Invasive species: an alien species whose introduction does or is likely to cause economic or environmental harm or harm to human health.

Native species: with respect to a particular ecosystem, a species that, other than as a result of an introduction, historically occurred or currently occurs in that ecosystem.

Nonindigenous species: Any species or other variable biological material that enters an ecosystem beyond its historic range.

Non-native species: with respect to a particular ecosystem, a species that, other than as a result of an introduction, historically did not occur in that ecosystem.

Pathways: natural and human connections that allow movement of organisms or their reproductive materials, such as seeds, spores, or eggs, from place to place.

Pathogen: a microbe or other organism that causes disease.

Risk assessment: a science-based process to evaluate the economic and/or environmental risk(s) of invasive species.

Species: a group of organisms all of which have a high degree of physical and genetic similarity, generally interbreed only among themselves, and show persistent differences from members of allied groups of organisms.

Stakeholders: state, tribal, and local government agencies, academic institutions, the scientific community, nongovernmental entities including environmental, agricultural, and conservation organizations, trade groups, commercial interests, private landowners, and other interested parties.

United States: the 50 States, the District of Columbia, Puerto Rico, Guam, and all possessions, territories, and the territorial sea of the United States.

Watershed: the geographic area that drains to a single water body or hydrographic unit such as a lake, stream reach, or estuary.

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H. Appendices

I. Acronyms

AIS	Aquatic invasive species
AISMP	Pennsylvania Aquatic Invasive Species Management Plan
AISMPC	Aquatic Invasive Species Management Plan Committee
ANS	Aquatic nuisance species
BSP	DCNR Bureau of State Parks
DCNR	Pennsylvania Department of Conservation and Natural Resources
DEP	Pennsylvania Department of Environmental Protection
EPA	U.S. Environmental Protection Agency
OIE	Office International des Epizooties
PASG	Pennsylvania Sea Grant
PBP	Pennsylvania Biodiversity Partnership
PDA	Pennsylvania Department of Agriculture
PDH	Pennsylvania Department of Health
PennDOT	Pennsylvania Department of Transportation
PFBC	Pennsylvania Fish and Boat Commission
PFFPA	Pennsylvania Forest Products Association
PGC	Pennsylvania Game Commission
PISC	Governor's Pennsylvania Invasive Species Council
PLNA	Pennsylvania Landscape and Nursery Association
PISC	Pennsylvania Invasive Species Council
PSU	Pennsylvania State University
SAV	Submerged aquatic vegetation
SVC	Spring Viremia of Carp
SVCV	Spring Viremia of carp virus
TNC	The Nature Conservancy
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
USFWS	U.S. Fish and Wildlife Service
VHS	Viral hemorrhagic septicemia
WNV	West Nile virus
WPC	Western Pennsylvania Conservancy

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