

Pennsylvania Climate Adaptation Planning Report: Risks and Practical Recommendations



pennsylvania

DEPARTMENT OF ENVIRONMENTAL
PROTECTION

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More Information

For more information on climate adaptation in Pennsylvania, contact the Climate Change Program, Office of Energy and Technology Deployment, Pennsylvania Department of Environmental Protection (DEP) at 717-783-8411.

Visit the DEP website www.dep.state.pa.us for the links to the DEP climate reports under “Climate Change Advisory Committee.”

1. EXECUTIVE SUMMARY

Purpose and Vision

Changes to Pennsylvania's climate are happening now. The impacts from climate change are warmer temperatures, heat waves and drought, increase in precipitation, more frequent storm events and increased flooding. While there is uncertainty as to the extent and timing of these impacts, there is agreement from several impact assessment reports with the expected outcomes. Pennsylvania needs to identify the potential risks and adaptation strategies and move forward with implementing the recommendations to minimize the risks to the public.

Therefore, the purpose of the Pennsylvania Climate Adaptation Planning Report is to identify practical implementation strategies to address climate change impacts on the state's human environment, including the built environment, and natural resources. This report is the first statewide effort addressing the need for climate change adaptation planning in Pennsylvania.

This report provides current and relevant climate adaptation information to a diverse audience of legislators, government agencies, policy makers, educators, non-government organizations, business, industry, researchers, other stakeholders and the public. The role of the commonwealth for this adaptation planning effort is envisioned as an iterative process with periodically updated reports. It is an ongoing process that is not once-and-done but will require monitoring, feedback and oversight for the strategies to continue to be enhanced. This report is intended as a place to start as a working document for assessing development of the plan.

Need for Adaptation Planning

It is important to understand, prepare for and respond to climate impacts and the potential risks associated with these impacts. In many instances, some of these impacts are not new, such as flooding, but are expected to continue to increase in either frequency, severity or both. The strategies for effective responses are addressed in this report by identifying cross-cutting issues and a broad range of specific recommendations for human, natural and built systems. Adaptation planning needs to be mainstreamed as part of existing planning efforts and integrated into normal operating procedures.

With the passage of the Pennsylvania Climate Change Act, Act 70 of 2008, the Department of Environmental Protection (DEP) was authorized to prepare a report recommending mitigation actions that could be deployed to reduce Pennsylvania's contribution of greenhouse gas emissions. In December 2009, DEP released the "Pennsylvania Climate Change Action Plan", written in consultation with the 21-member Climate Change Advisory Committee (CCAC). Although not a requirement of Act 70 the DEP and the CCAC recognized the need to also address adaptation planning because climate impacts are already occurring and will continue

to occur even with lower carbon levels. The most effective response to climate change for the commonwealth is a combined strategy of both mitigation and adaptation.

During the Feb. 27, 2009 meeting of the CCAC, a motion was made and passed with unanimous support that the action plans should include a recommendation to the Governor and the Pennsylvania General Assembly to address adaptation. On March 18, 2010, a planning process to develop an adaptation report received the support of the CCAC. The body of this adaptation report will be incorporated into the next revision of the Action Plan.

Statewide Adaptation Planning: Framework for Four Working Groups

Four working groups were established to cover the broad array of impacted sectors. These working groups and a brief description of the sectors or areas of focus for each are identified below.

1. Infrastructure (transportation, energy, water, buildings, communications, land use);
2. Public Health and Safety (public health, emergency management);
3. Natural Resources (forests, freshwater, plants and wildlife, agriculture); and
4. Tourism and Outdoor Recreation (fishing, boating, sports, adventure, golf, skiing, gardening).

To provide balance, co-chairs for each group represent both public and private sectors. Outreach was conducted to encourage as much participation in the public meeting process as possible. Throughout 2010, more than 16 public meetings were held by the working groups during which a wide range of stakeholders contributed to discussions of impacts, potential risk and the establishment of a broad series of statewide strategies.

Collaboration among many different organizations is a noteworthy outcome, as it was the first time for many to sit around the table together and contribute their expertise across a wide range of sectors and share unique perspectives on climate adaptation. The stakeholders included leaders and experts from public and private organizations representing state and federal agencies; planning commissions; academia; non-government organizations (NGOs); business and trade associations; and members of the public. A complete list of the participants who participated in the public meetings is located in Appendix E.

Cross-Cutting Recommendations

Several cross-cutting recommendations were identified independently by the working groups and have value as “common threads” that tie together key strategies, as follows:

1. *Green infrastructure* practices are “no regrets” strategies that have multiple benefits for improved capture of storm water, water conservation, decreased sedimentation and pollution to waterways and less adverse impacts to the built environment and for wildlife. This innovative approach increases resilience to impacts resulting from climate change, such as greater precipitation and more frequent severe storm events, heat waves and droughts. Green sustainable practices include broad adoption of rain barrels and rain gardens, wetland development, green roofs, bioretention and green streetscapes to retain runoff and filter pollutants cost effectively. An example can be found in the case study for the City of Philadelphia’s Green City, Clean Waters program in Chapter 3.
2. *Walkable communities*, particularly sidewalks, trails and bike lanes, are growing in popular support and demand. These alternative forms of transportation provide health benefits and safe passage to numerous destinations and also reduce vehicle miles traveled resulting in lower carbon emissions. Communities that are expanding these recreation opportunities provide examples of both mitigation and adaptation measures that are win-win.
3. *Conserve wildlife and fish habitat* by building resilience to the impacts of climate change. Some conservation, agriculture and outdoor recreation measures already underway should be reviewed for their potential to help meet the challenges of a changing climate. Cross-cutting examples include use of riparian stream buffers, increasing native plantings, small dam removals and providing areas for refuge and connecting habitat corridors for species migration.
4. *Integrate adaptation and mitigation strategies as part of planning and operations* of government agencies, non-profit organizations, businesses, farms and academic institutions. These can provide cost savings while also resulting in numerous other benefits.
5. The CCAC should *include climate adaptation, including public health response, as a key component of future climate change action plans*. Adaptation planning plays a key role for Pennsylvania in its climate change strategy.
6. In order to be successful with implementation, the stakeholders of all four working groups recommend that the commonwealth should *support the establishment of a climate adaptation team* within state government to provide technical expertise, resources and enlist the services of stakeholders needed to implement plans for each of the sectors.

7. *Education and outreach* is a critical mission. The higher education community can play an important role to develop a coordinated strategy which includes increased understanding and awareness of the science-based approaches to climate change. Clear, coordinated messages relevant to the various stakeholders should provide practical information and provide opportunities for local engagement.

Summary of Recommendations

Each of the four working groups prepared individual narrative reports and matrices that identified key recommendations and strategies which are detailed in Chapters 3, 4, 5 and 6 and appendices of this report. Priority actions that are needed now and can be integrated into existing programs are important outcomes. Data gaps, references and case studies are part of the narrative report and expand upon these recommendations. A brief summary of the working groups' recommendations are as follows:

Infrastructure

- Review research for materials that might withstand higher temperatures to prevent buckling of roadways;
- Reduce peak and overall energy demand and improve energy conservation in buildings;
- Utilize renewable energy generation, especially during times of drought, recognizing that wind and solar generation do not require water resources;
- Integrate water management planning with no-regret cost effective priorities;
- Encourage water conservation and efficiency measures at all times;
- Support stormwater, land use and flood management to prioritize natural function and minimize hazards to existing structures;
- Implement, monitor and fund adaptation recommendations and build capacity within and outside state government; and
- Pursue research on data gaps.

Public Health and Safety

- Heat stress, flooding and drought are priority risks;
- Proactive planning has resulted in reduced mortality rates due to extreme heat events. Partners should implement guidelines to deal with threat of heat related illnesses and deaths;
- Take advantage of federal resources to implement measures to prevent and control adverse health effects caused by flooding and drought;
- Take advantage of grant opportunities for Environmental Health Tracking Program; and
- Support efforts to increase data quality for surveillance systems and data bases.

Natural Resources

- View existing actions through lens of climate change;
- Integrate climate change strategies into plans and budgets;
- Develop an integrated monitoring system;
- Create a consortium to promote collaborative research, monitoring and data sharing;
- Promote sustainable land use planning and development;
- Focus on building resilience into conservation networks; and
- Expand education and coordinate outreach on current and expected impacts and emphasize practical responses.

Tourism and Outdoor Recreation

- Increase use of green infrastructure, e.g. native grasses;
- Improve storage and reuse practices for stormwater;
- Increase shading and cooling by trees and misters;
- Conserve fish habitats by removal of small dams;
- Model sustainable practices at state-owned facilities;
- Provide business incentives such as tax credits; and
- Include adaptation criteria in grant programs.

2. INTRODUCTION

Climate Impacts

In recent years, people have started to observe the effects of a changing climate. Spring is arriving sooner, summers are hotter, and winter snowfalls are more erratic with less long term snow pack. Ecosystems and species are already responding. For example, researchers in eastern North America (including Pennsylvania) have documented earlier blooming times for plants, earlier arrival times for migrating birds and northward range expansion for butterflies. Ski resorts are adding year-round attractions. Scientists have reached consensus that climate change is happening now and there is wide agreement among scientific organizations that the cause is an increase in concentrations of greenhouse gases. The evidence is well supported by the scientific literature and is consistent with the findings of the National Academy of Sciences and other institutions that have a high degree of credibility.

Climate change is the long-term alteration in the characteristic weather conditions of a region, such as changes in precipitation and temperature.
- U.S. Geological Survey

DEP was directed by the Climate Change Act (Act 70 of 2008) to initiate a study of the potential impacts of global climate change on the state. A team of scientists from Penn State University conducted a study and released its report "PA Climate Impact Assessment" in June 2009. The report's main findings, based upon general circulation models, for the projected climate in Pennsylvania include the following impacts:

- **Warmer temperatures.** It is very likely that Pennsylvania will warm throughout the 21st century; the A2 high emission scenario projects almost a 7°F median warming by the end of the century.
- **More precipitation.** An overall increase in annual precipitation is likely; up in winter months, constant in summer months; decline in proportion of precipitation falling as snow.
- **More frequent and intense storm events; flooding.** Increase in heavy precipitation is predicted.
- **Longer dry periods; droughts.** Increase in soil-moisture-related droughts partly due to increased summer temperatures.

Need for Adaptation Planning

It is important to understand, prepare for and respond to climate impacts. This report identifies practical climate adaptation strategies from many sectors for the first time on a statewide basis. It builds upon the collaborative efforts by the Department of Conservation and Natural Resources, PA Fish and Boat Commission, PA Game Commission and The Nature Conservancy who issued a report in February 2010 titled "Weathering Climate Change: Framing Strategies to Minimize the Impacts on

Pennsylvania Ecosystems and Wildlife.” Sixteen organizations were interviewed for the report and agreed there was a need for long-term adaptation planning and research as well as collaboration among a broad spectrum of perspectives including state and federal agencies, non-profit organizations, academic researchers and other stakeholders. It was recommended that actions taken to minimize climate impacts should be integrated as much as possible into existing planning processes and priorities are necessary for Pennsylvania to compete for federal funds.

DEP was authorized under Act 70 of 2008 to prepare a report addressing mitigation actions to reduce the state’s greenhouse gas emissions. In December 2009, DEP released “PA Climate Change Action Plan”, written in consultation with the CCAC. Fifty-two specific recommendations were approved by the committee and comprise the Action Plan. In addition to the recommendations for emission reductions, DEP concurred with the committee’s recommendation to address adaptation to climate change. Although not a requirement of Act 70, this initiative was approved by the committee on March 18, 2010 and will be incorporated into the next revision of the Climate Change Action Plan.

Mitigation vs. Adaptation

How can we respond to climate change? Approaches tend to fall into two categories. Many strategies focus on ways to **mitigate** climate change, such as activities that reduce emissions of greenhouse gases into the atmosphere. As we have come to understand that not all climate change is preventable, some organizations have started to develop strategies to help human and natural systems **adapt** and adjust to the changes.

Statewide Adaptation Planning

Strategies were developed through four questions to frame the discussions with stakeholders.

- What are the key focus areas for vulnerability and risk caused by climate change?
- What efforts are currently addressing these key focus areas?
- What practical actions can be recommended with the resources that are available?
- What information is missing that needs to be addressed? Identify opportunities for collaboration.

Four broad sector workgroups were established to answer these questions. The participants from each group as well as state agency leaders and CCAC members attended a kick-off meeting in March 2010, followed by four public meetings for each workgroup for in-depth discussions held approximately every two months. The workgroups were organized around the following areas:

- Infrastructure (transportation, energy, water, buildings, communications, land use);
- Public Health and Safety (public health, emergency management);
- Natural Resources (forests, freshwater, plants and wildlife, agriculture); and
- Tourism and Outdoor Recreation (fishing, boating, sports, golf, skiing, gardening, hiking).

Each workgroup was led by two co-chairs, one from a government organization and one from NGO. The infrastructure workgroup was led by three co-chairs because of its large scope. The co-chair leaders and a list of the participants who provided expertise across a variety of sectors are located in Appendix B. Collaboration among many different organizations is a noteworthy outcome, as it was the first time for many to sit around the table together and share their unique perspectives on climate adaptation.

Each stakeholder group developed its own report found in Chapters 3, 4, 5 and 6. The reports were written primarily by the co-chairs with input from working group participants based entirely on the public meeting discussions. The working groups emphasized unique aspects of adaptation strategies in their reports that were most relevant to their areas of focus.

3. INFRASTRUCTURE WORKING GROUP

Pennsylvania's infrastructure is the framework for the state's economy. Clean, abundant water, safe roadways and reliable power are keys to a healthy quality of life for Pennsylvanians. From the beautiful architecture in Philadelphia's Boathouse Row to the graceful bridges in Pittsburgh's three river triangle, Pennsylvania needs to protect and develop resiliency for its infrastructure to adapt to impacts of its changing climate. Infrastructure – including buildings, roadways, public transit, water and sewage treatment facilities, flood management structures, communications and energy systems – is particularly vulnerable to climate change.

Greater periods of higher temperatures increase the demand for electricity, especially for cooling during the summer months. A greater number of extreme precipitation events increase the burden of stormwater runoff on water treatment facilities and flood management structures. Older buildings and infrastructure in Pennsylvania were built to standards not always meant to meet the challenges of our changing climate. Upgrading infrastructure, responding to storm events and rebuilding will increase costs to Pennsylvania businesses, government, municipalities and tax payers. According to the National Climatic Data Center, Pennsylvania has experienced over 156 storms from 2000 to 2010 with property damage over \$1 million from each storm. Total property damages over that time period are estimated at \$1.5 billion with crop damages of an additional \$3.02 million.¹ Investments in practices that provide protection and resiliency for infrastructure will allow Pennsylvanians to cost-effectively adapt to climate change and ensure healthy, livable communities.

Higher temperatures and extreme heat events impact the water, energy and transportation sectors. PJM Interconnection, LLC (PJM), the regional electric transmission organization, is responsible for providing reliable power during extreme heat events. As extreme heat events occur more frequently and last longer, electric generators and the grid (electric transmission system) become less efficient and are more vulnerable to outages. PJM will need to adjust their procedures to respond.

On the transportation front, extreme heat events impact roadways and public transit. For example, during a 2010 summer heat wave, the northeast corridor rail commuter trains had to lower train speed to prevent derauling caused by thermal misalignment of the train tracks and train service to some areas failed due to power outages and heat-related equipment failures. Amtrak responded by developing a heat wave response plan including posting rescue locomotives along the corridor, placing additional mechanics on trains, and carrying extra fluids and water after 900 passengers were stranded for two hours on a sweltering train outside Washington, DC.²

¹ National Climatic Data Center, <http://www4ncdc.noaa.gov/cgi-win/wwcqi.dll?wwevent~storms>. Retrieved 10/25/2010.

² "Amtrak Rolls Out Hot Weather Plan, Kathy Banks, NBC Washington, July 6, 2010, retrieved 10/27/2010.

Water infrastructure and the management of that infrastructure must also be adapted to a changing climate. Already, greater and more extreme heat events are resulting in warmer waterways. Many industrial facilities use water for processing and are required to discharge this water such that it complies with chemical, physical and biological characteristics that do not impair the quality of the water that receives the discharge. To determine what constitutes safe discharge water, regulators issue permits to industries with specific pollutant limits based on complex assessments of the waterway. As surface water temperatures rise, pollutant and therefore permit and regulatory limits will need to change requiring industrial and municipal users to adapt their practices to maintain healthy waterways. Change may include additional processing or use of new technology in the industry's practice. At lesser cost, a waterway's resiliency may improve by buffering it with vegetation and trees to increase natural cooling of the waterway.

Assessing the Risks and Vulnerabilities

For each of the climate conditions researchers indicate Pennsylvania will experience, the Infrastructure Working Group identified the key focus areas for vulnerabilities and risks to infrastructure. As the vulnerabilities and risks were classified, they appeared to fall into several categories that affected all types of infrastructure. Infrastructure was categorized into three main sectors – water, energy and transportation. The working group stakeholders tried to include other sectors in these main categories as well. However, these other sectors including buildings, land use, and communications deserve additional in depth discussion and research. The information was organized into a matrix in Appendix A with these overarching categories characterizing climate change:

- Higher temperatures during summer months;
- Wetter winters – more intense winter storms;
- More extreme heat events;
- More high impact storms resulting in more flooding and greater floods;
- Drier summers resulting in drought; and
- Sea level rise – salt water intrusion in the Delaware River.

Next, strategies were suggested to minimize risk. In an effort to prioritize actions, these strategies were then evaluated based on the following factors: cost, timeliness of implementation, political support, data availability, planning, risk level and co-benefits. An additional factor impacted the prioritization – risk to health and safety. Finally, adaptation strategies were ranked as high, medium or low priority based on the above factors.

Current Efforts to Address the Key Focus Areas

Many federal and state agencies and other organizations are currently developing strategies and programs to guide climate change adaptation efforts. Following is a brief description of a number of such programs.

Transportation – The United States Department of Transportation (U.S. DOT) has established a climate change clearinghouse that hosts valuable information and ongoing research results. In addition, it has funded various adaptation research studies that are currently being conducted including a study of regional impacts of climate change. For instance, the National Cooperative Highway Research Program is currently conducting a study titled, “Climate Change and the Highway System: Impacts and Adaptation Approaches.” Peer exchanges have also been conducted by the U.S. DOT and the American Association of Highway and Transportation officials to discuss the impacts and planning necessary for climate change adaptation. At the local level, some planning partners such as the Delaware Valley Regional Planning Commission have been engaging in discussion about how to plan for climate change adaptation. Generally, the discussions have been at a very high level and unlike states such as Alaska where they are feeling the impacts of climate change now, Pennsylvania and other northeast states are more focused on fixing their crumbling infrastructure. Pennsylvania Department of Transportation (PennDOT), as illustrated in the case study that follows, has engaged in a more robust communication effort for emergency storms and other situations which will assist the commonwealth in the future if more intense storms require road closures.

Energy Systems – The U.S. Department of Energy (DOE) has developed several programs for upgrading the electric grid. There is a regional planning effort to evaluate transmission developments that involves the states and the transmission organizations. DOE has also provided funding for Smart Grid efforts. DOE has an Office of Climate Change and Technology with programs for greenhouse gas reduction, renewable technology and energy efficiency programs.

The North American Electric Reliability Corporation (NERC) has formed a task force to assess the impact of climate change initiatives such as Smart Grid, fuel changes and renewable generation on the North American bulk power system. NERC is responsible for setting the technical standards that ensure reliability of the electric grid.

Pennsylvania House Bill 2200 (Act 129) has mandated a reduction in peak energy demand from Pennsylvania electrical distribution companies (EDCs) of 4.5 percent by 2012 in the top 100 hours of on-peak demand and an additional off-peak demand reduction of 3 percent. Act 129 also mandates the use of smart meters by EDCs. The EDCs have developed a myriad of programs to meet these energy use reduction goals including: weatherization programs, energy audits and energy efficiency measures for both new and existing construction in residential programs; and commercial and industrial programs focusing on energy efficiency, combined

heat and power systems, high efficiency heating and cooling, and upgrades to equipment.

Demand response efforts are receiving a lot of attention from the PA Public Utility Commission (PUC), PJM and from the Federal Energy Regulation Commission (FERC). Demand response allows users of electrical energy to reduce their demand for power and benefit financially from this reduction. Demand response reduces overall demand and can help reduce peak demand.

The Alternative Energy Portfolio Standards Act of 2004 (AEPS) requires EDCs and electric generation suppliers (EGSs) to supply 18 percent of electricity using alternative energy resources by 2021. EDCs and EGSs meet their AEPS requirements through the purchase of alternative energy credits (AECs) in amounts corresponding to the percentage of electricity that is required from alternative energy sources. One AEC represents one megawatt hour of electricity generated from a qualified alternative energy source such as wind, solar and biomass.

Water – Nationally, the U.S. Environmental Protection Agency (EPA) Office of Water summarized an assessment of how temperature and precipitation characterize streamflow, reservoir storage, evaporative loss, groundwater and other vulnerabilities to model water system management at several utilities. Growing populations in concert with a changing climate has caused some water utilities to address demand as well as supply.

Also, EPA's National Water Program Strategy: Response to Climate Change report was updated in September 2010 to guide the nation's preparedness for climate impacts on the nation's drinking water supply. Many key actions are proposed that will help states adapt and address cross-cutting issues that impact infrastructure, public health and natural resources. First, the report addresses water efficiency measures for residences, commercial and industrial sectors and to help water utilities control loss in distribution systems. The key actions also strive to protect human health and the environment through watershed-wide programs that respond to climate change impacts on waterborne diseases and assert the importance of protecting the water quality of sensitive source waters, headwater streams, wetlands and estuaries. Finally, important to water infrastructure, EPA proposes continuing the Climate Ready Water Utilities (CRWU) stakeholder process which offers expertise and supports an ongoing set aside for green infrastructure and water efficiency within the Clean Water and Drinking Water State Revolving Fund appropriations.

CRWU recommended many actions to adapt water system planning, design, financing and operation based on the conclusion that water utilities will be exposed to greater variability and less predictability in hydrological and meteorological conditions.

Across the nation, several states have produced climate change adaptation plans for water resources. The most recent of these is neighboring Maryland that expects building resilient water resources to require increased flexibility to incorporate natural infrastructure solutions, efficiency measures as well as cross-boundary planning and management.

Although there are no fully developed climate change adaptation plans that fall within Pennsylvania's jurisdiction, the agencies and organizations subsequently mentioned in this and the following paragraph have efforts dedicated to developing resilient water resources and management services. In Pennsylvania, the State Water Plan acknowledged climate change and the potential impact on Pennsylvania's water supply. The plan set the stage to "identify critical water areas, develop water budgets for these areas and promote water conservation and water efficiency programs" on a watershed basis. Several state agencies in Pennsylvania have jurisdiction over water resources and infrastructure. DEP, Department of Conservation and Natural Resources, the Fish and Boat Commission, Pennsylvania Infrastructure Investment Authority (PENNVEST), and the Department of Community and Economic Development all had varying roles in the development of this planning report.

Management of Pennsylvania's water infrastructure is additionally influenced by commissioned authorities and interstate compacts for the Lake Erie watershed, the Delaware, Susquehanna, Potomac and Ohio Rivers. The principal commissions vary in terms of their reach: the Delaware River Basin Commission regulates water withdrawals and water quality for the watershed, the Susquehanna River Basin Commission permits water withdrawals in its watershed, while the Ohio River Valley Sanitation Commission does not regulate but provides guidance to states administering the river's mainstem. Each commission has done some assessment of climate change impacts on water resources.

Recommendations

Recommendations for Actions with Available Resources

The Infrastructure Working Group identified the following as high priority and practical actions that could be taken in the near term.

Transportation:

- Review available research for potential materials that can be utilized that might withstand higher temperatures to prevent or reduce buckling of roadways and/or bridges due to concrete expansion and softening of bituminous pavements
- Perform work activities during cooler portions of the day to reduce impact of higher temperatures on materials or workers
- More intense inspection of transportation infrastructure after high impact events in areas that are subject to erosion

Energy:

- Reduce electricity demand (on-peak and off-peak) – PA EDCs must meet the requirements of Act 129 for peak and overall demand reduction; support the work of the PUC, PJM and FERC to encourage demand response and price responsive demand programs for Pennsylvania residential consumers, and commercial and industrial energy users
- Thermoelectric power generation accounted for 72 percent or 6,422 million gallons per day of total water withdrawals in Pennsylvania (DEP, 2003). Utilize renewable energy generation as an adaptation strategy, especially during times of drought, recognizing that wind and solar generation do not require water resources; develop on-site renewable resources as distributed generation, thereby reducing reliance on the transmission grid, lowering peak demand, with lower congestion costs and power prices; support energy storage options that can work with these renewables to meet energy demand during drought or air pollution advisory days
- Ensure that Pennsylvania participates in the Smart Grid planning processes
- Incorporate new climate change weather data in PJM's load forecast to better model energy demand and ensure appropriate electric transmission planning
- Have DEP work with PJM on planning efforts. Environmental regulations impact where new generation can be sited. PJM needs to be informed of the potential impact of siting restrictions; especially as air quality deteriorates and energy demand escalates
- Continue the efforts to upgrade Pennsylvania's housing stock through programs like Keystone Help and the rebate support for upgrading heating and cooling systems; consider expanding Keystone Help to allow for upgrades to a homeowner's water and wastewater systems
- PJM, FERC and NERC should develop climate change adaptation strategies as drought could cause curtailments at nuclear, coal and natural gas plants potentially impacting reliability of the grid.

Water:

- Integrate water management planning approaches to identify vulnerabilities and address risks with no-regret, low cost priorities including conservation and green infrastructure
- Encourage statewide water conservation and water use efficiency, not just in time of drought but at all times, so that both conservation and efficient water use become routine to Pennsylvanians; model incentives similar to EPA's WaterSense and continue the model of Green Reserve funding administered by PENNVEST

- Provide operators of both water supply and wastewater treatment facilities with statewide climate adaptation strategies and training following the proposed actions of CRWU
- Support actions to address statewide flood management assessments of existing infrastructure; prioritize natural flood plain restoration and continued funding to high hazard facilities
- Support state programs for stormwater and land use management practices that decrease flood potential with an emphasis on ecosystem-based strategies such as restoration of floodplains and wetlands and implementation of green infrastructure; continue to pursue program flexibility to encourage multi-municipal administration of stormwater planning.

Communications:

- Communication service providers and agencies like the Pennsylvania Emergency Management Agency (PEMA), PennDOT, Nuclear Regulatory Commission, the Pennsylvania State Police, and the Pennsylvania Department of Health should work together on a statewide effort to provide reliable communications especially in times of power outages and emergencies such as a natural disaster or evacuation events. Communications can quickly become over-taxed in an incident and exacerbate negative situations. This can become a public health and safety issue as conditions deteriorate.

Co-Benefits and Cross-Cutting Infrastructure Issues

Energy reliability will be of key importance for all the other sectors. Most infrastructure relies on the power grid. While adequate water supplies are imperative for a safe, reliable electric grid, water treatment and delivery systems are largely dependent upon power supplies.

In addition, the transportation infrastructure is the backbone of the economy. Without a safe, efficient and reliable transportation system, not only is public health and commerce jeopardized, but other sectors such as tourism also face serious impacts.

Data and Information Gaps

The Infrastructure Work Group prepared a reference section that summarizes some of the current research in the field. (References are located at the end of this chapter.) While much of this ongoing research is valuable, it will be critical to apply it to Pennsylvania in order to understand its implications. For instance, when it comes to water, there is little data available that shows where and to what extent increases in water temperatures will occur. In order to implement some strategies for water adaptation, this will be a critical piece of data the commonwealth will need. Similar examples can be found for transportation and energy across the state.

Ongoing/Next Steps

The Infrastructure Work Group has discussed and recommends several next steps.

1. The CCAC should include adaptation as a key component of future triennial climate change action plans. While adaptation is not statutorily required to be included in the action plan, the Infrastructure Working Group believes that adaptation planning plays a key role in the commonwealth's climate change strategy.
2. The commonwealth should form and fund a climate change adaptation team with the technical expertise, resources and appropriate stakeholders needed to provide adaptation plans for each of the infrastructure sectors.
3. Along with this team, the commonwealth should consider establishing the authority and funding to proceed with implementation and monitoring of a state adaptation plan once it has been developed.
4. In order to prepare for climate change, the commonwealth should be building capacity both within and outside of state government. Basic training should be provided to broad audiences of stakeholders including the public, legislators and state employees. Another component of this would be to launch a public education campaign that builds public support for the adaptation efforts.
5. Understanding that data gaps exist, the state should synthesize available data as suggested in the prior section. The Infrastructure Working Group recognizes that many issues under its purview needed further dialogue and study. For instance, the role of land use in adaptation planning deserves further consideration.

Case Studies

Green City, Clean Waters

The City of Philadelphia's 2009 Green City, Clean Water report outlined the long-term plan to control combined sewer overflows and ensure clean water through sustainable practices. The Philadelphia Water Department "developed an infrastructure management plan that will protect and enhance the region's waterways by managing stormwater runoff in a way that significantly reduces reliance on construction of additional underground infrastructure."³ The city's plan is supported by a Triple Bottom Line assessment that contrasted the value and costs of green infrastructure over traditional gray infrastructure approaches. These green infrastructure practices include broad adoption of rain barrels and rain gardens, wetland development, green roofs, bio-retention and green streetscapes to retain runoff and filter pollutants cost effectively. The investment in green infrastructure will

³ Green City, Clean Waters, The City of Philadelphia's Program for Combined Sewer Overflow Control, A Long Term Control Plan Update, Summary Report. Philadelphia Water Department, Office of Watersheds. September 1, 2009.

reduce impervious hardscapes, renew greenscapes and help address the estimated 80 to 90 percent of river pollution caused by stormwater carrying pollutants from impervious surfaces and into rivers by way of the area's 164 combined sewer overflow discharges. While this plan is being reviewed by EPA to address the city's compliance to the federal Clean Water Act, it is already fueled by a \$30 million loan from PENNVEST to kick start on-the-ground green infrastructure solutions; more than 1 million in grants from PENNVEST to area organizations to green streets and parks; and new municipal incentive and tax programs promoting green infrastructure and water efficiency to finance water management. These awards support the recommendations by the CRWU's stakeholder groups to EPA to "avoid making large, long-term investments that do not consider and reflect the potential need to adapt to or minimize climate impacts."⁴ The stakeholder group assessed current adaptation and mitigation in the water sector and resolved a need to balance conventional and non-conventional infrastructure; and recognized conventional systems as "less flexible and potentially more vulnerable to uncertain climate impacts." Philadelphia's Green City, Clean Water plan is also an incentive for cities such as New York, New York and Lancaster, Pennsylvania who are following the trend to establish sustainability for water management with greener practices.

Enhanced Emergency Communications During Storms

With predictions that the intensity and frequency of storms will increase over the next decades due to climate change, the procedures that state agencies have in place to deal with emergency situations will be more and more critical. On Feb. 14, 2007, the combination of a phenomenal ice storm, rapid freezing and a failure to follow procedures, left hundreds of people stranded overnight on Interstates 78, 80 and 81. Over the past three years, PennDOT has restructured its coordination with PEMA, Pennsylvania State Police and other local emergency organizations to improve its storm response. PennDOT has adopted a new interstate road closure protocol, strengthened its training programs and invested in information services to provide more accurate and up to date information on weather conditions. In addition, a traveler information system (511PA) has been implemented to provide the traveling public with updated information on road conditions. PennDOT's exceptional performance during the storms of 2009-2010 (three 20-inch storms) reflected the advancements that have been made. Pennsylvania has become a national leader in its storm response practices. With this implementation PennDOT is poised to be able to adapt to climate change and the predicted changes in winter storms.

⁴ Climate Ready Water Utilities Working Group final report to the Drinking Water Advisory Council. October 11, 2010.

Bringing the Smart Grid Home to Pennsylvania

Imagine an air conditioning system, after it receives a signal that the price of electricity has climbed above the price the user wants to pay, automatically resets to a higher temperature. The user is at work so they don't even notice the slightly warmer temperature. That's how the Smart Grid might work for a Pennsylvania consumer. The Smart Grid, in essence, is a grid with two-way communications – from the grid operator to the power consumer and vice-versa. Real-time price signals can provide real-time savings. The Smart Grid is much more than a simple communication to an air conditioner. The enhanced communications and real-time energy information from new technology on the grid will improve reliability, lower costs and reduce demand. New hardware will reduce losses and maximize power flows.⁵

⁵ Bringing the Smart Grid Idea Home, PJM, 2009.

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4. NATURAL RESOURCES WORKING GROUP

Risks and Vulnerabilities

Climate change is projected to increase temperatures in Pennsylvania by as much as 7° F during the next century and alter precipitation regimes in ways that cause greater flooding and more frequent droughts. Since temperature and precipitation are such fundamental determinants for the composition and function of ecosystems, we can expect to see widespread impacts to natural resources. Foresters, farmers, watershed managers and conservationists will need to adapt their management approaches in ways large and small as they seek to keep forestry, agriculture, fisheries and diverse natural ecosystems healthy in the face of major climate changes.

Expected climate change will shift six biological and environmental parameters, all of which could have major consequences for natural resources management in Pennsylvania. These shifts, as summarized in a presentation by Dr. Erica Smithwick from Pennsylvania State University to the Natural Resources Working Group, include: changes in species composition and ranges; altered disturbance regimes as the severity and frequency of flooding, fire and storm damages change; increased growth rates and earlier spring flowering times for some plants but not others; an expanded array of insect pests and pathogens; changes in river flows and shallow groundwater as precipitation patterns become more erratic; and exacerbation of existing stresses to natural and agricultural ecosystems, including habitat fragmentation, invasive species and nitrogen deposition from agricultural runoff, vehicle and power plant emissions.

The Natural Resources Working Group reviewed the biological and environmental dimensions of climate change and then identified specific risks and vulnerabilities for forest systems, freshwater systems, agricultural systems, and wildlife and native plant resources. Not surprisingly, there was considerable overlap. Five categories of risks/vulnerabilities were shared by all or most of the four natural resource areas. These include:

- Shifts in species composition that change ecological function and economic value;
- Interaction of stresses and disturbances, such as fire, storms, pathogens and invasive species, that could have unpredictable impacts on natural and agricultural systems;
- Barriers to connectivity at the landscape and regional scales that restrict the movement of wild species to new environments where they can survive;
- Changes to river and stream flows and shallow groundwater supplies that could have adverse impacts on aquatic and wetland species, crop varieties and livestock; and
- A lack of genetic diversity in some wild species and agricultural varieties that limits their ability to persist in the face of expected changes in temperature, precipitation and ecological conditions (e.g., new competitive species, changed soil biology and chemistry, etc.).

Cross-Cutting Resource Management Issues

After identifying risks and vulnerabilities, the forest, freshwater, agriculture and wildlife sub-teams identified management challenges posed by those risks. Once again, a significant number of management issues were shared by all or most of the sectors. Management issues are grouped by their focus on Species and Ecosystem Management, Environmental Management, and Education and Institutional Management.

Species and Ecosystem Management

The most important species and ecosystem management issues include the need to:

1. Adapt to changes in species composition and geographic ranges in both natural and agricultural systems. Examples include the northward shift of economically valuable black cherry and sugar maples, the integration of new crop types and varieties, and the possible transformation of cold water fisheries to warm water fisheries.
2. Counter increased stress on natural and agricultural systems from existing and new disturbances including temperature extremes, fire, drought, floods, wind and ice storms, pest and pathogen outbreaks, increased erosion, agricultural and urban stormwater runoff, and the spread of invasive species. Resilience to these threats is an important concept for planning adaptation strategies. For example, limestone spring streams with abundant, deep cold springs will be more resilient in the face of hot weather extremes than freestone streams that rely on surface and shallow groundwater sources. Trout conservation efforts are likely to be more successful in the limestone streams compared to other coldwater streams.
3. Protect, restore and connect core habitats that are large enough and resilient enough to sustain a diverse array of species and provide people with essential services including water filtration and flow, carbon storage, pollination and recreation.
4. Compensate for the decline in genetic diversity in many natural and agricultural species that makes them more vulnerable to diseases, insects, climate extremes and other disturbances. These declines have been largely due to the loss of large populations due to habitat loss and over-harvesting in the case of natural species and breeding programs that have emphasized productivity over local adaptation in the case of agricultural species.

Environmental Management

The most important environmental management issues include the need to:

1. Cope with physical and chemical changes in water flow and quality that are caused or exacerbated by climate change. Flooding and droughts will likely be more frequent as weather extremes become more common. Warmer temperatures will likely decrease river oxygen levels and cause other chemical shifts that affect aquatic species and water quality for human needs, including drinking, manufacturing and agriculture. Interaction with nutrient pollution may exacerbate these effects.
2. Understand how climate changes may affect soil biology, chemistry and physics and their implications for agricultural and forest productivity. Soil changes are also likely to have implications for water flow and quality since soil properties affect runoff rates and the filtration of nutrients and contaminants. Soil changes could cause major impacts to wildlife and plants since soil conditions provide the foundation for plant growth and much of the food web. In all cases, it is difficult to predict impacts and identify effective responses.

Education and Institutional Management

The most important education and institutional management issues include the need to:

1. Bolster public and policy maker awareness of existing and prospective climate impacts on natural and agricultural systems. Natural resource managers ultimately depend on public support to get the resources and policy changes they need to be effective. Polling indicates the public is confused about climate change and its impacts and they are less supportive of action to address climate impacts than they were a few years ago. Clear examples of how climate is impacting natural and agricultural systems and practical steps that can be taken to minimize impacts are needed.
2. Increase coordination among researchers and natural resource managers to achieve greater efficiency and effectiveness in monitoring, research and development of adaptation strategies. We face an era of government austerity at all levels. New challenges posed by climate change will likely need to be addressed with no increase – and very likely a decrease – in funding for natural resource management agencies. Collaboration will be essential to making progress in the fiscal environment likely to prevail for the foreseeable future.

3. Strengthen land use planning efforts at the county and township level. Land use planning and zoning are local responsibilities in Pennsylvania. Many local governments have limited capacity and need better access to information, technical assistance and tools to help them anticipate climate change impacts. Two important land-use planning issues are the role of climate impacts on runoff and flooding and the importance of maintaining large and connected core habitats.
4. Expand knowledge about the costs, benefits and co-benefits of taking action to reduce climate change impacts on natural resources. There are many possible actions for reducing climate change impacts but there is relatively little data on their costs and benefits. Some actions are likely to generate far more benefits than costs, especially those actions that generate co-benefits. For example, removal of an old mill dam lowers water temperatures and helps aquatic species survive warmer summer temperatures. It also restores fish habitat connectivity and reduces the risk of downstream flooding and sediment releases if the dam fails. The co-benefits include improved recreational fishing and reduced property owner liabilities that should make this action attractive to the public and policy makers.

Adaptation Principles and Recommendations

Humans rely on healthy ecosystems for basic needs such as clean water, clean air, food, clothing, manufactured goods, medicines, recreation and quality of life. The Natural Resources Working Group identified some principles and recommendations aimed at addressing the critical risks and vulnerabilities to healthy, functioning natural ecosystems and agricultural systems defined above.

1. View actions through the lens of climate change. Some conservation and agricultural measures already underway should be reviewed for their potential to help meet the challenges of the changing climate. Some existing practices may further support resilience to climate change with only minor modifications, some actions may need no modification, and in some cases new directions or opportunities should be pursued to help meet the anticipated impacts. Actions with multiple climate adaptation benefits, like restoring networks of riparian buffers, should be prioritized.
2. Develop an integrated monitoring system. Past practices will not guide future practices under the new climate change scenario. We need to better understand both natural system changes and the impacts of specific adaptation strategies to make informed decisions. An integrated monitoring system should be developed to inform adaptive management strategies across the various sectors.
3. Integrate climate change strategies into organizations' plans and operations. Government agencies, non-profit organizations, businesses, academic

institutions and farms need to incorporate measures to address both mitigation and adaptation into existing programs, business plans and operations. This makes sense both as cost savings measures and the many other benefits to the organization and natural resource functions.

4. Create a consortium for coordination. Multiple sectors currently conducting research and monitoring need a formal forum to coordinate activities, share data, share effectiveness of management strategies, etc. In addition, information and actions need to be coordinated across disciplines for greatest efficacy and to ensure actions do not adversely affect other sectors. Limited resources also dictate a need to collaborate.
5. Promote sustainable land use planning and development. Intelligent land use planning promotes practices that provide the critical elements for quality of life for residents as well as protects and restores naturally functioning ecosystems and agriculturally productive lands. Land use planning should incorporate core habitat areas for vulnerable species, restore forested riparian buffers for healthy water systems, create and maintain connections to allow both ecological and recreation corridors, and reserve lands for agriculture.
6. Reduce risk and vulnerability by building resilience. Natural systems undergo stress from many sources, some natural and some human induced, some related to climate change and others not climate related. Efforts should be taken to build resilience and reduce susceptibility to diseases, pathogens and pests; reduce competition with invasive species; ensure genetic diversity; provide refugia and connecting corridors for migration; and minimize adverse impacts from human activities. Information should be developed to help guide businesses, farmers, agencies and other stakeholders to take practical measures to ensure healthy, resilient natural systems, diverse populations of plants and wildlife, and productive sustainable farming practices.
7. Develop a coordinated education and outreach strategy. School Curricula and education to homeowners, landowners, businesses should be developed and enhanced to better connect human needs with the importance of freshwater systems, forests, agricultural lands and species to economic vitality, safety, health and recreation. Clear, coordinated messages relevant to the various stakeholders should provide practical information and provide opportunities for engagement.

Data and Information Gaps

In weighing the risks and vulnerabilities that climate change presents to Pennsylvania's natural resources and agriculture, and in formulating an adaptive response, it is important to acknowledge areas where there is a lack of readily available or shared information. The Natural Resources Working Group considered the following data and information gaps as a background to its discussions.

1. Develop a better understanding of which data is relevant to climate change adaptation, and ensure that high-quality data is collected. For example:
 - What indicators should be used to monitor the effects of climate change on PA forests, freshwater, agriculture and plants / wildlife?
 - Where can existing high-quality data be found to establish baseline conditions for species and habitats? How can new data be collected?
2. Increase the monitoring of species and habitats, particularly those that are vulnerable, against an established baseline over the long term. Model the effects of various climate change scenarios to create projections for species and habitats, which can then be compared to monitoring observations. For example:
 - Can monitoring of water quality and chemistry be increased; and correlate the data to climate change observations?
 - Can the sustainability of PA agriculture under various climate change scenarios be assessed?
3. Increase collaboration, create networks and share data at local, state and regional levels. For example:
 - Can a formal climate change working group be established? Who should be included?
 - Can expanding regional agricultural planning initiatives be considered?
4. Better understand how climate change interacts with other stressors, such as invasive species, pests, and pathogens. For example:
 - Can predictive modeling for invasive species that may move into the state be conducted?
 - Can research and monitoring of insect and pathogen stresses in forest habitats be expanded?
5. Better understand how climate change may affect or be affected by decisions about land use and energy development, and how this might impact species, habitat and connectivity across the state. For example:
 - Would thresholds for water withdrawals help reduce climate change stresses on sensitive aquatic species?
 - Would increased wood biomass harvesting further stress forest habitats already under stress from climate change?
6. Better understand species' habitat needs, and also model/project whether and how they will move across the state in response to their relative vulnerability to climate change stresses. For example:
 - Can we determine habitat needs for fish, mussels and other sensitive aquatic species?
 - Can we identify and protect potential pathways for species migration?

Next Steps

Many initiatives are already underway or in the process of development at various levels and in many organizations at the federal level and within Pennsylvania. Below are some key programs and actions that will influence Pennsylvania's future eligibility for federal funding, for scientific resources to inform decisions and for guiding sustainable practices to ensure that Pennsylvania's agricultural industry thrives, our hardwood forests remain healthy and productive, our rivers and streams retain their quality and biological diversity and that our native wild plants and wildlife survive.

State Level Activities

- PA Act 70 Climate Change Adaptation: The members of the Natural Resources Working Group determined that implementing adaptation strategies to ameliorate climate change impacts is critical to the future well-being of the state. As a result, the Natural Resources Working Group collectively determined to continue to collaborate and implement a work plan of actions in 2011 and beyond.
- The Wild Resource Conservation Program (WRCP) has identified climate change as a key priority. WRCP will convene a diverse group of stakeholders to identify continuing research and monitoring needs for species identified by the Climate Change Vulnerability Index tool as highly vulnerable to climate change. This work would serve to coordinate discussion, data sharing and development of common messages and themes, encourage citizen species monitoring, and encourage collaboration. Education to schools and other stakeholders are anticipated to be products as well coming from this effort. In addition, WRCP is funding research projects to determine the impacts of climate change on vulnerable species.
- Pennsylvania's Wildlife Action Plan (WAP): As a Congressional requirement to pro-actively address the decline of species and associated habitats, each state and U.S. Territory completed a State Wildlife Action Plan (SWAP) in 2005. In the intervening years, improved understanding of climate change has underscored the need to implement these plans and to incorporate new actions where suggested by new data or analyses. Although in its original plan Pennsylvania acknowledged climate change as an issue, recent studies provided additional information on potential future conditions. A detailed Climate Change Adaptation Plan is anticipated when the PA-WAP is revised in 2015.

Federal Level Activities

- The White House issued an Executive Order to federal agencies in 2009 that in addition to other roles and responsibilities, the agencies shall participate actively in the interagency Climate Change Adaptation Task Force. This task force is engaged in developing domestic and international dimension of a U.S. strategy for climate change adaptation through which the agencies' policies and practices can be made compatible and be reinforced. The first annual report of the Interagency task force can be found at:
<http://www.whitehouse.gov/sites/default/files/microsites/ceq/Interagency-Climate-Change-Adaptation-Progress-Report.pdf>
- The U.S. Fish and Wildlife Service (USFWS) recently completed *Rising to the Urgent Challenge: Strategic Plan for Responding to Accelerating Climate Change*. The USFWS will be examining all decisions and actions through the lens of climate change. The document commits to “a philosophy of interdependent, collaborative conservation rooted in Climate Change Principles.”
- The Federal Department of Interior has instituted two new initiatives, the [Climate Science Centers](#) and [Landscape Conservation Cooperatives](#) which will form the cornerstones of an integrated approach to climate-change science and adaptation. Each has a distinct science and resource-management role but also shares complementary capacities and capabilities. This strategy will serve the department's land, fish, wildlife, water, marine, tribal and cultural heritage managers, as well as for federal, state and local.
 - [Download Secretarial Order No. 3289 Establishing Interior's Climate-Change Response Strategy](#)
 - [Download Interior's Plan for a Coordinated, Science-Based Response to Climate Change Impacts on Our Lands, Water, and Wildlife Resources](#)

The climate science center in which Pennsylvania will participate has yet to be designated; however, Pennsylvania falls into three Life Cycle Costs, the North Atlantic, Upper Midwest and Great Lakes, and the Appalachian.

- The National Wildlife Federation recently released a draft guide to climate change vulnerability assessment on natural systems.

Case Studies

Forest and Bird Impacts

The Northern Research Station of the U.S. Forest Service (USFS) developed a website showing the projected movement of habitat for 134 tree species and 147 bird species under different emissions scenarios and using different climate change models. Louis Iverson, Anantha Prasad, Steve Matthews and Matt Peters produced this very dense and rich information. It can be found at:

<http://www.nrs.fs.fed.us/atlas/>

Forest Management for an Uncertain Climate Future: Tools and Training

Land managers need specific information, strategies and tools to address the unique challenges of managing forests under uncertain and changing climate and ecosystem response. Sustainable forest management is critical for both the adaptation of forests to changing climatic conditions as well as mitigation of increased levels of atmospheric greenhouse gases. The uncertainty of future climatic conditions necessitates adaptive techniques and strategies that provide flexibility and enhance ecosystem resistance and resilience. The USFS Northern Research Station created a rich resource of information to support sustainable forest management. It can be found at:

<http://www.nrs.fs.fed.us/niacs/tools/uncertainclimate/>

Plants and Wildlife Vulnerability Tool

NatureServe developed a tool, the Climate Change Vulnerability Index (CCVI), to identify plant and animal species that are particularly vulnerable to the effects of climate change. The index uses readily available information from the Pennsylvania Natural Heritage Program (PNHP) data sets on species' natural history, distribution and landscape circumstances to predict whether it will likely suffer a range contraction, population reductions or both during coming years. The index can be used as part of a variety of analyses, including assessing the relative risk of species listed in the Pennsylvania SWAP or as part of any assessment of the vulnerability of species to climate change.

The full draft US Department of Agriculture report covers several topics and examines impacts across the United States. It is available at:

<http://www.usdaclimatereport.com>

Delaware Watershed Changes

The Delaware River watershed may be more vulnerable than other watersheds in Pennsylvania to climate change. One reason is that more people – more than 5 million – live in the Delaware than any other watershed in the state and most of them live near the tidal Delaware, the only part of Pennsylvania that will feel the effects of

sea level rise. Sea levels may rise by a foot or more during the next decade exposing public infrastructure, private property and human lives to damaging high tides and storm surges. In addition, the Delaware has experienced several devastating floods and droughts during the past decade that foreshadow impacts from expected changes in precipitation and runoff caused by climate change. To anticipate these changes, the Delaware River Basin Commission reviewed possible climate change impacts in its 2008 *State of the Basin Report*. It identified a number of actions that are needed including better monitoring, scenario modeling and evaluation of possible adaptation options such as reducing consumption through water conservation, revising stormwater management practices, and both structural and natural strategies for flood prevention. More information can be found at:

<http://www.nj.gov/drbc/SOTB/hydrology.pdf>

Brubaker Farms

Brubaker Farms is located in Mount Joy, Lancaster County and is owned by Luke and Barbara Brubaker in partnership with their two sons, Mike and Tony. The farm consists of livestock including hundreds of dairy cows and 48,000 broiler chickens. Brubaker Farms participates in a nutrient trading project with Mount Joy Authority and operates a manure digester which produces energy for the farm and neighboring communities. The digester generates approximately 4 to 5 MW of electricity per day with capacity to supply electricity for approximately 150-200 homes per day. State and federal funding and loan assistance was provided for the project. Solar panels will be added to the new heifer barn to supply additional electricity. The farm recently partnered with the Somat Company and Elizabethtown College to use the college's food waste as a feedstock for the digester. The food waste had been de-watered by the Somat Company.

http://www.nativeenergy.com/pages/brubaker_family_dairy_farm_methane_project/425.php

<http://readme.readmedia.com/Green-Innovation-Turns-Elizabethtown-College-Food-Waste-into-Electricity/1770578>

KEY ISSUES AND PRIORITY ACTIONS

PLANTS / WILDLIFE

KEY ISSUE 1: Species vulnerability to climate change

1. Complete climate vulnerability assessment by PNHP and consider habitat and ecosystem vulnerability assessment.
2. Locate existing or collect new data to establish baseline conditions for vulnerable species and establish a central database for vulnerable and ecologically valuable species / habitats.
3. Establish a statewide monitoring and research network that includes universities, community colleges and environmental groups.

KEY ISSUE 2: Phenological disruption

1. Create a centralized and coordinated phenological network in Pennsylvania
2. Evaluate the consequences of and the potential responses to phenological disruptions

KEY ISSUE 3: Invasive species and pathogens

1. Conduct predictive modeling and risk assessment for invasive species and pathogens that may be moving into the state
2. Incorporate climate change into the invasive species management plan
3. Establish monitoring and an early detection plan for invasives and pathogens and do something to control them

KEY ISSUE 4: Ability of species to migrate, disperse and change ranges

1. Identify and protect vital corridors and refuges using existing studies and additional research as needed
2. Reestablish necessary corridors

KEY ISSUE 5: Maintaining ecosystem function and resilience

1. Manage for ecological function and biodiversity by restoring ecosystem process (fire regimen, hydrology, etc.)
2. Identify and prioritize habitat and ecosystems most vulnerable to climate change and other stressors
3. Reduce non-climate stressors that will further climate change stresses
4. Develop protective measures, which include genetic and biological diversity concerns, for these at risk habitats and ecosystems

KEY ISSUE 6: Working across geographic and organizational boundaries

1. Establish a formal climate change working group building onto existing partnerships, comprised of PA Game Commission, PA Department of Conservation and Natural Resources (DCNR), PA Fish and Boat, federal agencies, academic institutions, the business community and environmental NGOs
2. Collaborate with existing regional climate change initiatives
3. Explore developing new collaboratives with surrounding states

FRESHWATER

KEY ISSUE 1: Thermal Changes to Rivers, Streams, Lakes and Wetlands

1. Develop and use ecological flow thresholds to manage withdrawals so they do not increase thermal stress on sensitive species and habitats

KEY ISSUE 2: Altered hydrology, Changes in Natural Flow Regimes, Changes in Groundwater Use and Recharge

1. Insuring adequate quality and quantity
2. Revise storm water regulations to accommodate increases in precipitation and run-off
 - a. Update and install storm water Best Management Practices
 - b. Restrict use of impervious surfaces in key watershed areas
 - c. Restore floodplain wetlands and forest areas to reduce runoff amounts and rates
 - d. Develop or apply management practices to increase groundwater recharge for storm water control and wastewater systems
3. Encourage/educate/inform homeowners, farmers, recreational industry and commercial users to use rainwater catchments to lower demand for groundwater and surface water systems
4. Improve knowledge about key factors promoting recolonization by extirpated fish and mussels
5. Promote more expansive source water and groundwater infiltration zone protection by local governments and land trusts

KEY ISSUE 3: Declining Riparian Ecosystem and Watershed Conditions

1. Expand or restore riparian buffers where degraded or absent
 - a. Evaluate tree species to replace loss of eastern hemlocks in riparian areas
 - b. Evaluate planting of more southern riparian species to out compete new invasive infestations
 - c. Promote planting of more tolerant native species and prevent sale of invasive species in nursery trade for riparian plantings
 - d. Expand or revise current minimum riparian buffer zones to better protect thermal conditions on all streams, but especially headwater/small streams
2. Protect and restore forest cover in riparian areas through easements, CREP, WRP, etc.

KEY ISSUE 4: Changes in Water Quality and Chemistry

1. Increase monitoring of water quality and chemistry issues
 - a. Correlate climate and water temperature data / investigate whether higher temperatures will affect water quality / chemistry
 - b. Tighten restrictions on use, handling and transport of toxic chemicals and produced waters from hydraulic fracturing for natural gas development
2. Monitor and encourage reduction of thermal discharges, either individually or cumulatively, have significant deleterious impacts on aquatic life

KEY ISSUE 5: Changes in aquatic ecosystem and species composition (including native, exotic, invasive species, pathogens)

1. Identify and protect refugia for different aquatic habitats and species; identify and protect refugia for flow sensitive species in each basin
2. Identify critical habitat needs and life cycles for fish and mussel species (and other aquatic invertebrates) to better target protection and management actions; include examination of thermal tolerance ranges and thermal impacts for sensitive aquatic species

KEY ISSUE 6: Engage and educate / inform constituents on climate change impacts on aquatic systems and their ecological, recreational and economic consequences (benefits?).

1. Inform sport fishermen and other stakeholders about the importance of climate change impacts on freshwater aquatic systems
2. Develop ways to engage groups (TU Chapters, watershed associations, conservation districts, etc.) already involved with informing constituents to help get the word out
 - a. Provide partner organizations with informational materials
 - b. Work with partner organizations to provide more effective outreach venues

FORESTS

KEY ISSUE 1: Connectivity

1. Assess the state's ecological matrix with core and hub areas, identifying existing and missing ecological corridors
2. Prioritize protection of key habitat areas and ecological corridors (including bogs, fens, other key wetlands, boulder fields, barrens, ridge-top and riparian corridors, etc.)
3. Secure funding to better protect vulnerable habitat areas and corridors, restore damaged priority corridors, and help landowners minimize fragmentation from energy extraction and generation activities
4. Enact legislation to mandate restoration of original vegetation of cleared gas well pads, similar to mining laws
5. Work with the legislature and state agencies to promote and expand programs that assist and reward landowners for protecting or restoring critical habitats and corridors, including corridors through urban and agricultural areas (e.g. CREP, TreeVitalize, Clean and Green, tax incentives)
6. Ensure that maintenance of plantings is an integral component of urban programs

KEY ISSUE 2: Interactions of Stressors

7. Monitor, model and survey critical ecological indicators that can be used to improve adaptive management by public and private landowners
8. Expand use of prescribed fire to diminish fuel build-up and promote fire-dependent (oak-pine barrens) and fire-facilitated (oak-hickory forests) ecosystem; and dedicate resources to better monitor ecological response to fire and better utilize data collected to inform burning practices and policies
9. Expand programs for insect and pathogen threats, including research, monitoring and bio-controls; and create flexible funding mechanism to enable timely response of control measures to address immediate threats
10. Assess potential interaction of increased biomass harvesting with areas vulnerable to nutrient leaching from atmospheric deposition
11. Define critical Marcellus shale gas forest functions and value and manage to sustain those

AGRICULTURE

KEY ISSUE 1: Increased need for water

1. Water recycling
2. Use grey water

KEY ISSUE 2: Increased invasive species, including pests and pathogens

1. Learn about management strategies for invasive species (including pests/pathogens) from states where they are already established
2. Make invasive species (e.g., multiflora rose, autumn olive) valuable as a biofuel or animal feed

KEY ISSUE 3: Changes in agricultural production and practices

1. Expand technical assistance programs to help farmers make decisions about sustainable crops and production practices (e.g., Penn State Ag. Extension, NRCS, county conservation districts, county extension agents).
2. Preserve crop and livestock genetic diversity
3. Assess sustainability of Pennsylvania agriculture under climate change scenarios

KEY ISSUE 4: Changes in land use

1. Expand regional planning initiatives, especially in agricultural areas, with focus on agricultural security zones and to recognize local food security

5. TOURISM AND OUTDOOR RECREATION WORKING GROUP

Pennsylvania has a diverse natural landscape and rich outdoor, cultural and historical heritages. Across the state, residents and visitors utilize parks and trails for recreation; enjoy bird watching and nature photography; visit historical sites; attend fairs and festivals; participate in outdoor sports; hunt in its forests and fish in its rivers, lakes and streams.

Climate change scenarios for Pennsylvania predict higher average temperatures and slightly increased precipitation in the form of more severe storms. Some recreational activities, like winter sports, will see increasingly shrinking seasons, while many other activities will experience longer seasons but may be adversely affected by higher temperatures in the summer months. The challenge for stakeholders in the tourism and outdoor recreation sectors is to make proactive adjustments to schedules and infrastructure that help organizations and businesses become more resilient to climate change impacts and that permit Pennsylvania's residents and visitors to enjoy its resources to the maximum extent possible.

Assessing the Risks and Vulnerabilities

The Tourism and Outdoor Recreation Working Group assessed risks and vulnerabilities by identifying and grouping related tourism and outdoor recreation activities that have the potential to be impacted by climate change. For each activity, the group identified how the activity would be impacted and whether those impacts would be positive or negative. A prevailing theme is that there will be longer seasons for many activities, but that those seasons will be characterized by hotter weather and more severe storms. In some cases, activities may be lost entirely if the weather gets too warm. The activities, impacts, and adaptation strategies are attached in Appendix A.

Recommendations

Tourism and Outdoor Recreation recommendations are grouped into three major categories, with specific examples provided in Appendix A. All of the recommendations have the potential to benefit multiple tourism and outdoor recreation activities. Many of the recommendations are expanded upon in the Co-Benefits and Cross-Cutting Issues section. The recommendations include specific actions that can be undertaken by units of government and private businesses.

1. Actions

Efforts have been undertaken to prioritize adaptation projects. Prioritized projects are those that include ways to better use, restore and enhance natural systems (e.g., native grasses vs. lawns) to the benefit of existing infrastructure. In some cases, additional and retrofitted infrastructure will be

needed (e.g., more urban walking and biking trails to maximize longer seasons and more participants). Facilities that use water should focus attention on capturing stormwater from larger, more frequent storms (e.g., golf courses should capture and store water for use throughout the year). Since many activities will ideally be moved to cooler times of the day such as early mornings and evening hours, increased considerations such as lighting and expanded park hours are needed to accommodate events in the dark. Areas in which outdoor activity occurs will need to be shaded (e.g., trees and shade structures) and have places for participants to cool off (e.g., misters). Where natural systems are part of the recreational activity, steps should be taken to conserve and enhance fish and wildlife habitat (e.g., small dam removals and riparian buffers).

2. Incentives, Methods and Procedures

These recommendations include institutional next steps that private organizations and units of government, especially the commonwealth, should take to promote the sorts of actions recommended in this report. State and private foundation grant programs should include adaptation evaluation criteria. Model greening practices such as those outlined in the Keystone Principles (the Keystone Principles are described in Case Study 2 of this chapter) and included in the Statewide Comprehensive Outdoor Recreation Plan should be implemented as model practices by state agencies. The commonwealth should offer tax credits and other business incentives to encourage the adoption of adaptation practices (e.g., incentives for ski areas to diversify their facilities for more warm-weather activities). Commonwealth agencies should include staffing and funding resources focused on implementing adaptation programs.

3. Schedules

Work, school, sports, outdoor recreation and other schedules will need to change to accommodate participation in activities earlier and later in the day and at different times of the year. For example, it may be too hot for children to play football in August or September, so the season may need to start in October and last until later in the year. Similarly, state agencies may need to adjust the times of certain seasons (e.g., state park hours) given changing usage patterns. Facilities such as amusement parks may need to adjust or add schedules for personnel, particularly those who can administer first aid to visitors who suffer heat-related health problems.

Co-Benefits and Cross-Cutting Tourism and Recreation Issues

As the stakeholders explored ways that climate change is likely to impact different forms of recreation and tourism, they were surprised to discover the extensive number of adaptation “solutions” that could provide benefits to other areas. Many of

the suggested solutions are equally applicable to concerns about health, economics, infrastructure, fish and wildlife. Some examples with descriptions of how they provide multiple benefits are detailed below.

- 1) Gardening with less water and native plants.** Gardening is currently the number one hobby in America. It has always been popular in Pennsylvania, and a major income generator through hobby farms, backyard vegetable gardens, ornamental flowers, shrubs and trees, and increasingly popular backyard fruit-tree cultivation. Stakeholder analysis shows that water conservation will become more important as climate change shifts rainfall patterns favoring plants that can withstand drought and rainfall extremes. Rain gardens that use native, more weather-tolerant plants also provide better groundwater recharge and require less water consumption. They provide habitat for declining pollinators and other native wildlife, and require less mowing, which reduces carbon emissions that fuel climate change. Gardening with native plants, and using rain barrels, cisterns and other water conservation measures, provides multiple benefits.
- 2) Golf Course Management for Water Conservation.** Golfing is also a popular sport in Pennsylvania that may grow as the state's largest demographic group – baby boomers – continues to retire and have more time to recreate. With climate change, the opportunity to golf year-round will grow, but increasing temperatures will make mid-day golfing less tolerable and water conservation more important. Adapting golf course management towards greater utilization of water conservation and use of more native plants can decrease water consumption and lessen impacts on groundwater and nearby streams and mitigate impacts to associated aquatic species that may already be stressed by higher temperatures. Use of native plants can lessen mowing and fertilizer use resulting in lower carbon emissions. More water features can provide water sources for birds and other wildlife.
- 3) Multi-use Trails and Greenways.** The 2009 Statewide Comprehensive Outdoor Recreation Plan (SCORP) surveyed Pennsylvanians and documented the increasing popularity of trails for hiking, biking, kayaking and canoeing, horseback riding, ATVs and many other uses. Trails and greenways are also used by wildlife, and will become increasingly important as travel corridors for wildlife that need to migrate to survive climate change. Managing trails by creating more usable corridors and crossings for wildlife, more water sources for human users stressed by higher temperatures, and connecting paths to schools, workplaces and retail centers promotes pedestrian use and provides benefits to wildlife and people. Our climate benefits from reduced carbon emissions when people hike or bike on the trails instead of driving a vehicle.

- 4) Walkable Communities.** The SCORP also found growing popular support and demand for alternative forms of transportation, particularly sidewalks and bike lanes. These additions provide health benefits to an increasingly overweight and sedentary population, and also reduce vehicular trips that result in reduced carbon emissions. There are many great examples of communities expanding recreational opportunities through walking and biking routes, including Carlisle Borough and Fayette County.
- 5) Leading by Example.** Recent state-agency investments in recreation and tourism amenities at state parks and state forests have helped showcase “green” building and green site-design practices for thousands of visitors across Pennsylvania. For example, DCNR’s new Nature Inn at Bald Eagle State Park is heated and cooled by renewable geothermal energy, recycles water on-site, uses recycled and energy-efficient building materials, and landscapes with native plants. It also expands recreation opportunities for visitors who may not want to or be able to tent camp. Signage and exhibits on these green features at the Inn help visitors who came to recreate go home more knowledgeable about how their building and landscaping choices can help wildlife, energy and water conservation.
- 6) Double-Duty Recreation Facilities.** Communities across the country are starting to look at flood control differently, and finding room for a multitude of recreational benefits when they do. In part because of its large number of stream and river miles (86,000) and topography, Pennsylvania is the most flood-prone state in the nation. Using riverfront lands for compatible recreation, like walking paths, bike lanes, soccer fields and other flood-tolerant uses can help communities limit flood damage and reconnect residents and visitors to our rivers again. Restoring wetlands for flood abatement can also provide waterfowl habitat and breeding habitat for fish and amphibian species. Pittsburgh, Philadelphia and many smaller riverfront cities across Pennsylvania have been investing in riverfront improvements and recreation to spark downtown economic revitalization and boost tourism. According to the American Planning Association, an initial \$2 million public investment to reduce flooding and improve recreational assets along the South Platte River in Denver has generated \$1.24 billion of public and private investments over the past 10 years.
- 7) Helping Recreation and Tourism Become more Energy Efficient.** One of the observations stakeholders made in their analysis is that hotter temperatures may require scheduling shifts for many recreational activities to early morning and evening hours when temperatures are cooler. Imagine little league baseball at 8 p.m., or tee times for golf at 5 a.m. Lighting will obviously be needed for some of these adjustments, which affords an opportunity to use energy-efficient lighting. Other energy requirements, such as fans and air conditioners for indoor recreation, will also increase in usage and should be linked to greater energy efficiency. Large-scale municipal investments in energy-efficient equipment and

appliances should spur more widespread conservation among homeowners and more advances in energy-efficient technologies.

- 8) Helping Recreation Itself Adapt.** Throughout the analysis, stakeholders realized that some forms of recreation may benefit from climate change – such as golf – that can be played year-round, while others – such as skiing – will be hurt. How to help both winners and losers make the transition to a warming climate with less snow and ice, more extreme and less predictable weather, and increased water shortages will take technical and financial assistance. Creating a business ombudsman or technical assistance center for affected recreational industries and a source of grant funding or tax incentives to help industry and municipalities make those transitions will be an important cross-cutting effort. It also provides an opportunity to help applicants find creative ways to achieve multiple benefits that they might not have considered on their own. The stakeholders strongly urge that such an office be created now to take advantage of opportunities before they become crises. If centered in state government, the stakeholders suggest that at minimum there be representation from Department of Community and Economic Development and DCNR, as well as the private sector. An important message for public outreach is the connection between healthy well-being and outdoor recreation and other “green” activities.

Data and Information Gaps

What are the behaviors and needs of recreational users?

- Include adaptation questions in future versions of the following: Statewide Comprehensive Outdoor Recreation Plan; United States Fish and Wildlife Service National Survey of Hunting, Fishing, and Wildlife-Associated Recreation; anticipated Pennsylvania Fish and Boat Commission survey of current and lapsed anglers and boaters; creel surveys
- Take advantage of existing state data collection vehicles, such as those mentioned above, as well as five-year state land-use reports, forest assessments, visitor-use monitoring surveys, periodic economic analyses of recreational assets like trails and greenways, recreation-association and industry newsletters, surveys, and county tourism data collections
- Monitor visitor use at public and private venues

What are the economic and non-economic (e.g. health) costs and benefits of an adaptation activity?

- What are the co-benefits of an activity?
- What are the associated negative externalities?
- How can behaviors, needs, costs, benefits and trends be measured long-term?

Case Studies

Case Study 1: Waterfowl Migration

As ducks, geese and other water-dependent birds migrate south for the winter, the majority of them seek out freshwater lakes, coastal marshes and saltwater estuaries in the United States. Millions of birds migrate through the Great Lakes and New England to wintering areas along the Mid-Atlantic coast, primarily the Chesapeake and Delaware Bays. Many others continue on to the Southern states and coasts, where water and food are abundant.

Late season migration is primarily affected by cold weather and the availability of open water. As lakes, ponds and streams freeze over, waterfowl are pushed southward in search of open water on which to feed and roost. Warmer fall and winter temperatures in northern regions are beginning to change these migratory patterns. In some instances waterfowl are over-wintering in more northerly locations and spending less time in more traditional wintering grounds to the south.

Lake Erie is one the great stopover points for migrating waterfowl in the East. Hundreds of thousands, if not millions, of waterfowl and shorebirds stop to rest and feed in the shallow lake and Presque Isle Bay, building energy reserves before continuing their journey south. As the lake freezes it creates a two-fold effect: complete freezing prevents evaporation of the water and serves as a catalyst for the birds to continue their migration.

Historically, Lake Erie has completely frozen over nearly every year. However, over the last 10 years, the lake has only completely frozen over twice. With rising temperatures, it is presumed the lake will completely freeze over less frequently. The consensus is that many birds will “short-stop” at the lake and surrounding areas rather than continue south. In addition, with no or minimal ice cover, the lake evaporates at a faster rate, causing habitat deterioration in coastal marshes and shorelines, a situation that is already causing problems throughout the Great Lakes region.

Hunters in the Lake Erie region may be delighted by the news, but it carries with it the potential loss of habitat and access. Hunters in southern Pennsylvania and in states further south, where many Pennsylvania hunters travel to hunt, may see and harvest fewer birds if warming trends continue.

For more information on the possible effect climate change will have on traditional waterfowling, see the National Wildlife Federation’s publication, *The Waterfowler’s Guide to Global Warming*.

Case Study 2: Liberty Lands Park, Northern Liberties Neighborhood, Philadelphia

General Project Description

Liberty Lands is a two-acre public park in a densely-developed former industrial neighborhood just north of Center City. Near to the Delaware River, the area is attracting artists, young professionals and “green” developers. Years of advocacy and fundraising by the community and help from the City of Philadelphia Brownfields Office created the park, now owned by the Northern Liberties Neighbors Association and maintained by a friend’s group.



In 2006, the Neighbors Association collaborated with the Philadelphia Office of Watersheds and the PA Horticultural Society to create the park to both strengthen the community and offer an environmentally sound remedy to stormwater problems on surrounding streets. The former brownfield was transformed into a green community gathering space complete with children’s playgrounds – both structured and natural – 37 garden plots, local artwork, grassy amphitheater and new festival stage, ADA accessible walkways, a butterfly garden and a Native American herb garden all available for community use.

Advancing Pennsylvania’s Keystone Principles:

- **Redevelop First:** Successful redevelopment of a former brownfield
- **Provide Efficient Infrastructure:** A short walk for most Northern Liberties residents, the park is accessible by rail, bus, car, or bicycle and only blocks from the Delaware River, where a waterfront greenway is planned
- **Concentrate Development:** Liberty Lands Park is part of an overall neighborhood revitalization plan to provide accessible green infrastructure and community-centered open space as an integral part of development practices
- **Foster Sustainable Businesses:** Projects included naturalized ADA access, a new stage using recycled plastic lumber, three man-made rain gardens and other unique stormwater management features
- **Restore Environment:** The cleared site (1996) previously housed a vacant industrial building, it was restored with grassy areas, rain gardens planted with wetland plants and native trees, and a natural playground
- **Enhance Recreation:** The site now provides community programming including a summer movie series, music festivals and a place for children’s parties, with the neighborhood association serving as “caretaker”

Project Benefits and Impact

- *National Pilot:* DCNR was successful in having Liberty Lands selected as part of the Sustainable Sites Initiative, the first national, voluntary set of performance benchmarks to encourage sustainable design, construction and maintenance of landscapes.
- Attraction of new housing and commercial investment: Two new condominium developments (one named “Park View”) about the park. New commercial space has been opened on the street level.
- Community Engagement and Education: The park design process involved extensive interaction with residents of all ages. A small steering committee of volunteers was created (the Liberty Lands Committee) to review park activities, recruit volunteers, plan workdays, organize events, etc.



- Improved stormwater management: The system is a sustainable loop starting with rainwater and stormwater flow into the rain garden and the cisterns, naturally filtering and seeping into the soil, recharging the groundwater and watering the trees and gardens.

Case Study 3: Recreational Fisheries

Climate change adaptation strategies for recreational fisheries, as well as other game animals, can serve as an important link in developing general adaptation strategies for natural resources. Case studies of climate change adaptation strategies for recreational fisheries may have as their foundation ecological enhancements to help sustain fish populations. The use of the resource as a recreational fishery may be considered a secondary factor, yet provide an incentive and serve as a common goal to implement a project. In the report, *Beyond Season’s End – A Path forward for Fish and Wildlife in the Era of Climate Change*, case studies were highlighted for both coldwater and warmwater fisheries. In one such case study, activities were directed at restoring eastern brook trout populations in a West Virginia stream. As stated in the report,

“The project will create a coldwater refuge and promote increased brook trout numbers within the larger headwaters of the South Branch Potomac River by restoring the subwatershed of Thorn Creek. The project proposes to restore degraded springs, stream channels and riparian habitats along the entire stream network and to remove existing stream passage and water temperature barriers so that brook trout can occupy the full extent of their historic habitat in the Thorn Creek system.”

Further, in the project update, after its initial implementation, it was noted that fourteen landowners had entered into conservation agreements and that specific on-the-ground activities included livestock exclusion fencing, solar-powered watering systems, riparian reforestation, and removing barriers to fish passage. Consequently, this project has climate change adaptation strategies that benefit both recreational fisheries as well as general aquatic habitats. Sustaining this fish population provides recreational opportunities and enhances the ecological conditions of the stream.

Case Study 4: The Nature Inn at Bald Eagle State Park

DCNR's new Nature Inn at Bald Eagle State Park is currently registered with the US Green Building Council's internationally recognized Leadership in Energy and Environmental Design (LEED) Green Building Rating system with a Gold LEED Certification goal. The environmental goals of the project were met by starting with sustainable site development. Building on a previously disturbed site eliminated the need to disturb more native park lands; and new impervious surfaces were kept to a minimum. Stormwater can often collect sediment, oils and other contaminants as it drains across roads, parking lots, walkways and roof surfaces. The design of the Nature Inn site directs stormwater towards rain gardens and pervious surfaces like stabilized turf parking areas. In these areas it is allowed to infiltrate into the ground and be cleaned naturally rather than being funneled to the adjacent lake where it could harm aquatic wildlife and pollute the waterway. Onsite infiltration also helps recharge the groundwater to reduce the need for irrigation.

Adding to the reduction of stormwater runoff while also reducing the building's domestic water use is a rainwater reclamation system made up of four 600-gallon cisterns and five 50-gallon rain barrels. The rain barrels provide irrigation water while the cisterns collect rainwater that is then filtered and distributed throughout the facility for toilet flushing. The system provides enough water to flush the Inn's toilets more than 1,200 times. Together with native, water-efficient landscaping, low-flow faucets, dual-flush toilets, and water-efficient laundry equipment the Inn is expected to achieve at least a 30 percent reduction in water use compared to a typical similar facility.

*The Nature Inn at Bald Eagle –
Rainwater Collection Cisterns*



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6. PUBLIC HEALTH AND SAFETY WORKING GROUP

Assessing the Risks and Vulnerabilities

The Public Health and Safety Working Group (PHSWG) prioritized potential issues and identified the following three areas as important risks related to climate change for Pennsylvania: 1) heat stress; 2) flooding; and 3) drought. Vulnerable groups include the elderly, the poor, infants and children, those with underlying chronic diseases, and those with disabilities such as difficulty in communicating in a second language or illiteracy.

In addition, there are significant risks related to climate change that have the potential for more widespread vector-borne diseases and health effects from air quality problems. Because many infectious diseases (e.g., West Nile virus and Lyme disease) are influenced by temperature, humidity and other climate variables, climate change may affect the spread of these diseases or the intensity of disease outbreaks. Climate change may also lead to increased problems with allergies since a warmer climate can promote the growth of molds, weeds and other irritants that cause allergic reactions in certain sensitive individuals. Although climate change is a global issue, it has the potential to significantly impact the health of citizens of Pennsylvania.

The PHSWG also developed a scientific paper and relevant models (see Appendix D) where adaptation planning is discussed in more detail. The components identified in the models can be used to develop an adaptation plan tailored to any specific climate change event in any part of the state.

Heat Stress

Heat stress will be a significant climate change event for Pennsylvania since heat is already the leading cause of weather-related deaths each year in this country (3). In addition to death, heat stress can also lead to a variety of illnesses, including heat exhaustion, heat cramps and heat stroke, and can exacerbate pre-existing chronic conditions, such as some respiratory, cerebral and cardiovascular diseases. Counts of these deaths and illnesses are likely significantly underreported since criteria used in making these measurements vary and heat is rarely used as an official cause of death. Pennsylvania has two major metropolitan areas (Philadelphia and Pittsburgh) and the urban built environment specific to these two geographic areas of the state may exacerbate heat-related environmental conditions and associated heat-related health problems.

Although climate change is likely to increase the number of heat-related deaths and illnesses in Pennsylvania, many of these are preventable using appropriate precautions, such as increased air conditioning use and decreased time spent outdoors during a heat spell. From a public health perspective, proactive heat wave response plans (including heat wave early warning systems, heat advisories, availability of cooling stations, and other preventive measures) are an important and sustainable adaptation strategy.

The PHSWG has developed a model (Attachment 1 in the white paper) on heat stress delineating the important components in Pennsylvania for effectively dealing with this problem—Health (susceptible populations; partners; data bases/sources) and the Environment (cooling stations; transportation; homeless shelters; hospitals/medical centers/outpatient care centers; developing a prototype for risk mitigation). The model also outlines a systems approach that can be used to understand the interaction of these various factors.

Flooding

A second example of an extreme weather event of particular concern to Pennsylvania and the public health community is flooding because of the expected increased frequency of these events due to climate change (2). The potential adverse impact of flooding on the mortality and morbidity patterns in an affected community can be sizeable.

As with other extreme weather events, groups vulnerable to flooding include the elderly, the poor, infants and children, those with underlying chronic diseasesw those with disabilities. Flooding is of particular concern to Pennsylvania because of the current frequency of these events and the extensive distribution bodies of water throughout the state. The potential adverse impact of increased flood events on mortality and morbidity patterns in an affected community can be sizeable. Particularly, those who live in areas that have experienced little or no flooding in the past can be at greater risk of adverse health effects since they are not as well prepared and are less experienced in dealing with floods.

Understanding potential flood zones in Pennsylvania is important to preparedness for both homeowners who may be affected by flooding as well as potential responders (e.g., the Pennsylvania Emergency Management Agency and local emergency responders and managers) who will coordinate the appropriate response to an event.

The PHSWG has developed a model (Attachment 2 in the White Paper) on flooding delineating the important components in Pennsylvania for effectively dealing with this problem—Health (health effects and susceptible populations; partners; data bases/sources) and the Environment (components of managing risk).

Drought

A third example of an extreme weather event of particular concern to Pennsylvania and the public health community is drought. Since public health experts operate today with only limited guidance on preparedness and response regarding this hazard, Center for Disease Control (CDC) developed a new guide (10) to aid public health professionals in this area. Important topics covered in the report include health issues, preparedness and response approaches, and future needs.

CDC has provided an overview of drought- and water-related information and principles. (i.e., definition of drought, U.S. drought and water-use trends, relationship between drought and climate change, water distribution, water treatment and classification, and water-related policy). CDC has addressed numerous drought-related public health effects, which are organized into several broad categories within the document. These categories include:

- Compromised quality and quantity of potable water;
- Compromised food and nutrition;
- Diminished living conditions (as they pertain to energy, air quality, and sanitation and hygiene);
- Recreational risks;
- Mental and behavioral health;
- Vulnerable populations; and
- Increased disease incidence (for infectious, chronic, and vector born/zoonotic diseases).

The PHSWG has developed a model (Attachment 3 in the Appendix) on drought delineating the important components in Pennsylvania for effectively dealing with this problem—Health (health effects and susceptible populations; partners; data bases/sources) and the Environment (components of managing risk).

Recommendations

1. Pennsylvania is one of 28 states that have developed a strategic climate change plan that does not include a public health response (11). The Pennsylvania strategic climate change plan should be revised to include a section that addresses the public health response. This report should be considered in the development of the revised plan.
2. Although climate change is likely to increase the number of heat-related deaths and illnesses in Pennsylvania, many of these are preventable using appropriate precautions, such as increased air conditioning use and decreased time spent outdoors during a heat spell. From a public health perspective, proactive heat wave response plans (including heat wave early warning systems, heat advisories, availability of cooling stations, and other preventive measures) are an important and sustainable adaptation strategy. A model public health early warning system for heat waves was established by the Philadelphia Department of Public Health and can be used as a prototype in other parts of the state.
3. Government agencies and other partners in Pennsylvania should implement appropriate measures to prevent and control adverse health effects caused by flooding. In her narrative on “floods,” Malilay provides guidance on this

topic by reviewing issues on mitigation, warning and preparedness, needs assessment, surveillance, response and recovery, and health education (14). The schematic on flooding attached to this report also includes critical components of a model to help prevent flood-related adverse health conditions.

4. Government agencies and other partners in Pennsylvania should implement appropriate measures to prevent and control adverse health effects caused by drought conditions. The CDC report on this topic (10) can assist public health professionals on preparedness and response measures regarding this hazard. The Association of State and Territorial Health Officials also developed guidelines in 2008 (15) to help public health professionals deal with the threat of mosquito-borne diseases that may increase during drought conditions.
5. Should CDC expand the Environmental Public Health Tracking (EPHT) grant program to include activities related to the public health consequences of climate change, PA Department of Health should take advantage of the availability of these federal resources. DOH and other interested partners should also search out new areas for funding support in this area and continue to develop expertise in surveillance, health education and other areas of public health that will contribute to the body of knowledge about how climate changes in Pennsylvania may be impacting the lives of residents.
6. A review of environmental health indicators for climate change in the U.S. released in 2009 shows that data exist for many environmental and health measures, but more research is needed to evaluate the sensitivity and usefulness of the measures (16). Government agencies and other partners in Pennsylvania should support efforts to increase data quality and availability and to develop new surveillance databases, especially for climate-sensitive morbidity. EPHT could play a significant role in this effort.
7. The 2008 report by the National Academies on Climate Change recommends increasing interdisciplinary collaboration among medical and health professionals and other environmental and social scientists to better understand the linkage between climate change and disease (17). Government agencies and other partners in Pennsylvania should continue to support efforts such as this in the state in the future.

Co-Benefits and Cross-Cutting Health Issues

The focus on co-benefits and cross-cutting issues for Pennsylvania public health and safety issues relates to two preventative strategies:

- **MITIGATION** which involves attempts to monitor, slow, stabilize or reverse the process of heat stress, floods and drought by implementing recommendations of the public health responses outlined in this document

- ADAPTATION which involves developing ways to protect the population and places by reducing their vulnerability to and lessen the impact of dangers of heat stress, floods, drought and real-time monitoring of the results of actions taken

However, for the most effective response for the commonwealth – *both* strategies are necessary.

Data and Information Gaps

Long-term data are provided on heat stress, flooding and drought through morbidity and mortality statistics and vital statistics from local, state and federal sources. In addition, a number of diverse partners and agencies participate in the transfer of organization-specific information described in the attachments of the white paper. Real-time and near real-time data sources and processes, such as Pennsylvania's Real Time Outbreak Detection System (RODS), need to be developed and incorporated within any action plans for climate change health effects monitoring and mitigation. Traditional public health surveillance systems and vital statistics databases do not collect/provide data for use in emergent situations.

Although there are currently some deficiencies for both mortality and morbidity patterns as well as environmental data sets that may relate to climate change in Pennsylvania, these deficiencies should improve with further expansion of the Public health Tracking program administered by the DOH and improved environmental data collection and use by the DEP and other appropriate partners.

Ongoing/Next Steps

Ongoing/next steps entail monitoring the implementation of the recommendations of this report. In addition, securing additional federal funding for the commonwealth's National Environmental Public Health Tracking Program is highly desirable.

The EPHT Program offers states a unique opportunity to leverage existing public health information technology capabilities and data available through the network to incorporate climate change surveillance.

Case Studies

Heat Stress – A model public health early warning system for heat waves was established by the Philadelphia Department of Public Health following a major heat wave in the 1990s. An evaluation of the program has clearly demonstrated that the system saves lives and that the cost of running the system is low compared with the estimated value of a life lost (4). The public health early warning system for heat waves established by the Philadelphia Department of Public Health can serve as a model in other parts of the state.

Flooding – In January 1996, a winter blizzard followed by a flood on the Susquehanna River due to a warming spell resulted in an increase in morbidity and mortality directly related to this event (5-7). Residents experienced various health problems, including carbon monoxide poisoning due to use of space heaters in

homes without proper ventilation. Drivers also experienced similar problems from exhaust systems in idling cars when blocked by the snow. Some residents had problems with flooded basements that affected their heating systems because of fuel leaks. The DOH provided technical advice for homeowners on unacceptable air levels of fuel oil in a home and steps that needed to be taken to address these problems, including having the air sampled and evacuating the home if levels exceeded certain guidelines. DOH also requested technical assistance from CDC to study the pattern of mortality that resulted from the event (6).

Environmental Public Health Tracking Program – In 2002, Congress provided CDC with funding to develop an EPHT Program and network that would build capacity to understand and respond to environmental health issues and explore links between environmental hazards and chronic disease. Currently, the Tracking Network's data and measures focus on:

- Health data that show the rates of certain non-infectious diseases or conditions like poisoning by carbon monoxide or lead, asthma, cancers and birth defects;
- Exposure data that tell us about the concentrations of certain chemicals inside people's bodies; and
- Hazard data that tell us about contaminants and pollutants that may be found in air and water.

The Tracking Network offers states a unique opportunity to leverage existing public health information technology capabilities and data available through the network to incorporate climate change surveillance.

- The Tracking Network has already built a geospatial information technology platform for bringing together health and environmental data;
- Adding new data, tools, business processes and partners specific to climate change will maximize existing resources;
- Spatially enabled public and secure web interfaces (portals), which already exist, will facilitate quicker access to information;
- CDC has built a broad coalition of users, data providers and champions with local, state, federal and international public health and environmental agencies that can be leveraged to begin development of robust climate change tracking; and
- CDC and its state and local partners also collaborate with the Council of State and Territorial Epidemiologists in evaluating and pilot testing possible climate change indicators.

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APPENDIX A Infrastructure Matrix

Current and Future Climate Changes Relevant to Infrastructure	Sector	Vulnerabilities	Risk	Adaptation Strategy Recommendations	Factors for Priority Consideration	Priority	
Higher temperatures during summer months and extreme heat events	Transportation	Buckling of roadways and/or bridges due to concrete expansion and softening of bituminous pavements	State maintains over 40,000 miles of roadways and 25,000 bridges. Local system includes over 70,000 miles of roadway and 6,300 bridges over 20 feet in length and an unknown number of bridges less than 20 feet.	Review available research for potential materials that can withstand higher temperatures	Low cost to assess research that is already going on. Research is currently being conducted and will not be available for 3 to 5 years. Need information on materials being developed/used in other parts of the country (ie. CA, ALASKA). High cost to implement research.	High priority	
	Transportation	Higher temperatures may impact construction schedules due to impacts on materials and personnel.	Materials may not set or cure due to higher temperatures and workers are more susceptible to heat related injuries	Perform work activities during cooler portions of the day, i.e. work during the night time hours	Increased project costs. Able to implement immediately. Mostly supported by the public. Safety for workers and drivers needs to remain a priority. <i>Co-benefit of reduced traffic.</i>	High Priority	
	Transportation	Buckling of paved runways	Pavement deformations create a hazard to aircraft tires during critical high-speed takeoffs and landings.	More frequent inspections and installation of heat/pressure sensors or other technology (cameras?) in the pavement for real-time anticipation of failure.	High cost to implement especially on high traffic airports. Political challenge exists if delays increase. Technology still in development so long term implementation timeframe.	High Priority	
	Transportation	Thermal misalignment of passenger and freight railways	Extreme heat can cause rail lines to expand creating the phenomenon known as a sun kink or nervous rail. This adversely affects the rail gauge and if left unrepaired could cause trains to derail.	More frequent inspections and additional tie anchors will need to be installed to all of the approximately 12,000 miles (2 rails per 6,000 liner miles of track) of track in the Commonwealth.	High cost to implement. Not sure if data is available. Planning and outreach needed. Privately owned infrastructure so long term implementation	Priority due to safety and economic considerations, but risk is relatively low due to the amount of heat necessary.	
	Transportation		High impact thunderstorms	Increased risk of lightning strikes, hail and tornados causing airport closures, delays and flight diversions	Improve forecasting techniques	High cost for all airports to implement. More infrastructure will be needed at airports, especially small airports. Technology is currently available	High priority due to safety and economic considerations for airports lacking infrastructure
					Prepare for flight delays and diversions	relatively easy to implement, but high cost	Medium priority, more of a comfort issue

Current and Future Climate Changes Relevant to Infrastructure	Sector	Vulnerabilities	Risk	Adaptation Strategy Recommendations	Factors for Priority Consideration	Priority
	Transportation	Invasive plant species management	Invasive species encroach on right of way and limit sight distances causing safety issues.	Research and employ herbicide management techniques to control invasive species	Medium cost due to increased maintenance required to control invasive species. Research is ongoing.	Medium Priority
	Energy	Invasive plant species management, faster growth of trees.	Damage to equipment from vegetation. Additional costs for vegetation management – more manpower spent on vegetation management. As power lines heat up, they may sag, touching trees, shorting out and causing outages.	Continued vegetation management research to develop cost effective strategies.	Medium cost due to increased maintenance required to control invasive species. Research is ongoing. Planned for in company requirements for vegetation management.	Medium priority – this is a long-term issue. Currently being addressed, may need more resources as temps increase.
Higher Temperatures during summer months and extreme heat events	Energy	Higher overall demand for energy from existing generators for cooling	<p>Use renewable energy generation – like solar and wind, especially during drought or air pollution action days. Encourage renewables as distributed generation to reduce peak usage, and to reduce congestion costs and power prices. More demand response and support for energy efficiency standards. Smart grid technology – including price responsive demand which allows consumers to cut their power usage as demand increases and prices increase. Additional funding for solar projects to reduce demand from fossil fuel generators during hottest times. New building standards for existing and new construction – better insulation, better window glazing in new and existing homes. Tree planting and use of roof materials to reflect heat to combat “heat island” effect. Continued funding for the Keystone Help program that provides loans for energy efficiency upgrades for homeowners.</p> <p>A 1.8 degree average increase in temperature will require 5-20% more power generation in PA for cooling. [Global Climate Change Impacts in the US, Thomas Karl, Jerry Meilillo, and Thomas Persterson, Cambridge Univ. Press, 209, p. 54.]</p>	<p>For more renewable energy generation and solar projects – high cost, but funding and political support exist now, short time frame to implement. Smart grid technology – high cost to implement, fed funds are available and support is there now. This is also part of the federal planning process. New building standards have political support, higher short term costs, but long term savings on energy costs. Roof materials or green roofs, low to moderate costs with long term benefits. To reduce overall demand – high cost, strong political support, as a result of Act 129, facilities are currently planning for reduced demand. Keystone Help has political support, easy to implement, need to identify more funding.</p>	<p>High priorities - reduce overall demand, increase renewable energy generation, energy efficiency and incorporate smart grid technology</p>	

Current and Future Climate Changes Relevant to Infrastructure	Sector	Vulnerabilities	Risk	Adaptation Strategy Recommendations	Factors for Priority Consideration	Priority
	Energy	Higher peak demand requiring new generation	To ensure reliable electric service, more generation may be needed as the highest demand days increase in total power needed and the number of days of high demand.	Reduction of demand as above. Smart grid and price responsive demand to lower peaks.	Long term implementation and high costs. See above.	High priorities - reduce peak demand, increase storage for renewable energy generation, energy efficiency and incorporate smart grid technology
	Energy	Decrease in transmission efficiency as temperature rises – higher demand needed to meet existing load	As demand increases, the temperature of transmission lines increases, causing the lines to sag. As the temperature of a line increases, its ability to transfer electricity decreases causing more demand just to meet existing load. Can result in the loss of the line, property damage from fire and wildfires.	Review of transmission and distribution system design standards, perhaps as part of regional transmission planning efforts.	Medium cost, long term implementation	Medium priority
	Energy	Lower reliability caused by higher demand, less congestion, more demand trying to go thru the same pathways) – will result in more brown-outs (voltage drops) and black-outs(complete loss of power)	More brown-outs and black-outs will impact the economy of the region and health and safety of Pennsylvanians	Incorporate climate forecasts in the transmission planning process rather than relying on historical weather forecasts. Review transmission and distribution design standards.	Data is currently being developed. Data could be used in planning. Low cost initiative.	Medium priority
	Energy	Difficulty in siting new generation as air quality deteriorates	Increased congestion of power flow – leading to higher costs and more failures.	Incorporate climate change impacts in transmission planning processes. More interagency cooperative efforts for environmental regulations and energy planning with transmission organizations.	Low cost. Incorporate into planning efforts.	Medium priority, long term implementation

Current and Future Climate Changes Relevant to Infrastructure	Sector	Vulnerabilities	Risk	Adaptation Strategy Recommendations	Factors for Priority Consideration	Priority
Higher Temperatures during summer months and extreme heat events	Water Supply	Available water for use reduced	Surface water supplies decrease due to greater evaporation. Groundwater supplies taxed as demand increases.	Statewide groundwater and surface water management planning enhanced to address climate change. Promote water efficiency and conservation at the local level.	Low cost, effort has wide political support	High priority
	Water Supply	Warmer water temperatures may impact uses by some industrially permitted users	Energy use increase for cooling or adoption of alternative technology	Reduce water temperatures by installing riparian buffers along a corridor. Require use of closed loop cooling system to reduce thermal stress on waterways.	Low to moderate cost	Medium priority
	Water Supply	Warmer water temperatures will impact water quality	The quality of water supplies may not meet drinking water standards	Statewide groundwater and surface water management planning enhanced to address climate change. Water suppliers will need to increase conservation and efficiency to meet customer demands and explore options for expanding supply in some cases.	Low cost, effort has wide political support	High priority
	Wastewater	Warmer water temperatures will require industrial discharges to reduce discharge volumes or temperatures to meet water quality standards	Permitted dischargers will need additional technology or alternative operations	Statewide groundwater and surface water management planning enhanced to address climate change. Industrial and municipal wastewater treatment best management practices and standards reflect climate change.	Moderate cost.	Medium priority
	Wastewater	Warmer water temperatures will require municipal wastewater dischargers to do more to meet standards to avoid harmful levels of bacteria and other pollutants	Permitted dischargers will need to meet water quality standards with additional technology or alternative operations	Additional training resources for treatment plant operators. Adopt best available technologies. Prevent polluted stormwater runoff through green infrastructure practices.	Moderate cost	Medium priority, long term implementation
	Communications	Power disruption/outage frequency and severity affects communication equipment	Loss of critical communications	Statewide effort to ensure communications maintained	Moderate to high cost	High priority
	Communications	Destruction of equipment and increased maintenance	Loss of critical communications	Statewide effort to ensure communications maintained	Moderate to high cost	High priority

Current and Future Climate Changes Relevant to Infrastructure	Sector	Vulnerabilities	Risk	Adaptation Strategy Recommendations	Factors for Priority Consideration	Priority
Wetter winters – more intense winter storms	Transportation	Winter Flooding – increased damage due to ice dams and other debris blocking water flow	Increased funding required for emergency maintenance, safety and economic issues due to flooded roads and bridges	Change design standards for areas that may be prone to flooding	Actually changing design standards is low cost but implementing changes is high cost and has a long term implementation timeframe. Implementation of debris dams would have higher costs due to inspections that are required.	High Priority
	Transportation	Roadway degradation due more water in the soil and increased freeze/thaw cycle.	Increased funding required to fix potholes and supportive road bases	Research and employ different materials or techniques to reduce moisture that penetrates road surfaces	Low cost strategy for research. Research is currently being done. May be higher cost for implementation due to higher cost materials, but we don't know.	Medium Priority
	Transportation	Runway degradation due to more water in the soil and increased freeze/thaw cycle.	Pavement deformations create a hazard to aircraft tires during critical high-speed takeoffs and landings.	More frequent inspections and airports may need to purchase pothole repair equipment in order to facilitate real-time safety repairs.	Low cost strategy for research. Research is currently being done. May be higher cost for implementation due to higher cost materials, but we don't know.	High priority due to safety and economic considerations
Wetter winters – more intense winter storms	Transportation	Wind shear	Closing airports	Airports will need to design additional terminal space for feeding and housing stranded passengers as well as purchasing additional forecasting equipment.	High cost for all airports to implement. More infrastructure will be needed at airports, especially small regional airports. Technology is currently available	Medium priority, more of a comfort issue
			Aircraft mishap	Develop and implement new aircraft parking requirement	Low cost of design and implementation with existing ground crews	Medium to low priority, logistics issue not relating to public safety
				Cancel and divert more flights	High economic cost in loss of revenue from canceled flights and connecting flights from diverted airports	High priority due to safety and economic considerations

Current and Future Climate Changes Relevant to Infrastructure	Sector	Vulnerabilities	Risk	Adaptation Strategy Recommendations	Factors for Priority Consideration	Priority
	Transportation	Erosion of rail beds and ballast	Many railroads run parallel to rivers and streams making them extremely susceptible to erosion, undercutting or complete washout.	Increased inspection and construction of a comprehensive levee system.	High economic cost for increased inspections and studies to determine if mitigation, such as a levee, is needed	High priority due to needed infrastructure and the lack of, or cumbersome nature of detours
	Energy	Transmission and distribution problems	Reliability issues and more outages	Use weather forecasting that takes into account climate change rather than relying on past weather patterns only. Increased maintenance and outage prevention by distribution companies.	Moderate to high cost	High priority
More Extreme Heat Events	Water	Increased winter stormwater runoff increases pollutants associated with road treatment	Water treatment facilities burdened; municipal stormwater permits require modification; non-point runoff impacts water quality	Best Available Technology for road treatment must advance; road and parking lot buffers and vegetated filters required	Moderate cost	Medium priority – long term
	Energy	Too much demand for electricity may overload the grid – grid manager would have to shed load (cut off demand) – resulting in brown outs and blackouts	Reliability issues and more outages	Reduce peak demand and improve demand response efforts that reduce load during high demand	Moderate cost	High priority
More high impact storms with more flooding	Transportation	More damming effect at bridges leads to the potential for greater loss of structure and property damage adjacent to transportation infrastructure	Higher insurance rates for property owners and washed out bridges cause lengthy detours	Consider relocation of roadways located in floodplains?	High cost associated with design, construction and purchase of new right-of-way	Low Priority
	Transportation	Closure of airports due to high impact weather events	Delays to inbound and outbound aircraft as well as increased hazards to in-flight aircraft due to additional icing and wind shear.	Airports will need to design additional terminal space for feeding and housing stranded passengers as well as purchasing additional de-icing and forecasting equipment.	High cost for all airports to implement. More infrastructure will be needed at airports, especially small regional airports. Technology is currently available	High priority due to safety and economic considerations

Current and Future Climate Changes Relevant to Infrastructure	Sector	Vulnerabilities	Risk	Adaptation Strategy Recommendations	Factors for Priority Consideration	Priority
More high impact storms with more flooding	Transportation	Extreme cold weather events exacerbate micro-structural flaws in passenger and freight rail.	Each time a micro-structural defect is subjected to extreme cold it may grow in size, increasing the odds of structural failure.	Increased non-destructive inspections such as ultrasonic inspections	Extremely high economic cost to implement. Technology is currently available but not utilized in this	Relates to health and safety however, due to high cost recommend medium priority relating to long-term infrastructure protection
	Transportation	Ports of Philadelphia and Erie are susceptible to flooding due to storm surge	Increased wave action and flooding may damage or destroy docks and freight handling equipment	Construction of moving seawalls	High economic cost to design and implement	Medium priority relating to long-term infrastructure protection
	Transportation	Shipping interests in the Port of Pittsburgh due to its narrow channel	High wind causing ships to run aground outside of the channel	Do not operate shipping interests during high impact storms.	High economic cost in failure to operate shipping and dredging the channel	High priority as shipping delays will force shippers to utilize other transportation means
	Transportation	More need for emergency operations and maintenance on both bridges and adjacent properties due to increased flooding.	Flooding causing fast currents and high water	Do not operate shipping interests during high impact storms.	High economic cost in failure to operate shipping	High priority as shipping delays will force shippers to utilize other transportation means
	Transportation	Increased erosion of soil and sedimentation deposits in streams, waterways and stormwater retention systems	Loss of transportation infrastructure structural support due to scour and carrying capacity of waterways and stormwater retention systems due to sedimentation	Change design standards or move roadways to prevent flooding	High economic cost to relocate roadways	Low Priority due to cost to relocate roads.
	Transportation	More damage to transmission and distribution lines – flooding of both above and underground lines and equipment	Reliability issues and more outages	More intense inspection of transportation infrastructure after flooding events for those areas susceptible to erosion.	Moderate cost and time for additional inspection. High cost to address scour.	High priority due to safety.
	Energy			Identify at risk facilities – protect, move or add redundancies.	Moderate to high cost – cost savings by avoiding outages	High priority

Current and Future Climate Changes Relevant to Infrastructure	Sector	Vulnerabilities	Risk	Adaptation Strategy Recommendations	Factors for Priority Consideration	Priority
	Water Supply and Wastewater	Existing infrastructure stressed by increased water volumes	Negative water quality impacts from increasing stormwater runoff and combined sewer overflows. Greater risk of flooding especially where there are high hazard dams and flood walls.	Green infrastructure practices and natural flood plain management to retain water and reduce imperviousness incentivized and funded; high hazard dams repaired or removed; instream hard infrastructure upgraded or removed	Moderate to high cost	High priority
	Water Supply and Wastewater	Rising sea level and intense storms may flood wastewater and drinking water treatment facilities.	Service interrupted, sewage overflows or contaminated drinking water	Service interrupted, sewage overflows or contaminated drinking water Strategies: a) Avoid building and re-building facilities in high risk areas and b) simultaneously improve wetland and floodplain function to minimize downstream risks. b) Re-locate high-risk facilities as a long term solution but c) where possible, in the short term, build berms at the facility and as far away as possible from the vulnerable waterbody to preserve natural function while protecting the facility.	Whereas 'a' is a planning strategy and thus no real 'added' cost, 'b' & 'c' deliver on-the-ground implementation. 'B' is a no-regrets, cost effective solution but possibly not a complete solution. Thus 'c' and 'd.' 'C' is costly, so 'd' offers a relatively inexpensive 'fix' but 'd' should not be engaged without a plan and actions toward 'c.'	
	Stormwater	Existing infrastructure overloaded; unable to manage volume and meet water quality goals	Pollutant loads to waterways from non-point sources increases during storm events; resulting in more impairment and necessitating treatment	Green infrastructure practices and natural flood plain management to retain water and reduce imperviousness incentivized and funded	Low to moderate cost	High priority
	Communications	Equipment flooded and stored materials damaged	Loss of critical communications	Statewide effort to ensure communications maintained	Moderate to high cost	High priority

Current and Future Climate Changes Relevant to Infrastructure	Sector	Vulnerabilities	Risk	Adaptation Strategy Recommendations	Factors for Priority Consideration	Priority
Drier summers – drought	Energy	Decrease in water availability for generation cooling and for hydropower generation	Nuclear plants, large coal plants and other generators could be curtailed when river levels fall or by thermal limits on water discharge. Reduced stream flow causes a decrease in hydropower generation.	Identify at risk facilities. Develop additional cooling strategies.	Moderate to high cost	High priority
	Water Supply	Low flow conditions, water users may be curtailed.	Permitted withdrawals will require modification; more watersheds and sectors will require permitting or planning. Reservoirs unable to meet need.	Statewide water management planning to address cumulative impacts to protect quality and supply and incentivize conservation. Encourage the development of local water restriction plans on outdoor watering during droughts.	Moderate	High priority
	Water Supply	Increased irrigation needs	Crop damage, lower yields	Best practices should be identified and used for agricultural activities	Moderate cost – potential energy and cost savings	Medium priority
	Wastewater	Low flow conditions, higher contamination concentrations could exceed discharge limits. Extreme low flow could cause loss of treatment capabilities	Risk to downstream users including drinking water supplies	Statewide water management planning to assess cumulative impacts to protect quality and supply and incentivize conservation	Moderate	High priority
Sea level rise- salt water intrusion	Energy	May impact water intakes on Delaware River	Could cause corrosion or cooling problems.	Identify at risk facilities – protect, move or add redundancies.	Moderate to high cost	Low priority – long term issue
	Transportation	At three feet above sea level, the port of Philadelphia would be flooded by an expected 1 to 2 meter sea level rise.	Loss of ship yard to include dry dock and repair facilities	Private companies may be required to relocate or abandon critical infrastructure.	High cost to design and implement	Medium priority relating to long-term infrastructure protection
	Transportation	Underground subway/trolley lines may flood resulting in increased need for pumping and tunnel sealing.	Loss of largest fresh water port in the country.	Move the port further inland at the cost of moving a comprehensive rail yard and sections of the city of Philadelphia	High cost to design and implement	Medium priority relating to long-term infrastructure protection
	Transportation		Loss of underground subway/trolley lines on transportation corridors.	Install pumping stations and sensors to detect if sea water is ponding with in the underground facility to prevent derailments.	High cost to install.	Medium priority.

Current and Future Climate Changes Relevant to Infrastructure	Sector	Vulnerabilities	Risk	Adaptation Strategy Recommendations	Factors for Priority Consideration	Priority
	Transportation	The fresh water port of Philadelphia could become a salt water port	Increased barnacle growth on piers and pilings	Increased inspections and cleaning cost	Medium cost due to increased maintenance cost required to control invasive species.	Medium priority relating to long-term infrastructure protection
	Water Supply	Water intakes along the Delaware River may have increased salt levels	Water supplies may require additional treatment or intakes may require relocation; municipal suppliers may need to purchase water from upstream sources	Conservation and re-use practices will reduce costs to municipalities forced to address salt infused supplies	Low to high cost range; intersects other priorities	Med priority – long term issue
	Communications	Increased flooding of equipment and corrosion from salt water	Loss of critical communications	Statewide effort to ensure communications maintained	Moderate to high cost	High priority
Communications information from <i>New York City Panel on Climate Change 2010 Report</i> – Ann. NY Academy Science 1196(2010) 63-85 by Rae Zimmerman and Craig Faris						

APPENDIX B Natural Resources Matrix

Natural Resource Sector Adaptation Recommended Actions				
Risk / Vulnerability	Wildlife / Plants	Agriculture	Freshwater	Forests
Shifts in species composition that could change ecological function and economic value	<p>1) Complete PNHP climate vulnerability assessment (CCVI) and consider habitat / ecosystem vulnerability assessment.</p> <p>2) Locate existing new data to establish baseline conditions for vulnerable / ecologically valuable species / habitats.</p> <p>3) Establish a statewide monitoring / research network that includes universities, colleges and environmental groups.</p>	<p>1) Assess sustainability of PA agriculture under climate change scenarios.</p> <p>2) Expand technical assistance to farmers to make decisions about sustainable crops and practices.</p> <p>3) Expand regional planning initiatives, with focus on agricultural security zones / recognition of local food security.</p>	<p>1) Improve knowledge about key factors promoting recolonization by extirpated fish and mussels.</p> <p>2) Identify critical habitat needs for fish, mussels and other sensitive aquatic species to better target protection and management.</p> <p>3) Inform sport fishermen and other stakeholders about the importance of climate change impacts on freshwater systems.</p>	<p>1) Assess the state's ecological matrix with forest core and hub areas, identifying existing and missing corridors.</p> <p>2) Promote and expand programs that assist and reward landowners for protecting or restoring critical habitats and corridors.</p>
Interaction of stresses and disturbances, such as fire, storms, pathogens, and invasive species, that could have unpredictable impacts on natural and agricultural systems	<p>1) Identify and prioritize habitats and ecosystems most vulnerable to climate change and other stressors. 2) Conduct predictive modeling and risk assessment for invasive species and pathogens that may be moving into the state.</p> <p>3) Incorporate climate change into the invasive species mgmt. plan.</p> <p>4) Establish monitoring and early detection plan for invasives and pathogens, and do something to control them.</p> <p>5) Reduce non-climate stressors that will further climate change stresses.</p>	<p>1) Learn about management strategies for invasive species from states where they are already established.</p> <p>2) Make invasive species (e.g., multiflora rose, autumn olive) valuable as a biofuel or animal feed.</p>	<p>1) Increase monitoring of water quality and quantify and correlate to climate and water temperature data.</p> <p>2) Monitor and encourage reduction of thermal discharges, either individually or collectively, that have significant negative impacts on aquatic life.</p> <p>3) Revise stormwater regulations to accommodate increase in precipitation and run-off (update BMPs, restrict impervious surfaces, restore floodplains and forests).</p> <p>4) Evaluate planting of more southern riparian native species to out-compete invasive infestations.</p>	<p>1) Monitor, model and survey critical ecological indicators that can be used to improve adaptive management.</p> <p>2) Expand use of prescribed fire to diminish fuel build-up and promote fire-dependent and fire-facilitated ecosystems; and dedicate resources to better monitor ecological response to fire and better utilize data collected to inform practices and policies.</p> <p>3) Expand programs for insect and pathogen threats. Including research, monitoring and controls.</p> <p>4) Assess potential interaction of increased biomass harvesting with areas vulnerable to nutrient leaching from atmospheric deposition.</p>
Barriers to connectivity at the landscape and regional scales that restrict the movement of wild species to new environments where they can survive	<p>1) Identify and protect vital corridors and refuges using existing studies and additional research as needed.</p>	<p>1) Promote retention / restoration of natural riparian covers and hedgerows.</p>	<p>1) Promote removal of small dams to increase connectivity.</p> <p>2) Replace poorly designed</p>	<p>1) Better protect vulnerable habitat areas and corridors, including ridge-top and forested riparian corridors;</p>

Natural Resource Sector Adaptation Recommended Actions				
Risk / Vulnerability	Wildlife / Plants	Agriculture	Freshwater	Forests
	2) Reestablish necessary corridors.		culverts that restrict connectivity where roads cross streams.	restore damaged priority corridors; help landowners minimize fragmentation. 2) Enact legislation to mandate restoration of original vegetation of cleared gas well pads, similar to mining laws. 3) Ensure that maintenance of plantings is an integral component of urban programs.
Changes to river and stream flows and shallow groundwater supplies that could have adverse impacts on aquatic and wetland species, crop varieties and livestock	1) Manage for ecological function and biodiversity by restoring hydrology. 2) Reestablish necessary corridors.	1) Use water recycling to address increased need / limited supply for water. 2) Encourage re-use of grey water.	1) Develop and use ecological flow thresholds to manage withdrawals to reduce thermal stress on species and habitats. 2) Encourage homeowners, farmers, recreational industry and commercial users to use rainwater catchment to lower demand for ground - and surface water systems. 3) Promote more expansive source water and groundwater infiltration zone protection by local govts. and land trusts.	1) Prioritize protection of key habitat areas and ecological corridors (including bogs, fens and other key wetlands, boulder fields, barrens).
A lack of genetic diversity in some wild species and agricultural varieties that could limit their ability to persist in the face of expected changes in temperature, precipitation, and ecological conditions (e.g., new competitive species, changed soil biology and chemistry, etc.)	1) Create a centralized and coordinated phenological network in PA. 2) Evaluate the consequences of and the potential responses to phenological disruptions. 3) Develop protective measures, which include genetic and biological diversity concerns, for at-risk species and habitats.	1) Preserve crop and livestock genetic diversity.	1) Identify and protect refugia for sensitive aquatic habitats and species. 2) Protect / restore riparian buffers where degraded or absent, and expand buffer zone to protect thermal conditions on all streams, but especially headwater / small streams.	1) Work with US Forest Service to ensure continued appropriate genetic diversity of tree species in PA.

**APPENDIX C
Tourism and Outdoor Recreation Matrix**

Activity	Winner	Positive Impacts	Loser	Adverse Impacts	Adaptation Strategy Recommendations (to exploit or counter those impacts)
Cultural and Heritage					
Historic Sites	X	Longer tourist season; warmer weather	X	Re-enactments (Gettysburg, Brandywine, Washington's Crossing); too hot	Adapt costumes, tour times and events to lessen impacts of hot temperatures
Family/Group Activities	X	Longer season	X	Hotter; more severe storms	Work with local rec boards, county parks to adapt schedules and events, educate citizens
Festivals and Fairs	X	Longer season	X	Hotter (for attendees and people in costume); more severe storms; stinging bees	Need to adjust times and months during which outdoor festivals and fairs take place
Outdoor Movies, Plays, Concerts	x	Longer season			

Activity	Winner	Positive Impacts	Loser	Adverse Impacts	Adaptation Strategy Recommendations (to exploit or counter those impacts)
Passive Recreation Activities (listed don't fit well together)					
Driving for Pleasure	X	Better driving conditions (due to less snow and ice); less freeze/thaw; fewer potholes; more road trips	x	More severe storms	Promote alternative transportation (electric cars, etc)
Fall Foliage Viewing			X	Stressed northern hardwoods (maple, beech, birch)lose foliage faster; range shift; uncertain what will happen	Bureau of Forestry and tourism professionals develop outreach materials and adjust schedules
Picnicking	X	Longer season	X	Hotter; more severe storms	
Outdoor Sports, Spectators					Add ice machines, plant more trees and provide more shade and water for human sports spectators

Activity	Winner	Positive Impacts	Loser	Adverse Impacts	Adaptation Strategy Recommendations (to exploit or counter those impacts)
Theme Parks					
Amusement Parks	X	Longer season	X	Hotter; more severe storms	More shading, misters, and water fountains
Water Parks	X	Longer season	X	Hotter; more severe storms	
Nature Centers	X	Longer season	X	Hotter; more severe storms	
Zoos					Need to keep zoo animals cool
Individual/Aerobic Activity					
Walking	X	Longer season	X	Hotter; more severe storms	Invest in non-powered transportation modes and infrastructure
Jogging	X	Longer season	X	Hotter; more severe storms	Develop safer places to jog at night or early morning, more water fountains and shade along routes.
Hiking	X	Longer season	X	Hotter; more severe storms; poison ivy; more ticks	Need to minimize tick concerns -- educate people about personal care (tick repellent; white clothing; how to remove them)
In-Line Skating	X	Longer season	X	Hotter; more severe storms	
Triathlons, Marathons (Competitive vs. Fundraisers)					Adjust schedules toward cooler times, educate participants about risks, have more medical personnel on hand

Activity	Winner	Positive Impacts	Loser	Adverse Impacts	Adaptation Strategy Recommendations (to exploit or counter those impacts)
Swimming Lake	X	Longer season	X	Hotter; more aquatic weeds; more storms; flooding; bacteria problems when it gets too hot	Continue to monitor public lake swim areas for water quality and temperature
Pool	X	Longer season	x	Bacteria problems when it gets too hot	
Beach Use	X	Longer season	X	Hotter; more severe storms	
Nature Viewing Fish Viewing				Stressed fish; drought; flashier flows	
Birding and Birdwatching	X	Species at edge of southern range; might see more non-native birds blown in by storms	X	Species at edge of northern range; timing of prey availability and birds arriving in spring is off (birds will starve)	Build more wetlands along streams and rivers

Activity	Winner	Positive Impacts	Loser	Adverse Impacts	Adaptation Strategy Recommendations (to exploit or counter those impacts)
Mammals (e.g., Elk)			X	Elk range shift north	Right-of-way plantings as migratory corridors (e.g., native plants that do not require mowing)
Night Sky Viewing	X	Warmer and longer season	X	More storms	Promote lower and energy efficient lighting and limited lighting
Bicycling					
Mountain Biking	X	Longer season	X	Hotter; more severe storms	Educate on increased risk
Road Biking	X	Longer season	X	Hotter; more severe storms	Invest in non-powered transportation modes and infrastructure
Fishing					
Ice Fishing			X	Less ice; aquatic invasive species (AIS)	Educate ice fishermen on risks and dangers of thinner ice
Coldwater (Trout)			X	Warmer water; AIS; drought; stormwater	Small dam removal, reforestation, water quantity conservation
Warm Water (Bass)	X	Warmer water; expanded range	X	Might be too warm; AIS; drought; stormwater; saltwater intrusion; potential for fish kills due to stress	Build more wetlands along streams and rivers

Activity	Winner	Positive Impacts	Loser	Adverse Impacts	Adaptation Strategy Recommendations (to exploit or counter those impacts)
					Educate anglers about shifting species composition (e.g., coldwater to warm water; fresh to salt water)
					Fishing and boating access
					Need to prepare for a shift to warm water species production at fish hatcheries
					Need to prepare for shift to warm water game species
Camping					
RV'ing	X	Longer season	X	Hotter; more severe storms	
Tent Camping	X	Longer season	X	Hotter; more severe storms; poison ivy	
Animal Activities					
Dog Walking	X	Longer season	X	Hotter; more severe storms	Provide more shaded walking routes and dog parks, water sources for dogs and humans
Horseback Riding	X	Longer season	X	Hotter; more severe storms; ticks; animals are stressed (need to keep them cool)	Provide more shaded riding routes, water sources for horses and humans

Activity	Winner	Positive Impacts	Loser	Adverse Impacts	Adaptation Strategy Recommendations (to exploit or counter those impacts)
Zoos	X	Better for warm weather animals; longer season	X	Worse for cold weather animals; increased costs of operations to keep people cool	Research needed on warmer-weather impacts to specific species and best practices
Race Tracks and Racinos	x	Longer season	x	Harder to keep animals cool	Need to keep animals cool at horse race tracks (racinos)
Other					
Geocaching	X	Longer season	X	Hotter; more severe storms	
Playground Use	X	Longer season	X	Hotter; more severe storms	More shade and water sources
Horseshoes					
Disc Golf (big in state parks; around Phila.)					More shade and water sources
Adventure Activity					
Hang Gliding	X	Longer season	X	Hotter; more severe storms	
Rock Climbing	X	Longer season	X	Hotter; more severe storms	
Bouldering	X	Longer season	X	Hotter; more severe storms	
Storm Chasing	X	More storms			

Activity	Winner	Positive Impacts	Loser	Adverse Impacts	Adaptation Strategy Recommendations (to exploit or counter those impacts)
<p>Hunting</p> <p>Waterfowl</p>	X	Less mortality of resident geese	X	Great Lakes not freezing, so birds not migrating to PA; prairie potholes drying up and eliminating nesting areas; predators doing better on the prairies (e.g., striped skunks, foxes, and raccoons can over-winter better); potential for avian cholera	Build more wetlands along streams and rivers; research into migratory shifts to help educate public and potentially adjust hunting seasons and limits
Deer	X	Less winter mortality; earlier leaf out in spring give them more food	X	Less snow for tracking	Right-of-way plantings as migratory corridors (e.g., native plants that do not require mowing); hunter education on impacts of warmer climate on species and on public health
Small Game			X	Denser vegetation as cover for the game	see above
Bear			X	Increase nuisance with decreased hibernation	see above

Activity	Winner	Positive Impacts	Loser	Adverse Impacts	Adaptation Strategy Recommendations (to exploit or counter those impacts)
Elk			X	Range shifts north	see above
Winter Sports					
Downhill Skiing			X	Less snow; less water for snow-making; lack of predictability (infrastructure and staffing implications); need 5 days of 28 degrees and below to make snow	5% of people ski; 1% do summer activities at ski resorts -- need to promote and market those activities
Snow Tubing			X	Less snow; less water for snow-making; lack of predictability (infrastructure and staffing implications); need 5 days of 28 degrees and below to make snow	Educate people how to exploit larger infrequent snowfalls (e.g., don't throw cross county skis away)
Cross Country Skiing	X	Occasional heavy snows	X	Less snow	see above
Snowshoeing	X	Occasional heavy snows	X	Less snow	see above
Snowmobiling			X	Less snow	see above

Activity	Winner	Positive Impacts	Loser	Adverse Impacts	Adaptation Strategy Recommendations (to exploit or counter those impacts)
Motor Biking					
ATVing	X	Longer season	X	Hotter; more severe storms	Build ATV parks
Dirt Biking	X	Longer season	X	Hotter; more severe storms	Need to minimize the environmental impacts of additional trail usage (e.g., ATVs)
Road Touring			X	Hotter; more severe storms	Promote energy efficient bikes
Boating					
Powered	X	Longer season	X	Hotter; more severe storms; drought; flooding; AIS	Augment fishing and boating access and adapt for longer seasons; more dock slip space
Unpowered (Kayaks, Canoes)	X	Longer season	X	Hotter; more severe storms; drought; flooding; AIS; long periods when it is too dry; flashier flows	Create and improve more access points and portages for anticipated increasing use
Tubing					
Whitewater Rafting					
Waterskiing	X	Longer season	X	Hotter; more severe storms; more aquatic vegetation	Educate and equip outdoor recreators with the means to prevent spread of invasives

Activity	Winner	Positive Impacts	Loser	Adverse Impacts	Adaptation Strategy Recommendations (to exploit or counter those impacts)
Golf	X	Longer season	X	Hotter; more severe storms; need more water at same time water is becoming scarcer; need to mow more; pesticides	Promote native grasses, more trees for shade, onsite water use and recycling, adjusted tee times in cooler temperatures
Outdoor Organized Team Sports (Little Leagues, High School, College, Pro)	X	Longer season	X	Hotter; more severe storms; may shift indoors (which requires infrastructure and energy); need to do more at night	Build or retrofit athletic fields in floodplains, provide more shade and water sources, shift to more evening activities
					Need to redefine seasons (e.g., too hot in August; season extends to December when it would have ended in November)
					Need for more medical staff at places where people congregate and recreate in hot weather and may suffer heat stress

Activity	Winner	Positive Impacts	Loser	Adverse Impacts	Adaptation Strategy Recommendations (to exploit or counter those impacts)
Yard Work Gardening	X	Longer season	X	Hotter; more severe storms; more water needs; pests	Promote onsite water use and recycling (rain barrels, drip hoses, native plants)
Recreational Mowing	X	Longer season	X	Hotter; more severe storms; more water needs; pests	Promote alternatives, including meadows, native plants, trees

Actions	Examples	Co-benefits
Prioritize and direct green infrastructure funding	tree planting	carbon sequestration, wildlife habitat (e.g., migratory corridor), nutrient reduction, property values
	wetlands	stormwater management, water quality, wildlife habitat, flood control
	vegetative modifications (native grasses vs. lawns)	minimize invasive species, reduced pesticide and herbicide use, pollinator habitat, reduced carbon emissions
	small dam removal	recreational swimmer and boater safety, flood storage
	riparian buffers (including shading of streams)	stormwater management, water quality, wildlife habitat, flood control, reduced costs and impacts to gray infrastructure
Invest in infrastructure and retrofitting; accommodate the outdoor activities that will be engaged in by the most people.	urban trails	
	walkable, bikeable, non-powered communities	
Promote stormwater management and reuse	ski areas	
	golf courses	
	athletic fields	
Infrastructure to accommodate evening and early morning activities	lighting (with steps to minimize negatives to wildlife)	
Shading and cooling	tree planting and misters	
Conserve habitats for cool and cold water/weather species and enhance habitat for warm water/weather species	small dam removal and riparian buffers to shade streams	

Incentives, methods, and procedures	Examples
Give criteria for adaptation strategies in grant programs	state grants: PennVest; governor's Action Team; H2O PA private foundations
Where feasible, require state agencies model practices on our own properties. Add programming to explain climate change impacts.	state parks, boat ramps, rest stops, office building grounds
Provide business incentives	small business loans tax incentives to install green infrastructure that incorporates adaptation
Staff capacity and budgets to help promote and implement adaptation	

Schedules	Examples
<p>Adjust work, school, sports schedules to accommodate earlier and later activities and different times of year. Modify school year to deal with hotter weather and allow for recreation during cooler weather.</p> <p>Encourage employers to adjust work schedules to accommodate outdoor recreation</p>	<p>start football season in September rather than August</p>
<p>Need to adjust hunting, fishing, camping, state park seasons</p>	<p>longer camping seasons at state parks</p> <p>start trout season earlier in the year</p>

APPENDIX D

PUBLIC HEALTH AND SAFETY SCIENTIFIC PAPER

CLIMATE CHANGE

In early 2010 DEP created the PHSWG as one of four working groups to assist DEP on its overall climate change initiative. The PHSWG consisted of two co-chairs (a representative of the DOH and a faculty member of Temple University) as well as representatives of other federal and state agencies and other interested groups. The PHSWG met four times during 2010 and was asked to develop a summary report for PADEP that would be part of PADEP's Final Adaptation Report on Climate Change. This report represents the PHSWG Final Report outlining those health and safety considerations related to climate change that are important to Pennsylvania.

According to the Interagency Working Group on Climate Change, global climate has become one of the most visible environmental concerns of the 21st century (1). This ad hoc group was formed by participating federal agencies and organizations at the invitation of the National Institute of Environmental Health Sciences, the National Oceanic and Atmospheric Administration (NOAA), the CDC, and the EPA in 2009. The group believes that climate change is currently affecting public health through numerous environmental consequences, including sea-level rise, changes in precipitation resulting in flooding and drought, heat waves, changes in intensity of hurricanes and storms, and degraded air quality, that are anticipated to continue into the foreseeable future.

According to CDC, there is widespread scientific consensus that the world's climate is changing (2), leading to anticipated effects such as those just described. Each of these changes has the potential to have a negative impact on human health, resulting in excess numbers of deaths, injuries and illnesses. Because many infectious diseases (e.g., West Nile virus and Lyme disease) are influenced by temperature, humidity and other climate variables, climate change may affect the spread of these diseases or the intensity of disease outbreaks. Climate change may also lead to increased problems with allergies since a warmer climate can promote the growth of molds, weeds and other irritants that cause allergic reactions in certain sensitive individuals. Although climate change is a global issue, it has the potential to significantly impact the health of citizens of Pennsylvania.

The PHSWG reviewed material available on public health issues associated with climate change, including the CDC website for Climate Change (2) and CDC's table describing possible weather events, health effects, and sensitive populations related to climate change. Based on this review, the PHSWG agreed to use the table as a template in its own considerations on vulnerabilities and risks due to climate change that are important to Pennsylvania. The PHSWG also prioritized potential issues and identified the following three high priority areas: 1) heat stress; 2) flooding; and

3) droughts. The PHSWG also developed relevant models (see attachments) that outline key issues on these three topics that pertain to the state.

Heat Stress

Heat stress will be a significant climate change event for Pennsylvania since heat is already the leading cause of weather-related deaths each year in the U.S. (3). In addition to death, heat stress can also lead to a variety of illnesses, including heat exhaustion, heat cramps, and heat stroke, and can exacerbate pre-existing chronic conditions, such as some respiratory, cerebral, and cardiovascular diseases. Counts of these deaths and illnesses are likely significantly underreported since criteria used in making these measurements vary and heat is rarely used as an official cause of death. Vulnerable populations include children, the elderly, low income individuals, and socially isolated people. Pennsylvania has two major metropolitan areas (Philadelphia and Pittsburgh) and the urban built environment specific to these two geographic areas of the state may exacerbate heat-related environmental conditions and associated heat-related health problems.

Although climate change is likely to increase the number of heat-related deaths and illnesses in Pennsylvania, many of these are preventable using appropriate precautions, such as increased air conditioning use and decreased time spent outdoors during a heat spell. From a public health perspective, proactive heat wave response plans (including heat wave early warning systems, heat advisories, availability of cooling stations, and other preventive measures) are an important and sustainable adaptation strategy.

A model public health early warning system for heat waves was established by the Philadelphia Department of Public Health following a major heat wave in the 1990s. An evaluation of the program has clearly demonstrated that the system saves lives and that the cost of running the system is low compared with the estimated value of a life lost (4).

The PHSWG has developed a model (Attachment 1) on heat stress delineating the important components in Pennsylvania for effectively dealing with this problem - Health (susceptible populations; partners; data bases/sources) and the Environment (cooling stations; transportation; homeless shelters; hospitals/medical centers/outpatient care centers; developing a prototype for risk mitigation). The model also outlines a systems approach that can be used to understand the interaction of these various factors.

Flooding

A second example of an extreme weather event of particular concern to Pennsylvania and the public health community is flooding because of the expected increased frequency of these events due to climate change (2). The potential adverse impact of flooding on the mortality and morbidity patterns in an affected community can be sizeable.

In January 1996, a winter blizzard followed by a flood on the Susquehanna River due to a warming spell resulted in an increase in morbidity and mortality directly related to this event (5-7). Residents experienced various health problems, including carbon monoxide poisoning due to use of space heaters in homes without proper ventilation. Drivers also experienced similar problems from exhaust systems in idling cars when blocked by the snow. Some residents had problems with flooded basements that affected their heating systems because of fuel leaks. DOH provided technical advice for homeowners on unacceptable air levels of fuel oil in a home and steps that needed to be taken to address these problems, including having the air sampled and evacuating the home if levels exceeded certain guidelines. DOH also requested technical assistance from CDC to study the pattern of mortality that resulted from the event (6).

Although the 1996 Susquehanna River flooding was not as extreme as the flooding caused by Hurricane Agnes in 1972 (8), the event demonstrated that flooding episodes in Pennsylvania can happen at various times of the year. The event also highlighted the fact that Pennsylvania historically is vulnerable to flooding. In fact, the worst flash flood in the nation's history happened in Johnstown in 1889 when the South Fork Dam broke killing 2,200 persons (9).

As with other extreme weather events, groups vulnerable to flooding include the elderly, the poor, infants and children, those with underlying chronic diseases, and those with disabilities. Particularly those who live in areas that have experienced little or no flooding in the past can be at greater risk of adverse health effects since they are not as well prepared and are less experienced in dealing with floods. Understanding potential flood zones in Pennsylvania is important to preparedness for both homeowners who may be affected by flooding as well as potential responders (e.g., the Pennsylvania Emergency Management Agency and local emergency responders and managers) who will coordinate the appropriate response to an event.

The PHSWG has developed a model (Attachment 2) on flooding delineating the important components in Pennsylvania for effectively dealing with this problem—Health (health effects and susceptible populations; partners; data bases/sources) and the Environment (components of managing risk).

Drought

A third example of an extreme weather event of particular concern to Pennsylvania and the public health community is drought. Since public health experts operate today with only limited guidance on preparedness and response regarding this hazard, CDC developed a new guide (10) to aid public health professionals in this area. Important topics covered in the report include health issues, preparedness and response approaches, and future needs.

CDC has provided an overview of basic drought- and water-related information and principles (i.e., definition of drought, U.S. drought and water-use trends, relationship

between drought and climate change, water distribution, water treatment and classification, and water-related policy). CDC has addressed numerous drought-related public health effects, which are organized into several broad categories within the document (10). These categories include:

- Compromised quality and quantity of potable water;
- Compromised food and nutrition;
- Diminished living conditions (as they pertain to energy, air quality, and sanitation and hygiene);
- Recreational risks;
- Mental and behavioral health;
- Vulnerable populations; and
- Increased disease incidence (for infectious, chronic, and vector born/zoonotic diseases).

The PHSWG has developed a model (Attachment 3) on drought delineating the important components in Pennsylvania for effectively dealing with this problem—Health (health effects and susceptible populations; partners; data bases/sources) and the Environment (components of managing risk).

Environmental Public Health Tracking Program

In 2002, Congress provided CDC with funding to develop an EPHT Program and network that would build capacity to understand and respond to environmental health issues and explore links between environmental hazards and chronic disease. The Tracking Network is the first national resource providing standardized environmental and public health data in one, searchable database. Currently, the Tracking Network's data and measures focus on:

- Health data that show the rates of certain non-infectious diseases or conditions like poisoning by carbon monoxide or lead, asthma, cancers and birth defects;
- Exposure data that tell us about the concentrations of certain chemicals inside people's bodies. For example, childhood blood lead levels will be available on the Network; and
- Hazard data that tell us about contaminants and pollutants that may be found in air and water.

The Tracking Network offers states a unique opportunity to leverage existing public health information technology capabilities and data available through the network to incorporate climate change surveillance.

- The Tracking Network has already built a geospatial information technology (IT) platform for bringing together health and environmental data (e.g., air, water, asthma and vital statistics in time and space).

- Adding new data, tools, business processes and partners specific to climate change will maximize existing resources and prevent duplication of effort.
- Spatially enabled public and secure web interfaces (portals), which already exist, will facilitate quicker access to information that can be utilized to drive coordinated multi-agency public health action related to climate change.
- CDC has built a broad coalition of users, data providers, and champions with local, state, federal and international public health and environmental agencies that can be leveraged to begin development of robust climate change tracking. A content work group (CWG) for climate change has been formed and meets regularly. A nationally consistent definition of heat waves is being formulated in collaboration with CDC, NOAA and the National Weather Service.
- CDC and its state and local partners also collaborate with the Council of State and Territorial Epidemiologists in evaluating and pilot testing possible climate change indicators.

According to EPA, climate change will affect air quality leading to worsening regional ozone pollution, with associated risks of respiratory infections, aggravation of asthma, and premature death. CDC's National Asthma Control Program helps state health departments build asthma programs, bolster surveillance, implement interventions, and foster partnerships. A nationally consistent definition of "heat waves" is being formulated jointly by CDC, NOAA, and the National Weather Service. Increased frequency of higher temperature peaks, longer durations of these peaks and occurrence earlier in the season compared to other years are being considered in the final model and definition of heat waves.

Before 1998, cities and states did not collect asthma information uniformly. The National Asthma Control Program has helped state health departments standardize detailed data collection, which simplifies the comparison of disease rates across jurisdictions.

CDC-funded state asthma control programs now measure adult and child prevalence, indicators of asthma control, hospitalizations, and deaths. Some states also track asthma in the Medicaid population, costs attributable to asthma, or asthma management indicators (e.g., asthma action plans, detailed medication use, school days or workdays missed due to asthma, or emergency department visits).

According to the most recent figures, in FY 2009 only 33 states and D.C. received CDC funding for state asthma control programs. Not all states that apply for funds receive grants because there are often insufficient funds appropriated for this program.

In FY 2009, only 22 states (including Pennsylvania with funding to DOH) and New York City received CDC EPHT grants. Not all states that apply for funds receive grants because there are often insufficient funds appropriated for this program. Plans for the network include monitoring new environmental hazards (such as climate change), additional health outcomes, and additional state participation.

The PHSWG had numerous discussions about the relevance of climate change to the programs of CDC's national EPHT program to Pennsylvania. Since DOH is funded by this program, the agency expects that future grant requirements will incorporate both environmental and health data sources that monitor trends in the state in this area over time. The health data sources could include mortality and morbidity measures for heat stress as well as adverse health outcomes associated with future flooding events.

Federal Funding Opportunities

In recent years, the federal government has allocated several billion dollars annually for projects to expand the understanding of climate change and to reduce carbon dioxide and other greenhouse-gas emissions. Most of that spending is done by the Department of Energy and by the National Aeronautics and Space Administration. The work is coordinated in the Executive Office of the President. Successive Administrations have tracked the funding of climate change programs and the cost of tax incentives related to climate change through what is sometimes called the "climate change budget." That budget typically has included federal efforts allocated in several categories:

- Technology programs that develop, demonstrate, and deploy new products or processes to reduce greenhouse-gas emissions;
- Scientific research directed toward explaining the processes of climate change and monitoring the global climate;
- Assistance to other countries as they work to reduce greenhouse-gas emissions; and
- Tax incentives that encourage businesses and households to adopt technologies that curtail the use of fossil fuels and reduce greenhouse-gas emissions.

In addition to CDC offering federal funding for the EPHT program, other federal organizations offer funding for climate-sensitive health issues. According to the EPA, climate change will affect climate-sensitive diseases, including vector-borne diseases such as West Nile Virus. Infectious disease surveillance systems, such as ArboNET, provide public health officials and health care providers with information about disease activity in their states. Having effective surveillance systems on the ground is essential as public health officials prepare for an increase in vector-borne diseases as a result of warming temperatures.

In FY 2008 CDC funded all states except Alaska to participate in "ArboNET." ArboNET is a web-based surveillance data network comprising 54 state and local public health departments and CDC developed in 2000. Arboviruses are transmitted by insects such as mosquitoes and ticks. States voluntarily submit data to ArboNET on West Nile Virus, Colorado tick fever, dengue, Japanese encephalitis, yellow fever, and other domestic and imported arboviruses. In addition, states report results from environmental surveillance (e.g., testing mosquitoes, birds, and horses for evidence of arbovirus infection) based on activities conducted by local health departments and mosquito control agencies within the state. One of the major strengths of ArboNET is that it collects human, animal, and ecologic data, which provides users with a broad picture of

arbovirus transmission activity by region. In addition, because it is internet-based, it offers the potential for real-time reporting (11).

EPA is supporting states to take significant action to curb greenhouse gases. In Region 9, California is leading a coalition of states in efforts to address climate change. EPA is working closely with state partners to provide funding and to help assess and reduce greenhouse gas emissions.

The U.S. Department of Agriculture has also made funding available for counties that qualify for drought assistance (e.g., a 30 percent drop in crop production or loss of livestock). After the department declares a county drought emergency, counties qualify for low interest loans that become available through their farm service agencies.

Recommendations

1. Pennsylvania is one of 28 states that have developed a strategic climate change plan that does not include a public health response (11). The Pennsylvania strategic climate change plan should be revised to include a section that addresses the public health response. This report should be considered in the development of the revised plan.
2. Government agencies and other partners in Pennsylvania should implement appropriate measures to prevent adverse health effects caused by heat waves. In his narrative on “heat waves and hot environments,” Kilbourne provides guidance on this topic by reviewing the timing of preventive measures, the content of prevention programs, and target groups (12). EPA developed a guidebook in 2006 to assist communities in preparing for and responding to excessive heat waves (13). The schematic on heat stress attached to this report also includes critical components of a model to help prevent heat-related adverse health conditions. The public health early warning system for heat waves established by the Philadelphia Department of Public Health can serve as a model in other parts of the state. An evaluation of the Philadelphia program has clearly demonstrated that the system saves lives during severe heat waves.
3. Government agencies and other partners in Pennsylvania should implement appropriate measures to prevent and control adverse health effects caused by flooding. In her narrative on “floods,” Malilay provides guidance on this topic by reviewing issues on mitigation, warning and preparedness, needs assessment, surveillance, response and recovery, and health education (12). The schematic on flooding attached to this report also includes critical components of a model to help prevent flood-related adverse health conditions.
4. Government agencies and other partners in Pennsylvania should implement appropriate measures to prevent and control adverse health effects caused by drought conditions. The CDC report on this topic (10) can assist public health professionals on preparedness and response measures regarding this hazard.

The Association of State and Territorial Health Officials also developed guidelines in 2008 (15) to help public health professionals deal with the threat of mosquito-borne diseases that may increase during drought conditions.

5. Should CDC expand the EPHT grant program to include activities related to the public health consequences of climate change, DOH should take advantage of the availability of these federal resources. DOH and other interested partners should also search out new areas for funding support in this area and continue to develop expertise in surveillance, health education, and other areas of public health that will contribute to the body of knowledge about how climate changes in Pennsylvania may be impacting the lives of residents.
6. A review of environmental health indicators for climate change in the United States released in 2009 shows that data exist for many environmental and health measures, but more research is needed to evaluate the sensitivity and usefulness of the measures (16). Government agencies and other partners in Pennsylvania should support efforts to increase data quality and availability and to develop new surveillance databases, especially for climate-sensitive morbidity.
7. The 2008 report by the National Academies on climate change recommends increasing interdisciplinary collaboration among medical and health professionals and other environmental and social scientists to better understand the linkage between climate change and disease (17). Government agencies and other partners in Pennsylvania should continue to support efforts such as this in the state in the future.

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ATTACHMENT 1

HEAT STRESS AND A MODEL FOR MITIGATING RISK TO ENVIRONMENTAL SUCCEPTIBILITIES

I. HEALTH

A. Susceptible Population

- i. Elderly
- ii. Very Young
- iii. Disabled/III
 1. Respiratory Conditions
 2. Cardiovascular Conditions
- iv. Athletes/Hot Weather Runners/Outdoor Games Participants
- v. Outdoor Construction/Other Outdoor Workers
- vi. Firefighters/Police
- vii. Outdoor Campers/Counselors
- viii. Animals
 1. Pets (e.g., at Risk in Homes and Vehicles)
 2. Farm Animals

B. Partners

- i. Surrogate Care Givers
 1. Relatives
 2. Neighbors
 3. Friends
 4. Schools (e.g., for Athletes)
 5. Physicians
 6. Veterinarians (e.g., for Pets and Animals at Risk)
 7. Healthcare Providers
 8. Emergency Medical Services/Ambulance Drivers (e.g., Outdoor Workers)

- ii. Service Organizations
 1. Police
 2. Fire Department
 3. Visiting Nurses
 4. 911
 5. Meals on Wheels
 6. Town/City Planning Input
 7. Other (e.g., Utilities)
 8. Department of Aging (e.g., for Prescriptions and Meals)
 9. Department of Public Welfare
 10. Pennsylvania Department of Transportation
 11. Office of Health Equity
 12. United Way
 13. American Lung Association (Asthma)
 14. Senior Centers

- 15. Day Care Centers
- 16. Community Centers
- 17. Church Groups

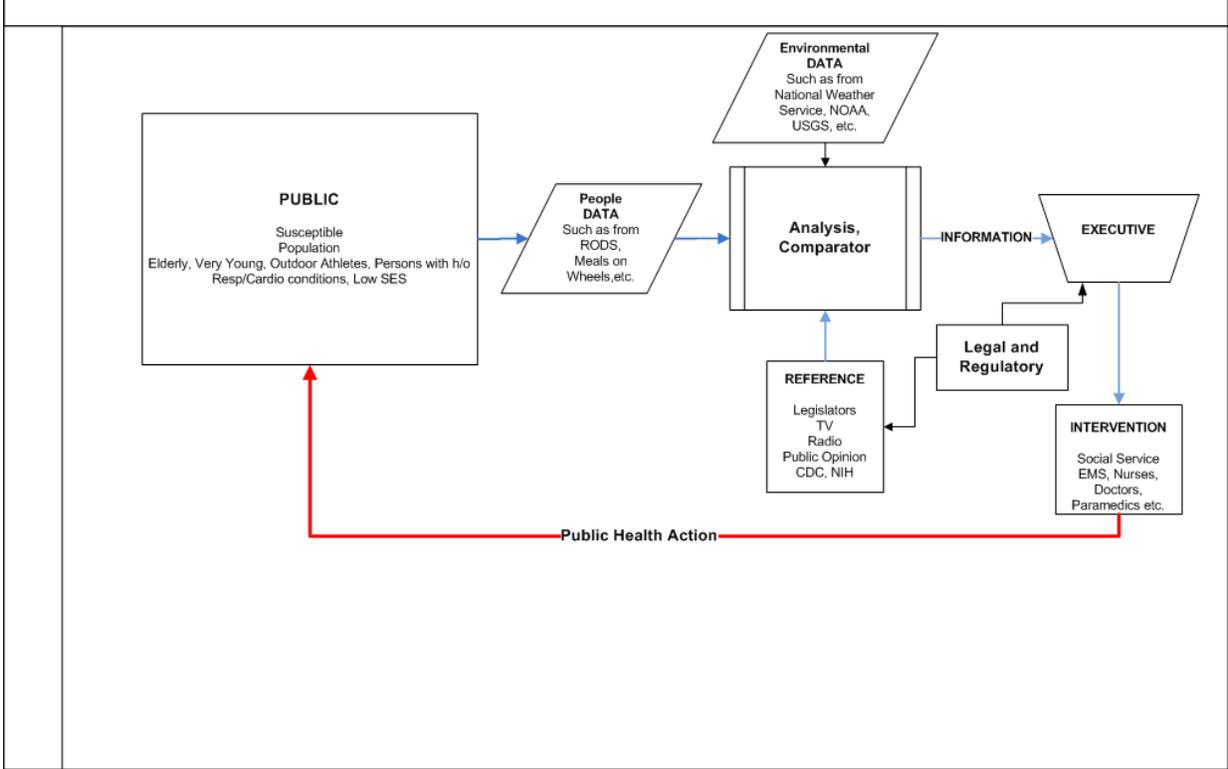
C. Data Bases/ Sources

- i. Real-time Outbreak and Disease Surveillance (RODS) system (i.e., for Emergency Department Data)
- ii. Pennsylvania Health Care Cost Containment Council (PHC4) (i.e., for Inpatient Hospital Admissions Data)
- iii. National Weather Service
- iv. National Oceanic and Atmospheric Administration (NOAA)
- v. United States Geological Survey (USGS)
- vi. U.S. Census
- vii. Pennsylvania Vital Statistics (i.e., for Heat Related Deaths)
- viii. Pennsylvania Department of Environmental Protection (e.g., Forecasting, Monitoring, Ozone, and Heat Monitoring Throughout the State)
- ix. EPA
 - 1. National Emissions Inventory
 - 2. Air Quality System for Monitoring
 - 3. National Air Toxic Assessments (NATA)

II. ENVIRONMENT

- A. Cooling Stations
 - i. Options (e.g., Fans, Air-conditioning)
- B. Transportation (e.g., Free Public Transportation on Ozone Action Days)
- C. Homeless Shelters
- D. Hospitals/Medical Centers/Outpatient Care Centers
- E. Developing the Prototype for Risk Mitigation
 - i. Use of the Internet
 - ii. Fact Sheets
 - iii. Support from PADEP
 - iv. Information Technology Input
 - v. Use of Data Bases
 - 1. Identification of those at Risk
 - 2. Telephone/Addresses/Internet Connections
 - 3. Privacy
 - vi. Funding Sources
 - 1. Federal
 - 2. State
 - 3. Local (e.g., Discounts for the Elderly at Retail Stores for Air-conditioners)
 - vii. Promoting the Solution
 - 1. Communications
 - 2. Marketing
 - 3. Public Relations

SYSTEMS APPROACH TO MANAGE CLIMATE CHANGE HEALTH EFFECTS



ATTACHMENT 2

FLOODING HAZARDS AND MANAGING RISK

I. HEALTH

A. Health Effects

- i. Drowning
 1. Susceptible Population
 - a. Residents Living in Floodway and Floodplain
 - b. Citizens Driving through Flooded Roadways
 - c. Emergency Medical Services Personnel
 - i. Volunteer Firemen
 - d. Emergency Management Personnel
 - ii. Infectious Diseases from Flood Waters
 1. Susceptible Population
 - a. Residents Living in Floodway and Floodplain
 - b. Emergency Medical Services Personnel
 - i. Volunteer Firemen
 - c. Emergency Management Personnel
 - d. Post Flood Assessment Personnel
 2. Increase in vector and water-borne diseases
 - a. Deceased livestock
 - iii. Molds and Fungi Exposures during Recovery Efforts
 1. Susceptible Population
 - a. Residents Living in Floodway and Floodplain
 - b. Construction Contractors
 - iv. Food supply shortages
 - v. Safety
 1. Susceptible Population
 - a. Exposure to downed power lines
 - b. Power outages (critical care facilities)
 - c. Improper use of emergency heating
 - d. Evacuation issues
 - e. Debris injuries

B. Partners

- i. Pennsylvania Department of Environmental Protection
- ii. Pennsylvania Emergency Management Agency
- iii. Pennsylvania Department of Community and Economic Development
- iv. Pennsylvania State Association of Township Supervisors
- v. Pennsylvania State Association of Boroughs
- vi. County Commissioners Association of Pennsylvania
- vii. Pennsylvania Association of Floodplain Managers
- viii. Susquehanna River Basin Commission
- ix. Delaware River Basin Commission
- x. Federal Emergency Management Agency

- xi. National Oceanic and Atmospheric Administration National Weather Service (NWS)
- xii. U.S. Geological Survey (USGS)

C. Databases/Sources

- i. Flood Insurance Policies
- ii. Digital Flood Insurance Rate Maps
- iii. NWS Advanced Hydrologic Prediction Service
- iv. Flood inundation Maps
- v. USGS National Water Information System
- vi. Dams and Levee databases
 - 1. State level
 - 2. Federal level

II. ENVIRONMENT

A. Infrastructure inundation

- i. Power generating facilities
- ii. Rail lines
- iii. Wastewater treatment facilities
- iv. Water treatment facilities

B. Managing Risk

- i. Floodplain Management
 - 1. Municipal Ordinances
- ii. National Flood Insurance Program
- iii. FEMA Hazard Mitigation Grant Program
- iv. FEMA Pre-Disaster Mitigation
- v. FEMA Flood Mitigation Assistance
- vi. FEMA Repetitive Flood Claims
- vii. FEMA Severe Repetitive Loss
- viii. State and County Hazard Mitigation Plans
- ix. Dam and Levee inspections and certifications
- x. Bridge inspections
- xi. Promoting the Solution
 - 1. Public Outreach
 - 2. NWS Turn Around Don't Drive Campaign
 - 3. Communications
 - 4. Marketing

ATTACHMENT 3

DROUGHT HAZARDS AND MANAGING RISK

I. HEALTH

A. Health Effects

- i. Hunger and famine
 1. Susceptible Population
 - a. Very young
 - b. Elderly
 - c. Infirm
 - d. Low-income urban and rural
- ii. Ecosystem change affecting wildlife and fish
 1. Susceptible Population
 - a. Subsistence hunting and fishing
- iii. Disease from Lack of Available Clean Water
 1. Susceptible Population
 - a. Residents with poor public water supplies
 - b. Residents with self-supplied water
 - c. Residents with poor public sanitation
- iv. Wildfires
 1. Susceptible Population
 - a. Commonwealth Residents
- v. Particulate emissions
 1. Susceptible Population
 - a. Residents along dirt and gravel roads
- vi. Vector disease increase
 1. Susceptible Population
 - a. Commonwealth Residents

B. Partners

- i. Pennsylvania Department of Environmental Protection
- ii. Pennsylvania Department of Health
- iii. Pennsylvania Emergency Management Agency
- iv. Pennsylvania Department of Agriculture
- v. Pennsylvania Fish and Boat Commission
- vi. Pennsylvania Game Commission
- vii. County Commissioners Association of Pennsylvania
- viii. Susquehanna River Basin Commission
- ix. Delaware River Basin Commission
- x. Federal Emergency Management Agency
- xi. U.S. Environmental Protection Agency
- xii. Centers for Disease Control and Protection
- xiii. National Oceanic and Atmospheric Administration National Weather Service (NWS)

- xiv. U.S. Geological Survey (USGS)
 - xv. U.S. Natural Resource Conservation Service (NRCS)
 - xvi. Pennsylvania Farm Bureau
 - xvii. USDA Farm Service Agency
 - xviii. Pennsylvania State Nurses Association
 - xix. Other health care providers
 - xx. Public/Municipal Water Suppliers
 - xxi. Private Water Companies
- C. Databases/Sources
- i. National Integrated Drought information System
 - ii. USGS Pennsylvania Drought Condition Monitoring website
 - iii. http://www.cdc.gov/nceh/ehs/Docs/JEH/2009/July-Aug_09_Kalis_Miller.PDF
 - iv. CDC's guidance document: When Every Drop Counts: Protecting Public Health During Drought Conditions—A Guide for Public Health Professionals
 - v. NOAA's Climate Adaptation (From Kim Hoover)

II. ENVIRONMENT

- A. Managing Risk
- i. State and County Emergency Operation Plans
 - ii. Municipal Emergency Operation Plans
 - iii. Water Supplier's Drought Contingency Plans
 - iv. Water Conservation Programs
 - v. Economic Cost/Benefit Assessments
 - vi. Promoting the Solution
 - 1. Public Outreach
 - 2. Communications
 - a. Pennsylvania Drought Task Force
 - b. River Basin Commissions
 - 3. Marketing

APPENDIX E

Acknowledgement for Co-Chairs

The Pennsylvania Department of Environmental Protection would like to acknowledge the dedication and leadership by the co-chairs who volunteered considerable time and attention to leading a combined 16 stakeholder working group meetings. The risks, vulnerabilities, recommendations and strategy outcomes contained in this Pennsylvania Climate Adaptation Planning Report were developed entirely through the stakeholder process. Thank you for your efforts!

Infrastructure

- Danielle Spila, PA Department of Transportation
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- Liz Garland, American Rivers

Natural Resources

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Public Health and Safety

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