CLIMATE CHANGE IN THE DELAWARE ESTUARY
TECHINICAL WORKSHOP
ON IMPACTS & ADAPTATION STRATEGIES
AND
AN EVENING TOWN SQUARE PUBLIC FORUM

May 6, 2008
Academy of Natural Sciences of Philadelphia

DRAFT Meeting Notes

Principle Workshop Goals*:*

1. To develop consensus on the most pressing science and management adaptation needs associated with climate change in the Delaware Estuary

2. To summarize these needs and a course of action for addressing climate change in our region

3. To begin to engage the public in discussing these topics during an evening Town Square meeting

Welcome Remarks – Dr. David Velinsky (Vice-President, Academy of Natural Sciences of Philadelphia)
On behalf of Dr. Brown, Dr. Velinsky welcomed the participants and provided a brief overview of the Academy of Natural Sciences and the natural history museum ANSP is the oldest natural history museum in America. He also highlighted how the Academy can assist in the understanding of climate change through research, collection of data to show climate and land use changes, diatom and other collections that show the impact of environmental changes over time (e.g., changes in phosphorous concentration in the estuary), etc. The Academy disseminates the information gained to resource managers and the public via town meeting forums. Thus, the Academy helps link research, education, and public outreach/involvement.

Opening Comments – Jennifer Adkins (Executive Director, Partnership for the Delaware Estuary)
- Ms. Adkins welcomed everyone and thanked the Academy for partnering with PDE.
- This workshop was developed to begin to develop a better understand of climate change impacts on the Delaware Estuary by providng a forum for stakeholders to come together to discuss what we know, what we don't know, and what we need to do. She then stated the three above goals.
- The coastal areas and estuaries have the most to lose from the effects of climate change.
- She stressed that how we address the reality of climate change today—preventing the worst and adapting to the rest—will shape the face of the Delaware Estuary in the future to come. PDE leads collaborative efforts to protect and enhance the resources of the estuary.
- She informed the audience that the PDE received official notice yesterday from EPA that it has been chosen as one of six national pilots for the EPA Climate Ready Estuary Program. This technical workshop and public forum will provide critical input for this initiative which will not only help the Delaware Estuary, but also other estuaries around the country.

Opening Address – **Dr. Radley Horton** (Columbia University and NASA)
"From Global to Regional: Perspectives on Climate Change"

Introduction and Framework

- To understand the problem, need to look at historical and recent trends and variability.
- To help predict what could possibly happen in the future, need to use global models on a regional scale. However, there are at least two types of uncertainty with models: 1) the amount of future greenhouse gas emissions—from human and natural sources, and 2) the climate system itself and how it responds to a given amount of greenhouse gases. Uncertainties increase when using models on a regional basis because of local variability.
- Extreme events often show the signature of climate change, and we need to identify these events. Even with model predictions, we need to be open to the idea that there are other possible outcomes and unexpected changes. From a risk management perspective, need to consider other scenarios as well as worst case.
- There was a rapid increase in carbon dioxide (~35%), methane, and nitrous oxide around the time of the industrial revolution.
- Historical temperature change reveals year-to-year variability, although the trend shows an increase in temperature over time and a graph of the data shows a steeper and steeper slope as we get closer to the present.
- Global climate models are the best tools we have for predicting future climate changes. Scientific understanding has improved, more observations have been collected to show trends, and computing power has improved. However, major challenges with models remain (e.g., modeling ice sheets).
- Models have been shown to be fairly accurate. When global models were run using increased greenhouse gas concentrations, the model predicted near actual temperature increases—when compared to actual data—versus keeping gas concentrations constant in the model.

Climate Projections

- Models predict the following global changes:
  - Average temperature increase of 3°F to 7°F is expected by 2090. Regional changes could be more significant (e.g., northern hemisphere model prediction of a 10°F increase).
  - Decrease in precipitation in the subtropics and an increase in precipitation in the mid/high latitudes (i.e., farther from equator). The increase in precipitation in the tropics might be offset by evaporation due to higher temperatures. Thus, countries that are most responsible for climate change may not suffer the most impact.
  - Sea level rise of 7 to 23 inches, with virtually no chance of no sea level rise.
  - Increase in extreme events (e.g., more droughts, coastal flooding and intense precipitation events)
- Regional climate change predictions can be done in one of two ways:
  - Simulation – limited domain size using global model
  - Statistical downscale – linking climate projections to type of statistics a region has seen in the past (model is more useful)
- Based on 14 models using 30 years of data (1970-1999), models predict the following for the Mid-Atlantic Region:
  - Increase in average annual temperature—the farther into the future the prediction, the more uncertainty there is in the range of the temperature increase
  - Increase in precipitation, but the amount of the increase is even more variable (i.e., uncertain) than the predicted temperature increase
  - Sea level rise caused by warming of ocean and melting ice
  - Increased storm surge, even if rate of storms does not change (i.e., more intense storms)
  - Increased sea level rise in conjunction with coastal storm surges could have an even greater impact on humans and the environment
  - Small changes in temperature can have a huge impact on extreme temperature events and could result in an order of magnitude increase in coastal flooding events by 2080s

- Daily increase in sea level can impact groundwater intrusion (i.e., groundwater can be contaminated with saltwater as sea level rises).
- Precipitation changes are less certain than temperature changes and coastal flooding.
- Negative and positive feedbacks can result in unexpected changes (e.g., release of greenhouse gases from permafrost as it melts).
- A significant decrease in the Arctic Sea ice extension was observed in September 2005 from the previous 27 years. The decrease was even greater from 2005 to 2007 than the previous 27-year change. The models did not predict this. There is 50% less Arctic Sea ice in 2007 than there was in 1950. In March 2008, there was little change in the ice extension from the long-term average, indicating that the September 2007 observation could possibly be an anomaly or that the variability is limited in late winter. One thing the Arctic ice extent map does not show is the thickness of the ice. The ice is likely to melt this summer because it is so thin. We'll need to watch and see what happens this summer.
- Arctic Sea ice changes can have the following impacts:
  1) Decrease in ice may delay the onset of fall and winter and reduce severity of winter (because the air is warmer because less ice)
  2) Change in temperature gradients and increased storms
  3) Accelerated Greenland ice sheet melting resulting in sea level rise
- As the ice melts, it could be a major source of greenhouse gases in the future.

Impacts

The following impacts are likely to occur as a result of the above described changes due to global warming:

- Potential increased water quantity and decreased quality (e.g., increased precipitation can increase turbidity, salt-water intrusion).
- Rapid changes can impact biodiversity (i.e., plants and animals cannot adapt as fast as the temperature and other changes).
- Timing and amount of snowmelt can impact regional areas (e.g., increased stream flow and earlier peak stream flow).
- Changes in the timing of spring events can disturb ecosystems (e.g., timing of migration and feeding of animals may not change with earlier spring events resulting in an inadequate food supply).
- Infrastructure is at risk from increased flooding.
- More inland flooding is likely due to drainage problems.
- Coastal ecosystems will be compromised the most.

Solutions

The following actions were suggested to help lessen the rate and impact of global warming:

- Use less energy
- Use less carbon-intensive energy sources (e.g., move away from coal)
- Enhance carbon sinks (e.g., forestation, carbon storage technology possibly in the future)
- Encourage technology innovations
- Adapt to the eventual impacts of global warming, but do we want to design and prepare for the mean/average event or the less likely but more dangerous event?
- Climate engineering (not yet technologically feasible)
- Doing nothing is an option

Need to continue to watch the science because there will be surprises in the type and extent of changes and impacts predicted.

Conclusions

- We do not know as much as we think we do.
- Uncertainty does not argue for inaction.
- Long-term planning can lessen negative outcomes and increase positive outcomes of climate change.

- The adaption option could result in a growth industry (e.g., new technologies).

1st Panel Presentations and Discussion

Moderator: Mr. Daniel Soeder *(USGS and PDE)*

- The PDE Science and Technical Advisory Committee (STAC) works with the Estuary Implementation Committee to implement the Comprehensive Conservation Management Plan (CCMP).
- STAC consists of 21 scientists ranging in disciplines (e.g., ecology, biology).

Panel Presentations:

Ms. Amy Shallcros *(DRBC)*

"Water Balance, Freshwater Flow, and Precipitation Associated with Climate Change in the Delaware Estuary Watershed"

- DRBC as established under a United States Supreme Court Decress is the water resources management agency for shared waters of NJ, NY, PA, and DE..
- Facts about the Delaware River Basin:
  - Relied upon by nearly 15 million people (~5% of U.S. population)
  - Drains 0.4 of 1% of the continental U.S. land area
  - Home to a variety of land uses from urban to rural, including the largest freshwater port in the world and a national park
  - Houses a variety of reservoirs for water supply, flow augmentation, hydropower, multi-purpose, and flood loss reduction
- Computer models predict the following regional changes due to global warming:
  - Temperature increase of 3°C to 5°C (for every degree Celsius increase in temperature, the atmosphere's capacity to hold water increases by 7%)
  - There is less confidence in the precipitation and runoff predictions (0 to 20% increase in precipitation and 25% decrease to a 20% increase in runoff)
- Reservoirs in the basin have a 71.4 billion gallon capacity of storage.
- Important to recognize that the reservoirs were designed and built for water storage not for flood control
- Flood control (e.g., spill way size) and drought preparations (e.g., reservoir capacity) are based on past worst events. Planners will need to consider the possibility of more severe events than have occurred in the past.
- The following impacts are expected due to changes in temperature and precipitation:
  - Less snow and earlier onset of spring
  - More frequent heat waves (implication for increase in use of water supply)
  - Higher evapotranspiration
  - Increased seasonality
  - Higher annual stream flow, but more frequent low flows
- There are many uncertainties that need to be considered, including the following:
  - Will increased precipitation offset an increase in water loss due to evapotranspiration?
  - Will there be more days for groundwater recharge when the ground is not frozen and more water can infiltrate?
  - What about changes in vegetative cover? Does more vegetation mean more canopy cover interception of rainfall?
- In the last 6 years there has been more than 71 inches in departure from normal precipitation in some areas of the basin.
- NJ data shows increased average precipitation over time, with greatest increase in the northern part of the state.
- This year there has been a series of really wet and dry spells. Between 2001-2007 we had two of the driest months and five of wettest months on record, plus five of the warmest and five of the second warmest months.

- At the Belvidere Gage, the rainfall deficit was 54 inches below normal for the six-year period between 1961 and 1966, inclusive.
- The changes described are likely to have the following impacts on the water supply:
  - More intense and farther apart events resulting in the need for more flood control and flow augmentation.
  - Evapotranspiration increase (because the atmosphere holds more water when it is warm) will alter the water balance causing less water to infiltrate into ground
  - Loss of snow pack decreases the available "storage"
  - Salinity will result in the need for more advanced water treatment and may jeopardize some intakes due to the increased salt line
- There have been three major floods in recent years in the Delaware Basin. Increased flooding means more potential for debris in the river and backups along structures (e.g., abandoned piers) in the river.
- Resources managers need to balance the competing uses of reservoirs: power supply, water supply, and flood control.

Dr. Michael Craghon (Middle Atlantic Center for Geography & Environmental Studies)
"Sea-level, Salt Marshes, and Coastal Systems"

- Global sea level has risen about 1 inch in the last 10 years, which corresponds to 12 inches per century. Since 1900 sea level has risen 7 inches.
- Global see level is projected to rise 12 to 16 inches in the 21st century.
- Increased sea level is due to thermal expansion (52%), glacier and ice caps (25%), Greenland and Arctic ice sheet (15%), and the remainder unaccounted for (10%).
- Local monthly mean sea level increases:
  - Cape May, NJ 1965-1999 3.8-3.9 mm/yr
  - Lewes, DE ~3 mm/yr
  - Philadelphia 1900-1999 2.75 mm/yr increase
- The global average increase in sea level has been 1.8 mm/yr in the second half of 20th century. During that same time, the Delaware Estuary has seen an increase of 0.5-2.6 mm/yr because the shoreline is subsiding. This will result in 4-8 inches more "sinking" in next 100 years. That means that the Delaware Estuary will see a total of 16-24 inches sea level increase in the next 100 years (12-16 inches global average plus 4-8 inches due to local sinking). That means that the 21st century rate increase will be ~50% greater than 20th century (i.e., present rate plus 2 mm/year).
- Salt marsh geomorphology
  - As water level increases, flooding of the marshes increases. When the floodwaters recedes, sediment remains and increases the height of the marsh.
  - If there was no sea level rise, the marsh would be covered with sediment and no longer exist; therefore, marshes need some sea level rise.
  - On the other hand, if there is no sedimentation, there will be increased flooding and deterioration of the marsh (i.e., land loss). Louisiana has lost land area the size of Delaware.
  - Over time the system generally preserves itself with sediment and sea level rise impacts.
  - For most of the Jersey shore and Delaware Estuary, at the current rate of sea level rise the marshes will be ok, but if the estimated increase of 2mm/yr occurs, a large percentage of marshes will be converted to open water.
- Transgression
  - An alternate way for marshes to exist
  - The entire system moves up slope along with rising sea level
  - Can be blocked by natural (e.g., bluffs, cliffs) and man-made features (e.g., bulk heads, sea walls)
- Although transgression is a way that nature preserves marshes, it can be halted due to "coastal squeeze" (i.e., sea level rise on one side and an impassable barrier on the other side of the marsh).
- The Delaware Estuary has approximately 700 km^2 of wetlands, but only 100 to - 250 km^2 of land that can go through transgression, resulting in a significant loss of salt-water marshes.

- Salt marches need sea level rise to continue to exist, but not too fast because sedimentation cannot keep up with rising water (expected rise in 21st century is too fast)
- Marshes also need sediment from external sources and changes in flood magnitudes could impact sediment delivery to marshes. (Sediment Budgets)
- Marshes have the ability to "migrate" through transgression, but in the Delaware Estuary there is not enough space for transgression to continue for all marshes.
- What can we do
  - Globally, stop making the problem worse (not much that can be done about this locally)
  - Manage and augment sedimentation supply (e.g., artificial sedimentation; decrease shoreline energy to help with erosion)
  - Plan for marsh transgression and remove impediments where possible (e.g., sea walls and dikes).

Dr. Michael Kearney (College of Geography, University of Maryland)
"Assessing the Response of Coastal Marshes to Sea Level Rise at a Coast-wide Scale"

- Chesapeake Bay has had a slow rate of sea level rise (~0.56 mm/yr) over the last 1000 years (due to "Little Ice Age" ending in ~1850s).
- Post 1950s data from Baltimore Tidal Gauge shows evidence of anthropogenic sources increasing sea level 30 cm (1 foot) over the last century.
- Blackwater Marsh has lost about half of its acreage since about 1920.
- Human activities (e.g. diking, ditching, nutrient overgrazing) cause loss of marshes.
- With sea level rise the following occurs resulting in the loss of marsh land:
  - slow vertical accretion (low tidal flushing)
  - plants die back (especially during droughts)
  - build up of nutrients (nitrogen and phosphorus) and low oxygen concentration
  - formation of rotten spots and then small ponds
  - ponds coalescence to big ponds resulting in loss of marshes
- Mapping of marshes not very good in the early 20th century; therefore, it is difficult to determine the exact amount of marsh loss.
- Marsh loss occurs via shore erosion and in the interior areas from coalescing ponds.
- There are wide variations in accretion rates between interior marsh sites and channel/shoreline marsh sites; interior accretion rate is slower.
- Sediment elevation table measurement technique measures short-term accretion. This is not an effective method. Surface material usually rots away by the end of the season.
- Satellite data is remote sensing data (i.e., observation/proxy) that is used in spectral analysis. Vegetation peaks at longer wavelengths at the near infrared as does water. This is solved by the use of spectral indices. As marshes decrease, the spectral band for water increases. The actual site is then field validated. This analysis results in a marsh loss condition map (surface loss, not subsurface). This technique allows us to see changes over time because satellite images are taken regularly (often at least annually).
- By 1999, marsh loss was such that with any slight perturbation, there was a big impact on the marsh.

Dr. David Velinsky (ANS Philadelphia)
"How Will Climate Change Affect Water Quality and Biogeochemical Processes in the Delaware Estuary?"

- There is not much information available on the direct impacts to water quality from global warming.
- The main driving forces impacting water quality in estuaries:
  - Precipitation intensity increase results in more runoff and higher levels of contaminants and nutrients in the estuary.
  - Temperature increases causes harmful algae blooms and other biogeological changes.
  - Sea level increase impacts salt intrusion and marsh degradation (as shown in previous presentations).
  - Salt line could move up the bay by 3 to 30 miles with sea level increase of 0.7 to 2 meters.
- Management of reservoirs is a key issue in salt-water movement up bay; drinking water and other intakes would be impacted.
- Precipitation changes result in impact of non-point source loads.
- Biogeochemical cycling will be impacted. Remineralization rates will change with changes in temperature, which will impact oxygen consumption.
- Air water exchange: PCBs range in volatility. Loss of PCB out of estuary is directed from water to air. An increase in temperature (5°C) will result in 20% more PCBs to air, resulting in more global transport of these compounds throughout the world.
- There has been a 50% decrease in tidal freshwater marsh since the 1970s.
- Carbon and mass balance in tidal marshes: sea level goes up, marsh plants die due to salt water, sedimentation occurs, resulting in salt intrusion upstream to tidal freshwater area.
- As salinity increases with rise in sea level, phosphorous retention decreases resulting in greater remineralization and sulfate reducers increase.
- Future concerns:
  - Climate change will occur in the next 20 to 50 years
  - Salinity intrusion reduces freshwater availability
  - Nutrient contaminant loading will alter water quality
  - Loss of tidal marshes and filtering capacity
- Future directions:
  - Monitor key ecosystem variables (DEWOOS monitoring system)
  - Improve communication and management of water flows among user groups
  - Reduce nutrient and contaminant loading
  - Manage land for marsh migration
  - Adaptive management strategy (i.e., monitor changes, make adjustments/adaption based on observed changes, monitor how these adjustments impact the estuary, and then make additional adjustments as necessary)

Dr. Danielle Kreeger (PDE)
"Climate Change, Watershed Change and Ecological Interactions in the Delaware Estuary"

<u>Effects on biology and ecology</u>

- Even without climate change issues, the Delaware Estuary area is already a complex landscape.
- Disruptions in species and communities will occur as a result of temperature increase, salinity changes, sea level rise, and storm intensity increases.
- As production of carbon dioxide increases, there may be twice the increase in oxygen consumption, which could lead to increasing organic material and anoxic conditions in estuaries.
- Species shift with changes in environmental tolerances, but they do not often shift as coherent assemblages (i.e., some species may change and adapt to new conditions, whereas some species in the same original ecosystem may not, or not at the same rate as others). One impact of this is a greater opportunity for invasive species to get a foothold in new areas.
- Even without climate change impacts, marshes are not necessarily in good shape as it is—most are already in some form of degraded condition. We have to contemplate whether we should spend

resources on maintaining the conditions of current marshes rather than building more marshes, even though only less than 5% of pre-settlement era marshes remain.
- Recent outbreaks of marsh dieback—brown areas near the middle of the marsh—occur at mostly interior lower elevations. This raises the question of if/how mosquito ditches deprive the interior of sediment and also how will sea level rise interact with other management practices?

Take Home Points
Disruption – species and community effects
Disconnects – decoupling of ecological interactions
Thresholds – non-linear biological responses
Synergisms – climate change interacting with watershed change
Change Happens – Change is a natural process and we cannot stop it. It is the rate of change that is of concern and how we can deal with these changes.

Disconnects
- What if horseshoe crabs started spawning earlier, will shorebirds, which rely on the crabs for food—know and be able to adjust their migration schedules?

Thresholds
- The stepwise linear increases that we see in sea level rise and temperature may have non-linear biological responses (abrupt vs. smooth changes). For example, species extinction is abrupt.
- Extreme events can push many animals past their limits (i.e., abrupt response).
- Even if we reduce other stressors—because we know we cannot stop climate change—ecosystems will not return to their previous (pre-stressed) state (i.e., true restoration is not possible).
- Oysters (and other shellfish) provide filtration. The shellfish population is declining. Shellfish revitalization programs are underway, but the increasing salinity caused by climate change increases the rate of disease. There are two diseases that are more virulent in higher salinity, and even just a 2 parts per thousand increase could result in significant oyster loss, even past the "point of no return."
- Longer growing season (as a result of climate change) may help oysters grow quick enough to withstand disease pressure, if we can keep them from going past point of no return (due to other pressures). Also, if there is no winter kill (as a result of increased temperature), the oysters have a better chance to survive.

Synergisms – climate change interacting with watershed change
- Not sure how the combination of climate change—resulting in sea level, salinity, temperature, and sediment changes—and land use changes—channel deepening and freshwater inflow–impact marsh ecosystem biological communities.

What can we do?
- Build resiliency (e.g., build buffer lands)
- Restore and enhance, but do so smartly (e.g., regional coordination), keeping in mind that complete restoration may not be possible. Therefore, the focus should be on functional services that estuary provides.
- Monitor and study
- Work to slow climate change
- Develop an understanding of the consequences we have discussed: disruptions, disconnects, and thresholds
- Consider climate change and other changes together (not separate from each other)
- Accept that change will occur because restoring to past conditions may not be possible
- Work together to solve the problem

Panel Discussion of Challenge Questions

Q. If dredging goes to 45 feet, tidal amplitude will go up 9 feet which could be a threshold event that will drown freshwater marshes. Are there any comments on how dredging in marshes will effect the estuary?

A. Dr. Kreeeger: STAC is focusing on this issue. Increased deeper channels may increase sediment removal, but impacts as a result of dredging are not well understood, and we need more studies.

Q. To what extent is data being shared among organizations and can you envision a better system?

A. Mr. Soeder: We recognize the need to share data. There are many data collection efforts going on in the estuary. Sharing data is an issue because data collection is being done independently of the estuary program by different organizations. It is difficult to use other's data to meet the program's needs because these studies are done with their own objectives in mind and data is collected differently. We are working toward coming up with one common database/data warehouse. We have spoken with DuPont to see what data they have available from their site-specific monitoring.

A. Dr. Kreeger. Different states and different reporting requirements for each state contribute to data comparability, sharing, quality, and format issues. Last year the Delaware Estuary Bay was selected as one of three national pilots looking at data gaps and data needs to potentially link up watershed monitoring to ocean observing programs (e.g., NOAA, USGS). A report was prepared on a national integrated reporting system, but because the project was not funded, it was only a paper exercise. Hopefully, there will be funding in the future to move to the demonstration phase.

Challenge Question #1: **What information gaps or key questions remain regarding the expected environmental consequences of climate change in the Delaware Estuary and its watershed? [What do we need to know].**

Ms. Amy Shallcros

- Need tools to collect and analyze the data.

Dr. Michael Kearney

- Need better decision support system—something that helps decision makers reach decisions that benefit the environment.
- Need to know more about thresholds because some systems could change overnight resulting in an irretrievable loss.

Dr. David Velinsky

- Need monitoring to monitor change

Dr. Danielle Kreeger

- Need to know what are the synergisms? What are the impacts of climate change layered on top of other changes?
- There is no coordinated wetland monitoring and assessment activities among states. Get monitoring assessment work underway to think about where we might be able to make a difference to help marshes.

Challenge Question #2: **What are our options and what actions are suggested to adapt and/or mitigate for the environmental effects of climate change in the Delaware Estuary and its watershed?**

Dr. Michael Craghon

- In habitat restoration there are institutional problems that need to be overcome. Permitting is the biggest problem because it costs a lot of money to hire engineers to do studies required for permits. Need to lessen bureaucratic hurdle for environmentally beneficial projects.

- The public does not understand what sea level rise means. Need to incorporate sea level rise into infrastructure designs (e.g., bridges). Need to make problems relevant and what 4 mm/year increase means to quality of life and infrastructure (e.g., increased road flooding in 20 years).

Dr. Michael Kearney
- Need coordinated effort among states.
- Focus on smaller projects to maintain the marshes we have. USACE only interested in big scale restoration. Smaller projects may be necessary to maintain what we now have. Big projects often do not get done because they are expensive.
- Need to explain rates and impacts to the public, resource planners, and politicians. Make it accessible and understandable to public, and communicate why it is important.

Dr. David Velinsky
- Get information out to the public, resource managers, and politicians.

Dr. Danielle Kreeger
- Echoed Dr. Craghon's thoughts on permitting.
- Need to focus on regional restoration coordination and look at this issue on a watershed scale. Need to maximize natural capital and maintain essential functions from headwater to bay. Need to answer the question of what types of habitats at watershed level are the most important to sustain watersheds and estuaries.
- Need more advocacy. May need to accentuate the reality and focus on fear to motivate people.

2nd Panel Presentations and Discussion

Moderator: Carol Collier (DRBC)
- Need to look at uncertainty, and not just data. Previous events may not be indicative of future events.
- We might be able to make a difference if do a better job at land management, but there are a lot of things we cannot control (e.g., migratory patterns).

Panel Presentations:

Mr. Howard Neukrug (Philadelphia Water Department)
"Clean Water…Green City"

<u>Philadelphia Water Department (PWD)</u>
- The City of Philadelphia is taking climate change seriously through a number of initiatives..
- Looking into clean water and a green city
- Linking issues that are land based and those that are water based and then linking to infrastructure issues
- Changing into a green utility includes: adaptation, mitigation, and sustainability.
- Operating drinking water and wastewater treatment plants that will be impacted by climate change, including treatment (e.g., as a result of saltwater intrusion) and discharge (e.g., capping of methane gas) impacts

<u>PWD Concerns</u>
- Old infrastructure on top of increased precipitation likely to cause increased flooding and other issues
- Intrusion of salt water into water supply and other water quality concerns
- Other issues include flooding, water management, water quality, and drought
- Regional environmental quality is very important. Need to sustain aquatic life in an already stressed ecosystem, on top of climate change issues.
- Sea level rise issues – 10-23 inch increase projected

Mitigation

How the PWD is reducing its greenhouse gas emissions:

- Using biogas emissions at the facility or selling to the power utility
- Installing solar panels on the vast property owned by the utility
- Using microturbine technology. In places where there is more water pressure than is needed, using turbine generator to reduce pressure and produce energy.
- Purchasing renewable energy (e.g., using wind energy to supply PWD energy needs and having wind turbines at PWD facilities)

Adaptation

- Offset Storm intensity
  - Street greening program – water captured and used instead of being treated
  - Storm water parks and wetlands – storm water directed to a wetland for filtration instead of being sent to a WWTP
  - Riparian buffers and open space – relationship between land planning and water management
  - Captured and infiltration systems – capture storm water from the roof into underground infiltration bed or use porous pavement
  - Educate homeowners and business (e.g., green roofs and other small projects)
- Reduce Heat Island Effect
  - Green roofs
  - Bio-retention and rain gardens (other benefits include infiltration as well as enhanced aesthetics)
  - Storm water management and architecture – use unusual techniques to capture water

How PWD is Increasing Sustainability

- Creating wetland parks
- Using porous pavement
- Waterfront planning
- Already achieved Local Action Program Goal of reducing emissions by 10% below 1990 levels. Original goal was supposed to be met by 2010.

Mr. Robert Graff (Delaware Valley Regional Planning Commission – DVRPC)
"Regional Planning Impacts"

- The DVRPC is a federally designated metropolitan planning organization for the nine county Philadelphia region. It is mostly focused on transportation, which entails other planning for the region.
- There are approximately 5.5 million residents in the region, and the population has sprawled, land development occurring at five times the rate of population growth. This has resulted in a vehicle miles driven increase of 60%, while population increased 5% in last 20 years (1980-2000).
- Greenhouse gas emissions in NY and PA are about equally distributed among transportation, electricity production, and the residential/commercial community.
- 3 Keys to Mitigation:
  - Reduce demand for services that use energy – i.e., use less energy (e.g., drive less and heat less)
  - Increase efficiency of those things that need/use energy
  - Use less carbon energy (i.e., use cleaner energy)
- There is lots of activity at the municipal and county level to address climate change, but it is not well coordinated among municipalities.
- DVRPC is conducting an inventory of regional greenhouse gases as part of a pilot for EPA to develop methodologies at the regional level.
- DVRPC is integrating climate change considerations into long range plans (including brownfields development, ozone reduction activities, and transportation improvement programs) as well as

including climate change impacts into new projects (e.g., open space projects, bridges, Transportation Improvement Projects).

- A DVRPC 2004 climate change report focused on climate change impacts on wetlands, salinity, hazard waste sites, public access sites (e.g., parks), and water quality.
- Current regulations protect wetlands from human interference but not from sea level rise. Sea level rise will cause loss of wetlands on vacant land (because sea level will rise faster than sedimentation deposits) and on land where we have built structures. Waterfront revitalization and parks on waterfronts can reduce help reduce the impact.
- Sea level rise will increase salinity upstream and it will be difficult to protect water intakes from salinity.
- Many hazardous waste sites, Superfund sites, and solid waste landfills are located on land that will be inundated with water when sea level rises, thus potentially releasing toxics into the estuary. These sites need to be cleaned up before sea level rise occurs, and future placement of these types of sites should be in locations that will not be impacted by sea level rise.
- A 2008 transportation study by the Transportation Research Board noted several impacts of climate change on transportation:
  - The increase in air temperature will make it more difficult to fly airplanes, resulting in the need for longer runways, lighter loads, and more nighttime takeoffs.
  - An ice-free NW passage may impact ports and the accompanying sea level rise will impact bridge clearances and inundation of roads; plus there will be increased travel disruption due to increased precipitation.
  - There will be more frequent hurricanes resulting in many of the same transportation impacts that were seen in New Orleans.
- Key Lessons
  - Historical data is no longer useful for predictions or future planning purposes (e.g., storm capacity, what to plant in open space).
  - There are issues with lifecycle analysis of bio\low carbon fuels.
- Challenges
  - Politics is not very good at dealing with future problems (vs. current ones) or causes vs. symptoms.
  - Mitigation (reducing greenhouse gases) is altruistic (i.e., the benefits are shared globally), whereas adaptation is selfish because the benefits are captured locally. It is actually a blessing that gas prices have risen because it makes the altruistic reduction of fuel use (releasing greenhouse gases) more selfish and likely to occur.
- Hope
  - Carbon dioxide decrease is a co-benefit of other planning activities (e.g., getting jobs and workers near each other, use of non-motorized vehicles, car sharing).
  - Climate change action plans produce other benefits such as economic and social development planning.

Dr. Andrew E. Huemmler (University of Pennsylvania)
"Emerging Policy and Technical Solutions"

- This presentation focuses on mitigation rather than impact or adaption. Dr. Huemmler suggested that rather than focusing on adapting to the impacts of climate change, that we think about adapting to the impacts of the proposed mitigation activities.
- Originally the issue was called global warming, then it was called climate change, and now it is referred to as catastrophic climate disruption.
- There are three solutions to climate change: mitigate, adapt, or suffer.
- Basic concept is to reduce greenhouse gases to mitigate climate change. As temperature change increases, the impacts increase. For example, at a 2°C increase, there will be a rise in storm intensity; whereas, at a 4°C to 5°C change, we will see a rise in sea level that could threaten major cities. Therefore, most of policy to date has been developed based on this 2°C increase.

- To avoid the extreme impacts from a higher temperature increase, we need to stabilize carbon dioxide in the atmosphere. Based on the predicted temperature rise as a result of carbon dioxide concentration in the atmosphere, a goal of 450 ppm of carbon dioxide in the atmosphere by 2035 has been chosen.
- To achieve the 450 ppm concentration, we need to shift from a business as usual carbon path to a reduction of 80% by 2050.
- The cost estimates of global warming range from a reduction in GDP of 1% to 20% depending on the amount of temperature increase.
- The Stern Review (2006) estimated that to stabilize climate at manageable levels would cost 1% of GDP. This would result in a concentration of 500 to 550 ppm carbon dioxide. To stabilize carbon dioxide levels at 450 ppm, it would probably take 2% of GDP.
- Economic stimulus package of 2008 is about a 1% GDP effort, indicating that policy changes of this magnitude are possible.
- Stern used a discount rate of 0.1%. Typical discount rates are 3% to 5% per year. With typical discount rates, actions taken today that will have benefits in 100 years are accord almost no current value. Stern thinks that our grandchildren are just as important as we are now, so we should not use typical discount rates. This is a strong case for spending money now.
- The Stern report concludes that we need to adopt a global price for putting carbon into the atmosphere and a need for a technology policy.
- Current debate is going on in Washington regarding Cap & Trade vs. a Carbon Tax. With a carbon tax, we would be able to collect from a few upstream producers, but we would need to pick the correct price – not an easy thing to do – to see the desired amount of emission reduction.
- Cap and Trade has been implemented by the European Union for several years and can be used as a template. It has also been adopted by many states, and a federal policy is likely in the future because all of the current presidential candidates are in favor of it. Current bills would cap the amount of carbon dioxide in atmosphere and ramp down over time.
- *Liberman and Warner Bill* (Oct 2007) would cap 75% of total emissions, focus on big emitters (e.g., fuel producers, transportation sector), with an initial decline of 15% then 70% by 2050.
- Those who could cost effectively reduce their emissions would sell their allowance to those who could not. There is a huge debate on how to allocate allowances (e.g., grandfather, allocate, sell) and who should get the allowances. Additionally, if carbon prices get too high, will that have negative impact on the economy?
- The Princeton Mitigation Initiative has identified eight technical stabilization strategies using current technologies:
  - Efficiency – double the efficiency of cars; produce electricity cheaper, insulate your attic
  - Biofuels – increase use by 30% (this would require that we plant an area the size of India with biofuel crops)
  - Natural sinks – would require that we plant new forests the size of the Continental U.S.
  - Solar energy – need 700 times as much solar power as what we have today
  - Wind – need 30 times as much wind power as we have today
  - Fuel switching – substitute 1400 natural gas plants for an equal number of coal facilities
  - Carbon capture and storage (capture and inject into saline aquifers)
  - Nuclear power – need triple the worlds current number of facilities

The above would need to be done quickly, and there is even more needed in carbon intense areas (1400 times more solar power, 60 times more wind; and 6 times more nuclear facilities).

Robert Haddad (DARRP, NOAA)

"Adaptive Strategies to Climate Change: Predictive Response and Restoration!?"

- Accomplishments in Delaware include more than 500 acres of restoration.
- "Adaption to climate change is now inevitable…The only question is will it be by plan or chaos?"
- Adaptation web links provided in presentation
- What about?
  - Erosion and remobilization of contaminants

  - Increased risk of spills – pipeline infrastructure, shoreline infrastructure, well-heads, arctic shipping lanes
  - Changes in estuarine circulation and contaminant fate and transport
  - Changes in bioavailability of contaminants (e.g., metals)
- Predictive response and restoration
  - Assess/Evaluate potential "at risk" industrial infrastructure and hazardous waste sites
  - Work with partners to develop adaptive response
  - Develop appropriate adaptive strategies for future restoration
- Watershed database and mapping project used for predictive response and restoration
- Look at what happened in Louisiana after Katrina to see what could potentially happen here (e.g., oil spills and other hazardous material releases, containment area flooding). Secondary/cascading effects of oil and hazardous substance releases include impacts on recreational, ecological, and commercial activities (e.g., traffic closures, fishing bans).
- Potential approaches to the problem:
  - Re-analyze sea level changes in face of infrastructure and future restoration (e.g., understand how sea levels might change and what type of restoration we might want to use)
  - Couple potential ecological changes with increased risk of spills and contamination
  - Develop tools to better identify risks and improve predictions
  - Develop ways to conduct risk and vulnerability assessments
  - Work with industry to develop a risk evaluation that would lead to a decision tree for potential and necessary actions
- Challenges
  - Incorporate predictive impacts into regional and facility-specific contingency plans
  - Incorporate vulnerability assessments into on going and future restoration plans
  - Promote habitat restoration that mitigate climate change
  - Identify and overcome institutional barriers (e.g., as a result of the many state and municipalities in the region)
- A series of restoration and adaptation examples from the U.S., Canada, Europe, and developing countries

What is the one/first thing you would do?

- Change laws related to electricity pricing. Currently, as customers use more electricity, the per unit rate decreases. This needs to be changed so that as usage increases, so does unit cost.
- See Princeton mitigation stabilization wedges in Huemmler presentation: increase renewable fuels (e.g., wind, solar); sequester carbon; and look at new sites for major power plants (but not on wetlands).
- Obtain national (and beyond) political support. Currently, there really can only be regional adaptation changes because there is no national political will to make global changes. Because the cause of the warming is global, locally we cannot do much about mitigation.
- Create a national energy policy, because there is only so much we can do locally and regionally.
- Work on how we communicate issues and ideas to each other and to the public. Need to figure out a way to bring together all the things we have been discussing today (e.g., water resource programs, sustainability programs, climate change programs).

Are there things we can be doing on a municipal/county/state level?

- Conduct a regional and municipality level inventory of greenhouse gas emission.
- Track and manage municipality energy use better (rather than just "pay the bills").
- Initiate and encourage local projects: solar panels on houses, high efficiency heating equipment, car share, etc.
- Keep the local legislature informed that the municipalities are interested in relevant climate change legislation at the state and national level.
- See the City of Philadelphia Local Action Plan for climate change for examples.

- More communication and education at the entire watershed/basin level. If sea level rises, need to have more water stored upstream to keep fresh water flowing down the Delaware to keep salt water out of intakes. How do we keep fresh water in the upper basin to serve down stream?
  - Reduce water demand so more water remains in the river
  - Develop ways to intercept severe events to store excess water for future use (e.g., dry dams)

Comment/Question: How big should our economy be to address or be able to adapt to climate change?
Response: Need to spend 1 to 2% of GDP and make some of these investments/changes to afford us time to answer that question. The economy can grow in a sustainable way. To solve these problems need to have a healthy and growing economy in a traditional sense to get to some of the more expensive solutions we may need.
Response: Economy needs significantly less carbon per capita use and less resource withdrawal per capita.
Response: The problem is a lot larger than the U.S. economy. How does the U.S. turn around and grab leadership in addressing this issue? Need to take a larger look at the global economy

Comment/Question: What is the acronym for the institute that helps local municipalities?
Response: ICLEI – International Counsel for Local Environmental Initiatives

Comment/Question: Is there promise in markets established around natural capital (e.g., offering incentives for restoration and preservation)?
Response: Make sure that cap and trade is implemented at the federal level. For markets to work and entrepreneurs to step in, need aggressive cap and trade system with no backsliding.
Response: Natural resource restoration is one area that can be used as an example.
Response: One mechanism would be to make investments in developing countries (keeping land as it is) for carbon offset.

Comment/Question: What is the dust bowl analogy for climate change (dust bowl days of the 1930s resulted in the creation of the soil conservation agency)?
Response: High energy prices – peoples' actions change more in response to $4.50/gal gas than they do to a 450 ppm atmospheric concentration of carbon dioxide. Environmental issues can be solved using economic drivers (e.g. fuel costs).
Response: Not sure that there is an impending threat out there that will wake us up. What will change our thinking is our realization of the current economic situation. Need to wake up to the fact that we are missing an opportunity to change our economy with energy efficient investments.
Response: Need to bring home the external costs of our lifestyle (e.g., climate change as a result of carbon monoxide emissions from fossil fuels). Once companies have to pay for those external costs, they will pass that along to the consumer, which will initiate more of the changes we have discussed.

Comment/Question: What is the best role for the partnership to play in turning the tide and addressing some of these issues?
Response: Integrating disparate and diverse voices and keeping the goal of watershed restoration/area impacts in mind, rather than individual objectives.
Response: Help determine where additional sustainable energy sources can be developed (e.g., where to locate solar panels, wind turbines).
Response: Take on advocacy role for the estuary and be the primary spokesperson for these issues, and look at solutions (water based or land based).
Response: Remain engaged in ongoing and upcoming regional and multi-state initiatives.
Response: Coordinate input and put forth funding needs/priorities to legislature.

Town Square
The purpose of the Town Square session is to educate the public and bring together experts to try and explain how climate change will impact us as individuals.

Panel Presentation and Discussion

Jennifer Adkins – Moderator

Keynote Speaker – Dr. Lovejoy (*Climate Change: Prospects for Nature*)
Introduction
- In 1859 Dr. Arrhenius asked why the earth had a habitable climate. He was the first to put forth the idea of the greenhouse effect. His temperature predictions come out nearly the same as new supercomputer models. This is not new science, we just have a deeper and more complex understanding.
- For the first 100 thousand years there is nothing but abrupt climate change. In the last 10,000 years there has been an unusual period of stability. This encompasses the time frame of all human recorded history and the origin of human settlement. The entire human enterprise is based on a stable climate, which is not a safe assumption. Biodiversity and ecosystems are also used to a stable climate.

Responses in natural world to climate change
- Lakes freezing later; glaciers retreating; tropical glaciers retreating and will be gone in 10 years. Biggest change is in ice and water at north pole over the arctic ocean (in 2015 the arctic could be ice free in the summer)
- Increased seismic activity due to increased melting that lubricates glaciers and gets them moving
- Sea rising because as water warms it expands
- Probable increased frequency of tropical storms
- Increase in wildfires in western U.S. because of warmer, longer summers
- Flowering plants changing lifecycle (e.g., blooming earlier)
- Animals also changing (e.g., migrating earlier)
- Species changing where they live (e.g., butterflies moving northward in distribution in U.S.)
- National Arbor Day Foundation issued revised hardiness zone map due to climate change (for planting tree species)
- It has gone beyond individual anecdotal examples, now it is statistically robust that plant, fish, and other species are changing where they live (e.g., southern boundary of eelgrass marching northward year after year).
- The altitude at which clouds form has been moving up resulting in an increasing number of dry days in cloud forests in the tropics.
- Predation of one species by another that is moving into once uninhabited territory
- Change in coral wreaths, which are very sensitive to change in temperature, results in bleaching events and decrease in aquatic wildlife.
- Arctic cod only exist under ice. As the edge of ice retreats from land, nesting seabirds cannot fly to their food source at the edge of the ice.

What does it all look like looking ahead?
- A doubling of the pre-industrial carbon dioxide atmospheric concentration results in a 20% extinction of species (e.g., five computer models predict virtually no sugar maple).
- American Ash is being negatively impacted due to one more breeding season of a “bug” that harms the tree species.
- Hawaiian honeycreepers only live in the upper areas of the Hawaiian Islands due to increased mosquitoes carrying malaria.
- Species in high altitudes will be very vulnerable as will those along the coast and low-lying islands because they will have nowhere to go.
- There is a b leak outlook for tropical coral wreaths.

- Some species may decline in some areas and expand in others.
- Climate change is not new. The big difference is that we live in landscapes that have been modified by human activity (i.e., obstacle courses for plant and animal species).
- Species do not move together in response to climate change. Individual species will move in their own direction at their own rate and the current ecosystems will disassemble into ecosystems that are hard for us to imagine.
- Coniferous forests are dying because the native pine bark beetle is able to get in one generation more (result in fire and timber management problem).
- Increased acidity (30% more acid) in the world's oceans is caused by sheer increase in concentration of carbon dioxide, which changes into carbonic acid. The increased acidity impacts shell development of aquatic species.

What can be done?
- Revise conservation strategies
- Limit greenhouse gas concentrations
- There is no single energy solution. Multiple things need to be done in conjunction.
- Minimize stressors that will be exacerbated by climate change
- Downscale climate projections (i.e., analyze and determine kilometer by kilometer changes)
- Tropical deforestation causes one of every five molecules released to atmosphere; therefore, need to curb this activity.

Conclusion
- Climate change is much more urgent than people understand.
- The earth's climate has already increased ¾ of degree since pre-industrial times, and even if we cease all greenhouse gas emissions immediately, we still will have an increase of at least another ¾ degree because of the greenhouse gases already in the atmosphere.
- Coming to grips with the issue means learning how the issue impacts us locally.

Ms. Collier – summary of earlier sessions
- The impacts of climate change include an increase in temperature, precipitation, and sea level. The sea level rise is expected to be more significant in the Delaware Estuary area because we of the compound issue of land subsidence, resulting in an overall 16 to 24 inch increase in sea level rise (2 feet).
- Impacts
  - Water quality—may not be able to meet current standards we have set.
  - Water quantity supply and flood mitigation will be impacted.
    - Sea level rise will mean we need more fresh water from reservoirs to keep the salt line down.
    - There will be more flood events; therefore, we will need more flood control.
    - Loss of snow pack, which helps recharge reservoirs, will result in extended droughts.
    - Increased infrastructure flooding (e.g., WWTP often located at lowest point) will occur.
  - Exceedance of thresholds—all of a sudden we will be a at a tipping point, but we do not know where those tipping points are.
  - Eco-system services
    - Increased wildfires
    - Increased invasive species
- Change in flora and fauna due to decoupling of symbiotic relationships Tidal marshes are the "kidneys of the ecosystem" and they need some sea level rise to exist (due to sedimentation). However, the current rise in sea level may be too fast for marshes to survive.
- Wetlands naturally march inland, but our infrastructure gets in the way.
- Even a 2 mm/year increase in sea level will result in significant land loss.
- Marsh die back may be caused by legacy mosquito ditching practices because it may result in a lack of sediment that marshes need to survive.

Needs
- More comprehensive and real-time monitoring
- Look at impact of dredging
- Do we need to build more reservoirs or can we use storm water infiltration (e.g., porous surface), quarries, etc?
- Need a faster, easier way to obtain permits for environmentally friendly projects.

Solutions
- Mitigation – reduce greenhouse gases
- Adaptation
  - Prioritize those wetlands that can best be mitigated
  - Think about where we live. Think about 100-year flood with changes in sea level rise
  - How are we going to make sure we have enough water
  - Find out Local environmental and carbon footprint to find out how to reduce energy uses and impact
- Adaptation to climate change is inevitable, but will it be by plan or chaos (quoted)?
- We can be ready to adapt to climate change even though we cannot prevent it.

Mr. Seymour *Regional Climate Change Action*
- Hundreds of cities and communities around the country are addressing global issue in the structure of local politics by taking steps to address climate change. By themselves they will not result in big change to the problem, but it will put pressure on the federal government for change.
- Even if we cannot impact changes in the Amazon Forest, we can impact things locally. Local planning activities (e.g., environmental, transportation, population, employment, air quality) can impact climate change.
- The rate of land development increased five times the population growth during the last 70 years. The mass movement of people from cities to suburbs from the 1970s to 2000s has resulted in heavy dependence on cars (25% growth in cars and 50% increase in miles traveled).
- Local responses include:
  - Pennsylvania is transitioning from coal.
  - NJ adopted an 80% reduction in greenhouse gas levels by 2050 from 2006 levels.
  - City of Philadelphia has developed a local action plan for climate change.
  - Montgomery County, PA has adopted greenhouse gas reduction goals.
  - Other climate change efforts in the region include local government and other organization clean energy initiatives as well as training for green collar jobs.
- 2004 Report (impact of 1 meter rise in sea level on region)
  - When initially released report, had a hard time getting anyone to listen
  - Now the issue has gained public support
- 2006 "Post Global" economic development strategy
  - Need to move away from oil and change energy regime. Hopefully this will create a hook to get attention from leaders and public.
- Other efforts: Conferences to educate, inventory of eco industries, inventory of greenhouse gas emissions (to measure impact and progress), forum for developers talking about barriers and opportunities for green buildings
- Working on action plan for mitigation
- The climate of eastern Pennsylvania will feel like Georgia or Florida under the high greenhouse gas emission scenario.
- Greenhouse gas inventory underway:
  - Can use at regional, local, and state level
  - Will help us jump toward action and understanding options
  - Have engaged stakeholders (e.g., business, elected officials)
  - Will integrate work into DVRPC planning activities as well as planning at other levels (business, local, state, regional). Climate change needs to be factored into every decision.

- Sound planning also impacts climate change (e.g., building communities near where people work and live to decrease driving, smarter land development—clustering, preserving habitats and natural corridors).

Facilitated Discussion with Audience

Comment/Question: Is it too late to turn back from global warming?
Response: The climate has already changed and will change more even if we cease to emit greenhouse gases today. Although there are some ways to sequester carbon dioxide to get it out of atmosphere, we are stuck with a certain amount of increase in temperature, but there are things we can do.

Comment/Question: When is the federal government going to do something (e.g., subsidies for low-emission vehicles).
Response: The good news is that in advance of the federal government doing much, there are major moves being made by regions (e.g., New England, CA, Chicago). The issue is also being championed by corporate leadership and corporations are bringing their weight to bare on the issue. Additionally, each candidate has a policy to address the issue.
Response: Opportunities for business will also help.

Comment/Question: Is exhaustion of oil fields a better prod for action than talking about global warming, which doesn't seem to affect people personally.
Response: Understanding local and economic impacts will help people champion the issue. Fuel choice may be driven by economics but will have impact on climate change issues.

Comment/Question: Heat is the greatest of all natural disasters in the Philadelphia area (e.g., heat waves). In a bad year, there are 115 deaths from excess heat. Climate change has a direct impact on heat events, which has direct impact on the health of residents. There are more deaths each year from heat than cold in Philadelphia. Codes have been revised to require cooling mechanisms in structures in Philadelphia.
Response: Climate change does increase frequency of extreme events. Seemingly small changes have significant impacts.

Comment/Question: What mitigation ideas do you have for the general public and organizations to modify their behavior towards sustainable living and to improve water quality?
Response: Provide municipalities with information to encourage them to do their carbon footprint. Individuals can reduce water demand, and think about their lifestyle (e.g., live close to work).
Response: There is a need for monitoring, but there is limited funding. Need to get the public involved in monitoring to gather data to see if we are reaching any of the thresholds we discussed earlier.
Response: The earlier you see change coming, the better. The more the public knows and sees the changes, the more involved they will be.

Comment/Question: Technology changes may still allow us to rely on cars (e.g., electric cars), but this will not change our behavior (e.g., moving closer to where we work).
Response: Technology will emerge because it will be profitable. Economic pressures will be a motivation for behavior changes (e.g., increase in fuel results in decreased in driving).

Comment/Question: Those that contribute the least to greenhouse gases and global warming seem to be impacted the most (locally – poor and elderly – and globally). What is being looked at as far as impacts on particular populations and what can we do about that?
Response: This country as a whole is in a better position to look at and react to the issues.

Response: There is already a large mobilization to help Africa. If we chose to ignore the issue elsewhere, it would come back to bite us (e.g., environmental refugees would decrease world stability).

Response: The Philadelphia Global Water Initiative encourages water officials in Philadelphia to look beyond this region and help those in other regions. DRBC is concerned about hazardous waste sites on the shore, which are often situated in low-income areas. DRBC is working with EPA Region 2 and 3 to prioritize these sites and clean those up that are on the river.