

Climate Change, Global Warming and Ocean Levels



Climate Change, Global Warming and Ocean Levels in Hampton Roads

Global warming is too serious for the world any longer to ignore its danger or split into opposing factions on it.

—Tony Blair, Prime Minister of Great Britain, 1997-2007

Hampton Roads could be a very different place for our great-grandchildren to live, if predictions by reputable scientists concerning global warming and rising sea levels come true. In a nutshell, here's what might happen: Large amounts of prime beach and waterfront property will sink underwater; our tunnels will periodically fill with water; our port facilities will incur huge costs in order to continue operating; many residential and commercial properties will become uninsurable; and certain wildlife and fauna will disappear.

Global Warming

Few reputable scientists argue against the proposition that the Earth has been getting warmer, though not all agree why the warming has been occurring. Even so, average global temperatures have been rising for at least 50 years. Graph 1 illustrates this trend.

The average rise in sea levels worldwide has been about 8 inches per century, or about 2 millimeters per year. Graph 2, which depicts average sea-level measurements from 23 long tide gauges in locations around the world that have been geologically stable, illustrates this trend.

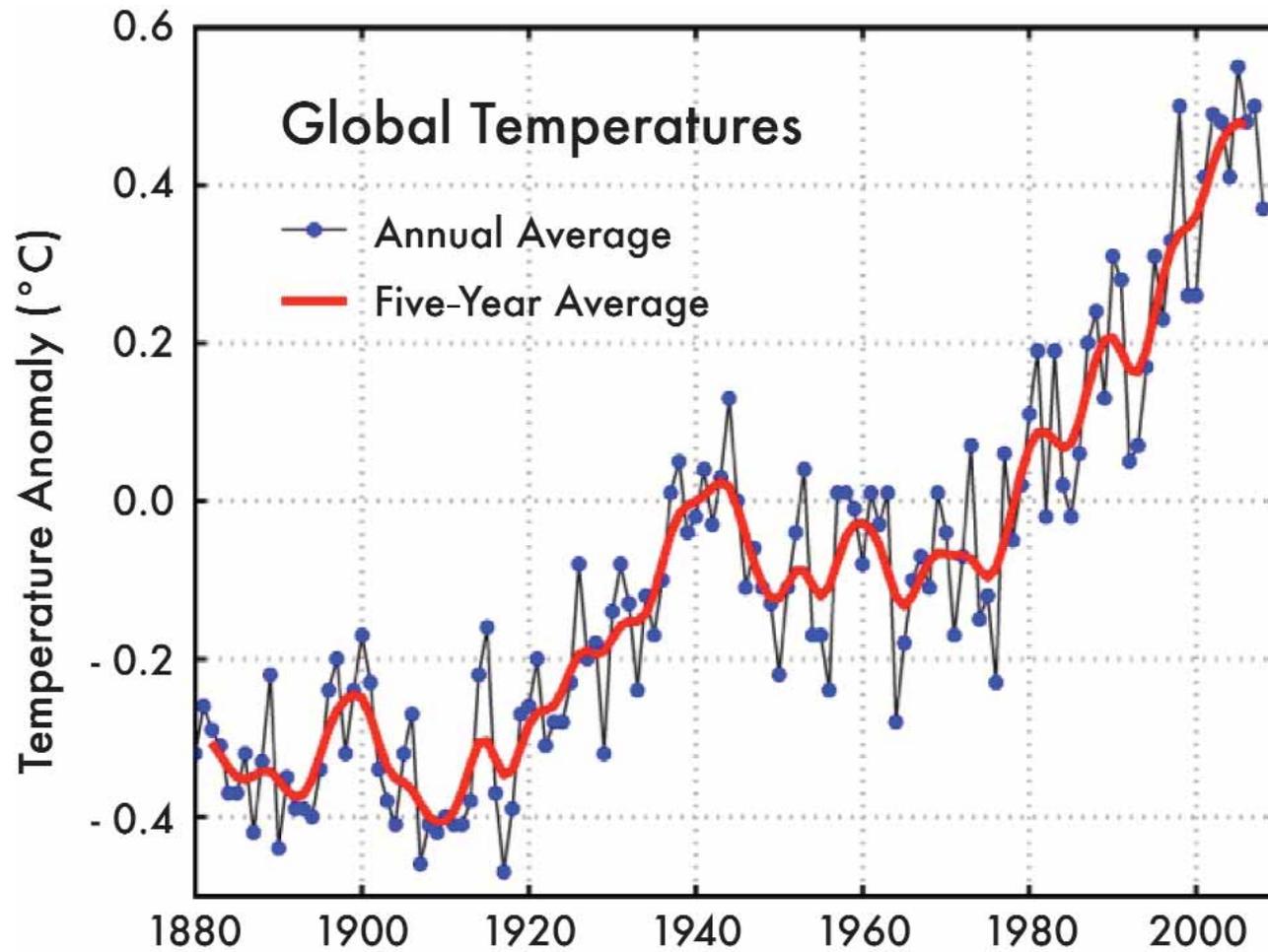
Several reputable models predict that Hampton Roads will be more than 3 degrees Celsius (5.4 degrees Fahrenheit) warmer by 2100. The Intergovernmental Panel on Climate Change's Fourth Assessment Report states that its current climate models predict that mean global warming in 2100 will range from 1.1 degrees C to 6.4 degrees C higher than today. A mid-range estimate, and

one that assumes only moderate changes in carbon emissions over this century, forecasts global warming of 2.8 degrees C (5.04 degrees F).

Scientists at George Mason University and the Center for Ocean-Land-Atmosphere Studies in Maryland predict warming for the same period in Virginia and nearby areas to be 3.1 degrees C (5.58 degrees F) and precipitation to increase by 11 percent.

Global warming comes about in part because of increased burning of fossil fuels, such as coal and oil, and from deforestation. All of these activities result in the concentration of heat-trapping "greenhouse gases" in the atmosphere that prevent heat from escaping into space. According to the Environmental Protection Agency, energy-consuming activities account for three-quarters of human-generated greenhouse emissions, mostly in the form of carbon dioxide emissions from burning fossil fuels. Industrial processes (such as the production of cement, steel and aluminum), agriculture, forestry, other land use, waste management and transportation are also significant sources of greenhouse gas emissions.

GRAPH 1
GLOBAL WARMING: 1880-2000



Source: Wikipedia.com

Rising Sea Levels

Warming of the Earth increases the thermal volume of water in the ocean; water molecules expand when heated. However, warming also melts ice, for example, at the poles, though notably also in non-polar locations such as Mount Kilimanjaro and Glacier National Park. Although this melting occurs slowly, it pushes more water into our oceans. Warmer, larger oceans also alter weather patterns and may lead to more frequent and severe weather conditions, including hurricanes. Graph 2 illustrates average rising sea levels since 1880, based upon observations at 23 geologically stable sites around the globe.

According to a study endorsed by the Organization for Economic Cooperation and Development, Hampton Roads is the 10th-largest coastal metropolitan area in the world in terms of total assets exposed to increasing flooding from rising sea levels. This reflects the fact that much of the land in our region is at or near sea level. It does not take very much of a rise in the sea level for water to spill over the land. Graph 3 illustrates especially vulnerable regions of the United States, including Hampton Roads.

Approximately 3.4 million people in the mid-Atlantic coastal region (about 10 percent of the U.S. population) live on land less than one meter above monthly highest tides (“Coastal Sensitivity to Sea Level Rise: A Focus on the Mid-Atlantic Region,” U.S. Climate Change Science Program, Environmental Protection Agency, January 2009, p. 333). This has particular relevance to Hampton Roads because the sea level is expected to rise between 0.7 meters and 1.6 meters (2.3 - 5.2 feet) by 2100, according to the Chesapeake Bay Program’s Scientific and Technical Advisory Committee. Table 1 summarizes the evidence on rising sea levels in Hampton Roads and other Atlantic Coast communities.

Let’s assume that a mid-range estimate of a 3.7-foot higher sea level is correct for 2100. Vast areas of the region will be inundated with water unless a massive dike and levee system is developed to prevent such flooding. Most of the land east of highway U.S. 17 could be covered with water. From north to south, vast areas of Mathews, Gloucester and York counties, most of Poquoson, and much of the cities Hampton, Norfolk,

TABLE 1

POTENTIAL FOR SHORELINE CHANGES DUE TO SEA-LEVEL RISE ALONG THE U.S. MID-ATLANTIC REGION RATES OF RELATIVE SEA-LEVEL RISE FOR SELECTED LONG-TERM TIDE GAUGES

Station	Rate of Sea- Level Rise (mm/yr)	Time Span of Record
Atlantic City, NJ	3.98 ±0.11	1922-1999
Philadelphia, PA	2.75 ±0.12	1900-1999
Lews, DE	3.16 ±0.16	1919-1999
Annapolis, MD	3.53 ±0.13	1928-1999
Solomons Island, MD	3.29 ±0.17	1937-1999
Washington, DC	3.13 ±0.12	1931-1999
Hampton Roads, VA	4.42 ±0.16	1927-1999
Wilmington, NC	2.22 ±0.25	1935-1999
Charleston, SC	3.28 ±0.14	1921-1999
Miami, FL	2.39 ±0.22	1931-1999
Key West, FL	2.27 ±0.09	1913-1999

Sources: Woods Hole Science Center and the U.S. Geological Survey

Chesapeake and the Virginia Beach oceanfront will be under-water unless protected by dikes and levees. A recent report, “The Impact of Climate Change on Hampton Roads,” written by the Hampton Roads Research Partnership and funded by NASA Langley Research Center, provides detail.

There is yet another fly in the ointment for Hampton Roads, however. Most of the land in our region is slowly sinking at a rate between 0.15 meter and 0.23 meter (5 - 7.5 inches) per century. The land continues to sink because of the “isostatic rebound” of the crust of the Earth from the weight of long-absent glaciers, groundwater removal and slippage of the coast into the crater we now

know as the Chesapeake Bay. The bottom line is that this “sinking land effect” must be added to the projected sea-level rises we have just noted in order to determine the total tidal increase that we will observe in Hampton Roads.

What does all of this add up to? Table 2 reports estimates of the impact of water inundation on regional habitat (much would be destroyed), while Graph 3 illustrates the flooding impact of various magnitudes of hurricanes upon Hampton Roads. The colored areas will be covered by water when a hurricane strikes. While designed to illustrate hurricane water damage, Graph 3 also aptly shows which regional land areas are most susceptible to water coverage from rising sea levels. There is a very high correlation between those land areas that would be covered with water in a hurricane and the land areas that would be inundated by slowly rising sea levels (unless countered by dikes and levees).

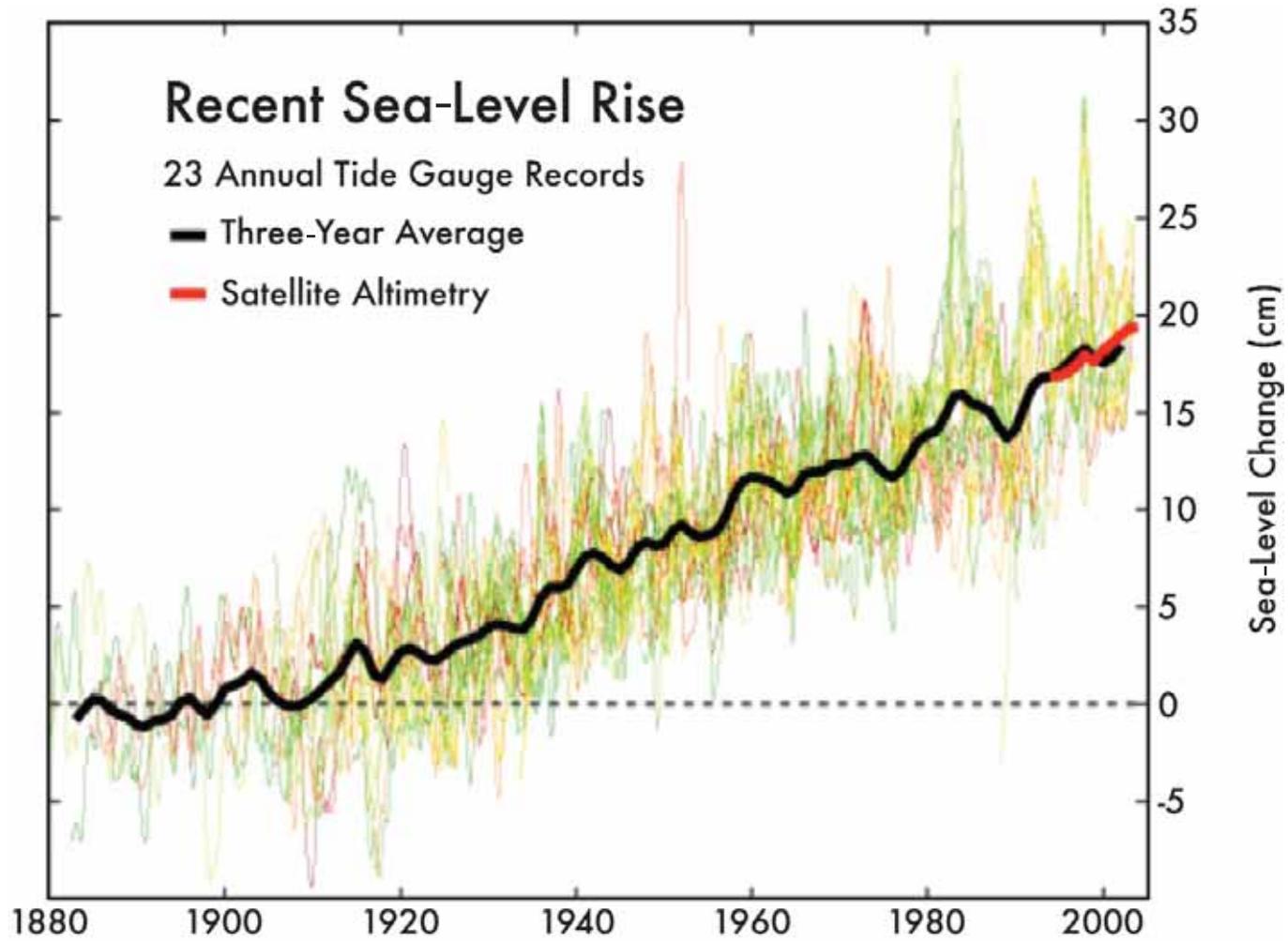
An unpublished Pennsylvania State University master’s thesis, “Modeling the Vulnerability of Coastal Communities to Hurricane Storm Surge Associated with Sea-Level Rise: A Case Study of Hampton Roads, Virginia” (PSU, Lisa M. Rygel, 2004), found that the areas with the highest risk of exposure to storm-surge flooding in Hampton Roads are the heavily developed portions of Norfolk, Portsmouth, Chesapeake, Virginia Beach and Hampton. It is not unoccupied, low-value land that will be covered with water as sea levels rise.

TABLE 2
PROJECTED CHANGES IN COASTAL HABITAT BY 2100 WITH
A 27.2-INCH SEA-LEVEL RISE
SELECTED REGIONS OF TIDEWATER, VIRGINIA

	Upper Tidewater Region		Lower Tidewater Region (Norfolk and Virginia Beach)	
	Acres	Relative Change	Acres	Relative Change
Undeveloped dry land	-18460	-17%	-10780	-19%
Tidal fresh marsh	-8	-3%	-17	-38%
Tidal swamp	-680	-30%	-2290	-83%
Brackish marsh	-8130	-85%	-890	-29%
Tidal flats	-1940	-76%	-740	-67%
Estuarine beach	+1860	8-fold	+560	4-fold
Ocean beach	na	na	-87	-79%
Transitional salt marsh	+4370	11-fold	+1170	14-fold
Salt marsh	+2260	12-fold	+4040	255-fold
Estuarine open water	+15740	14%	+5360	10%

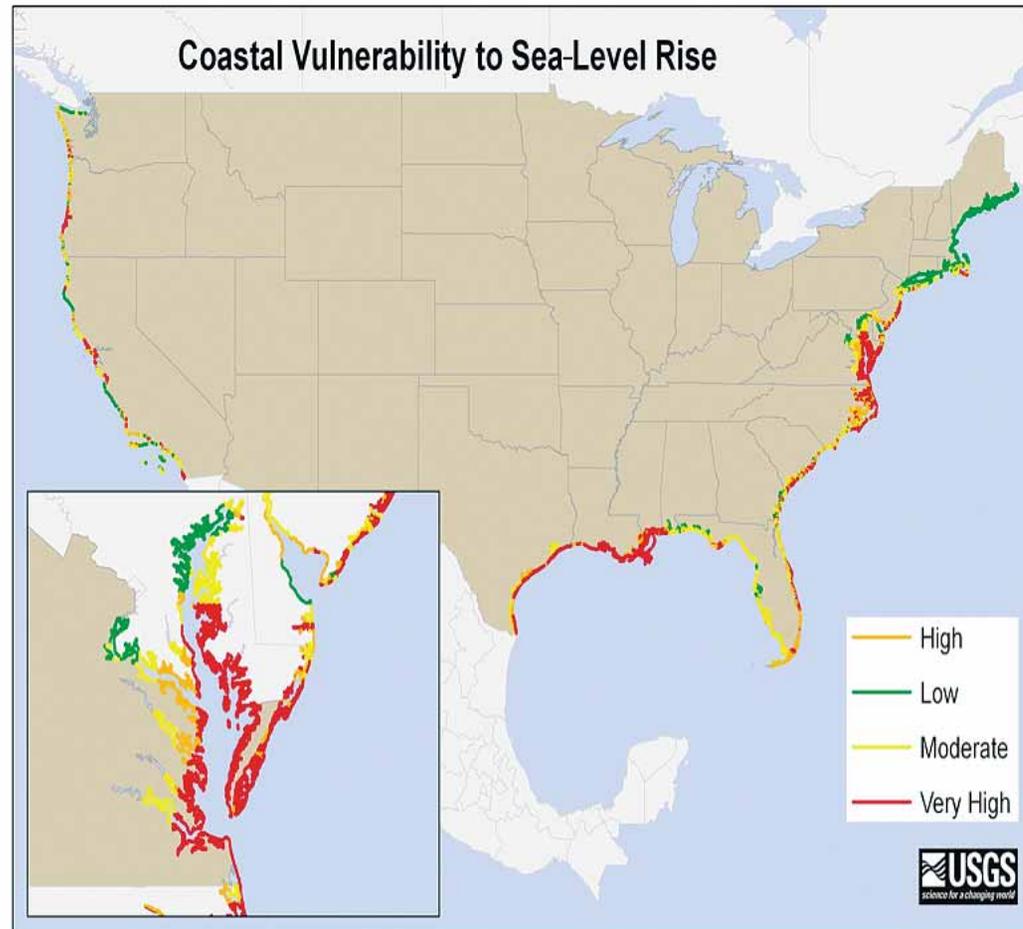
Source: “Sea-Level Rise and Coastal Habitats of the Chesapeake Bay,” National Wildlife Federation, 2008

GRAPH 2
RISING WORLDWIDE SEA LEVELS



Source: Wikipedia.com

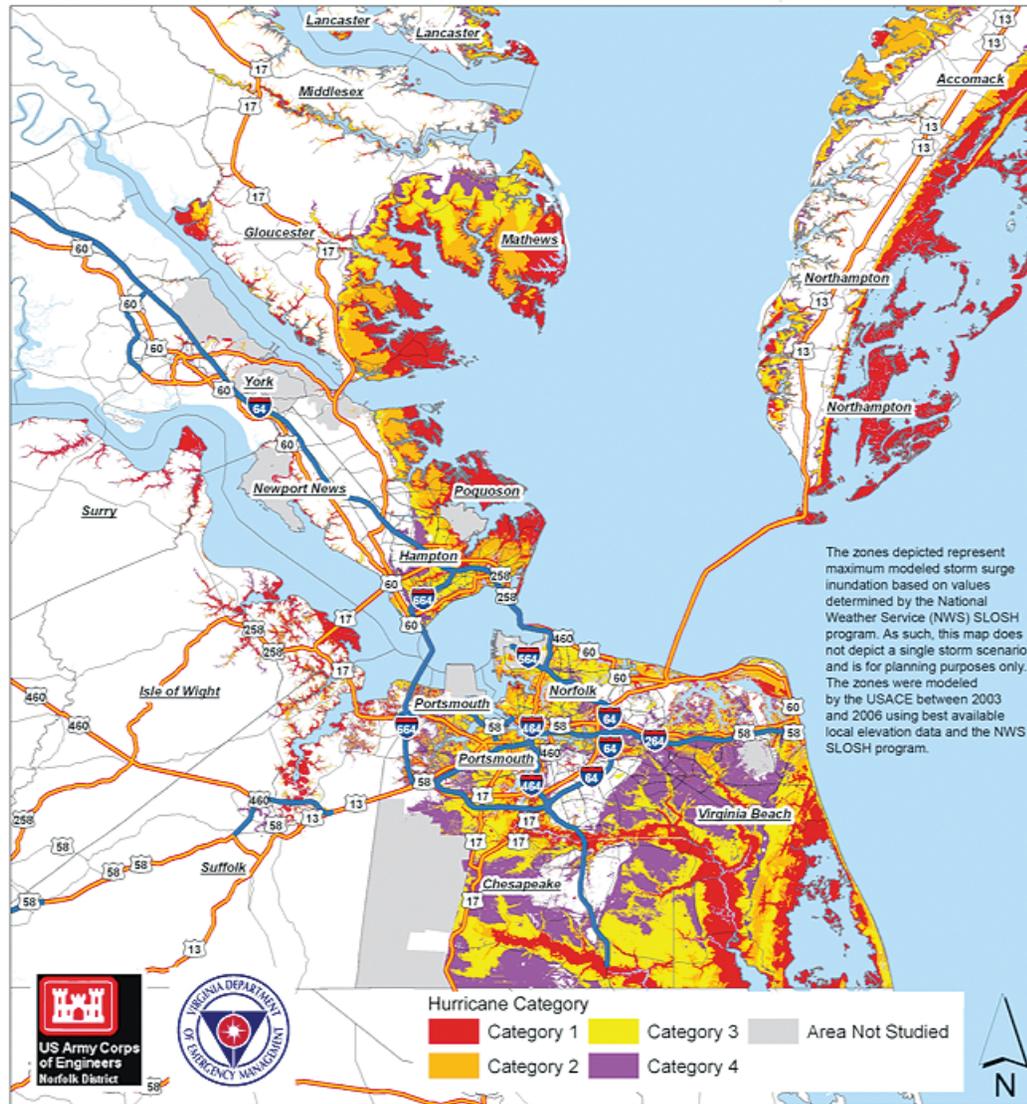
GRAPH 3



Source: Virginia Coastal Zone Management Program, Virginia Department of Environmental Quality

GRAPH 4

MAXIMUM STORM SURGE INUNDATION 2008 VIRGINIA HURRICANE EVACUATION STUDY



Source: Virginia Coastal Zone Management Program, Virginia Department of Environmental Quality

Adverse Impacts

Gov. Timothy Kaine's Commission on Climate Change ("Final Report: A Climate Change Action Plan," December 2008, available at www.deq.Virginia.gov) found that the impacts of climate change and global warming for the Hampton Roads region and the Commonwealth could include:

- Sea-level rise could pose a serious threat to roads, railways, ports, utilities and other critical infrastructure.
- National security could be affected, as several major military installations are located in low-lying areas.
- Insurance rates could continue to increase along coastal areas and the availability of insurance could become an increasing problem.
- Some of the region's "foundation species," such as blue crabs, eelgrass and oysters, could decline or disappear.
- Coastal wetlands that serve as a critical habitat for the Chesapeake Bay's plants and animals could be lost.
- An increase in extreme weather events would affect people's health, safety and homes.
- Responses to climate change mandated by all levels of government would affect the way people live, play and do business.

The National Wildlife Federation report "Global Warming and Virginia," updated in March 2008, offers some additional dire predictions for the Commonwealth:

- Warmer water temperatures due to global warming could encourage the spread of diseases among oysters in the Chesapeake Bay.
- Warmer average temperatures could increase concentrations of ground-level ozone, which is known to aggravate respiratory problems such as asthma.

- Loss of wildlife and habitat could mean a loss of tourism dollars.
- Sand replenishment costs for beaches would range between \$200 million to \$1.2 billion by 2100.

The greatest impact of climate change for transportation systems will be flooding of coastal roads, railways, transit systems and runways because of global rising sea levels, coupled with storm surges, and exacerbated in some locations by land subsidence, according to "Potential Impacts of Climate Change on U.S. Transportation," a 2008 report by the Transportation Research Board of the National Academies.

Crystal Ball Gazing

How accurate are the predictions that we have reported above? There are some naysayers. The Virginia Climate Change Council, a wing of the Virginia Manufacturers Association, issued a report in early 2009 titled "Simplifying Climate Change & Global Warming." In the report, the council argued that "thirty percent of climate scientists worldwide disagree that human introduced greenhouse gases are causing climate warming and slightly over 14 percent are undecided because the science of climate change and global warming is ever changing." They conclude that "due to the legitimate uncertainty about the precise causes we urge caution before deciding a course of action to implement solutions." The Cato Institute ran a full-page advertisement in *The Washington Post* on March 30, 2008, that included the names of 115 scientists who endorsed a statement that said in part that the "alarm regarding climate change is grossly overstated."

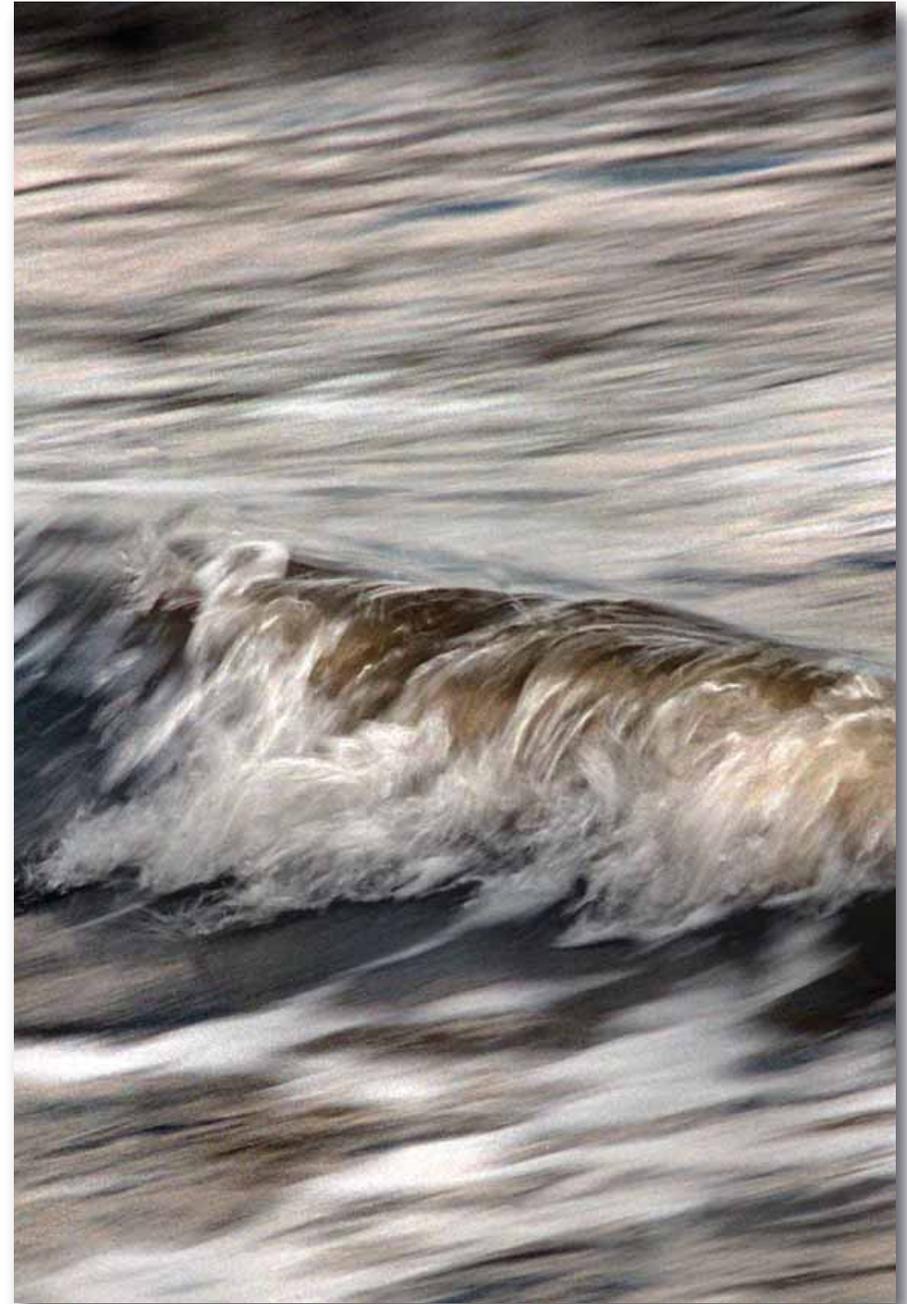
Nevertheless, very few reputable scientists dispute the contention that global warming is occurring, even though there is some disagreement over the precise causes of that warming. Further, in 2007 a group of three- and four-star flag and general officers from all the services – Army, Navy, Air Force, Marine Corps and Coast Guard – and representing all combatant commands, was convened by the Center for Naval Analyses to examine the issues relating to climate change and global warming. These participants, accompanied and sup-

ported by service scientists, had no axes to grind and probably would have preferred to issue a “no problems” report because of the competition for limited funding any global warming conclusion might encourage. Even so, their report, “National Security and the Threat of Climate Change,” was strikingly clear in its tone:

As military leaders, we know we cannot wait for certainty. Failing to act because a warning isn't precise enough is unacceptable. The intelligence community should incorporate climate consequences into its National Intelligence Estimate. The National Security Strategy should directly address the threat of climate change to our national security interests.

The 2008 National Intelligence Assessment reiterated these judgments and concluded that climate change is a serious threat to national security and long-term global stability. A Strategic Environmental Research and Development Program has been launched to evaluate sea-level rise and the ecological impacts on military installations posed by climate change.

The National Council for Science and the Environment in its January 2008 report, “Climate Change: Science and Solutions,” lists its No. 1 reason why we must act now: “Global climate change is not a future or hypothetical situation; it is occurring now with some of its effects happening more rapidly than the scientific models have predicted.”



Sobering Conclusions

Professor John P. Holdren of Harvard University, president and director of the Woods Hole Research Center, has placed the issue in perspective:

Global warming is a misnomer, because it implies something that is gradual, something that is uniform, something that is quite possibly benign. What we are experiencing with climate change is none of those things. It is certainly not uniform. It is rapid compared to the pace at which social systems and environmental systems can adjust. It is certainly not benign. We should be calling it "global climatic disruption" rather than "global warming." ("Meeting the Climate-Change Challenge," National Council for Science and the Environment, Jan. 17, 2008)

The necessity for society to take a long-range view of global warming is emphasized in the Federal Coastal Zone Management Act (16 US Code § 1451), which provides that "because global warming may result in a substantial sea-level rise with serious adverse effects in the coastal zone, coastal states must anticipate and plan for such an occurrence." Alas, a key finding of the U.S. Climate Change Science Program report, "Coastal Sensitivity to Sea Level Rise: A Focus on the Mid-Atlantic Region," issued in January 2009, is that "the comprehensive high-resolution and precise analyses of the spatial distributions of population and infrastructure vulnerable to sea-level rise in the Mid-Atlantic required for planning and response do not exist at the present time."

Action is needed on three fronts. First, Hampton Roads as a region must do its part initially to control and subsequently to diminish carbon emissions. This will not be easily accomplished, but certainly will involve less vehicular travel and greater attention to green building practices.

Second, the Commonwealth of Virginia would be well advised (for a variety of reasons) to increase the taxes it imposes on gasoline and diesel fuel. These taxes have not risen since the 1980s. Higher fuel taxes easily are the most efficient way to decrease carbon emissions from vehicles, and this conclusion would hold even if Virginia and Hampton Roads did not need additional revenue to deal with road and rapid-transit transportation needs.

Third, Hampton Roads must prepare for gradual, but seemingly inexorable increases in ocean and river water levels. A century of evidence documenting rising water levels – international, national and regional – warns us about what is coming. If current trends continue, then sea levels in Hampton Roads in 2020 will be at least another 2 inches higher than today. We will see the ocean creep up into backyards and witness increased flooding during rainstorms and at high tide. Only those with no concern for the future can afford to ignore this development. This directly implies that we ought to be actively planning a system of dikes and levees unless we intend to forfeit huge portions of our land to the sea.

We belabor the obvious when we observe that the planning and construction of dikes and levees is so far removed from public attention in Hampton Roads that anyone who broaches the subject is likely to elicit a quizzical look. After all, isn't there a consensus regionally that transportation improvements actually constitute our major agenda item? Probably. However, we predict that increased flooding in future years, capped by some disaster, will inspire epiphanies on the subject among citizens, businesses, the defense community and elected officials. The region will then predictably move into crisis mode. In the meantime, we harbor the modest goal of increasing regional awareness of the looming issues associated with the rising sea levels that will occur because of global warming and other factors.

