

CLIMATE CHANGE ADAPTATION ACTION PLAN 2017 UPDATE

Executive Order 13653

Preparing the United States for the Impacts of Climate Change

Executive Order 13693

Planning for Federal Sustainability in the Next Decade

DOE Partnership for Energy Sector Climate Resilience



TVA Climate Change Adaptation Action Plan

Forward

The Tennessee Valley Authority (TVA) was created in 1933 and charged with a unique mission to improve the quality of life in a seven-state region through the integrated management of the region's resources. TVA is unique among power generators in that the Agency was created to both further economic development and protect and improve the natural resources of the Tennessee Valley region. Today, the results of TVA's efforts are apparent in the abundant natural resources in the region and the opportunities they afford.

TVA established its initial Climate Adaptation Statement in 2011, following the release of Executive Order (E.O.) 13514, *Federal Leadership in Environmental, Energy and Economic Performance*. The Statement was updated to its current version in 2014, following the release of EO 13693, *Planning for Federal Sustainability in the Next Decade* in 2013.

This updated 2016 Adaptation Plan describes TVA's activities to evaluate the most significant climate change related risks to, and vulnerabilities in, Agency operations and missions in both the short and long term, and outlines actions that TVA is taking to manage these risks and vulnerabilities. It describes the climate adaptation programs, policies, processes and plans that TVA already has in place, as well as information about our progress on additional projects that help manage climate risks and build resilience in the short and long term.

It is increasingly recognized that many actions that enhance resilience to climate change and extreme weather can also contribute to reduced greenhouse gas emissions. For example, measures that enhance energy efficiency and reduce energy demand improve resilience to increasing heat waves as well as reduce GHG emissions. Distributed generated clean energy sources also offer climate mitigation and resilience efforts, improving system resilience to reduced water availability of energy generation, improving system resilience to reduced water availability and drought. Combined heat and power (CHP), improves efficiency by using waste heat, can also improve resilience while reducing emissions. In addition, smart grid, microgrids, and distributed generation systems add resiliency within local distribution systems and may reduce the number of outages, the number of users affected by each outage, and the duration of outages. Locations with microgrids may also have key services up and running more quickly following an outage for the benefit of the overall community, including places of refuge.

TVA has continued its efforts to ensure climate change adaptation is integrated into both agency-wide and regional planning efforts, in coordination with other Federal agencies as well as state and local partners, Tribal governments and private stakeholders. Examples include:

- The Climate Change Sentinel Monitoring (CCSM) program started in April 2013 with 18 stations is monitored by TVA and partners throughout the Tennessee River watershed. The goal of the program is to assess potential biological, ecological, and hydrological responses of aquatic ecosystems related to climate change.
- TVA participates in the Appalachian Landscape Conservation Cooperative (AppLCC) and communicates the findings of the AppLCC climate resilience assessment for aquatic habitats through the Tennessee River Basin Biodiversity Network (TRBBN).
- TVA is one of 18 electric utilities participating in DOE's *Partnership for Energy Sector Climate Resilience*. This Partnership is an initiative to enhance U.S. energy security by improving the resilience of energy infrastructure to extreme weather and climate change impacts.

While the scope, severity and pace of future climate change impacts are difficult to predict, the goal of TVA's adaptation planning is to ensure TVA continues to achieve its mission and program goals and to operate in a secure, effective and efficient manner in a changing climate. This *Plan* sets forth a flexible approach to climate adaption in preparing for a range of climate change impacts and extreme weather. While *The Quadrennial Energy Review* identified the need for better data, metrics, and analytical frameworks to help build resilience, reliability, and security in the energy sector, the flexible framework presented in this *Plan* paves the way for TVA move forward in making TVA's systems more resilient and can ultimately reduce costs.

Brenda E. Brickhouse
Vice President, Environmental and Energy Policy
Chief Sustainability Officer
Tennessee Valley Authority

TVA STATEMENT ON CLIMATE CHANGE ADAPTATION

TVA is a wholly-owned corporate agency of the United States. In 1933, Congress charged TVA with improving the quality of life in the Tennessee Valley region through the integrated management of the region's resources. As part of its regional resource mission, TVA operates the Nation's largest public power system and manages the Tennessee River and its tributaries. Congress has directed TVA to provide low-cost, reliable electricity, promote economic development, foster environmental stewardship, and stimulate technological innovation. As times changed, TVA changed with them, meeting new challenges and bringing new opportunities. Today, we continue to serve the people of the Tennessee Valley through work in three areas: Energy, the Environment, and Economic Development.

- **ENERGY: PROVIDE AFFORDABLE ELECTRIC POWER THROUGHOUT THE TENNESSEE VALLEY REGION**
TVA supplies reliable, affordable electricity to the Tennessee Valley region. It strives to meet the changing needs of local power companies and directly served industrial and federal customers for electricity and related products and services in a dynamic marketplace.
- **ENVIRONMENT: ACT AS A STEWARD OF THE VALLEY'S NATURAL RESOURCES**
TVA is tasked with the wise use and preservation of the region's natural resources. It manages the Tennessee River system and associated public lands to reduce flood damage, maintain navigation, support power production and recreational uses, improve water supply and air quality, protect shoreline, and cultural and historical resources.
- **ECONOMIC DEVELOPMENT: SERVE AS A CATALYST FOR SUSTAINABLE ECONOMIC DEVELOPMENT**
TVA works with local power companies; state, regional, and local economic development organizations, and federal agencies to build partnerships that help bring jobs to the Tennessee Valley and make the economy stronger to benefit the people of the region.

The TVA region encompasses 80,000 square miles in parts of seven southeastern states and TVA's power system serves the electrical needs of 9 million people. TVA is governed by a nine-member Board of Directors appointed by the President. TVA's power system and all stewardship activities have been self-funded since 1959 and 1999, respectively. TVA receives no appropriations.

TVA issued its initial Statement on Climate Change Adaptation in June 2011 and has applied it to its ongoing activities. This statement changes the format of that earlier statement and updates it.

TVA maintains its Climate Change Adaptation Plan as a cohesive part of its major planning processes--including integrated resource management, natural resource, and National Environmental Policy Act (NEPA) planning. As appropriate, TVA applies applicable Executive Orders (EO); such as, EO 13514, Federal Leadership in Environmental, Energy, and Economic Performance, and EO 13653, Preparing the United States for the Impacts of Climate Change as well as all guiding principles and planning frameworks and guidance complementary to these Orders.

While the scope, severity and pace of future climate change impacts are difficult to predict, climate change adaptation planning allows TVA to:

- identify possible impacts to mission achievement;
- assess potential consequences and ability to mitigate climate change;
- develop adaptation planning actions;
- ensure resources are invested wisely; and,
- support the Federal Government's leadership role in sustainability;

Specifically, Our Climate Change Adaptation Plan identifies:

- how climate change may impact TVA's ability to achieve its mission;
- ways the TVA can prioritize and measure its progress and its capability to adapt to current and future changes in climate;
- affected TVA departments, budgets and actions identified under this statement, considering that TVA will be dedicating non-appropriated funds, as practicable, at its discretion;
- coordination points with TVA's Leadership.

TVA's major planning processes, consistent with its Climate Change Adaptation Plan, identify opportunities as well as climate change risks with the potential to substantially impair, obstruct or prevent the success of Agency mission activities, both in the near term and particularly in the long term, using the best available science and information.

TVA will consider environmental justice impacts, consistent with its Climate Change Adaptation Plan, in a manner appropriate for the process used.

As appropriate, TVA will coordinate with other agencies and interagency efforts, including the Interagency Climate Change Adaptation Task Force, on climate change adaption issues that cut across agency jurisdictions.

TVA will update and revise its Climate Change Adaptation Plan annually prior to each TVA Strategic Sustainability Performance Plan (SSPP) report submittal as well as within one year of the quadrennial publication of the *National Climate Assessment*.

Adaption Planning Coordination and Implementation and Delegations

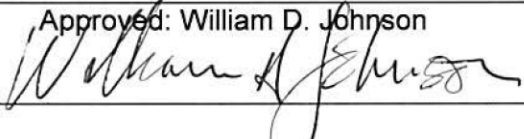
TVA's Chief Sustainability Officer (CSO) is responsible for ensuring implementation of all aspects of this statement, periodic reviews and updates to confirm it remains relevant. This statement does not alter nor affect any existing duty or authority of individual TVA business units.

Through this statement, development and implementation of TVA's Climate Change Adaptation Plan is guided by TVA's Environment and Energy Policy Group, the point of contact with the Office of Management and Budget (OMS) and Council on Environmental Quality (CEQ) on sustainability reporting. TVA's Environment and Energy Policy Group leads TVA's Adaptation Planning Program and governance structure which includes subject matter experts and representatives from multiple business units that work together with TVA's Sustainability Program to provide leadership and focus for TVA's adaptation efforts.

TVA's CSO and delegates authority to Business Unit Leaders and Representatives tasked with aligning adaptation planning goals and initiatives with their annual business planning process. Alignment with business planning ensures that resources are used most efficiently and opportunities to maximize sustainability benefits are identified and realized.

This statement is effective immediately and will remain in effect until amended, superseded, or revoked and its implementation is subject to the availability of funding.

Approval of TVA Statement on Climate Change Adaptation

| | |
|---|-------------------------|
| Approved: William D. Johnson  | Chief Executive Officer |
|---|-------------------------|

TVA Climate Change Adaptation Action Plan

EXECUTIVE SUMMARY

TVA established its initial *Climate Adaptation Statement* in 2011, following the release of Executive Order (E.O.) 13514, *Federal Leadership in Environmental, Energy and Economic Performance*. The *Statement* was updated to its current version in 2014, following the release of E.O. 13693, *Planning for Federal Sustainability in the Next Decade* in 2013.

The goal of TVA’s adaptation planning process is to ensure the Agency continues “to achieve its mission and program goals and to operate in a secure, effective and efficient manner in a changing climate.”

Building an effective portfolio of resilience measures requires planners to consider both short-term and long-term vulnerabilities and balance tradeoffs. Beyond estimated costs and benefits, resiliency planning improves with more detailed and updated information on stakeholder concerns, management objectives, resource availability (natural, human, and financial), science and technology, and other dynamic factors.

Ongoing efforts to address gaps in data, methodologies, tools and other resources are underway at TVA, and at academic, government, and industry organizations across the country. Continued communication, data sharing, and coordination on research best practices, resilience solutions and needs will help leverage resources, strengthen knowledge and projections, and improve resilience.

TVA’s *Environmental Policy* establishes a framework to guide its decision-making and future strategic development in meeting its environmental objectives, including climate change mitigation. Adaptation planning is complex. Solutions differ depending on context, local circumstance, and scale as well as on local culture and internal capacity.

TVA has continued its efforts to ensure climate change adaptation is integrated into both agency-wide and regional planning efforts, in coordination with other Federal agencies as well as state and local partners, Tribal governments and private stakeholders. Examples include:

- TVA is continuing its Climate Change Sentinel Monitoring (CCSM) program started in April 2013, with 18 stations being monitored by TVA and partners throughout the Tennessee River watershed. TVA worked with the Southeast Monitoring Network to select long-term monitoring stations and establish agreed upon monitoring protocols for the program. The goal of the program is to assess potential biological, ecological, and hydrological responses of aquatic ecosystems related to climate change. This program will assist TVA’s compliance with EO 13653 and EO 13693 that direct federal agencies to participate in a nationally integrated strategy toward sustaining quality of life considering risks related to climate change. CCSM is a component of TVA’s [Natural Resource Plan](#), which outlines TVA’s resource stewardship responsibilities for the future.
- TVA participates in the [Appalachian Landscape Conservation Cooperative](#) (AppLCC) and communicates the findings of the AppLCC climate resilience assessment for aquatic habitats through the [Tennessee River Basin Biodiversity Network \(TRBBN\)](#).

- TVA is one of 18 electric utilities participating in DOE’s [Partnership for Energy Sector Climate Resilience](#). This Partnership is an initiative to enhance U.S. energy security by improving the resilience of energy infrastructure to extreme weather and climate change impacts. TVA, as part of its participation, updated its existing *High Level Vulnerability Assessment and Adaptation Plan* to also meet DOE Partnership industry guidance. We also assisted in DOE Partnership Phase 1 Case Study, “Assessing the Costs and Benefits of Investments in Climate Resilience” with DOE/ORNL.
- TVA has completed its plan for Implementing Executive Order 13690, [Establishing a Federal Flood Risk Management Standard and a Process for Further Soliciting and Considering Stakeholder Input](#). EO 13690 expands the scope of flood plain reviews from 100-yr to 500-yr watersheds. Implementation will alter the design process for critical infrastructure construction within this zone.

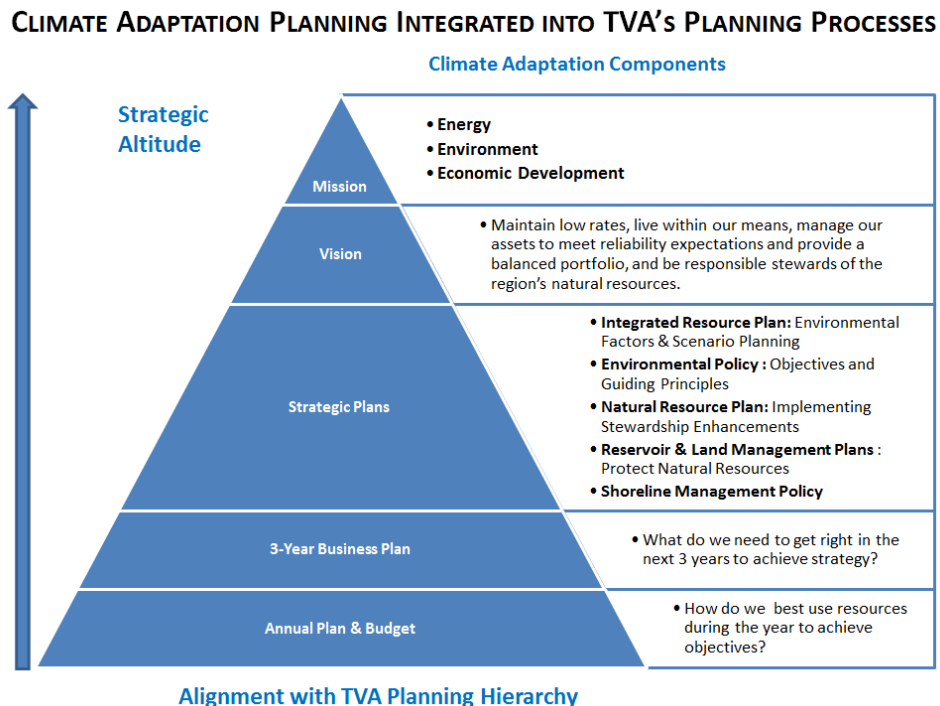
TVA’s Chief Sustainability Officer is responsible for its *Climate Change Adaptation Action Plan*. This updated 2016 Adaptation Plan describes TVA’s activities to evaluate the most significant climate change related risks to, and vulnerabilities in, Agency operations and missions in both the short and long term, and outlines actions that TVA is taking to manage these risks and vulnerabilities. It describes the climate adaptation programs, policies, processes and plans that TVA already has in place, as well as information about our progress on additional projects that help manage climate risks and build resilience in the short and long term.

A. TVA'S CLIMATE CHANGE ADAPTATION POLICY FRAMEWORK

The goal of TVA's adaptation planning process is to ensure TVA continues "to achieve its mission and program goals and to operate in a secure, effective and efficient manner in a changing climate." TVA has, in accordance with EO 13653, *Preparing the United States for the Impacts of Climate Change*, adopted an internal statement on climate change adaptation to establish an adaptation planning goal and to better understand the challenges and opportunities a changing climate may present to its mission and operations.

TVA manages the effects of climate change on its mission, programs, and operations within its environmental management processes. Its primary planning processes are its *Integrated Resource Plan* (IRP) and its *Natural Resource Plan* (NRP). As a Federal agency, TVA must also comply with the National Environmental Policy Act (NEPA); as well as applicable Executive Orders. Environmental goals are an integral part of how TVA does business and are tracked along with its other business objectives. Per EO 13653, TVA has completed a high-level climate change vulnerability assessment. TVA's adaptation planning activities are summarized in Figure 1.

Figure 1: Climate Adaptation Planning Is Integrated Into TVA's Planning Hierarchy



B. CLIMATE CHANGE RISKS AND OPPORTUNITIES

1. TVA's Mission and Vision

The Tennessee Valley Authority (TVA) was created in 1933 and charged with a unique mission to improve the quality of life in a seven state region through the integrated management of the region's resources. As it helped lift the Tennessee Valley out of the Great Depression and improved the overall resilience of the region, TVA built dams for flood control improved the waterways for commercial shipping, pioneered development of the fertilizer industry and restored depleted lands, provided some of the lowest cost power in the Nation, and raised the standard of living across the region.

The goal of TVA's adaptation planning is to ensure TVA continues to achieve its mission and program goals and to operate in a secure, effective and efficient manner in a changing climate. As times have changed, TVA has continued to advance, meeting new challenges and responding to new opportunities. Today, TVA continues to serve the people of the Tennessee Valley through its work in three areas: **Energy**, the **Environment**, and **Economic Development**.

- **Energy:** *Provide Affordable Electric Power Throughout the Tennessee Valley Region*
TVA supplies reliable, affordable electricity to the Tennessee Valley Region. It strives to meet the needs of local power companies and directly served industrial customers for electricity and related products and services in a dynamic marketplace.
- **Environment:** *Act As Steward Of The Valley's Natural Resources*
TVA manages the natural resources of the Valley for the benefit of the region and the nation. It manages the Tennessee River system and associated public lands to reduce flood damage, maintain navigation, support power production and recreational uses, improve water and air quality and supply, manage biodiversity and protect shoreline resources.
- **Economic Development:** *Serve As A Catalyst For Sustainable Economic Development*
TVA works with local power companies, local, state, and regional economic development organizations and other federal agencies to build partnerships that help bring jobs to the Tennessee Valley and make the economy stronger.

Initially, all TVA operations were funded by federal appropriations. Direct appropriations for the TVA power program ended in 1959, and appropriations for TVA's land and water, stewardship, management of the Tennessee River and watershed, economic development, and multipurpose activities ended in 1999. Since 1999, TVA has funded all of its operations almost entirely from the sale of electricity and power system financings.

The TVA Board also established a Regional Resource Stewardship Council (RRSC) under the Federal Advisory Council Act to advise TVA on its stewardship activities. In 2013, TVA also created a new Regional Energy Resource Council (RERC) under the Federal Advisory Council Act to advise TVA on its energy resources planning activities.

More detailed information about TVA's programs can be found in the annual reports (10-Ks), quarterly reports (10-Qs) and current reports (8-Ks) TVA files with the Security Exchange Commission. View [TVA Securities and Exchange Commission filings](#).

2. A Description of TVA's Programs

a. Low Cost, Reliable Power

TVA is primarily a wholesaler of electricity. TVA sells power to Local Power Companies (LPCs) which then resell power to their customers at retail rates. TVA also sells power to directly served customers, consisting primarily of federal agencies and customers with large or unusual loads. In addition, power that exceeds the needs of the TVA system may, where consistent with the provisions of the TVA Act, be sold under exchange power arrangements with other electric systems.

Power generating facilities operated by TVA on September 30, 2015, included 29 conventional hydroelectric sites, one pumped-storage hydroelectric site, nine coal-fired sites, three nuclear sites, 15 natural gas and/or oil-fired sites, one diesel generator site, 14 solar energy sites, digester gas co-firing capacity at one coal-fired site, biomass co-firing potential (located at coal-fired sites), and one wind energy site, although a certain number of these facilities were out of service as of September 30, 2015.

TVA intends to balance production capabilities with power supply requirements by promoting the conservation and efficient use of electricity and, when necessary, buying, building, or leasing assets or entering into power purchase agreements. TVA also intends to employ a diverse mix of energy generating sources and is working toward obtaining greater amounts of its power supply from clean (low or zero carbon emitting) resources.

The TVA transmission system is one of the largest in North America. TVA's transmission system has 70 interconnections with 12 neighboring electric systems, and delivered nearly 161 billion kWh of electricity to TVA customers in FY2015. In carrying out its responsibility for grid reliability in the TVA service area, TVA has operated with 99.999 percent reliability over the last 16 years in delivering electricity to customers.

TVA, in cooperation with its customers, continues to implement a broad portfolio of energy efficiency, demand response, and system load enhancement programs and projects designed to help reduce long-term energy supply costs in the TVA service area through EnergyRight® Solutions ("ERS") programs.

b. Environmental Stewardship

TVA's mission includes managing the Tennessee River, its tributaries, and public lands along the shoreline to provide, among other things, year-round navigation, flood damage reduction, affordable and reliable electricity, and consistent with these primary purposes, recreational opportunities, adequate water supply, improved water quality, and natural resource protection.

There are 49 dams that comprise TVA's integrated reservoir system. The reservoir system provides approximately 800 miles of commercially navigable waterways and also provides significant flood reduction benefits both within the Tennessee River system and downstream on the lower Ohio and Mississippi Rivers. The reservoir system also provides a water supply for residential and industrial customers; as well as, cooling water for some of TVA's coal-fired and nuclear power plants.

TVA's [Environmental Policy](#) provides objectives for an integrated approach related to providing cleaner, reliable, and affordable energy, supporting sustainable economic growth and engaging in proactive environmental stewardship. The [Environmental Policy](#) and [Natural Resource Plan](#) provides additional direction in several environmental stewardship areas, including water resource protection and improvements, sustainable land use, and natural resource management. TVA also manages approximately 11,000 miles of shoreline, 650,000 surface acres of reservoir water, and 293,000 acres of reservoir lands for cultural and natural resource protection, recreation, and other purposes.

c. Economic Development

Since its creation in 1933, TVA has promoted the development of the Tennessee Valley. Economic development, along with energy production and environmental stewardship, is one of the integrated purposes of TVA. TVA works with its LPCs, regional, state, and local agencies, and communities to showcase the advantages available to businesses locating or expanding in TVA's service area. TVA's primary economic development goals are to recruit major industrial operations to locate in the Tennessee Valley, encourage the location and expansion of companies that provide quality jobs, prepare communities in the Tennessee Valley for economic growth, and offer support to help grow and sustain small businesses. TVA seeks to meet these goals through a combination of initiatives and partnerships designed to provide financial assistance, technical services, industry expertise, and site-selection assistance to new and existing businesses. TVA's economic development efforts helped recruit or expand over 224 companies into the TVA service area during FY2015. These companies announced capital investments of over \$7.8 billion and the expected creation and/or retention of over 76,200 jobs.

d. River Management and Flood Control Activities

TVA manages the Tennessee River, its tributaries, and public lands along the shoreline to provide, among other things, year-round navigation, flood damage reduction, affordable and reliable electricity and, consistent with these primary purposes, recreational opportunities, adequate water supply, improved water quality, and natural resource protection.

TVA's integrated reservoir system provides 800 miles of commercially navigable waterways and significant flood reduction benefits both within the Tennessee River system and downstream on the lower Ohio and Mississippi Rivers. The reservoir system also provides a water supply for residential, municipal and industrial customers; as well as, cooling water for some of TVA's coal-fired and nuclear power plants.

The Tennessee River watershed has one of the highest annual rainfall totals of any watershed in the United States, averaging 51 inches per year. During FY2015, approximately 56 inches of rain fell in the Tennessee Valley. TVA manages the Tennessee River system in an integrated manner, balancing hydroelectric generation with navigation, flood damage reduction, water quality and supply, and recreation. TVA spills or releases excess water through the tributary and main stem dams in order to reduce flood damage to the Tennessee Valley. TVA typically spills only when all available hydroelectric generating turbines are operating at full capacity and additional water still needs to be moved downstream.

TVA tracks what might have happened had it never existed as a way of keeping track of how well its system is operating. It is estimated that since Norris Dam was finished in 1936, around \$5.4 billion in flood-related damages have been averted in the Tennessee Valley. Around \$5.8 billion in flood damages were averted by the Tennessee Valley reservoir system, if including the damages that didn't happen to locations along the lower Ohio and Mississippi Rivers.

e. Technological Innovation

TVA makes investments in science and technological innovation to help the agency meet future business and operational challenges. Each year TVA's annual research portfolio is updated based on a broad range of operational and industry drivers that help assess key technology gaps, performance issues, or other significant issues that should be addressed through research and development. Core research activities directly support optimization of TVA's generation and delivery assets, air and water quality, energy utilization, and distributed/clean energy integration.

Investments in TVA's research portfolio are supported through partnership and collaboration with LPCs, EPRI and other research consortiums, the DOE and other federal agencies, national labs, peer utilities, universities, and industry vendors and participation in professional societies.

3. Planning for Climate Change Related Risk: TVA's Adaptation Risk and Opportunities

All planning activities are always conducted under conditions of uncertainty. Adaptation planning is no different. TVA manages the effects of climate change on its mission, programs, and operations within its environmental management processes. Specific mitigation and adaptation analyses are incorporated in TVA's primary planning processes, including TVA's [Integrated Resource Plan](#) (IRP) and [Natural Resource Plan](#) (NRP). As a federal agency, TVA must also comply with the [National Environmental Policy Act](#) (NEPA).

Interagency efforts have been, and continue to be, underway to better understand the uncertainty associated with climate change. In the United States, the Global Change Research Act of 1990 mandates an assessment of the impacts of global change in the U.S. be conducted by the U.S. Global Change Research Program (USGCRP) every four years. EO 13653, *Preparing the United States for the Impacts of Climate Change*, contains a new requirement for all Federal agencies to update their Adaptation Plans within one year after the publication of each quadrennial *National Climate Assessment* (NCA) report.

a. High-Level Adaptation Risk and Opportunities Analysis

In response to EO 13653, *Preparing the United States for the Impacts of Climate Change*, and EO 13693, *Planning for Federal Sustainability in the Next Decade*, Table 1 summarizes the key high-level adaptation risks and opportunities to TVA's mission, programs, and operations in the short- and long-term. The risks and opportunities analyzed are within the ranges considered by TVA's current planning and evaluation processes as discussed in Section C.

Table1: Key High-Level Adaptation Risk and Opportunity Summary

| Key Issue | Description | Potential Short Term and Long Term Direct and Indirect Effects |
|---------------------------|---|--|
| Electricity Demand | Summer electricity demand may increase (especially in the South and Southwest, which generally have higher per capita electricity use.) | The NCA reported that in the Southeast, the number of observed extreme hot days has tended to decrease or remain the same while the number of very warm summer nights has tended to increase. The number of extreme cold days has also tended to decrease. Over time, however, the 2014 NCA projects demands for electricity for cooling will increase and demands for heating will decrease in every U.S. region as a result of increases in average temperatures and high temperature extremes. USGS NEX-DCP30 data is generally projecting about a 3° F Annual average Max Temperature increase, 2025-2050 for Tennessee. The 2009 NCA concluded the demand for cooling energy generally increases from 5% to 20% per 1.8° F of warming and demand for heating energy generally drops by 3% to 15% per 1.8° F of warming. Specific impacts are difficult to predict as many factors besides climate change affect energy demand (including population changes, economic conditions, energy prices, consumer behavior, conservation programs, and changes in energy-using equipment). USGCRP and DOE assessments also indicate that higher air and water temperatures may diminish the efficiency by which power plants convert fuel to electricity. |

| | | |
|---|--|---|
| Reservoir Operations and Hydropower Generation | Climate change, coupled with human adaptation, will influence both the demand for and supply of water. | These changes may affect hydropower generation, thermoelectric cooling, reservoir-based recreation, navigation, municipal and industrial uses, and environmental flows. Every adaptation and mitigation option involves tradeoffs in how it increases or decreases stress on energy systems and water and land resources. The NCA concludes that while some facilities may face water-related limitations, these could be offset to some degree by the use of innovative technologies. |
| | Reservoir operations include flood guides that are based upon TVA's hydrologic record and many years of operating experience. Several flood guides were changed as a result of the previous ROS process, and will continue to be reassessed over time. | A TVA Reservoir Operations Policy (ROP) was developed during the Reservoir Operations Study (ROS) and Environmental Impact Statement (EIS-2004). As recently as September of 2014, TVA discussed this topic with the Regional Resource Stewardship Council (RRSC), an independently chartered Federal Advisory Committee that is composed of a diverse group of external stakeholders. The RRSC unanimously reaffirmed TVA's reservoir operating policy as continuing to balance the multiple and often conflicting operating objectives of the Tennessee River System. |
| | Evaporative losses from industrial and thermoelectric cooling may increase. | The NCA concluded change in projected precipitation for the Southeast has high uncertainty, but that there is still a reasonable expectation of reduced water availability due to the increased evaporative losses resulting from rising temperatures alone. |
| | Precipitation could significantly increase. | The NCA concluded the frequency of extreme precipitation events has been increasing across the Southeast region, particularly over the past two decades. The <i>1988 TVA Sensitivity Study</i> concluded that major dams operating at or above normal maximum levels for extended periods of time may necessitate a reevaluation of dam safety at these projects. |
| | Precipitation could significantly decrease. | Conversely, drought is a normal component of the Southeast's climate system. The NCA also concluded projections of future precipitation patterns are less certain than projections for temperature increases. Because the Southeast is located in the transition zone between projected wetter conditions to the north and drier conditions to the southwest, many model projections show only small changes relative to natural variations. However, many models do project drier conditions in the far southwest of the Southeast region and wetter conditions in the far northeast of the region, consistent with the larger continental-scale patterns. The <i>1988 TVA Sensitivity Study</i> also concluded the reduced runoff conditions may decrease the likelihood of operations at or above maximum pool levels. |

| | | |
|--|--|--|
| <p><i>Effects of Changing Runoff and Water Temperatures</i></p> | <p>Climate change is expected to affect hydropower and thermoelectric power plants directly through changes in runoff (average, extremes, and seasonality) and indirectly through increased competition with other water uses. Higher water temperatures affect the efficiency of electric generation and cooling processes. It also limits the ability of utilities to discharge heated water to streams due to regulatory requirements and anticipated impacts to ecosystems and biodiversity.</p> | <p>EPRI research indicates that approximately 25% of existing electric generation in the U.S. is located in counties projected to be at high or moderate water supply sustainability risk in 2030. The NCA concluded that while some hydropower facilities may face water-related limitations, these could be offset to some degree by the use of more efficient turbines as well as innovative new hydropower technologies. The NCA also indicated a national average increase in annual precipitation, owing to significant increases across the central and northeastern portions of the nation and a mix of increases and decreases elsewhere. Changes in projected precipitation are small in most areas of the U.S, but vary both seasonally and regionally. The number of heavy downpours has generally increased and is projected to increase for all regions. Warmer air temperatures will result in warmer water. The 2009 EPRI report concluded that multi-model analyses of climate suggests that effects on most existing human uses of water (for example, for cooling water or hydropower) are also likely to be modest and occur within the range of existing adaptive capacity, although some adjustments in water planning will likely be necessary.</p> |
| <p><i>Extreme Weather</i></p> | <p>Severe weather, such as ice storms, thunderstorms, tornados and hurricanes can have a negative impact on energy infrastructure.</p> | <p>The NCA reported that, since 1980, the Southeast has had more billion-dollar weather disasters (hurricanes, floods, and tornadoes) than any other region in the United States. The frequency of extreme-precipitation-events has increased across the Southeast, particularly over the last two decades. The increase is pronounced across the lower Mississippi River Valley and along the northern Gulf Coast. Although the number of major tornadoes has increased over the last 50 years in the Southeast, there is no statistically significant trend.</p> |

| | | |
|----------------------|---|---|
| <p>Heat</p> | <p>The leading cause of weather-related deaths in the United States is heat. With the exception of the 1970s to the 1990s, when the use of air conditioning rapidly increased, the number of deaths due to heat is positively correlated with increasing temperature and humidity.</p> | <p>The NCA reported the Southeast as one of the few regions globally not to exhibit an overall warming trend in surface temperature over the 20th century. This “warming hole” also includes part of the Great Plains and Midwest regions in the summer. Temperatures increased rapidly in the early part of the 20th century, then decreased rapidly during the middle of the 20th century. Since the 1960s, temperatures have increased. Recent increases are most pronounced during summer, particularly along the Gulf and Atlantic coasts. Temperature trends over the period of 1895-2011 are found to not be statistically significant for any season.</p> <p>The NCA also concluded, although temperatures are expected to fluctuate over time due to natural climate variability, the Southeast is generally expected to experience a temperature increase during this century. Some major impacts of this projected warming trend included increases in the number of days exceeding 95°F. The GAO also observed that, apart from risks related to extreme weather events, increasing temperatures may decrease transmission system efficiency and could reduce available transmission capacity, as well as the overall efficiency of the grid.</p> |
| <p>Floods</p> | <p>Heavier precipitation can increase flood risk, expand flood hazard areas, increase the variability of stream flows (i.e., higher high flows and lower low flows) and increase the velocity of water during high flow periods, thereby increasing erosion. Precipitation changes can often be managed by the use of reservoirs, and can increase hydropower power production. Floods can also have adverse effects on water quality and aquatic ecosystem health.</p> | <p>The NCA reported, despite a long-term increase in extreme precipitation events, there is no discernible trend in the magnitude of floods along non-urbanized, unregulated streams across the Southeast region. The increase in extreme precipitation, coupled with increased runoff due to the expansion of impervious surfaces and urbanization, has led to an increased risk of flooding in urban areas of the region (e.g., the 2010 Nashville flood)</p> |

| | | |
|--|---|---|
| <p>Water Quality</p> | <p>Downpours can trigger sewage overflows and contaminated drinking water.</p> | <p>Warmer air temperatures will result in warmer water. Warmer water holds less dissolved oxygen making instances of low oxygen levels or “hypoxia” more likely; foster harmful algal blooms; and alter the toxicity of some pollutants. This will be more pronounced on mainstream reservoirs, where brief periods of low DO can already be observed during summer under drought conditions. The NCA reports that few studies have projected the impacts of climate change on nitrogen, phosphorus, sediment, or dissolved organic carbon (DOC) transport from land to rivers. However, given the tight link between river discharge and all of these potential pollutants, the NCA concludes areas of the U.S. that are projected to see increases in precipitation, and increases in intense rainfalls, may experience water quality challenges.</p> |
| <p>Temporal and Geographic Rainfall Variation</p> | <p>Change in extreme events, droughts, and daily and weekly flooding pose threats to the region’s infrastructure even when monthly and annual water supply does not change dramatically. Climate impacts in this category are related to changes in rainfall, and also to changes in temperature, which affects evaporation and evapotranspiration. While water is currently abundant, climate stressors could change that abundance, either locally or region wide, leading to impacts and the need for adaptive measures.</p> | <p>The <i>EPRI Report</i> concluded while changes in runoff in the TVA region are likely to be modest, some impacts could result from highly localized changes in the temporal distribution of precipitation that may have major impacts on both water supply and power supply along with recreation in specific parts of the TVA region--even if the region as a whole does not experience a major impact.</p> |
| <p>Prolonged Droughts</p> | <p>A changing climate, particularly in areas projected to be warmer and drier, is expected to lead to drought and stresses on water supply, affecting energy, water and land sectors in the United States.</p> | <p>Water resources in the Southeast are abundant and support heavily populated urban areas, rural communities, unique ecosystems, and economies based on agriculture, energy, and tourism. The region also experiences extensive droughts, such as the 2007 drought in Atlanta, Georgia that created water conflicts among three states. While the NCA concludes change in projected precipitation for the Southeast has high uncertainty, it also concludes there is still a reasonable expectation that there will be reduced water availability due to the increased evaporative losses resulting from rising temperatures alone.</p> |

| | | |
|---|--|---|
| <p>Decreased Dissolved Oxygen levels</p> | <p>Warmer air temperatures will result in warmer water. Warmer water holds less dissolved oxygen making instances of low oxygen levels or “hypoxia” more likely; foster harmful algal blooms; and alter the toxicity of some pollutants.</p> | <p>The NCA observes that few studies have projected the impacts of climate change on nitrogen, phosphorus, sediment, or dissolved organic carbon (DOC) transport from land to rivers. However, given the tight link between river discharge and all of these potential pollutants, areas of the U.S. that are projected to see increases in precipitation, and increases in intense rainfalls, like the Northeast, Midwest, and mountainous West may see decreases in dissolved oxygen. Prolonged, heavy releases at Kentucky Dam can lead to supersaturation of DO impacting aquatic life in the tailwater. TVA continually monitors and uses several methods to regulate and has ongoing programs to maintain Dissolved Oxygen below dams.</p> |
| <p>Biodiversity Impacts</p> | <p>The NCA concluded climate change impacts on biodiversity are already being observed in alteration of the timing of critical biological events such as spring bud burst and substantial range shifts of many species. In the longer term, there is an increased risk of species extinction. These changes have social, cultural, and economic effects. Events such as droughts, floods, wildfires, and pest outbreaks are already disrupting ecosystems. These changes limit the capacity of ecosystems, such as forests, barrier beaches, and wetlands, to continue to play important roles in reducing the impacts of these extreme events on infrastructure, human communities, and other valued resources.</p> | <p>The Tennessee Valley region supports a wide diversity of terrestrial and aquatic ecological habitats. This habitat diversity results in the area being one of the most species-diverse in North America and a center for unusually high levels of endemism (i.e. species confined to a particular geographic region). Potential climate impacts are related to changes in ecosystem type and acreage and measures of species diversity and can be attributed to changes in temperature, precipitation and atmospheric CO2 concentrations. At this time, it is uncertain where the greatest climate change-induced impacts to aquatic organisms and their ecosystems may occur. Predictions are further confounded by the probability that temperature change will likely not occur evenly across the Valley, as a result, it is difficult to predict how warm- and cold-water taxa will respond to changing water temperatures since other environmental factors such as land-use changes also strongly influence species population densities and geographic distributions. Highly specialized species restricted to higher elevations are expected to be impacted initially.</p> |
| <p>In-stream Habitats</p> | <p>Changes to in-stream flow levels may have substantial impacts on the habitats and biodiversity supported by rivers and other water bodies.</p> | <p>The <i>EPRI Report</i>, Potential Impact of Climate Change on Natural Resources in the Tennessee Valley Authority Region, concluded that changes to in-stream flow levels may have substantial impacts on the habitats and biodiversity supported by rivers and other water bodies in the TVA region. IPCC reports that low water levels can cause reproductive problems among fish and amphibian species and that river-spawning fish may also be directly impacted by changes in flow levels. The EPRI report concluded that, within the TVA region, the overall effects of climate change on in-stream flow will vary depending on run-off cycles, precipitation levels, and river characteristics. In-stream flow rates will also be indirectly affected by water management decisions between competing water uses.</p> |

| | | |
|--|--|---|
| Habitat Migration | Climate change may have an impact on animal and plant species. | The NCA concluded the lengthening of the frost-free season has been somewhat greater in the western U.S. than the eastern U.S., increasing by 2 to 3 weeks in the Northwest and Southwest, 1 to 2 weeks in the Midwest, Great Plains, and Northeast, and slightly less than 1 week in the Southeast. These differences mirror the overall trend of more warming in the north and west and less warming in the Southeast. |
| Air Quality | Changes in meteorological conditions could affect future ozone and PM _{2.5} concentrations. Climate change can also affect air quality by increasing emissions from natural sources and wildfires. | The NCA reported that several studies project that climate change could increase troposphere ozone levels over broad areas of the country, especially on the highest-ozone days. Climate change also has the potential to lengthen the ozone seasons (the months of the year when weather conditions, along with pollutants in the air, can result in the formation of elevated levels of ground-level ozone in particular locations around the country), and may increase individuals' vulnerability to air pollution. |
| Natural Resource-Based Recreation | Natural resource-based recreation in the TVA service territory could be affected directly by temperature and precipitation changes, as well as indirectly through effects on water resources, forests, and unmanaged ecosystems. | Recreation is sensitive to weather and climate. Climate change impacts to recreation can be difficult to project. As the climate warms, changes in precipitation and runoff are expected to result in both beneficial (in some regions) and adverse impacts. Warm and wet climate adaptation scenarios generally produce positive recreational impacts; whereas warm and dry scenarios generally produce negative recreational impacts. The <i>EPRI Report</i> concluded natural resource-based recreation in the TVA service territory could be affected directly by climate changes; such as, temperature and precipitation changes, as well as indirectly through effects on water resources, forests, and unmanaged ecosystems. |

b. External Partnership and Stakeholder Coordination

Partnerships are a critical component of TVA's future implementation, education and operations success. TVA, along with other agencies, is tasked with finding new and creative ways to deal with funding and personnel challenges to effectively manage nonrenewable resources.

EO 13653 encourages interagency collaboration to share the latest data and best practices on climate preparedness both across agencies as well as to support State, local, tribal, and private sector efforts to build climate preparedness.

TVA continues to develop its overarching public engagement programs to increase public awareness and promote opportunities for volunteer involvement, environmental education, financial/resource assistance and collaborative partnerships.

The TVA Board established a Regional Resource Stewardship Council (RRSC) under the Federal Advisory Council Act to advise TVA on its stewardship activities. In 2013, TVA also created a new Regional Energy Resource Council (RERC) under the Federal Advisory Council Act to advise TVA on its energy resources decision making processes..

c. Existing Cross-Cutting Planning Efforts

Strategic Sustainability Performance Plan (SSPP)

TVA's Chief Sustainability Officer (CSO) is also responsible for its Climate Change Adaptation Action Plan. TVA's Strategic Sustainability Performance Plan (SSPP) goals and current performance can be found on its current OMB Scorecard on Sustainability/Energy.

Environmental Justice Strategy

TVA will consider environmental justice impacts in a manner appropriate for the process utilized.

Applicable National Plans and Reports

As the science continues to evolve in key areas, TVA will continue to evaluate and update its high-level vulnerability assessment guidance as needed. In completing high-level vulnerability analysis, the following list of sources is intended to assist applicable planning processes with adaptation reference sources, including:

- [**Adapting to the Impacts of Climate Change, America's Climate Choices: Panel to the Impacts of Climate Change**](#): National Research Council, National Academy of Sciences, 2010.
- [**Distribution Grid Resiliency: Prioritization of Options**](#), Report 3002006668, EPRI, 2015.
- [**Electric Power System Flexibility: Challenges and Opportunities**](#), Report 3002007374, EPRI, 2016.
- [**Electric Power System Connectivity: Challenges and Opportunities**](#), Report 3002007375, EPRI, 2016.
- [**Electric Power System Resiliency: Challenges and Opportunities**](#), Report 3002007376, EPRI, 2016.
- [**Global Climate Change Impacts in the United States**](#), U.S. Global Change Research Program, 2009.
- [**High-Wind Risk Assessment Guidelines**](#), Report 3002003107, EPRI, 2015
- [**How the Transmission Resiliency Research Fits Together**](#), Report 3002006429, EPRI, 2015.
- [**National Action Plan: Priorities for Managing Freshwater Resources in a Changing Climate**](#), Interagency Climate Change Adaptation Task Force, October 2011.

- [***National Fish, Wildlife and Plants Climate Adaptation Strategy***](#), U.S. Fish and Wildlife Service, NOAA, AFWA, January 2012.
- [***National Ocean Policy Implementation Plan***](#), National Ocean Council, 2013.
- [***National Water Program 2012 Strategy: Response to Climate Change***](#), Environmental Protection Agency, December 2012.
- [***Opportunities to Enhance the Nation's Resilience to Climate Change***](#), Council on Climate Preparedness and Resilience, October 2016.
- [***Potential Impact of Climate Change on Natural Resources in the Tennessee Valley Authority Region***](#), Report 1021379, EPRI, November 2009.
- [***Reference Guide for Obtaining Input Data for Application of EPRI's Transmission Resiliency Framework to Severe Weather: Prioritizing Resiliency Investments***](#), EPRI, 2015.

C. TVA's Adaptation Planning and Evaluation Process

1. TVA's Environmental Policy

The focus on "Enhance, Protect and Reduce" aligns TVA's [Environmental Policy](#) with its Vision.

TVA will lead in reducing the environmental impact of its operations (including procurement, acquisition, real property or leasing decisions) and in protecting and enhancing the Valley's natural resources.

Figure 2: Overview of TVA's Environmental Policy



2. Guiding Principles for Climate Change Adaptation

The Support Document to the *Implementing Instructions* set out the following Guiding Principles for Climate Change Adaptation:

- Adopt integrated approaches
- Prioritize the most vulnerable
- Use best-available science
- Build strong partnerships
- Apply risk-management methods and tools
- Apply ecosystem-based approaches
- Maximize mutual benefits
- Continuously evaluate performance

3. TVA's Major Environmental Planning Processes

TVA's major environmental planning processes are its [Integrated Resource Plan](#) (IRP) and its [Natural Resource Plan](#) (NRP). Other applicable TVA planning processes include [Reservoir Land Management Plans](#)

and the TVA [Shoreline Management Policy](#).

As a Federal agency, TVA must also comply with the [National Environmental Policy Act](#) (NEPA); as well, as applicable Executive Orders, such as EO 13693, *Planning for Sustainability in the Next Decade*. Environmental goals are an integral part of how TVA does business and are tracked along with its other business objectives.

Each TVA major planning process shall identify any significant climate change risks. Significant climate change risks are those identified risks with the potential to substantially impair, obstruct, or prevent the success of agency mission activities, both in the near term and particularly in the long term, using the best available science and information. This identification should include:

- a brief statement of the rationale for classifying the risk as significant
- factors considered in the review
- any actions the agency believes may decrease the threat of the potential risk and
- whether the action can be addressed exclusively by the agency or if stakeholders will need to be involved.
- the Identification of any relevant milestones and responsible agency components or offices

Adaptation is about managing change and climate change is not the only factor. In general, planners must routinely make complex decisions under uncertain conditions. Decisions made now and in the future will influence society's resilience to impacts of future climate change. Replacement or restoration of assets to improve resilience can also be integrated into asset management, emergency management, hazard mitigation plans, planning project selection criteria, or environmental reviews.

In recognition of the significance of these decisions, the NCA presented information that is useful for a variety of decisions across regions and sectors, at multiple scales, and over multiple time periods. Other environmental and socioeconomic stressors interact with climate change and affect vulnerability and response strategies with respect to energy, water, and land systems. The availability and use of energy, water, and land resources and the ways in which they interact vary across the nation. Regions in the United States differ in:

- energy mix (solar, wind, coal, geothermal, hydropower, nuclear, natural gas, petroleum, ethanol);
- observed and projected precipitation and temperature patterns;
- sources and quality of available water resources (for example, ground, surface, recycled);
- technologies for storing, transporting, treating and using water;
- land use and land cover; and
- governance.

As a result, decision-making processes for each sector also differ, and decisions often transcend scales, from local to state to federal, meaning that mitigation and adaptation options can differ widely. Stakeholders should understand the interconnected nature of climate change impacts and the value of assessments would be improved if risks and vulnerabilities were evaluated from a cross-sector standpoint. There is broad consensus that the U.S. power system needs to be more resilient, flexible, and connected.

In the context of the power system, resiliency includes the ability to harden the system against high impact, low-frequency events and quickly recovery from them. Power system outages pose large financial impacts to a community, ranging from residential to small businesses and large corporations.

Adaptation planning is complex. There is no perfect, one-size-fits-all adaptation solution to the challenges of adapting to climate change impacts, as solutions will differ depending on context, local circumstance, and scale as well as on local culture and internal capacity. For the power system, enhanced resiliency will be based on three critical elements, with the most cost-effective approach usually a combination.

These three elements are:

- **damage prevention:** hardening the power system to limit damage using the application of engineering designs and advanced technologies;
- **system recovery:** restoring service as soon as practicable using tools and techniques and
- **survivability:** the use of innovative technologies in continuing some level of normal function without complete access to normal power sources.

Table 3. Resilience Strategy Examples

| Damage Prevention (Hardening) | System Recovery | Survivability |
|---|---|--|
| <ul style="list-style-type: none"> • Threat identification and assessment • Risk-based design standards, maintenance routines, and inspection procedures • Performance boundary identification • Risk-based operating practices incorporating lessons learned from past events • Integrated vegetation management • Cyber and physical security | <ul style="list-style-type: none"> • Rapid damage assessment and crew deployment • Readily available replacement components • Integrated Advanced Outage Management Systems (OMS), GIS and Asset Management Systems • Mobile tools to retrieve detailed information on assets in the field to prioritize component repair and replacement • Spare equipment strategies | <ul style="list-style-type: none"> • Basic level of service • Customer communication facilitation • Distributed generation options to enable urgent service • New business models and innovation to develop and fund programs for survivability of high-impact, low-frequency events |

a. TVA's Integrated Resource Plan (IRP)

TVA publishes an [Integrated Resource Plan](#) (IRP) to provide direction for how TVA will meet the long-term energy needs of the Tennessee Valley region. TVA’s current IRP was approved by its Board of Directors in August 2015.

This IRP and the associated [Supplemental Environmental Impact Statement](#) evaluate scenarios that could unfold over the next 20 years. They discuss ways that TVA can meet future electricity demand economically while supporting mandates for environmental stewardship and economic development across the Valley. As in the 2011 version, TVA’s 2015 IRP indicates that a diverse portfolio continues to be the best way to deliver low-cost, reliable electricity for TVA ratepayers.

The 2015 [IRP](#) was developed in collaboration with TVA customers and consumers, business and industry leaders, community, academia, environmental advocates, and others who depend on the public power that TVA provides in partnership with local power companies.

b. TVA's Natural Resource Plan (NRP)

Strategic guidance for carrying out many of TVA’s essential stewardship responsibilities is provided in TVA’s [National Resource Plan](#) (NRP). TVA is unique in that it was created to not only empower the economic aspects of the Southeast society but also to protect and improve the natural resources of the Tennessee Valley region.

TVA developed its [NRP](#) to guide the Agency’s natural resource stewardship efforts. The [NRP](#) addresses TVA’s management of biological, cultural, and water resources; recreation; reservoir lands planning; and public engagement. The goal of TVA’s [NRP](#) is to integrate the objectives of these resource areas, provide for the optimum public benefit, and balance sometimes conflicting resource uses. The [NRP](#) also guides TVA in achieving the objectives of its [Environmental Policy](#) for a more systematic and integrated approach to natural resource stewardship.

The [NRP](#) analyzes TVA's current activities, goals for improving current programs and initiating new programs, and the benefits associated with the implementation of programs in each of the six resource areas. Implementation will be staged over a 20-year period and reviewed and updated every five years.

As part of the process of developing the current [NRP](#), TVA also developed an associated Environmental Impact Statement (EIS). The NRP EIS describes the potential resource management programs and activities, alternative approaches to TVA's resource management efforts, and the environmental impacts of the alternatives, including the alternative comprising the [NRP](#).

c. TVA's Reservoir Land Management Plans

TVA develops comprehensive plans for the management of reservoir lands. [Reservoir Land Management Plans](#) are developed with participation by public agencies and officials, private organizations and individuals. Many of the land plans are available online.

d. TVA's Shoreline Management Policy

In 1999, after extensive environmental review and public comment, TVA inaugurated its [Shoreline Management Policy](#) to improve the protection of shoreline and aquatic resources while continuing to allow reasonable public access to both.

e. Executive Orders such as EO 13653 and EO 13693

TVA's innovative environmental programs also incorporate pertinent Executive Orders (EO) such as EO 13653, Preparing the United States for the Impacts of Climate Change, and EO 13693, *Planning for Federal Sustainability in the Next Decade*. Consistent with EO 13653 and EO 13693, and as part of its requirements for federal agency Strategic Sustainability Performance Plans (SSPP), TVA incorporates climate change adaptation planning as part of its integrated resource management. The TVA budget for meeting the climate adaptation planning provisions will be based upon non-appropriated dollars and is subject to the availability of funding as TVA deems appropriate and practicable.

4. TVA's Priority Actions

As part of its September 30, 2011 response to E.O. 13514, TVA identified 3-5 preliminary priority actions to improve its capability to assess and build resilience to climate impacts. Several portions of TVA's natural resource management program align with national climate change assessment programs, national data collection priorities and fulfill vulnerability assessment requirements. TVA intends to continue to focus on these priority actions as part of its NRP implementation.

Goal 1: Water Resources Management:

- Provide sustainable, healthy water resources by collaborating to improve and protect water quality in the Tennessee River Watershed.
- Prioritize programs to provide opportunities to conduct water resource improvement efforts on TVA-managed lands and facilities.
- Ensure a comprehensive approach to assess biological conditions across the Valley.
- Encourage the reduction of "energy intensity" of water consumption.

Goal 2: Reservoir Lands Planning:

- Develop Reservoir Land Management Plans
- Provide a holistic approach to balancing shoreline development, recreational use, sensitive and natural resource management needs, and other uses in a way that maintains regional quality of life and economic growth.
- Land planning is a systematic method of identifying and evaluating the most suitable use of public land under TVA stewardship.

Goal 3: Biological and Cultural Resources Management:

- Protect and conserve natural resources while promoting recreational opportunities throughout the Valley.
- Biological Resources will focus on three distinct areas: habitat management, land conditions assessments and dispersed recreation.
- Cultural Resources will prioritize monitoring and protection of archaeological sites through shoreline stabilization as well as through public education and outreach.

5. Performance Measures

Monitoring and evaluation serve a very important function in providing cost-effective policy. Monitoring and evaluation can identify advances in the underlying science, provide critical analysis of issues, and highlight key findings and key unknowns that can guide planners. Regular, iterative assessments also serve to improve resiliency planning related to climate change.

The [National Water Program 2012 Strategy: Response to Climate Change](#) found the most amenable approach for evaluating progress is to assess institutional progress toward becoming a resilient and adaptive program. TVA is adopting a phased approach that uses indicators of progress and emphasizes peer-to-peer learning rather than using a top-down mandate.

As appropriate, TVA will identify criteria for deciding which programs to target and how those criteria are identified and necessary. Each applicable process should consider whether or not climate change will impact their ability to procure critical materials or inputs, and seek to address those challenges, including the risk mitigation strategy chosen, the identification of any relevant milestones and responsible agency components or offices.

D. ACTIONS TO BETTER UNDERSTAND CLIMATE CHANGE RISKS AND OPPORTUNITIES

Responses to the climate change challenge will almost certainly evolve over time. Determining and refining adaptation responses will be an iterative process involving scientists, policymakers, and public and private decision makers at all levels. Table 4 summarizes TVA's planned near and mid-term actions to better understand climate change risks and opportunities as reported in its 2015 SSPP. Progress is expected to continue subject to budget approval and constraints.

Table 4: TVA Actions to Better Understand Climate Change Risks and Opportunities

| | | |
|--|--|---|
| TVA NRP Climate Sentinel Monitoring | Action Description | This program is listed in TVA's NRP and focuses on collecting biological, chemical and physical data in streams throughout the Tennessee Valley and surrounding areas. |
| | Action Goal | The goal of Climate Change Sentinel Monitoring is to assess potential biological, ecological, and hydrological responses of aquatic ecosystems related to climate change. |
| | Agency Lead | Natural Resources |
| | Risk or Opportunity | Better understanding of potential climate change effects on streams, including water quality and their unique biodiversity within the Tennessee River watershed |
| | Scale | Regional |
| | Timeframe | Monitoring began in FY2013 collecting data in up to seventeen sites a year. |
| | Implementation Methods | Percent samples completed; Complete and timely annual report. |
| | Performance | Ongoing |
| | Inter-Governmental Coordination | Coordination across Federal, state, tribal, or other partners are appropriate and critical to advance this action. |
| | Resource Implications | The NRP Climate Sentinel Monitoring has been integrated monitoring, modifications and additions with the existing monitoring program. TVA will be dedicating non-appropriated funds, as practicable, at its discretion. |
| | Challenges/Further Considerations | Continued funding. Balancing partnerships--aligning our efforts with what others are doing while maintaining our commitments as outlined within the NRP. |
| | Highlights of Accomplishments to Date | Continued participation in U.S. EPA's Regional Monitoring Network (RMN); Continued participation in the Appalachian Landscape Conservation Cooperative (AppLCC)' CY 16 Climate Change Sentinel Monitoring Report. |

| | | |
|-----------------------------------|--|--|
| Aquatic Ecology Management | Action Description | This NRP program focuses on the enhancement of aquatic biological communities in TVA streams, reservoirs and tailwaters. |
| | Action Goal | Identify and protect exceptionally diverse aquatic biological communities. |
| | Agency Lead | Natural Resources |
| | Risk or Opportunity | Protection and improvement of water resources in the Tennessee River watershed; one of the most biologically rich watersheds in North America. |
| | Scale | Regional |
| | Timeframe | Target priority watersheds, build partnerships. Continue NRP implementation |
| | Implementation Methods | Build partnerships; collaborate with partners to develop implementation plans, pool resources with other agencies and partners to implement protection and improvement measures. |
| | Performance | Ongoing |
| | Inter-Governmental Coordination | Coordination across Federal, state, tribal, or other partners are appropriate and critical to advance these activities. |
| | Resource Implications | TVA will be dedicating non-appropriated funds, as practicable, at its discretion. |
| | Challenges/Further Considerations | Continued funding. Balancing partnerships--aligning our efforts with what others are doing while maintaining our commitments as outlined within the NRP . |
| | Highlights of Accomplishments to Date | Willingness of other agencies and organizations to get involved, including the potential involvement of multiple Federal, state, and local organizations across the Valley. One example of a partnership-led effort is the Elk River Buffer Initiative. Over 15 agencies worked together to create an incentive program for landowners to establish buffers along the Elk River in Tennessee. To date the partners have leveraged over \$400,000 to establish over 200 acres of riparian buffer. |

| | | |
|---------------------------------------|--|--|
| Strategic Partnership Planning | Action Description | This NRP program focuses on building strong partnerships with state and other federal agencies, and with regional nongovernmental organizations, to address stewardship issues of mutual importance and drive measurable improvement of health of the region's waters. |
| | Action Goal | Communicate across state and federal agencies and NGOs around shared goals of preserving the world class biodiversity in the Tennessee River Watershed. |
| | Agency Lead | Natural Resources |
| | Risk or Opportunity | Develop shared understanding of potential climate change effects on the Tennessee River watershed and identify opportunities to improve and/or maintain water quantity and water quality. |
| | Scale | Regional |
| | Timeframe | Began in FY2013 and continuing through FY2020. |
| | Implementation Methods | Establish partnerships that will collaboratively advance TVA's water resource improvements, and also serve as potential sources of shared funding. |
| | Performance | Ongoing |
| | Inter-Governmental Coordination | Describe and reaffirm <u>current</u> partnerships and strengthen TVA participation with those agencies, NGOs, and other Valley and Federal Stakeholders. |
| | Resource Implications | Utilize existing resources to the extent possible and develop additional resources as new opportunities are identified. TVA will be dedicating non-appropriated funds, as practicable. |
| | Challenges/Further Considerations | Maintaining alignment with other agencies and ensuring adequate future funding. |
| | Highlights of Accomplishments to Date | TVA has lead the effort in development of the Tennessee River Basin Biodiversity Network, where federal, state, and local agencies are working together to protect and improve aquatic biodiversity in the Tennessee River basin. |

| | | |
|---|--|--|
| Water Resource Outreach Campaign | Action Description | This NRP program focuses on increasing public awareness and involvement through the promotion of water resource protection and improvement best practices. |
| | Action Goal | Communicate across state and federal agencies and NGOs around shared goals of preserving water resources in the Tennessee River Watershed. |
| | Agency Lead | Natural Resources |
| | Risk or Opportunity | Develop better understanding of potential climate change effects on the Tennessee River watershed and identify opportunities to increase public awareness of the issue. |
| | Scale | Regional |
| | Timeframe | Began in 2013 and continuing through 2020. |
| | Implementation Methods | Develop a matrix of public outreach topics, materials (existing or to be developed), and target audiences. Update existing and prepare new outreach materials and presentations. Develop and follow an integrated plan for delivering water resource outreach. |
| | Performance | Ongoing |
| | Inter-Governmental Coordination | Ensure TVA's efforts are coordinated with others. |
| | Resource Implications | Adequate funding must be procured and maintained. TVA will be dedicating non-appropriated funds, as practicable. |
| | Challenges/Further Considerations | Continued funding. Maintaining program focus over a long timeframe. |
| Highlights of Accomplishments to Date | TVA has initiated multiple outreach activities one of which is to set up a display and travel aquarium at major outdoor events throughout the Tennessee Valley to interact with stakeholders and provide information about aquatic life and importance of protecting aquatic biodiversity in the Valley. | |

E. Actions to Address Climate change Risks and Opportunities

Table 5 identifies the actions TVA will continue or initiate in FY2015 and beyond to address climate change risks and opportunities to its mission, programs, and operations. Progress is expected to continue subject to budget approval and constraints.

Table 5: TVA Actions to Address Climate Change Risks and Opportunities

| | | |
|---|---|--|
| Internal Climate Change Adaptation Oversight Process | Action Description | This action focuses on the identification of an internal process to ensure TVA has the needed capacity and organizational structures in order to effectively assess agency specific climate change risks and opportunities and implement appropriate adaptation actions. |
| | Action Goal | Continued Process Assessment and Recommendations |
| | Agency Lead | Environment and Energy Policy |
| | Risk or Opportunity | Efficient and effective oversight processes |
| | Scale | Regional |
| | Timeframe | Ongoing |
| | Implementation Methods | Updated Adaptation Plan; Updated High Level Assessment; Continued participation in DOE's <i>Partnership for Energy Sector Climate Resilience</i> . |
| | Performance | Ongoing |
| | Inter-Governmental Coordination | Continued participation in the Interagency Forum on Climate Change Impacts and Adaptation; Continued participation in the Federal Climate Change Adaptation Community of Practice. |
| | Resource Implications | TVA will be dedicating non-appropriated funds, as practicable. |
| | Challenges/Further Considerations | Organizational reorganization. |
| Highlights of Accomplishments to Date | Process maps completed. High-level policy review ongoing. | |

| | | |
|--|--|---|
| Internal Adaptation Investment/ Action Barrier Assessment | Action Description | This action focuses on the high-level identification of barriers that discourage investments or other actions to increase the Nation's resilience to climate change while ensuring continued protection of public health and the environment. |
| | Action Goal | High-level identification of significant adaptation investment/action barriers |
| | Agency Lead | Environment and Energy Policy |
| | Risk or Opportunity | More efficient and effective adaptation investment/action processes. |
| | Scale | Regional |
| | Timeframe | FY2014-FY2016 |
| | Implementation Methods | Continued participation in DOE's <i>Partnership for Energy Sector Climate Resilience</i> ; Finalization of Agency Flood Plain Management Implementing Plan; Revised NEPA Procedures |
| | Performance | Ongoing |
| | Inter-Governmental Coordination | Continued participation in DOE's <i>Partnership for Energy Sector Climate Resilience</i> |
| | Resource Implications | TVA will be dedicating non-appropriated funds, as practicable. |
| | Challenges/Further Considerations | Evolving cost-benefit calculation methodologies |
| | Highlights of Accomplishments to Date | Added the Rhodium Group (RHG) climate change projections (as used by DOE in its second installment of its Quadrennial Energy Review) as available TVA'GIS layers. |

| | | |
|--|--|---|
| Internal High-Level Agency Funding Assessment | Action Description | This action focuses on the high-level assessment of Agency funding programs that may, perhaps unintentionally, increase the vulnerability of natural or built systems, economic sectors, natural resources, or communities to climate change related risks. |
| | Action Goal | High-level identification of significant internal funding barriers. |
| | Agency Lead | Environment and Energy Policy |
| | Risk or Opportunity | Efficient and Effective Adaptation Processes |
| | Scale | Regional |
| | Timeframe | FY2014-FY2016 |
| | Implementation Methods | Continued participation in DOE's <i>Partnership for Energy Sector Climate Resilience</i> |
| | Performance | Ongoing |
| | Inter-Governmental Coordination | Continued participation in DOE's <i>Partnership for Energy Sector Climate Resilience</i> |
| | Resource Implications | TVA will be dedicating non-appropriated funds, as practicable |
| | Challenges/Further Considerations | Evolving cost-benefit calculation methodologies |
| | Highlights of Accomplishments to Date | Assisted in DOE Partnership Phase 1 Case Study, "Assessing the Costs and Benefits of Investments in Climate Resilience with DOE/ORNL" |

| | | |
|--|--|--|
| Identification of Opportunities to Support and Encourage Climate Resilient Stakeholder Investment | Action Description | This action focuses on a high-level identification of opportunities to support and encourage smarter, more climate-resilient investments by States, local communities, and tribes, including by providing incentives through Agency guidance, grants, technical assistance, performance measures, safety considerations, and other programs. |
| | Action Goal | Identification of opportunities to support and encourage climate resilient stakeholder investment. |
| | Agency Lead | Environment & Energy Policy |
| | Risk or Opportunity | Efficient and Effective Adaptation Processes |
| | Scale | Regional |
| | Timeframe | FY2014-FY2016 |
| | Implementation Methods | Continued participation in DOE's <i>Partnership for Energy Sector Climate Resilience</i> |
| | Performance | Ongoing |
| | Inter-Governmental Coordination | Continued participation in DOE's <i>Partnership for Energy Sector Climate Resilience</i> |
| | Resource Implications | TVA will be dedicating non-appropriated funds, as practicable. |
| | Challenges/Further Considerations | Evolving cost-benefit calculation methodologies |
| | Accomplishments to Date | Assisted Oak Ridge National Lab (ORNL) and the City of Knoxville in their efforts to create a presentation showing how climate change is expected to impact Knoxville and the surrounding region and how local communities can increase resilience in order to "protect our people, places, and value." |

| | | |
|--|--|--|
| External Coordination Efforts | Action Description | This action focuses on the identification of an internal process to coordinate its adaptation planning with related efforts among state, local, tribal, and territorial partners. These efforts include TVA's Regional Resource Stewardship Council (RRSC) and TVA's Regional Energy Resource Council (RERC) as well as TVA participation in the Appalachian Land Conservation Cooperative (AppLCC) and the Southeast Climate Science Center (CSC) . |
| | Action Goal | Efficient stakeholder project communication and coordination |
| | Agency Lead | Environment and Energy Policy |
| | Risk or Opportunity | Efficient and effective oversight processes |
| | Scale | Regional |
| | Timeframe | Ongoing |
| | Implementation Methods | Creation and maintenance of a high-level process map; Creation and maintenance of external adaptation project coordination table |
| | Performance | Ongoing |
| | Inter-Governmental Coordination | TVA participates in the AppLCC and communicates the findings of the AppLCC climate resilience assessment for aquatic habitats through the Tennessee River Basin Biodiversity Network (TRBBN), a multi-agency effort to communicate across state and federal agencies and NGOs around the shared goals of preserving world class biodiversity in the Tennessee River Watershed. |
| | Resource Implications | TVA will be dedicating non-appropriated funds, as practicable. |
| | Challenges/Further Considerations | Organizational reorganization. |
| Highlights of Accomplishments to Date | Creation of TVA's Regional Energy Resource Council (RERC). | |

| | | |
|-------------------------------------|--|--|
| Dry Ash Handling and Storage | Action Description | TVA has developed plans to eliminate all wet ash and gypsum storage at its operating coal-fired power plants and convert the ash and gypsum systems to dry storage. The movement away from wet fly ash systems will help to reduce the overall use of water in TVA's power generation facilities and help to meet sustainability goals as required by Executive Order 13693. |
| | Action Goal | Eliminate power generation wet fly ash systems and reduce water use. |
| | Agency Lead | Operations |
| | Risk or Opportunity | Water availability and use |
| | Scale | Regional |
| | Timeframe | FY2010-FY2020 |
| | Implementation Methods | TVA is committed to better management and use of potable and non-potable water resources. TVA's work to eliminate wet ash handling and storage will cut non-potable water use by 13% by FY2012 and 11% by FY2013. |
| | Performance | Ongoing |
| | Inter-Governmental Coordination | TVA is coordinating this work with the DOE Federal Energy Management Program (FEMP) and reporting progress through its Annual Report on Energy Management and OMB Scorecard. |
| | Resource Implications | TVA expects the overall program to cost \$1.5 to \$2 billion. TVA will be dedicating non-appropriated funds, as practicable, at its discretion. |
| | Challenges/Further Considerations | Achievement of the goal is contingent upon TVA Board approval of individual ash/gypsum dewatering projects. |
| | Highlights of Accomplishments to Date | TVA 's FY2016 reduction of non-potable water was 6,396 million gallons. TVA has already exceeded its 20% reduction goal in process water from a 2010 baseline by 2020. |

| | | |
|--|--|--|
| Greenhouse Gas Reduction | Action Description | <p>By 2020, TVA is projected to reduce CO₂ emissions by 60% below 2005 levels. By 2020 55% of TVA's generation will be carbon-free. On October 19, 2016, Watts Bar Unit 2 officially entered commercial operation. Watts Bar Unit 2 helps reduce valley and regional CO₂ emission rates while keeping electric rates low.</p> <p>In accordance with EO 13693, TVA has set additional GHG reduction targets for Scope 1, Scope 2 and Scope 3 activities and annually reports its progress as part of its Strategic Sustainability Performance Plan.</p> |
| | Action Goal | GHG emissions mitigation |
| | Agency Lead | TVA's Internal Energy Management Program |
| | Risk or Opportunity | Opportunity is a reduction in GHG emissions which could reduce the impacts of climate change. |
| | Scale | Regional. SSPP applicable Scope 1 and Scope 2 Targets are a 31.2% reduction by FY2025 from its FY2008 baseline. Scope 3 Target is a 20.7% reduction by FY2025 from its FY2008 baseline. |
| | Timeframe | FY2008 to FY2020 |
| | Implementation Methods | TVA is committed to reduction in energy used to power buildings and fuel vehicles. FY2025 Targets are a 31.2% reduction in Scope 1& Scope 2 GHG emissions and a 20.7% reduction in Scope 3 emissions |
| | Performance | Ongoing |
| | Inter-Governmental Coordination | TVA is coordinating this work with the DOE Federal Energy Management Program (FEMP) and reporting progress through its Annual Report on Energy Management and OMB Scorecard. |
| | Resource Implications | TVA will be dedicating non-appropriated funds, as practicable, at its discretion. |
| | Challenges/Further Considerations | Organizational reorganization |
| Highlights of Accomplishments to Date | TVA has been working to reduce energy use in its facilities since the late 70's. To date TVA facilities use almost half the energy of the average Federal building energy use. | |

LIST OF ABBREVIATIONS/TERMS

CCAAP - Climate Change Adaptation Action Plan
CO₂ - Carbon Dioxide
CSC - Southeast Climate Science Center
DOE - Department of Energy
EIS - Environmental Impact Statement
EO - Executive Order
EO 13653 - November 6, 2013 Executive Order, Preparing the United States for the Impacts of Climate Change
EO 13514 - October 5, 2009 Executive Order, Federal Leadership in Environmental, Energy, and Economic Performance
EP - Environmental Policy
EPRI - Electric Power Research Institute
FACA - Federal Advisory Council Act
FEMP - Federal Energy Management Program
FWS - U.S. Fish and Wildlife Service
GHG - Greenhouse Gas
IRP - Integrated Resource Plan
LCC - Appalachian Land Conservation Cooperative
LPC - Local Power Company
OMB - Office of Management and Budget
ORNL - Oak Ridge National Laboratory
NCA - U. S. National Climate Assessment
NEPA - National Environmental Policy Act
NGO - Non-Governmental Organization
NRP - Natural Resource Plan
NPS - National Park Service
RERC - Regional Energy Resource Council
ROS - River Operations Study
RRSC - Regional Resource Stewardship Council
SMP - Shoreline Management Policy
SMR - Small Modular Reactor
Smart Grid - Grid Modernization
SSPP - Strategic Sustainability Performance Plan
TVA - Tennessee Valley Authority
USGCRP - U.S. Global Change Research Program
8-K - Current Reports filed with Security Exchange Commission
10-K - Annual Report filed with Security Exchange Commission
10-Q - Quarterly Reports filed with Security Exchange Commission