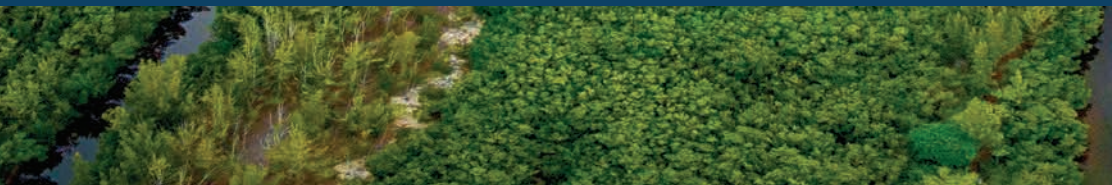
COASTAL & HEARTLAND NATIONAL ESTUARY PARTNERSHIP

FROM HEARTLAND TO COAST

Protecting our water, wildlife, and future

2019 Comprehensive Conservation and Management Plan for the CHNEP Area in Central and Southwest Florida



The CHNEP Comprehensive Conservation and Management Plan (CCMP) was first adopted in 2000, then updated in 2008 and 2013. It was developed in part with funds provided by the U.S. Environmental Protection Agency, Region 4 through a cooperative agreement.

This 2019–2023 CCMP Revision was developed by CHNEP staff and Management Conference, with assistance from Shafer Consulting. It is available as an environmentally-friendly PDF at www.chnep.org, or as a printed copy by request to the CHNEP office.

COASTAL & HEARTLAND NATIONAL ESTUARY PARTNERSHIP
326 West Marion Avenue
Punta Gorda, FL 33950-4417
941.575.5090 | 866.835.5785
www.CHNEP.org

◀ Cover photograph: Thunderstorm over Pine Island Sound | *Steve Russell.*

Uniting Central and Southwest Florida to Protect Water and Wildlife

FROM HEARTLAND TO COAST

Protecting our water, wildlife, and future

2019 Comprehensive Conservation and Management Plan for the CHNEP Area in Central and Southwest Florida

The COASTAL & HEARTLAND NATIONAL ESTUARY PARTNERSHIP (CHNEP) is a partnership of citizens, elected officials, resource managers, and commercial and recreational resource users who are working to improve the water quality and ecological integrity of the CHNEP area. A cooperative decision-making process is used within the partnership to address diverse resource management concerns in the 5,416-square mile CHNEP area.

CHNEP POLICY COMMITTEE

CITIES

Hon. Robert Heine Jr.
City of Arcadia

Hon. Billy Simpson
City of Bartow

Hon. Fred Forbes
City of Bonita Springs

Hon. Jessica Cosden
City of Cape Coral

TBD
City of Clewiston

Hon. Fred Burson
City of Fort Myers

TBD
City of LaBelle

TBD
City of Moore Haven

Hon. Debbie McDowell
City of North Port

Hon. Gary Wein
City of Punta Gorda

Hon. Mick Denham
City of Sanibel

Hon. Mitzie Fieldler
City of Venice

Mr. M.J. Carnevale
City of Winter Haven

Hon. Joanne Shamp
Town of Ft. Myers Beach

Hon. Katy Errington
Village of Estero

COUNTIES

Hon. Bill Truex
Charlotte County

Hon. Judy Schaefer
DeSoto County

TBD
Glades County

Hon. Colon Lambert
Hardee County

TBD
Hendry County

TBD
Highlands County

Hon. Frank Mann
Lee County

Hon. Misty Servia
Manatee County

Ms. Gaye Sharpe
Polk County

Hon. Nancy Detert
Sarasota County

AGENCIES

Mr. Brian Smith
United States Environmental Protection Agency

Mr. Jon Iglehart
Florida Department of Environmental Protection

Mr. Tom Graef
Florida Fish & Wildlife Conservation Commission

Mr. Don McCormick
Southwest Florida Regional Planning Council

Ms. Patricia Steed
Central Florida Regional Planning Council

Mr. John Henslick
Southwest Florida Water Management District

Mr. Chauncey Goss
South Florida Water Management District

CHNEP SENIOR STAFF

Ms. Jennifer Hecker
Executive Director

Ms. Nicole Iadevaia
Research and Outreach Manager

PREFACE

More than two decades since the Charlotte Harbor National Estuary Program (CHNEP) was established, much progress has been made — as evidenced by overall increases in seagrasses in Charlotte Harbor, expanding range of the endangered Florida panther (which currently resides almost exclusively in this region), and permanent protection of hundreds of thousands of acres of environmentally sensitive lands. Through the hard work of the prior CHNEP Directors and staff, partners, and volunteers, we have made great strides towards improving environmental conditions in many areas of the CHNEP.

However, many challenges remain. Some of our area experiences increased harmful algal blooms, wetland and habitat losses, and hydrologic alteration. Sea level rise is resulting in saltwater intrusion and higher "king tides" that are inundating communities. Record-setting temperatures and storm events are resulting in severe fires and flooding. Some previously identified actions still need to be completed and additional actions undertaken to address new threats and challenges.

In response, CHNEP is evolving with an expansion of our program boundary of more than 700 square miles inland to encompass the full extent of the Caloosahatchee River system, resulting in more partners from Florida's Heartland joining with partners from the Coast. Our new name reflects the unique strength of this partnership: Coastal & Heartland National Estuary Partnership. Our team of outstanding partners, committee members, staff, and volunteers are enthusiastically committed to carrying forth and building the good work of the organization.

CHNEP continues to be uniquely positioned to assist our governmental and non-governmental partners in working collaboratively to solve problems. Our non-regulatory science and consensus-based approach allows all stakeholders to guide and participate in regional protection and restoration efforts. Accordingly, this Revised 2019 Comprehensive Conservation and Management Plan (CCMP) was drafted collectively and represents a shared strategic vision of what is needed to protect the water and wildlife in this region.

Thank you to all CHNEP partners who contributed input and committed themselves to implementing the CCMP over the next five years. To those who are not yet CHNEP partners, please join us. It is only through combining our voices, knowledge, manpower, and resources that we will be able to preserve the environment and quality of life we all enjoy.

Executive Director

CONTENTS

5 PREFACE

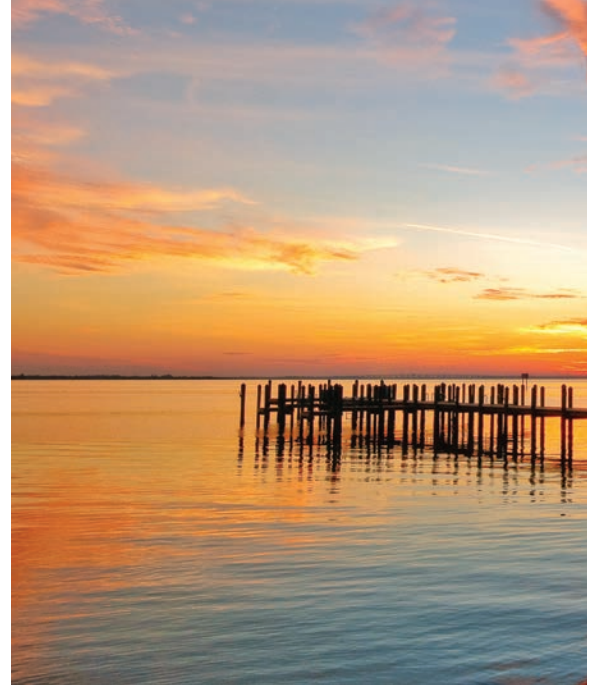
6 CONTENTS

8 EXECUTIVE SUMMARY

10 ABOUT THE CHNEP

17 ABOUT THE CHNEP AREA

26 ABOUT THE CCMP VISION AND STRATEGY



30

WATER QUALITY IMPROVEMENT ACTION PLAN

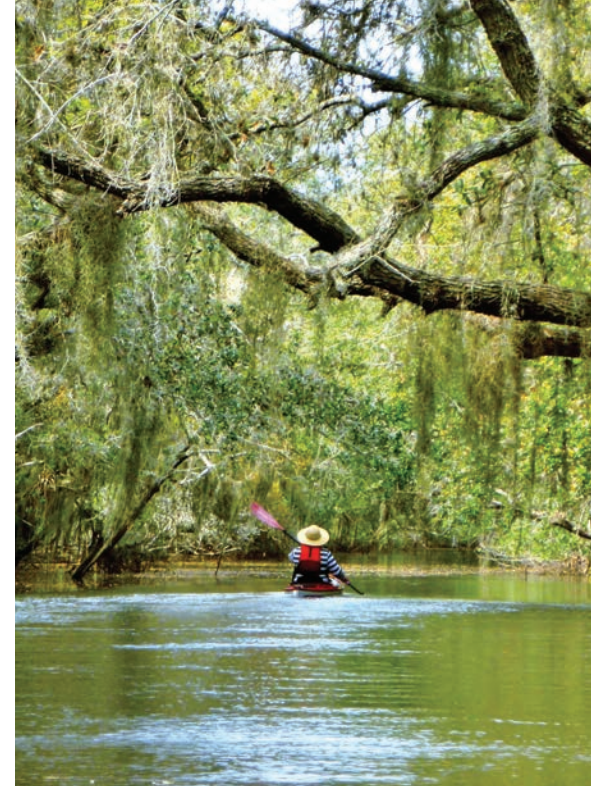
38 Action 1: Support a comprehensive and coordinated water quality monitoring and assessment strategy

44 Action 2: Develop water quality standards, pollutant limits, and cleanup plans

52 Action 3: Reduce urban stormwater and agricultural runoff pollution

60 Action 4: Reduce wastewater pollution

70 Action 5: Reduce harmful algal blooms



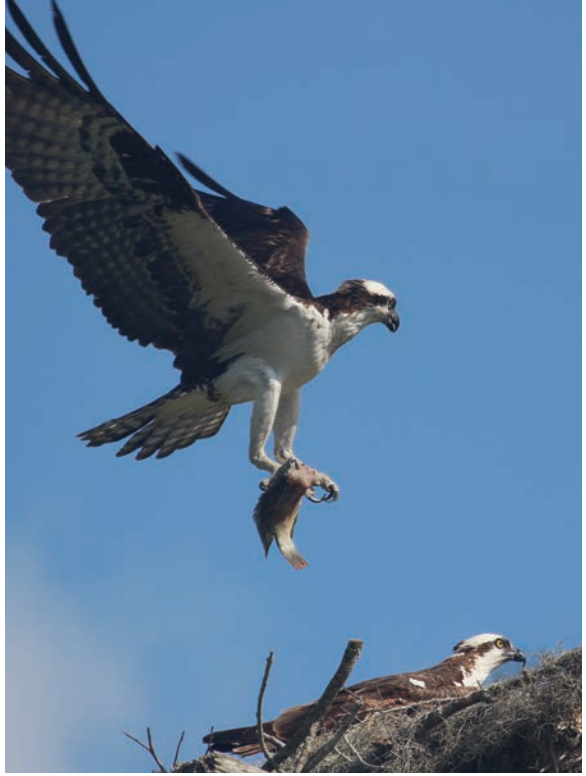
76

HYDROLOGICAL RESTORATION ACTION PLAN

82 Action 1: Conduct data collection, modeling, and analyses to support hydrological restoration

86 Action 2: Increase fresh surface water and groundwater availability to support healthy ecosystems

96 Action 3: Protect and restore natural flow regimes



102

FISH, WILDLIFE, & HABITAT PROTECTION ACTION PLAN

122 Action 1: Protect, restore, and monitor estuarine habitats

132 Action 2: Protect, restore, and monitor environmentally sensitive lands and waterways including critical habitat areas

142 Action 3: Assess and promote the benefits of land, waterway, and estuary protection and restoration

144

PUBLIC ENGAGEMENT ACTION PLAN

150 Action 1: Promote environmental literacy, awareness, and stewardship through expanded education and engagement opportunities for the general public

158 Action 2: Expand reach of education and engagement opportunities to new target audiences

164 Action 3: Strengthen non-profit partner collaboration in education and engagement programs

168 Action 4: Increase outreach to policymakers to enhance understanding and support for CCMP implementation

172 REFERENCES

178 ACRONYMS

180 APPENDIX: CROSSWALK of 2013 to 2019 CCMP ACTIONS

184 ACKNOWLEDGEMENTS

186 ACTION PLANS AT A GLANCE

EXECUTIVE SUMMARY

Central and Southwest Florida are celebrated for their waters. The interconnected water-based ecosystems stretching from inland lakes and rivers to the estuaries and Gulf of Mexico support diverse and abundant fish and wildlife. From Heartland to Coast, the environmental health of these systems underlies our quality of life and economy.

Over the years, the Coastal & Heartland National Estuary Partnership (CHNEP, formerly the Charlotte Harbor National Estuary Program) and its partners have successfully collaborated to protect and restore water quality and flows, habitats, and the fish and wildlife they support. As we celebrate our successes, we remain focused on the many challenges in our area. Continued rapid population growth, development, agriculture, and mining activities have transformed the landscape of Central and Southwest Florida. Declining water quality and supplies, as well as fish and wildlife population declines continue to be issues in some areas.

Climate change, including rising sea levels, warmer air and water temperatures, and more intense storms are exacerbating impacts. Priority environmental concerns include water pollution and altered natural flows, as well as habitat fragmentation, deterioration, and loss. CHNEP conducted a vulnerability assessment of its prior 2013 Comprehensive Conservation and Management Plan (CCMP), which guides the organization's work. Strategic activities were modified, eliminated, or added to reflect the need to minimize risks and support a more climate resilient community.

This five-year strategic plan, the 2019 CCMP, is designed to build on the principles that CHNEP was founded on — working on water quality, hydrology, habitats, fish and wildlife, and public engagement, while tackling new challenges. The four Action Plans in the 2019 CCMP are interconnected and synergistic. Each includes a Vision, Goal, Objective, and a Strategy of Actions and Activities to accomplish them.

The vision of the **WATER QUALITY IMPROVEMENT ACTION PLAN** is for waters to meet their designated human uses for drinking, shellfish harvesting, or swimming and fishing, while supporting appropriate and healthy aquatic life. Our strategy prioritizes five actions and multiple activities to support comprehensive and coordinated water quality monitoring programs and projects and programs that reduce pollution. Water Quality Improvement Actions are:

- Action 1 Support a comprehensive and coordinated water quality monitoring and assessment strategy
- Action 2 Develop water quality standards, pollutant limits, and cleanup plans
- Action 3 Reduce urban stormwater and agricultural runoff pollution.
- Action 4 Reduce wastewater pollution
- Action 5 Reduce harmful algal blooms

The vision of the **HYDROLOGICAL RESTORATION ACTION PLAN** is to provide appropriate freshwater flow to support healthy wetlands, rivers, and estuaries. Our strategy focuses on three Actions to support data-driven watershed planning and hydrological restoration projects to protect and restore natural flow regimes and provide sufficient fresh surface water and groundwater to natural systems. Hydrological Restoration Actions are:

- Action 1 Conduct data collection, modeling, and analyses to support hydrological restoration
- Action 2 Increase fresh surface water and groundwater availability to support healthy ecosystems
- Action 3 Protect and restore natural flow regimes

2019 CCMP cover: Thunderstorm over Pine Island Sound|*Steve Russell.*

The vision of the **FISH, WILDLIFE, and HABITAT PROTECTION ACTION PLAN** is a diverse environment of interconnected, healthy habitats that support natural processes and viable, resilient native plant and animal communities. Our strategy highlights three Actions to promote and facilitate permanent acquisition and effective protection and management of critical natural habitats including wildlife dispersal areas, movement and habitat migration corridors, wetlands, flowways, and environmentally sensitive lands and estuarine habitats. Fish, Wildlife, and Habitat Protection Actions are:

- Action 1 Protect, restore, and monitor estuarine habitats
- Action 2 Protect, restore, and monitor environmentally sensitive lands and waterways including critical habitat areas
- Action 3 Assess and promote the benefits of land, waterway, and estuary protection and restoration

The vision of the **PUBLIC ENGAGEMENT ACTION PLAN** is an informed, engaged public making choices and taking actions that increase protection and restoration of estuaries and watersheds. Our strategy calls for four Actions to promote environmental awareness, understanding, and stewardship to the general public, new target audiences, and policymakers; and strengthen non-profit partner collaboration in education and engagement programs. Public Engagement Actions are:

- Action 1 Promote environmental literacy, awareness, and stewardship through expanded education and engagement opportunities for the general public
- Action 2 Expand reach of education and engagement opportunities to new target audiences
- Action 3 Strengthen non-profit partner collaboration in education and engagement programs
- Action 4 Increase outreach to policymakers to enhance understanding and support for CCMP implementation

The CHNEP continues to be uniquely positioned to assist our governmental and non-governmental partners in working collaboratively to solve problems by bringing these entities together to address regional environmental issues. Our non-regulatory, science, and consensus-based approach allows all stakeholders to participate in protection and restoration efforts.

To improve implementation of the new 2019 CCMP, CHNEP is expanding its area from 4,700 to 5,416- square miles to encompass the freshwater basin of the Caloosahatchee River from the previous Tidal Caloosahatchee boundary at the Franklin Locks in Lee County, up to Lake Okeechobee in Glades and Hendry Counties. This change increases opportunities to better protect and restore the Caloosahatchee River and is consistent with the Partnership's watershed approach to managing the two other major rivers in the region: the Peace and Myakka Rivers. Additionally, to better reflect and acknowledge its many Heartland partners, the CHNEP has changed its name to the Coastal & Heartland National Estuary Partnership (CHNEP). The evolution of CHNEP and its CCMP positions the Partnership to be even more effective in protecting and restoring our waterways and other critical natural resources.

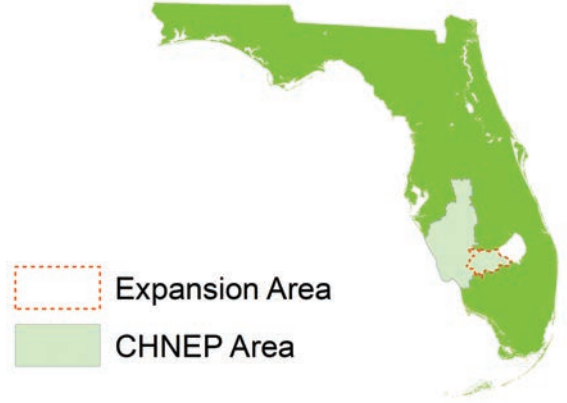
ABOUT THE CHNEP

Red Mangrove on Big Hickory Island, Fort Myers | *Carol McCardle.*

The U.S. National Estuary Program (NEP) was established by Congress in 1987 under the Clean Water Act and is administered by the US Environmental Protection Agency (EPA) to protect and restore estuaries along the coast of the United States. In 1995, former Governor Lawton Chiles submitted a nomination that the 4,700 square miles from Venice to Bonita Springs to Winter Haven be designated as an *Estuary of National Significance* and it was accepted into the NEP as the Charlotte Harbor National Estuary Program (CHNEP) on July 6, 1995. In 2019, the CHNEP area was expanded by 716 square miles to include the upper Caloosahatchee River basin (Figure 1), and the program name was changed to the Coastal & Heartland National Estuary Partnership (CHNEP). CHNEP is one of 28 NEPs throughout the United States, and one of four in Florida (along with Tampa Bay, Sarasota Bay, and Indian River Lagoon NEPs).

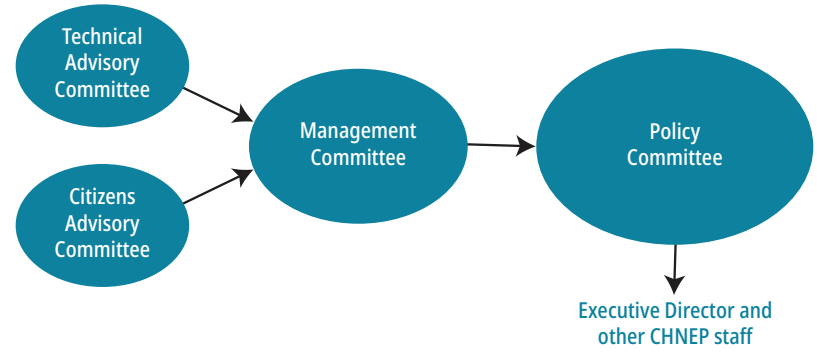
The 28 NEPs nation-wide each develop and implement Comprehensive Conservation and Management Plans (CCMPs), which are long-term strategic plans that contain actions to address water quality and living resource challenges and priorities as defined by local, city, state, federal, private and non-profit stakeholders. The CCMP is the strategic plan that guides the development of annual work plans and budgets to fulfill the purpose of a National Estuary Program to protect and restore the water quality and ecological integrity of estuaries of national significance. The first CHNEP CCMP was approved in 2000 and updated in 2008 and 2013.

Each NEP has a Management Conference (MC) that consists of diverse stakeholders and uses a collaborative, consensus-building approach to implement the CCMP. Moreover, each MC ensures that the CCMP is uniquely tailored to the local environmental conditions and is based on local input, thereby supporting local priorities. CHNEP brings together local public and private



◂ Figure 1.
The newly expanded CHNEP area extends 5,416 square miles from Florida's Gulf Coast to Florida's Heartland, including all or part of ten Counties. The expansion area includes the non-tidal portion of the Caloosahatchee River basin.

Figure 2. ▶ Organizational diagram of the CHNEP Management Conference.



organizations and citizens into a formal partnership charged with developing and implementing its CCMP to address environmental issues throughout the CHNEP area. In this way, the Partnership is designed to ensure it serves its governmental partners as well as the communities in its service area at large.

The Management Conference

The CHNEP is organized as a Management Conference of four Committees and CHNEP staff (Figure 2). Each Committee serves a specific purpose and brings together a diverse collective of expertise, interest, and perspective.

The ***Policy Committee*** establishes general policy for the CHNEP and has ultimate authority in Program direction and administration. The Policy Committee appoints members to other committees and approves budgets and work plans. Policy Committee members represent agency and elected leaders from the CHNEP area.

The ***Management Committee*** serves the important role of considering input from the Citizens Advisory Committee and Technical Advisory Committee, determining consensus, and advising the Policy Committee. The Management Committee reviews work plans, contract proposals, grants, work schedules, and products. Management Committee members are appointed by Policy Board members from their respective organizations.

The ***Citizens Advisory Committee*** (CAC) provides the critical link between the Partnership and the public, providing input about public concerns and ideas. The CAC is also an essential mechanism for sharing program information and resources with key community organizations and individuals that may not be directly involved with the Partnership.

The ***Technical Advisory Committee*** (TAC) provides scientific knowledge and technical expertise to CHNEP and its projects. The TAC identifies scientific problems and potential solutions. It helps develop work plans, requests for technical proposals, and reviews contract deliverables.

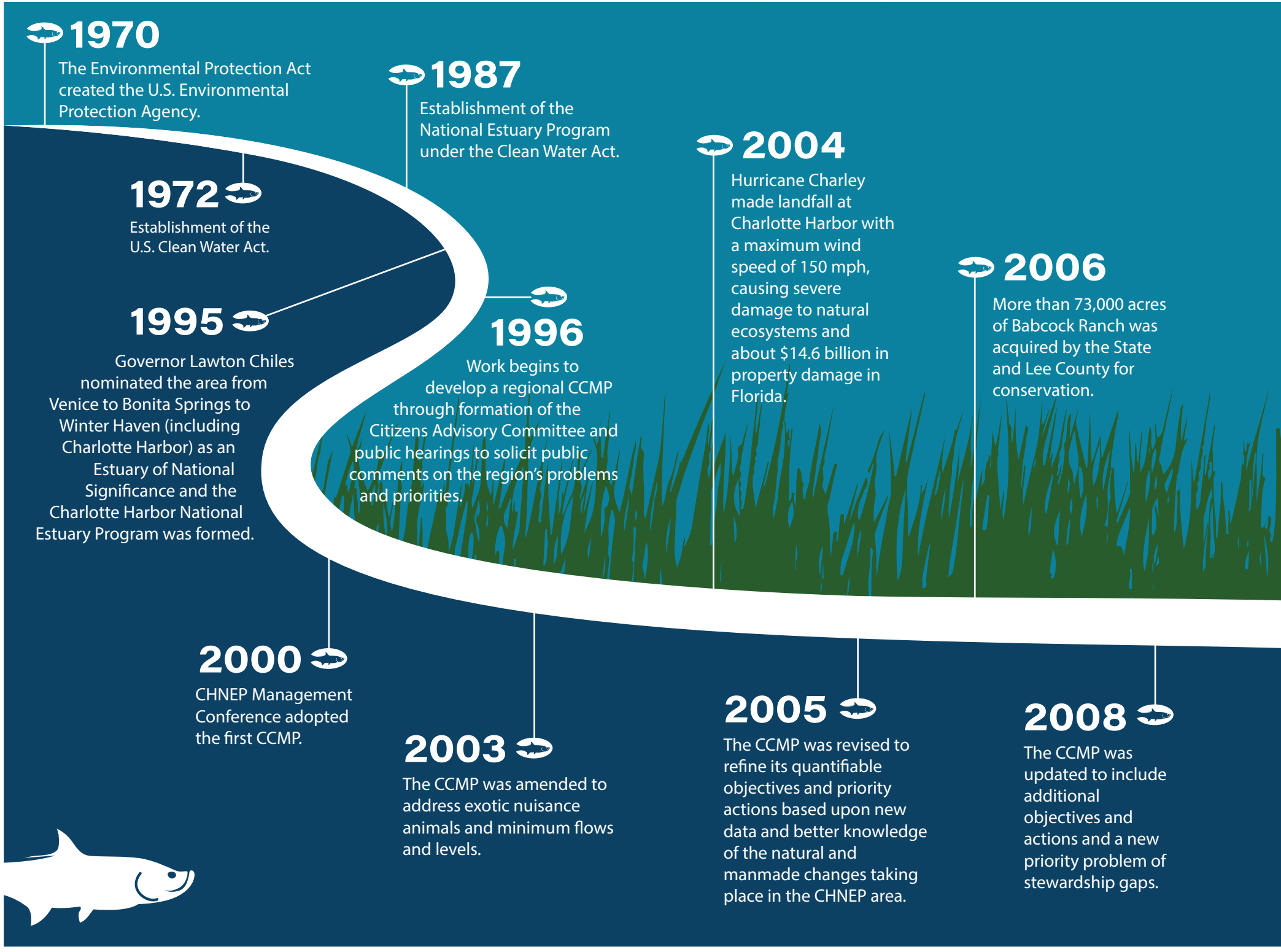
The ***CHNEP Staff*** works to enhance existing efforts and to improve coordination among the many active organizations in the region. The CHNEP staff supports the Management Conference structure and activities, prepares the annual work plan, locates and obtains funding for project implementation, and assists with CCMP implementation. To monitor progress, the CHNEP staff coordinates long-term monitoring and data management and supports its integration and dissemination to the public. The staff also supports and engages in public outreach and education initiatives.

Management Conference Members and Partners

CHNEP focuses efforts on the region's most important environmental issues and encourages public agencies and private organizations to work together to protect and restore critical natural resources within the CHNEP area. The CHNEP area includes all or part of ten counties, including a dozen incorporated cities, towns, and villages. The CHNEP area spans two water management districts, two regional planning councils, includes eight Federal Agencies (including the EPA that administers the NEP), and 26 Divisions of eight State Agencies that also have resource management responsibilities in the CHNEP area. In addition, there are more than 80 special districts, including coastal navigation, aquatic plant control, community development, conservation and easement, soil and water conservation, and water control authorities. The partnership also includes public and private universities and research institutes, as well as non-profit environmental land trust, education, and advocacy organizations (Table 1).

Table 1. CHNEP Management Conference members, partners, and major funders. Policy Committee members are designated with an asterisk.

COUNTIES & MUNICIPALITIES	AGENCIES	ORGANIZATIONS
Charlotte County*	BSCD	Audubon of the Western Everglades
Desoto County*	CFRPC*	Calusa Land Trust
Glades County*	CSWCD	Cape Coral Friends of Wildlife
Hardee County*	FDACS	Charlotte Harbor Environmental Center
Hendry County*	FDEP*	Coastal Wildlife Club, Inc.
Highlands County*	FWC*	Conservation Foundation of the Gulf Coast
Lee County*	FDEO	Environmental Confederation of SW Florida
Manatee County*	USFWS	Florida Gulf Coast University
Polk County*	GICIA	Florida Wildlife Federation
Sarasota County*	UF/IFAS	Friends of Charlotte Harbor Aquatic Preserve
City of Arcadia*	NOAA	Friends of Little Salt Spring
City of Bartow*	PRMRWSA	Lemon Bay Conservancy
City of Bonita Springs*	Sarasota-Manatee MPO	Manasota Waterways Civic Association
City of Cape Coral*	Sea Grant	Mosaic Company
City of Fort Myers*	SFWMD*	Mote Marine Laboratory
City of North Port*	SWFRPC*	National Association of Homebuilders
City of Punta Gorda*	SWFWMD*	North Port Friends of Wildlife
City of Sanibel*	USACE	Peace River Audubon Society
City of Venice*	USDA	Peace River Wildlife Center
City of Winter Haven*	USEPA Region 4*	Punta Gorda Isles Fishing Club
Town of Fort Myers Beach*	USGS	Sarasota Audubon
Village of Estero*	WCIND	Sanibel Captiva Conservation Foundation
		Sierra Club
		The Nature Conservancy
		Venice Area Audubon Society
		Wildlands Conservation


1970
The Environmental Protection Act created the U.S. Environmental Protection Agency.
1972
Establishment of the U.S. Clean Water Act.
1987
Establishment of the National Estuary Program under the Clean Water Act.
1995
Governor Lawton Chiles nominated the area from Venice to Bonita Springs to Winter Haven (including Charlotte Harbor) as an Estuary of National Significance and the Charlotte Harbor National Estuary Program was formed.
1996
Work begins to develop a regional CCMP through formation of the Citizens Advisory Committee and public hearings to solicit public comments on the region's problems and priorities.
2000
CHNEP Management Conference adopted the first CCMP.
2003
The CCMP was amended to address exotic nuisance animals and minimum flows and levels.
2004
Hurricane Charley made landfall at Charlotte Harbor with a maximum wind speed of 150 mph, causing severe damage to natural ecosystems and about $14.6 billion in property damage in Florida.
2005
The CCMP was revised to refine its quantifiable objectives and priority actions based upon new data and better knowledge of the natural and manmade changes taking place in the CHNEP area.
2006
More than 73,000 acres of Babcock Ranch was acquired by the State and Lee County for conservation.
2008
The CCMP was updated to include additional objectives and actions and a new priority problem of stewardship gaps.

MILESTONES: 1970-TODAY

2011

Urban fertilizer ordinances were adopted for all coastal counties in the CHNEP area.

2013

The CCMP was updated to incorporate new policies on seagrass and nutrient targets and other environmental indicators and targets.

2016

Seagrass coverage in Charlotte Harbor was restored to 71,000 acres, exceeding 1950's levels and reflecting improving water clarity in some estuaries.

2017

Approximately 4,000 acres of wetlands feeding three tributaries into Estero Bay were purchased and put into permanent conservation by Lee County (Edison Farms). Purchases like this propelled CHNEP to meet and exceed its CCMP interim Objective to double conserved lands from the 1998 baseline.

2018

Hurricane Irma made landfall near Marco Island and moved up the coast with a sustained wind speed of 111 mph, causing $50 billion in damages across Florida and widespread flooding and prolonged power outages leading to sewage spills.

2019

The CCMP was revised to: expand the CHNEP area to include the full length of the Caloosahatchee River, change the name to better acknowledge the Partnership's Heartland partners, incorporate a Climate Change Vulnerability Analysis, and add new science, accomplishments, and management priorities.

MAJOR ACCOMPLISHMENTS: 2013–2018

Addition of **46,141** acres of conservation lands, now totalling **564,289** acres.

Completion of **200** restoration and habitat management projects on **189,759** acres.

Addition of **1,867** new stations to the water quality monitoring network and collection of over **10.6** million water samples.

Overall expansion of seagrass to **71,000** acres, exceeding 1950's levels in Charlotte Harbor. 9 of 14 seagrass management segments now surpass their management targets.

Improvement in water quality in the Greater Charlotte Harbor Watershed (Conservancy of Southwest Florida Estuaries Report Cards 2011, 2017).

240,270 page-visits to the CHNEP Water Atlas and 70,842 unique site visits by people accessing water quality data, trends, and other documents.

3,245 new subscribers for CHNEP educational publications; 23,029 web page visits since the 2017 update; 1005 Facebook followers; and 490 volunteers.

6 Conservation Lands Workshops; **2** Watershed Summits; **5** professional development workshops; **6** Nature Festivals; plus many other events to raise awareness.

171,000 copies of Harbor Happenings magazine and **210,000** calendars distributed, featuring CHNEP programs and resources for clean water and habitat restoration.

ABOUT THE CHNEP AREA

CHNEP Boundary Expansion

In 2019, concurrent with this CCMP Revision and name change, CHNEP expanded its service area 716 square miles to encompass the freshwater basin of the Caloosahatchee River from the current Tidal Caloosahatchee boundary at the Franklin Locks in Lee County, up to Lake Okeechobee in Glades and Hendry Counties. This action was the result of a 2015 organizational retreat, where stakeholders from within the CHNEP and the general public convened to identify desired future priorities and opportunities. The idea to expand the CHNEP boundary to encompass the entire Caloosahatchee basin, both fresh and tidal, ranked in the top three. This change will create consistency, as the CHNEP already covers the entire basins of the other major rivers in the CHNEP area. It will also increase the effectiveness of the organization in being able to meet the goal of restoring the Caloosahatchee estuary, addressing all the hydrologic and water quality problems in the Caloosahatchee watershed. The CHNEP is beginning to identify and engage new partners and to seek new project and initiative opportunities in the expansion area to implement its desire to serve this new area. Information presented on the status of the CHNEP area in this Revision does not include the expansion area.

Priority Concerns in the CHNEP Area Basins

The newly expanded CHNEP area extends 5,416 square miles across eight complete watershed basins along Florida's Gulf Coast from Venice to Bonita Springs and in Florida's Heartland from Lake Hancock to Lake Okeechobee (Figure 3 on page 18). Extending over 130 miles north to south, the CHNEP area is defined by subtle topography, subtropical climate, diverse subtropical plant communities, and above all — abundant water above and below ground. The rivers in the CHNEP area often start far inland as headwater wetlands, lakes, creeks, and groundwater that combine and meander downstream. They flow through cities and towns, cattle pastures and citrus groves, pine flatwoods and cypress swamps. Along the coasts, they become tidal and pass through water control structures and conveyances as they wind through urbanized areas. Then they flow into bays, coastal waters, and out into the Gulf of Mexico. Where the freshwater rivers and creeks meet the salty water of the Gulf of Mexico, they form estuaries, which are one of the most productive natural systems on earth and spectacular havens for birds, fish, and other wildlife. A series of distinct, but related bays and estuaries make up the coastal environment of Southwest Florida. These bays and estuaries include Dona and Roberts Bays, Lemon Bay, Charlotte Harbor proper, Pine Island Sound, and Estero Bay. Together they form one of the largest estuarine systems in the state and are the most productive estuaries on Florida's west coast.

The Charlotte Harbor Aquatic Preserves are six contiguous aquatic preserves within the greater Charlotte Harbor estuary complex designated by the state Legislature for inclusion in the aquatic preserve system under the Florida Aquatic Preserve Act of 1975. From north to south, the preserves include Lemon Bay Aquatic Preserve, Cape Haze Aquatic Preserve, Gasparilla Sound–Charlotte Harbor Aquatic Preserve, Matlacha Pass Aquatic Preserve, Pine Island Sound Aquatic Preserve, and Estero Bay Aquatic Preserve (Figure 4 on page 19).

Dona and Roberts Bays Watershed

The Dona and Roberts Bays watershed, also known as the Coastal Venice watershed, starts north of the Venice Inlet, extends south to the southern tip of Venice Island and stretches inland northeast all the way to southern Manatee County. The historical watershed is highly altered from agricultural drainage projects, but the Dona Bay Restoration project seeks to divert and slow the flow of water through wetlands before reaching the bays. Intense coastal development has resulted in a 50% loss of historic wetlands and mangroves. Currently, 71% of the watershed is impaired for at least one water quality parameter and only 12% of the watershed is protected as designated conservation land. Water quality and wildlife habitat conditions have remained the same in recent years (CSWF 2011, 2017).

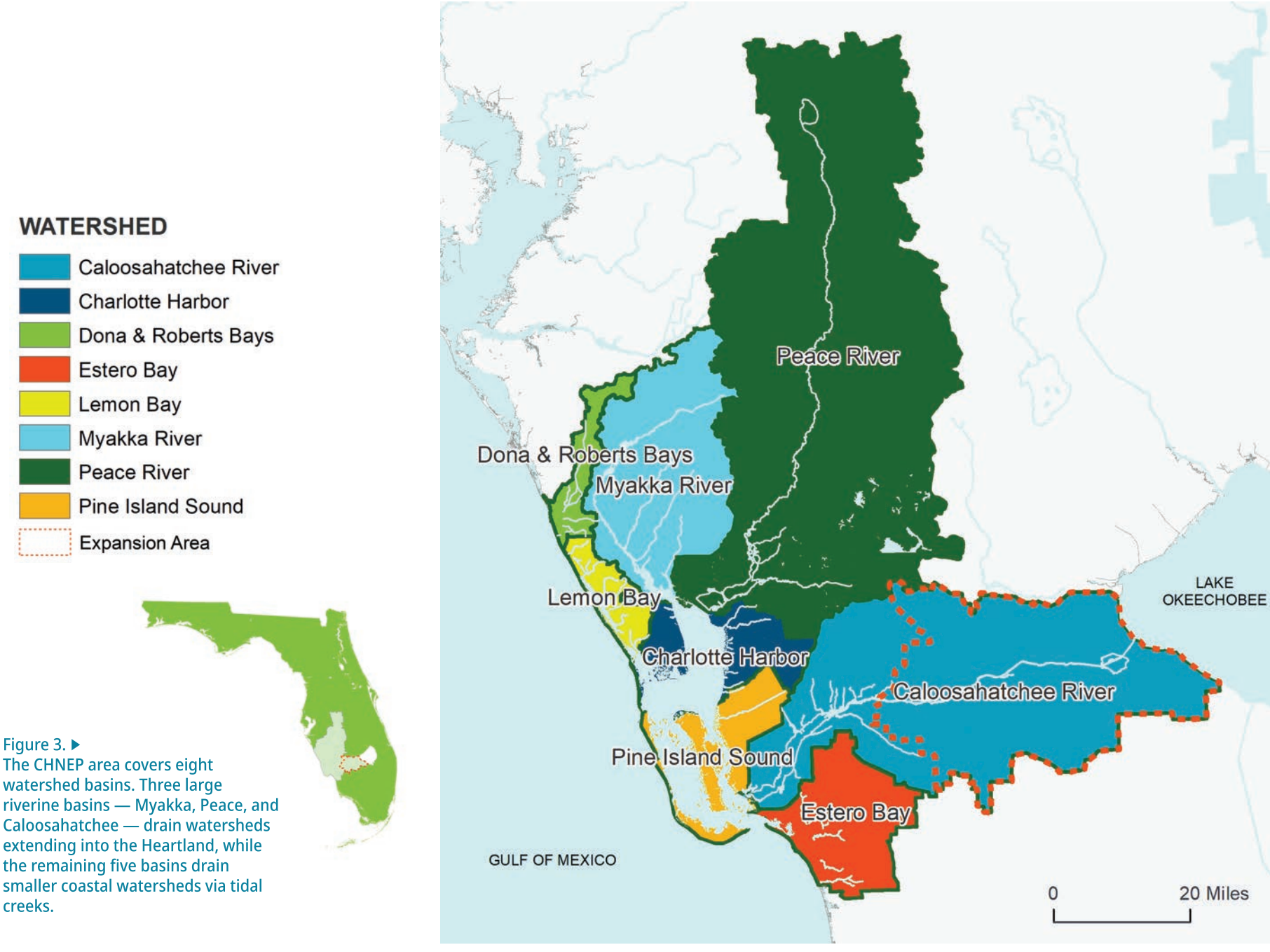
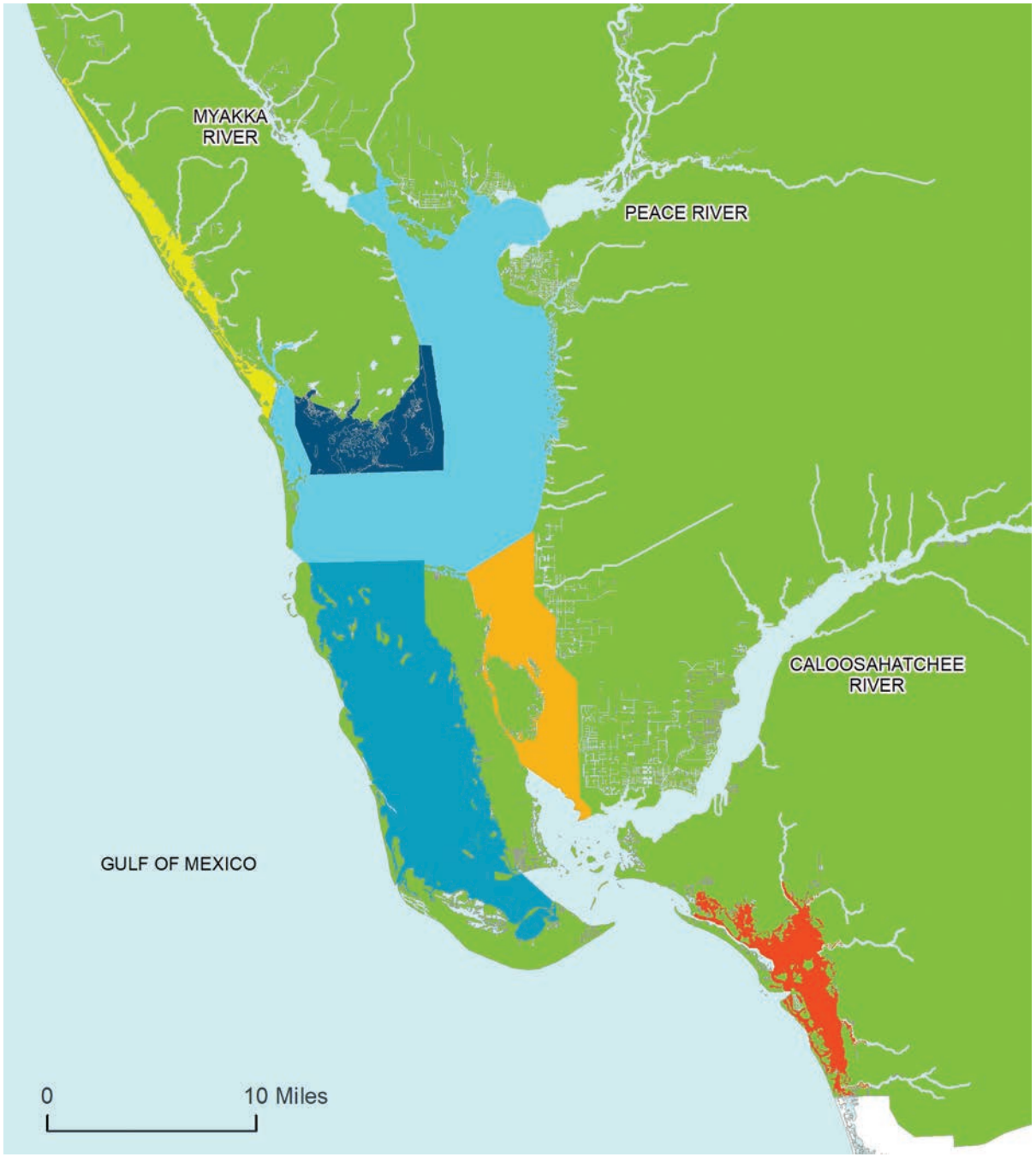


Figure 3. ▶
The CHNEP area covers eight watershed basins. Three large riverine basins — Myakka, Peace, and Caloosahatchee — drain watersheds extending into the Heartland, while the remaining five basins drain smaller coastal watersheds via tidal creeks.



◂ Figure 4.
The Charlotte Harbor Aquatic Preserves are six contiguous aquatic preserves within the greater Charlotte Harbor estuary complex designated by the state legislature for special protection.

Lemon Bay Watershed

From South Venice to the Gasparilla Island Causeway, Lemon Bay is dominated by beaches, barrier islands, and mangroves. There are five tidal creeks that drain into Lemon Bay: Alligator Creek, Woodmere Creek, Forked Creek, Gottfried Creek, and Ainger Creek. While the coastal fringe is developed with Old Florida neighborhoods, the watershed still retains 70% of its historic wetlands and 60% of its historic mangrove habitat. However, much of the watershed area has been drained and channelized, impacting water quality with stormwater pollution and septic tank leaching. Currently, 95% of the watershed is impaired for at least one water quality parameter, with high levels of heavy metals, specifically mercury, high nutrient concentrations, and low levels of dissolved oxygen. Wildlife habitat and water quality conditions are unchanged in recent years (CSWF 2011, 2017).

Stump Pass connects Lemon Bay to the Gulf of Mexico. Stump Pass Beach State Park is a hotspot for local boaters|*Neil Heisner.*

Greater Charlotte Harbor Watershed

The Greater Charlotte Harbor watershed is the largest in Southwest Florida and includes the three basins of the Myakka River, Peace River, and Charlotte Harbor proper. It begins at the headwaters of the Myakka River in Manatee County and the Peace River in Lakeland and extends down to Port Charlotte where the rivers empty into Charlotte Harbor. More than half of the watershed is impaired with dissolved oxygen, nutrients, and heavy metals. Water quality has improved slightly in recent years, along with seagrass coverage in the estuary (CSWF 2011, 2017).

Myakka River

The Myakka River watershed has the largest contiguous wetland landscape of the seven river watersheds. The 66-mile river begins its southerly flow from headwaters in Manatee and Hardee counties. After following a narrow floodplain forest corridor, the river slows and enters a series of lakes in Myakka River State Park, the largest state park in Florida. Deer Prairie Creek and Big Slough feed the river as it widens and enters Charlotte Harbor. The 34-mile portion of Myakka River in Sarasota County is designated a “Florida Wild and Scenic River.”

Cattle ranching dominates most of the watershed, especially upstream of Myakka River State Park. To satisfy the need for range and pastureland, much of the watershed was drained and diverted. These alterations enabled some drainage area to be used for row crops and citrus groves. Other parts of the upper and central Myakka River

watershed have been acquired for state management and protection.

In the lower portion of the Myakka River watershed, urban development is displacing agriculture. Former grazing lands along the banks of the lower Myakka River are now being converted to urban uses, mostly homes. Construction is occurring on the vast inventory of lands that were platted in the 1960s. At that time, these plats displaced agriculture in western Port Charlotte and in the City of North Port. Myakahatchee Creek, a tributary of the Myakka River, is now an important source of drinking water to some North Port residents.

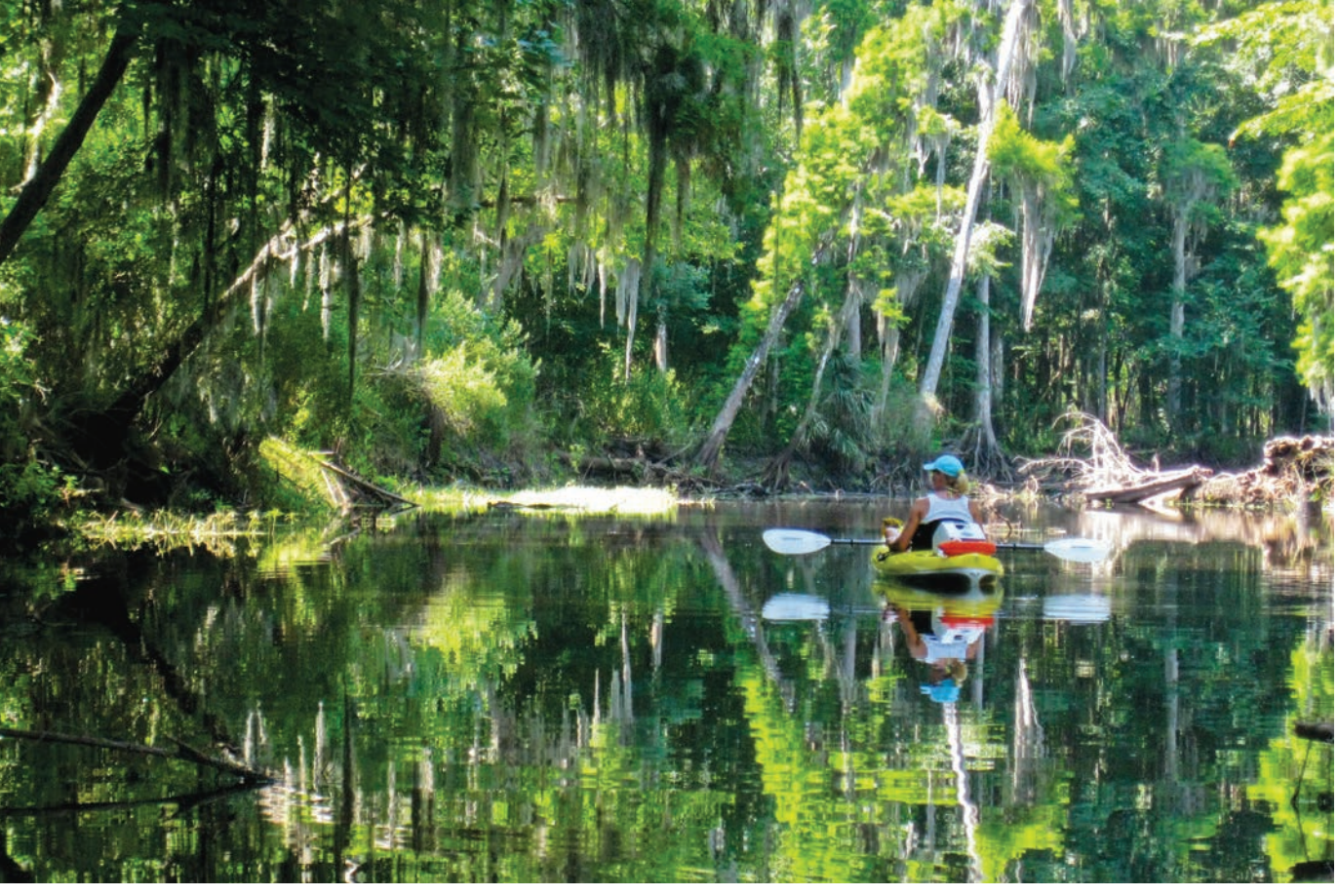
Peace River

At 2,315 square miles, the Peace River watershed is the largest and most diverse in the CHNEP area. The river originates at the Green Swamp in central Polk County, draining a series of wetlands and lakes. The rate of flow is directly proportional to groundwater levels. Underground and overland flows follow natural and altered paths through canals, flood control structures, former and active phosphate mines, wetlands, and Lake Hancock. South of Lake Hancock, canals and tributaries combine to define the main channel of the Peace River that eventually flows over 100 miles southwest to Charlotte Harbor.

Phosphate mining has been a major land use in the Polk County headwaters of the Peace River for more than a century, altering the hydrology, flora, and fauna of the landscape. State law requires all lands mined after July 1, 1975, to be reclaimed. In addition, the adoption of a state trust fund in 1977 allowed a portion of areas mined prior to 1975 to be voluntarily reclaimed. Citrus, cattle ranching, and row crop farming also occur in Polk County, but are more common downstream in Hardee, DeSoto and Highlands counties.

▲ Myakka River State Park in the Myakka River Watershed is one of Florida's most popular State Parks|*Priscilla McDaniel.*

The Peace River is the largest freshwater contributor to Charlotte Harbor. It is a source of drinking water for about 300,000 people in Charlotte, DeSoto, and Sarasota counties. Due to the effects of reduced rainfall, mining, agriculture, and municipal water uses, freshwater flows have declined, threatening the ecology of the river system and Charlotte Harbor. Reduced flows are most apparent upstream, although declines have also been recorded in the Peace River as far downstream as Arcadia.



▲ The Peace River originates at the Green Swamp in central Polk County and flows over 100 miles southwest to Charlotte Harbor | *Priscilla McDaniel.*

Charlotte Harbor and Myakka and Peace River Estuaries

Charlotte Harbor proper lies primarily in Charlotte County and connects to the Gulf of Mexico through Boca Grande Pass. The salinity regime of the Harbor changes dramatically with the season. Tides from the Gulf of Mexico affect water levels far up the Myakka and Peace Rivers. During low river-flow periods, saltwater migrates up the river; during higher river-flows, freshwater lowers salinities in the rivers and lower Harbor.

Although the Harbor has an area of about 130 square miles, much of it is very shallow. Areas of deep Harbor water extend up into the lower Myakka and Peace Rivers. Sandy shelves make up the Harbor "walls," including Cape Haze on the western and Punta Gorda and Cape Coral on the eastern walls. These east and west walls are covered by seagrass beds — essential habitat for young fish and other wildlife.

In addition to the designated Gasparilla Sound-Charlotte Harbor Aquatic Preserve and the Cape Haze Aquatic Preserve, the public owns many of the wetlands, mangrove forests, and salt marshes surrounding the Harbor. Very large buffer areas, part of the Charlotte Harbor Preserve State Park and mangrove islands, are also publicly owned.

Pine Island Sound Watershed

The Pine Island Sound watershed includes Matlacha Pass, Pine Island Sound, and San Carlos Bay, as well as the bay and barrier islands of Pine Island, Cayo Costa, Captiva, North Captiva, and Sanibel. The Sanibel River on Sanibel Island is a unique feature — one that is not present on most barrier islands. Dredging in the 1950s changed the slough's course and the island's historic wetland habitats. Pine Island separates Pine Island Sound from Matlacha Pass and provides both areas with limited freshwater from small creeks and wetland areas. Direct rainfall and runoff from western Cape Coral are the major freshwater inputs to the system. Periodically, during large freshwater releases from the Caloosahatchee River, outflow can discharge through San Carlos Bay into southern Pine Island Sound and southern Matlacha Pass. Dredging and altered timing and volumes of freshwater discharges from the Caloosahatchee River system have harmed the estuary.

While the Pine Island Sound watershed has 69% of its historic coastal wetlands, upland development has degraded water quality mainly from residential stormwater and septic/sewage pollution, agricultural runoff, and Caloosahatchee River discharge. Water

quality impairments, particularly high levels of metals and low dissolved oxygen, remain a concern. Nevertheless, the area provides excellent quality essential habitat for over 450 different species of fish, invertebrates, and birds. Seagrass beds are extensive and mangrove coverage is 3% higher than historic levels (CSWF 2011, 2017).

Caloosahatchee River Watershed

The Caloosahatchee River watershed starts inland at Lake Okeechobee and terminates in San Carlos Bay. Much of the western portion of the watershed has been urbanized by the growth of Fort Myers and Cape Coral, while the eastern portion is dominated by large agricultural land use. Historic dredging, ongoing development, and freshwater discharge from Lake Okeechobee have greatly changed the flow regime of the area, adding more freshwater and nutrients to the system and reducing historic wetlands and mangrove habitats by 63%.

The priority concerns for the watershed include habitat loss and poor water quality, leading to loss of submerged aquatic vegetation and shellfish, and frequent, harmful, blue-green algae blooms. Currently, 94% of the watershed is impaired for at least one water quality parameter. Water quality and wildlife habitat remain poor (CSWF 2011, 2017).

Caloosahatchee River

Historically, the Caloosahatchee River originated as overland flow through marshlands and swamp forest until it was connected to Lake Okeechobee in 1881. Since then, the U.S. Army Corps of Engineers (USACE) converted the upper river into a canal, connected the lake to the river, and controls discharge by structures and locks. Today, Franklin Lock in Lee County separates the fresh water of the river from the saltwater of the estuary. The lock also marks the beginning of the 30-mile tidal watershed of the Caloosahatchee River that starts at the lock and continues to the Gulf of Mexico.

Twentieth century transportation, drainage, irrigation, and waste disposal have greatly altered the Caloosahatchee River and its watershed. Its historical headwaters at Lake Hicpochee were drained when the C-43 canal was dug through it to connect the Caloosahatchee River to Lake Okeechobee. Its channels were straightened, shorelines hardened, and oyster reefs dredged. Remnants of the old river course, termed "oxbows," were cut off from the main river stem when it was straightened. Many uplands and wetlands east of Franklin Lock have

Pine Island separates Pine Island Sound from Matlacha Pass and provides both areas with limited freshwater from small creeks and wetland areas|*Mary Lundeberg.*

been converted to intensive agricultural uses. Today, the river often receives too much or too little flow of polluted water.

In addition to the upstream channel, small creeks and tributaries contribute significant volumes of freshwater to the river. The Orange River is a tributary of the Caloosahatchee River, located in Lee County. Part of the Great Calusa Blueway, the brackish Orange River starts out wide and deep, flowing through stretches of natural habitats. Upstream, the river gets narrower, shallower, and clearer. Widely spaced homes are sited along its entire length, but there is little boat traffic since the river is a no wake zone. Considerable freshwater runoff also enters the river and estuary from an extensive network of manmade navigation and drainage channels.

Kayakers tour Estero Bay. The Bay and its barrier islands are popular for ecotourism and recreation | *Wikimedia Commons.*

Estero Bay Watershed

The Estero Bay watershed extends from Fort Myers south to Bonita Springs and empties into Estero Bay, a lagoonal estuary protected by 6 barrier islands: Estero Island, Lovers Key, Long Key, Black Island, Big Hickory Island, and Little Hickory Island. Extensive seagrass beds in its shallow waters support juvenile fish and crabs, and numerous mangrove islands support large bird rookeries. The Estero Bay Aquatic Preserve was Florida's first aquatic preserve, dedicated in December 1966. The state also protects tributaries in the Estero Bay watershed with the *Outstanding Florida Waters* designation. As with Charlotte Harbor, the public owns many of the wetlands, mangrove forests, and salt marshes surrounding the bay.

The coastal side of the watershed is highly developed with inland areas continuing to grow. Freshwater input is fed by various smaller creeks and two minor rivers: the six and a half mile Estero River and the nine-mile Imperial River in southern Lee County. Nutrient runoff and upland discharge remain a priority concern, especially because low freshwater input makes the watershed highly sensitive to surface runoff. Poor water quality, altered hydrology, and boater damage have also caused a loss in historic seagrass and oyster coverage.

Currently 84% of the watershed is impaired for at least one water quality parameter. However, habitat loss has not been as dramatic as in other watersheds. About 57% of historic wetlands and 86% of historic mangrove habitat are still intact. Water quality and habitat remain largely unchanged in recent years (CSWF 2011, 2017).

The Gulf of Mexico

While outside of the CHNEP area, the Gulf of Mexico is critically linked to the health of its estuaries. Warm water temperatures in the Gulf create ideal conditions for powerful hurricanes, which can cause extensive damage to human and natural environments in the estuaries and watersheds of the CHNEP area. In 2004, Category 4 Hurricane Charley struck the northern tip of Captiva Island near Cayo Costa with peak winds of 150 mph and made landfall in Punta Gorda. The storm caused severe damage to natural ecosystems and about $14.6 billion in property damage in Florida. In 2018, Hurricane Irma struck Southwest Florida with sustained winds of 111 mph, causing widespread flooding and power outages leading to sewage spills and $50 billion in property damage across Florida.

About half the Gulf's area is comprised of shallow continental shelves, many of which are exploited for oil by offshore oil rigs. In 2010, the Deepwater Horizon oil platform exploded causing an oil slick that expanded over hundreds of square miles of ocean surface, significantly harming marine life and coastal wetlands. Fortunately, the spill did not reach the Charlotte Harbor area. Although oil spills of such large magnitude are relatively rare, the National Response Center reports that there are thousands of minor accidents in the Gulf every year. While offshore oil drilling does not occur off Florida's coasts, there remains interest in oil exploration and extraction here.

Harmful red tide algal blooms commonly form in the Gulf of Mexico and can be swept into Southwest Florida beaches and estuaries by currents and winds. Once inshore, red tide outbreaks can be prolonged by high nutrient concentrations in waterways. Red tide kills birds, fish, turtles, marine mammals and other aquatic life, and can cause respiratory problems for humans.

▲ Commercial fishing is an important industry in the Gulf of Mexico. Many commercially important offshore fishery species use estuarires for their early life history stages|*Steve Conley.*

The Gulf produces more shellfish, finfish, and shrimp annually than major fishery areas in New England, Chesapeake, and the south- and mid-Atlantic combined. Many offshore fishery species, like gray snapper and gag grouper, use estuaries for critical early stages of their life history. There is a need to assess the relative importance of different estuarine habitat types to offshore fisheries production.

From Heartland to Coastal communities, environmental quality defines quality of life. The rich diversity of interconnected ecosystems stretching from the inland riverine headwaters to the estuaries and Gulf of Mexico support agriculture, fishing, mining, recreation, and tourism valued annually in billions of dollars. Through time, humans transformed the landscape, creating legacy challenges for environmental protection and restoration. The large size and diversity of the CHNEP area creates challenges for managers and citizens alike. The work of CHNEP, guided by its CCMP, plays a critical role in improving regionally coordinated management as well as public education about the interconnections among the benefits we treasure.

ABOUT THE CCMP VISION AND STRATEGY

Great horned owl mom and chick, Cape Coral Florida | *John McConnell.*

This 2019–2023 CCMP Revision was developed over a 16-month period through a strategic planning process with the CHNEP Management Conference and invited public comment. Collectively, more than 100 citizen volunteers, scientists, engineers, resources managers, and elected officials contributed their time, essential knowledge, and informed opinions throughout the revision process. While this Revision resulted in a major reorganization of the 2013–2018 CCMP, the original Vision, Goals, and Objectives are reaffirmed through the same four Action Plans: Water Quality Improvement; Hydrological Restoration; Fish, Wildlife, and Habitat Protection; and Public Engagement.

The four Action Plans were developed sequentially, including a review of accomplishments from 2013–2018 and discussion of continuing and emerging challenges and opportunities. The 64 Actions and 412 Strategies of the 2013–2018 CCMP were consolidated, moved or restated (see Appendix on page 180), thereby streamlining the strategy with 15 Actions and 27 Activities, while adding detailed and updated information about Activity location and timeline, lead and responsible parties, and potential costs and funding sources. The 2013–2018 CCMP Quantifiable Objectives and Environmental Indicators and Targets were carefully considered, refined, and restated as 30 Performance Measures across 27 Activities that are measurable and achievable by CHNEP partners and/or CHNEP staff within the 5-year timeframe of the 2019–2023 CCMP.

Supporting Documents

Several important documents supplement the 2019–2023 CCMP Revision by providing additional detailed strategies for CCMP implementation:

- **Monitoring Strategy** (to be adopted in 2020) will outline methodologies for tracking Performance Measures that indicate changes within the CHNEP area and the effectiveness of CCMP Actions and is relevant across all Action Plans.
- **Finance Strategy** (to be adopted in 2020) will describe the strategy for long-term financial sustainability to implement the CCMP through diverse resources and partners.
- **Communication and Outreach Strategy** (to be adopted in 2020) will specify guiding principles and tactics for implementing the Public Engagement Action Plan to ensure community involvement and ownership in CCMP implementation.
- **Habitat Restoration Needs Plan** (2019) provides analysis and recommendations on habitat restoration priorities to help implement the Fish, Wildlife, and Habitat Protection Action Plan, including climate change considerations. The Plan guides habitat conservation, restoration, sustainability, resiliency, and connectivity throughout the CHNEP area.
- **CHNEP Climate Change Vulnerability Analysis** (2018) analyzes climate change induced risks to implementing CHNEP programs and achieving CCMP goals and objectives. Program specific findings from the Analysis are incorporated throughout all Action Plans.
- **Policy Review Procedures** (2018) outlines the CHNEP Policy Committee's role in policy and details procedures to develop and transmit CHNEP policy positions.
- **The CHNEP Water Atlas** is a publicly accessible online tool providing regional water resource data and information about watersheds and ecosystems in the CHNEP area. The CHNEP Water Atlas features a user-friendly interface accessing water quality data, interactive maps, graphs and charts, and easy-to-understand explanations of environmental science.

Environmental Justice

CHNEP encompasses urbanized and rural communities, affluent and underserved communities, and primarily senior as well as mixed-age communities. Some areas are ethnically diverse, whereas other areas are predominantly Caucasian. Several of the counties in the CHNEP area are coastal with economies centered primarily on tourism and real estate, while most inland counties have agricultural-based economies. Serving such a diverse population brings unique challenges that the CHNEP is committed to overcoming. Throughout this CCMP, there are activities aimed at serving our diverse community and prioritizing equitable allocation of staffing and resources to provide more support to underserved communities.

Focusing on providing information in multiple ways, conducting environmental education out in the various communities CHNEP serves, and providing small Conservation Grant assistance to new groups and partners are some of the ways we intend to "level the playing field" for access to the services and resources the CHNEP offers. Going forward, we strive for environmental and economic equity in forging shared solutions where disparate interests and viewpoints are heard and mutually satisfying outcomes are achieved. This not only is the right path forward, but ultimately will broaden the base of public support needed for environmental protection for generations to come.

▲
Sea level rise will impact coastal areas throughout Southwest Florida. Assessments of sea level rise and other climate change impacts were used to inform decision-making during the 2019 CCMP Revision process|*Sue Taylor.*

Climate Change Considerations

The U.S. EPA set a goal for all National Estuary Programs to be "climate ready" by 2020. CHNEP did this by adapting the 2019 CCMP revision to address climate change risks. As Central and Southwest Florida continue to experience climate change, adaptation planning will be crucial to minimize adverse effects to coastal and inland systems. In 2018, CHNEP conducted a vulnerability assessment to determine the most important potential risks to the quantifiable objectives in the CCMP's four priority areas: water quality degradation, hydrologic alterations, fish and wildlife habitat loss, and stewardship gaps. After consulting with stakeholders and management conference members, CHNEP identified four primary climate stressors that created 48 specific climate risks within the listed priority areas.

These risks were evaluated for their likelihood and level of impact to CCMP quantifiable objectives based on the most recent climate change data. Five experts were surveyed in areas relating to climate science and coastal planning and asked to rate each risk on a qualitative scale (low, medium, high) for both likelihood of occurrence and level of impact to the specified objectives. Similar feedback was also gathered from the general public and participants at the 2018 CHNEP Conservation Lands Workshop. The climate risks found to pose the highest threat were: overloaded stormwater systems, septic failure, loss of coastal vegetation, and habitat loss or degradation. The results of the Climate Change Vulnerability Assessment (CHNEP 2018a) were used by CHNEP management conference members to inform decision-making during the 2019 CCMP Revision process. Strategic Activities were modified, eliminated, or added to reflect the need to minimize these risks and support a more climate resilient community.

Our Strategic Plan

The four Action Plans of the CCMP are interconnected and synergistic. Each includes a Vision, Goal, Objective, and a Strategy of Actions and Activities to accomplish them (see Action Plans At A Glance on pages 186–195).

WATER QUALITY IMPROVEMENT

VISION: Waters that meet their designated human uses for drinking, shellfish harvesting, or swimming and fishing, while supporting appropriate and healthy aquatic life.

GOAL: Water quality improvement.

OBJECTIVE: Meet or exceed water quality standards for designated uses of natural waterbodies and waterways with no degradation of Outstanding Florida Waters.

STRATEGY: Support comprehensive and coordinated water quality monitoring programs and projects and programs that reduce pollution and pollutants entering waterways.

HYDROLOGICAL RESTORATION

VISION: Appropriate freshwater flow across the landscape to sustain healthy wetlands, rivers, and estuaries.

GOAL: Enhanced and improved waterbodies with more natural hydrologic conditions.

OBJECTIVE: Adequate aquifer recharge and freshwater volume and timing of flow to support healthy natural systems, meet water quality criteria, and protect the designated use.

STRATEGY: Support data-driven watershed planning and hydrological restoration projects to protect and restore natural flow regimes and provide sufficient fresh surface water and groundwater to natural systems.

FISH, WILDLIFE, & HABITAT PROTECTION

VISION: A diverse environment of interconnected, healthy habitats that support natural processes and viable, resilient native plant and animal communities.

GOAL: Natural habitat protection and restoration.

OBJECTIVE: Permanently acquire, connect, protect, manage, and restore natural terrestrial and aquatic habitats.

STRATEGY: Promote and facilitate permanent acquisition and effective protection and management of critical natural habitats including wildlife dispersal areas, movement and habitat migration corridors, wetlands, flowways, and environmentally sensitive lands and estuarine habitats.

PUBLIC ENGAGEMENT

VISION: An informed, engaged public making choices and taking actions that increase protection and restoration of estuaries and watersheds.

GOAL: Public education and engagement.

OBJECTIVE: Increase the proportion of the population that supports and participates in actions to protect and restore estuaries and watersheds.

STRATEGY: Promote environmental awareness, understanding, and stewardship to the general public, new target audiences, and policymakers; and strengthen non-profit partner collaboration in education and engagement programs.

WATER QUALITY IMPROVEMENT ACTION PLAN

VISION: Waters that meet their designated human uses for drinking, shellfish harvesting, or swimming and fishing, while supporting appropriate and healthy aquatic life.

GOAL: Water quality improvement.

OBJECTIVE: Meet or exceed water quality standards for designated uses of natural waterbodies and waterways with no degradation of Outstanding Florida Waters.

STRATEGY: Support comprehensive and coordinated water quality monitoring programs, and projects and programs that reduce pollutants entering waterways.

ACTION 1: Support a comprehensive and coordinated water quality monitoring and assessment strategy

ACTION 2: Develop water quality standards, pollutant limits, and cleanup plans

ACTION 3: Reduce urban stormwater and agricultural runoff pollution

ACTION 4: Reduce wastewater pollution

ACTION 5: Reduce harmful algal blooms

◀ Sunrise over the Peace River | *Theodore Thelin.*

This Water Quality Improvement Action Plan addresses aspects of water quality specific to waters meeting their designated human uses for drinking, shellfish harvesting, or swimming and fishing, while supporting appropriate and healthy aquatic life. Water quality is one aspect of hydrology, the science of the physical and chemical properties of surface and groundwater, the occurrence and movement of water, and its relationship with the living and non-living environment (Bales 2015). Aspects of flow dynamics and surface and groundwater levels are addressed in the Hydrological Restoration Action Plan.

▲ Water quality on our coasts is affected by land uses upstream in the watershed | *Christine Faccone.*

Central and Southwest Florida are celebrated for their waters and abundant aquatic life, recreational opportunities, and economic activities they support. CHNEP and its partners have enjoyed many successes in protecting and restoring water quality to support its designated uses and look forward to continued successes.

Priority challenges for water quality improvements involve protecting and restoring waters that have deteriorated from inadvertent impacts caused or induced by human (anthropogenic) activities. Alteration of natural landscapes by anthropogenic activities like agriculture, mining, and residential and commercial development has interrupted the natural flow of water and changed water chemistry and quality. These activities release pollutants onto land and into waterbodies, decrease pervious land surface, increase pollutant laden runoff, and reduce the value and function of ecosystems for water filtration and recharge.

Agriculture is an economic engine in the area, second only to tourism. Citrus and beef cattle are the main agricultural products. In addition to feeding a nation, agricultural lands can provide many beneficial ecosystem services. For example, they can contain natural cypress heads and sloughs providing natural floodwater retention and treatment. Over time, agricultural land clearing, leveling, and drainage have transformed habitats. Advances in agricultural best management practices (BMPs) have reduced some environmental impacts; however, challenges remain. For example, operations not following BMPs can pollute surface water and groundwater with fertilizers, pesticides, and animal waste. Transformation of former ranches and farms in coastal counties to more intensive uses, such as residential and commercial developments, creates new challenges.

Mining and reclamation processes have significantly changed the landform of large areas within the CHNEP area, primarily phosphate and rock mining. Phosphate is

a significant management concern. The "Bone Valley" phosphate deposit extends over 500,000 acres and lies mainly within the Peace River watershed. Limestone and sand mining occur in South Florida, with mining operations near Corkscrew Swamp. Mining operations can negatively affect water quality, disrupt wildlife habitats, and change the way water is stored in the system. Reclamation, off-site mitigation, and preservation can reduce some of the negative environmental impacts associated with mining.

Residential and commercial development dramatically and permanently changed the character of the CHNEP watershed. Pastures, croplands, and natural areas were drained and cleared, and coastal lowlands were dredged and filled to create tens of thousands of home sites. Shoreline development transformed mangrove fringe and other wetland systems through construction of canals, seawalls, and riprap. Existing coastal residential centers expanded and became denser, resulting in increased stormwater and wastewater, and decreased function of coastal habitats to absorb and filter pollutants. Development has dramatically reduced pervious surfaces that once allowed water to be stored and recharge underground aquifers. Modern stormwater treatment practices have improved retention and treatment in some developed areas, but wet treatment systems like stormwater ponds still treat less than 40% of the nitrogen and 65% of the phosphorus generated — contributing to downstream water quality issues (Harper 1999). Mitigation can help resolve some of the environmental impacts due to development, but non-point source pollution and increased runoff remain serious challenges.

▲ Changes in land uses in CHNEP area watersheds have impacted waters and waterways from the Heartland to the Coast | *László Bencze.*

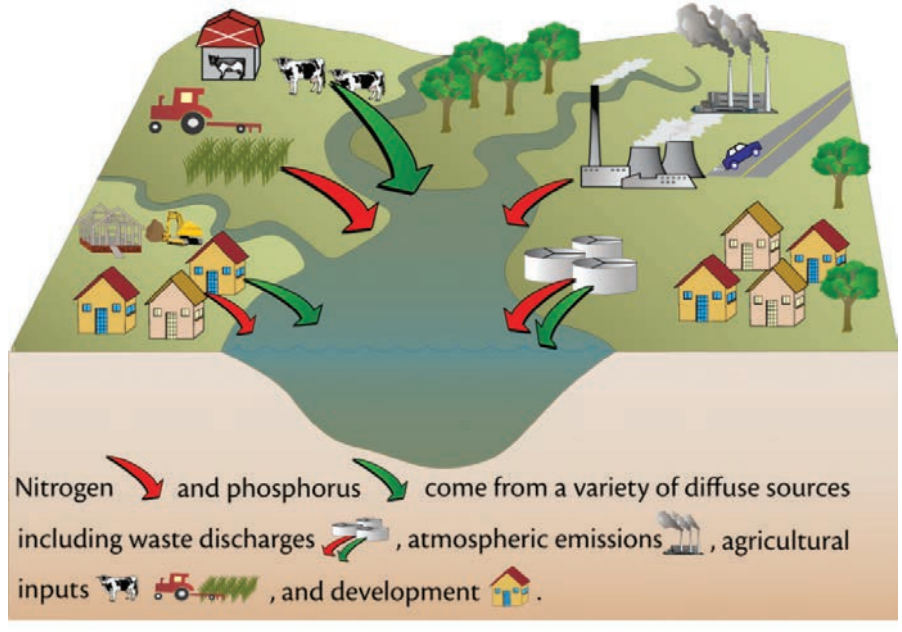
Threats to Water Quality

There are multiple threats to water quality in the CHNEP area, including excess nutrients, bacteria, low dissolved oxygen, reduced water clarity, toxins, plastics, and hydrologic alteration.

Excess Nutrients

Living things require nutrients to survive, grow, and reproduce. However, excess nutrients, including nitrogen and phosphorus, can feed harmful algal blooms, which can deplete dissolved oxygen and create toxins harmful to aquatic life and human health.

Excess nutrients in urban, agricultural, and industrial runoff are one of the leading threats to water quality in the CHNEP area (Figure 5). Scientists, managers, and policymakers need to gain a better understanding of the relative contributions of different sources of nutrient loadings to water bodies.



▲ Figure 5. Nitrogen and phosphorus come from a variety of sources in the watershed | *Lane et al. 2007; courtesy of the Integration and Application Network (ian.umces.edu) University of Maryland Center for Environmental Science.*

Wastewater treatment plants remove many harmful elements of wastewater, but treated wastewater can still contain a significant nutrient load. Treated wastewater can be disposed through different pathways, including discharge into surface waters, injection into underground wells and aquifers, release to infiltration basins and spray fields, or delivery to reuse irrigation systems. Onsite Sewage Treatment and Disposal Systems (OSTDS), like septic systems, are common in the CHNEP area where central sewage treatment is not available. When these systems malfunction, even one household can become a large local source of nutrients and bacteria.

Industries such as citrus processing, phosphate mining, fertilizer manufacturing, and animal feedlots are also sources of excess nutrients. Their discharges are regulated and must be permitted and meet federal and state standards.

Stormwater runoff can carry pollutants to waterways and waterbodies. Pollutants in stormwater are challenging to control because there is often no single identifiable point source. Stormwater pollutants can include fertilizers and pesticides from residential/commercial lawns, golf courses, and agricultural operations; litter, oil and toxins from roadways and parking lots; and waste from livestock, pets, and septic systems. Many residents and homeowner associations are unfamiliar with best management practices for their stormwater treatment ponds, and treatment effectiveness is highly variable.

The atmosphere also accepts, transports, and deposits nutrient pollution. Locally, nutrients are released into the air from vehicles and power plants. Pollutants can also be transported from distant sources into the CHNEP area by wind and deposited either directly into waters or indirectly through deposition in the watershed and carried by stormwater to waterways.

Bacteria

Bacterial contamination can affect our ability to use water for drinking, swimming, and shellfish harvesting. State of Florida water quality standards establish bacteria limits for different designated uses. For example, because shellfish like clams and oysters are filter feeders, they can accumulate and concentrate bacteria in their body tissues. If eaten raw, they can cause serious illness or

even death. Therefore, only regularly monitored waters with low levels of bacteria are opened for shellfish collection. Less stringent standards apply for aquatic recreation like swimming and fishing.

Bacterial contamination comes from a variety of sources, but of most concern is fecal waste from humans and other animals. Sources of fecal bacteria include septic systems, leaking sanitary sewer systems, confined animal feedlots, untreated waste from wastewater plant overflows and backups, and overflows from wastewater conveyance infrastructure like manholes and lift stations. Urban pet waste is another significant source of contamination. After heavy rainfalls, stormwater can carry bacteria from these sources to waterways and bays. Consequently, many approved shellfish harvest areas are closed after heavy rainfalls and swimming areas may be posted as unsafe for water recreation.

Low Dissolved Oxygen

Dissolved oxygen (DO) is an important indicator of water quality, as low DO can result in the death of fish and other aquatic organisms. Sources of aquatic oxygen include plant photosynthesis and wind-driven surface-air mixing. Oxygen is consumed by animal and plant respiration and decomposition. Factors that control dissolved oxygen levels are complex and can vary throughout the day and year and with water temperature and salinity. Low DO conditions can occur naturally in some habitats, such as in warm shallow waters of tidal creeks. Low DO can also occur in shallow estuarine waters during the rainy season when large volumes of freshwater runoff or discharge can create a freshwater lens that reduces the mixing of oxygen into deeper water. Excess nutrients in runoff can cause algal blooms, which can deplete DO when algae die and decompose. Nutrients and bacteria in sediments can also stimulate oxygen demand, leading to low DO. Suspended sediments and other particulate matter in the water can limit the availability of sunlight, which can decrease oxygen production by photosynthetic organisms.

Reduced Water Clarity

Water clarity is a measure of how far light penetrates through water. Sunlight can be absorbed or scattered in the water column when it interacts with suspended sediments and particles, phytoplankton, and dissolved materials. Reduced sunlight can limit the area of suitable bottom habitat available to seagrasses. Due to high spatial and temporal variability, long-term water quality monitoring is necessary to detect trends in water clarity. Because seagrass requires suitable water clarity to flourish, the sustained presence or absence of seagrass can be an important long-term bioindicator. Thus, seagrass targets established for each CHNEP estuary are an important water quality management tool.

Eroded sediments reduce water clarity downstream | *Sarasota County*.

▲ Plastic pollution of all sizes harms water quality and fish and wildlife | *Sarasota County.*

Toxins

Aquatic environments are the ultimate reservoirs for many toxic manmade chemicals. Toxins include heavy metals like lead and mercury, and pesticides and industrial chemicals like DDT, chlordane, dieldrin, and PCBs. Endocrine disrupting compounds, such as polybrominated diphenyl ethers (PBDEs, used as a flame retardant), bisphenol A (BPA, used to make plastic), and ethinyl estradiol (EE2, a synthetic estrogen used in oral contraceptives) are emerging pollutants of concern for environmental and human health. Known as ecoestrogens, these compounds are also found in pesticides, insecticides, and fungicides. A wide variety of pharmaceuticals and personal care products — including lotions, shampoos, sunscreens, perfumes, and cosmetics — contain constituents such as phthalates, parabens, glycol ethers, ultraviolet filters, polycyclic musks, and antimicrobials. These constituents are linked to adverse endocrine or reproductive effects in animals, whose tissues can accumulate toxins, making shellfish and fish harmful to humans.

Sources of toxins are numerous and expensive to monitor. Toxins can be released into the air from power plants, manufacturing facilities, or vehicles. They can be deposited on land and water through home, garden, auto, and boat maintenance activities, illegal dumping, and accidental spills. Stormwater can carry oil, heavy metals, lawn chemicals, and waste into waterbodies. Some toxic chemicals can accumulate in the sediments of lakes and estuaries, allowing their impact to continue for extended periods of time.

Toxins from pharmaceuticals and personal care products are present in treated wastewater discharges. For example, research in Tampa Bay has documented the presence of ecoestrogens in treated wastewater effluent (Cook 2015). Between 2006–2009, CHNEP sponsored several studies to investigate pharmaceuticals in tidal rivers. Ecoestrogens, steroids, impotence treatments, lipid-lowering drugs, and anti-depressant chemicals were either undetectable or at near-detectable levels (Gelsleichter 2008). Further research is needed to understand toxicity levels and the efficacy of various wastewater treatment technologies at removing these contaminants prior to discharge or reuse.

Plastics

Microplastics are an emerging pollutant of concern. They are commonly derived from the disintegration of larger plastic debris down to a size of 1–5 millimeters. In addition, microbeads from cleansers and cosmetics and microfibers from the laundering of synthetic clothing can pass untreated through septic systems and wastewater treatment plants and contaminate the environment. These microplastics do not break down, they only continue to break apart. They can also absorb chemical contaminants and become incorporated into sediments and embedded in the tissue of living things. CHNEP is a partner organization of the Citizen Science Marine Debris Monitoring and Outreach project funded by the Gulf of

Mexico Alliance (GOMA) Gulf Star Program grant. The GOMA project team trained CHNEP staff to collect and analyze water and sediment samples to identify microplastics, and in turn, CHNEP trains local organizations and volunteers to collect data. More information is needed to better understand how microplastics enter waterways, how they are distributed, what types are most common, and what impacts they may have on aquatic organisms.

Hydrologic Alteration

Hydrologic alteration, defined as "the manmade or man-induced alteration of the chemical, physical, biological, and radiological integrity of water" (Clean Water Act Section 502(19)), is viewed as a form of pollution under the Clean Water Act (Novak et al. 2016). Alterations in the timing, volume, velocity, and location of fresh surface water and groundwater flows can interact with and alter nutrient and bacteria concentrations, dissolved oxygen, sediment loads, salinity, and other aspects of water quality — negatively impacting biological aquatic systems. This CCMP addresses alteration of flows and levels of water in its Hydrological Restoration Action Plan.

Water Quality Challenges and Management Actions

- Translating water quality monitoring data into management action: Iterative and adaptive water quality modeling is needed to identify gaps in monitoring, assess water quality status and trends, and evaluate efficacy of pollutant management programs and projects.
- Determining appropriate nutrient limits: Establishing (and reevaluating) numeric nutrient criteria for freshwaters, estuaries, and tidal creeks to achieve ecosystem health and ensure safety for their designated use.
- Resolving competing funding demands: Funding for water quality management competes with other public policies, necessitating the need to find consensus and resources for water quality projects and programs.
- Balancing strategies for voluntary prevention versus mandatory correction: Failure to voluntarily use best management practices can degrade area-wide water quality. The cost-benefit of voluntary pollution prevention compared to additional regulations requires further evaluation.
- Coordination of intergovernmental support of common goals: Federal, state, regional, and local governments operate under complex governing statutes, ordinances, policies, and budgetary rules. Despite common goals for improving and maintaining water quality, individual organizational priorities and actions may not align.

The CHNEP Management Conference has identified five major Actions to improve water quality: Action 1 calls for a comprehensive and coordinated water quality monitoring and assessment strategy; Action 2 focuses on developing water quality standards, pollutant limits, and cleanup plans; Action 3 aims to reduce urban stormwater and agricultural runoff pollution; Action 4 seeks to reduce wastewater pollution; and Action 5 works towards reducing harmful algal blooms.

1 Support a comprehensive and coordinated water quality monitoring and assessment strategy

OBJECTIVES:

Continue to assist with collection of water quality data throughout the CHNEP area and support uploading and archiving of data in standard common public databases. Continue to analyze and identify water quality status and trends with appropriate modeling methods and tools. Identify water quality sampling gaps to ensure adequate consistent sampling across the CHNEP area. Identify, study, and monitor emerging pollutants of concern.

BACKGROUND:

CHNEP continues to build upon accomplishments to monitor, analyze status and trends, and protect and restore water quality. A major activity of the CHNEP is assisting partners with collecting, sharing, analyzing, mapping, and conveying complex technical information about water quality status and trends in an understandable manner. Water quality data are used by partners to assess resources and implement effective and efficient pollutant management programs and projects (see Water Quality Improvement Action 2*).*

Water Quality Monitoring

CHNEP manages the Coastal Charlotte Harbor Monitoring Network (CCHMN), a partnership of agencies initiated in 2001 that collects monthly water quality data using consistent, technically sound sampling design. Long-term random sampling of strategically located stations allows scientific assessment of status and trends. CCHMN field and laboratory partners collect and analyze water samples from 60 randomly selected field sites throughout 10 waterbodies each month, including Lemon Bay, Cape Haze/Gasparilla Sound, Charlotte Harbor, Pine Island Sound, Matlacha Pass, San Carlos Bay, Estero Bay, and the Tidal Myakka, Peace, and Caloosahatchee Rivers (Figure 6 on page 40). Fifteen water quality parameters are measured and analyzed using consistent field and laboratory methods (CHNEP 2015 and CHNEP 2016).

◀ Coastal Charlotte Harbor Monitoring Network (CCHMN) water quality sampling equipment.

Data are uploaded biannually by partners to WIN (Watershed Information Network), previously called STORET (Storage and Retrieval), a standard, common public database maintained by the Florida Department of Environmental Protection (FDEP). In addition, all contributing CCHMN laboratories and field monitoring agencies participate in Southwest Florida Regional Ambient Monitoring Program (SWF RAMP) quarterly meetings to help ensure region-wide data and methodology comparability. The SWF RAMP serves as a quality assurance forum for comparing split-sample laboratory results, resolving inconsistencies in results, and discussing pertinent water quality monitoring issues throughout the region.

Identifying waterbody impairments, establishing pollutant limits, and monitoring progress of corrective management actions all depend on the availability of accurate, high quality data. Protocols and procedures must be employed to ensure that data are properly collected, handled, processed, used, and maintained at all stages of the data life cycle.

CHNEP management activities for CCHMN include developing and updating Standard Operating Procedures and field Quality Assurance (QA) Plans, conducting annual field audits, contracting and assisting with field water quality sampling, assisting with equipment repair, hosting annual meetings, and participating in quarterly SWF RAMP quality assurance meetings. These activities are developed to be consistent with FDEP QA Rules (62-160, F.A.C.).

CCHMN supplements other ongoing water quality monitoring programs implemented by partners, including ongoing fixed station monitoring by counties, cities, agencies, and citizen scientists. The Charlotte Harbor Estuaries Volunteer Water Quality Monitoring Network (CHEVWQMN) is a volunteer-based sampling program coordinated by FDEP Charlotte Harbor Aquatic Preserve (CHAP) and Estero Bay Aquatic Preserve (EBAP). Volunteers collect field measurements and water quality data for 13 parameters at 50 fixed sites on the same day each month within one hour of sunrise. Nine waterbodies across the estuary are sampled, including Lemon Bay, Cape Haze/Gasparilla Sound, Charlotte Harbor, Pine Island Sound, Matlacha Pass, San Carlos Bay, Estero Bay and the Tidal Peace and Myakka Rivers.

CHNEP supports CHEVWQMN by assisting in conducting field sampling, transporting samples and supplies, participating in biannual

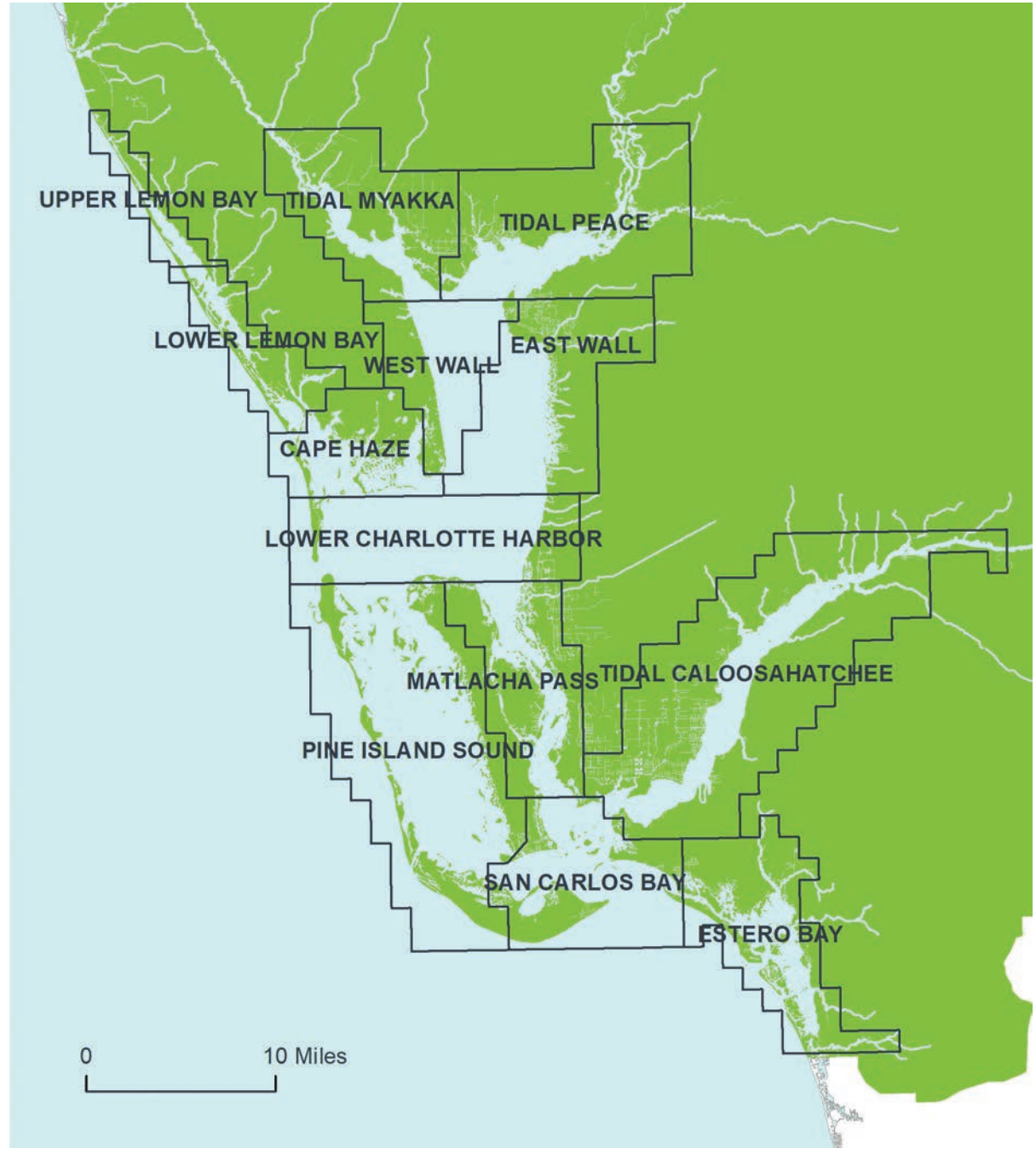


Figure 6. ▶
Coastal Charlotte Harbor Monitoring Network (CCHMN) water quality sampling strata. CCHMN field and laboratory partners collect and analyze water samples from 60 randomly selected field sites throughout 10 waterbodies each month.

Quality Assurance training sessions, providing access to data through the CHNEP Water Atlas, and training new volunteers as needed. CHNEP also supports Lee County Hyacinth Control District's Pond Watch and Cape Coral's Canal Watch, which engage homeowners to collect water samples from neighborhood ponds, lakes, and canals. Water quality analysis is performed by the sponsoring agency, and results are reported back to the volunteers.

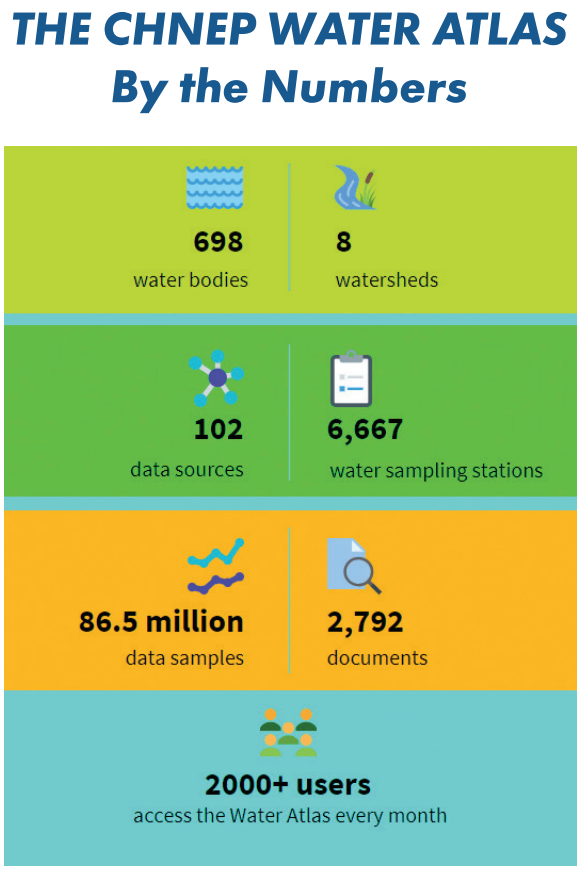
The CHNEP Water Atlas

CHNEP maintains the CHNEP Water Atlas, formerly the Charlotte Harbor Water Atlas. The CHNEP Water Atlas ensures that area scientists, resource managers and users, elected officials, and the public can access water quality data and other technical information. Launched in 2011 and managed by the University of South Florida in Tampa, the CHNEP Water Atlas is a user-friendly web-based tool that uses geographic information systems and a massive database. The CHNEP Water Atlas displays water quality and hydrology data using maps and charts, making data easier to visualize and understand. Data are available for 473 groundwater stations and 6,194 surface water stations from 102 different data sources, including biannual updates of CCHMN data from WIN (Figure 7). CHEVWQMN, Cape Coral Canal Watch, and the Lee County Hyacinth District Pond Watch sampling programs also provide data to the CHNEP Water Atlas. From 2013 to 2018, 1,867 new sampling stations and more than 10.6 million new samples were added.

CHNEP Water Atlas users can access pages for individual waterbodies — including lakes, ponds, bays, rivers, and streams to view associated water quality data. The Data Download tool allows users to view and graph data or to download raw data. The Real-Time Data Mapper tool has hundreds of stations that perform near-continuous monitoring of water quality, weather/rainfall, water flow, and water levels, with some sampling intervals as short as 15 minutes.

A core objective of CHNEP is to translate water quality data collected by CCHMN and other programs into actions aimed at protection and restoration. Analysis of water quality status and trends is essential to identify major sources of pollutants, provide more accurate measures of pollutant load limits, develop a basis for management plans, and evaluate effectiveness of management practices (see Water Quality Improvement Action 2). Previous analyses have led to development of water quality targets (CHNEP 2005) and numeric nutrient criteria for the estuary (Janicki Environmental 2010), as well as periodic watershed reports (CSWF 2005, CSWF 2011, CHNEP 2011, CSWF 2017). Annually, CHNEP's county and municipal partners evaluate water quality data from fixed-point monitoring programs to identify trends and corrective actions.

The CHNEP Water Atlas has recently been enhanced by new powerful data analysis tools that provide visualization of water quality status and trends. The Water Quality Contour Mapping tool shows changes in water quality at fixed periods, with monthly contour maps for 12 parameters. The Water Quality Trends tool displays results of



◀ Figure 7.
The CHNEP Water Atlas provides continuous access to water quality data and other technical information to area scientists, resource managers and users, elected officials, and the public. *http://chnep.wateratlas.usf.edu.*

a statistical ten-year trend analysis. The Water Clarity Report Card shows improving, stable, or declining water clarity in areas of the estuary with seagrass protection and restoration targets. CHNEP continues to support development and use of these and other types of sophisticated numerical and spatial modeling techniques (*e.g.*, pollutant load models) for protecting and restoring water quality.

The long-term monitoring strategy of CHNEP and its partners provides regional, technically sound, and timely data and analyses that can identify water quality status and trends for specific waterbodies. This strategy enables scientists, managers, and policymakers to evaluate management actions and decide whether water quality meets or violates a specific target level according to FDEP rules for water quality standards and assessment methods (62-302 and 62-303, F.A.C., respectively). As environmental conditions change due to anthropogenic and climate stressors, water quality sampling gaps may emerge. There is a need to identify gaps where redundancies exist or where data are insufficient to meet FDEP quality assurance or quality control (QA/QC) requirements for impairment determination, as well as for Total Maximum Daily Load (TMDL) and Basin Management Action Plan (BMAP) development and compliance (see Water Quality Improvement Action 2). The CHNEP will continue to coordinate and adapt, working with partners to identify emerging needs and seek funding, equipment, volunteers, and other resources to enable additional sampling in essential areas.

STATUS:

Ongoing. Previous 2013–2018 CHNEP CCMP Water Quality Actions WQ-B, WQ-C, and SG-S are combined here and updated to incorporate new information on CHNEP activities. Quantifiable Objectives WQ-2 and SG-3 from the 2013–2018 CHNEP-CCMP are carried forward and updated as Performance Measures.

RELATED ACTIONS:

- Water Quality Improvement Action 2: Develop water quality standards, pollutant limits, and cleanup plans
- Fish, Wildlife, and Habitat Protection Action 1: Protect, restore, and monitor estuarine habitats

ACTIVITIES:

Assist with the consistent and efficient collection of technically sound long-term water quality data throughout the CHNEP area, including supporting key programs like the Coastal Charlotte Harbor Water Quality Monitoring Network, partners' long-term fixed stations, and volunteer monitoring programs like the Charlotte Harbor Estuaries Volunteer Monitoring Network, Lee County Pond Watch, and the Cape Coral Canal Watch programs. Work with partners to obtain additional resources, increase efficiencies, and identify and fill sampling gaps.

Location: CHNEP area sampling stations from Lemon Bay to Estero Bay.

Responsible parties: CHNEP (Lead), SWFWMD, SFWMD, FDEP (Lead for data sufficiency and QA/QC), FDACS, FWC, CHAP, EBAP, SCCF, Calusa Waterkeeper, FGCU, County and Municipal governments.

Timeframe: Ongoing; Monitoring Strategy and Communication and Outreach Strategy to be adopted in 2020.

Potential annual cost and funding sources: $1M–10M/ Section 320 Funds, additional CCHMN funding from SWFWMD, in-kind support from SFWMD, FDEP, FWC, CHAP, EBAP, SCCF, Calusa Waterkeeper, County and Municipal governments.

Benefits: Sufficient long-term technically-sound data to support identification of waterbody improvements or impairments, pollutant limits, and corrective management actions to improve water quality.

5-year Performance measure: Maintenance or increase of the current spatial and temporal extent of ambient water quality monitoring data collection with appropriate QA/QC.

Support uploading and archiving of data in standard, common public databases, including FDEP's database and the CHNEP Water Atlas.

Location: CHNEP area.

Responsible parties: CHNEP (Lead for data input to the CHNEP Water Atlas), the CHNEP Water Atlas, SWFWMD, SFWMD, FDEP, FWC, CHAP, EBAP, SCCF, Calusa Waterkeeper, County and Municipal governments.

Timeframe: Ongoing; Monitoring Strategy to be adopted in 2020.

Potential annual cost and funding sources: $100,000–$499,999 /Section 320 Funds, in-kind support from SWFWMD, SFWMD, FDEP, FWC, CHAP, EPAP, SCCF, Calusa Waterkeeper, County and Municipal governments.

Benefits: Publicly accessible comprehensive database of water quality in waterbodies throughout the CHNEP area.

5-year Performance measure: Updates of water quality data to the CHNEP Water Atlas at least twice per year, and continuous public online access to water quality data via the Water Atlas.

Assess and report water quality status and trends to identify water quality.

Location: CHNEP area.

Responsible parties: CHNEP (Lead for the CHNEP Water Atlas), FDEP (Lead for TMDL/BMAP), FWC, SWFWMD, SFWMD, County and Municipal governments.

Timeframe: Ongoing; Monitoring Strategy and Communication and Outreach Strategy to be adopted in 2020.

Potential annual cost and funding sources: $100,000–$499,999/Section 320 Funds.

Benefits: Readily accessible and reliable index of water quality status and trends.

5-year Performance measure: Creation and dissemination of water quality status summaries for all basins in the CHNEP area at least once per year.

Identify, study, and monitor new emerging pollutants of concern and their potential sources.

Location: targeted areas in the CHNEP area.

Responsible parties: CHNEP, Florida Sea Grant, UF/IFAS Extension, NOAA, FDEP, FGCU, County and Municipal governments.

Timeframe: Ongoing; Monitoring Strategy to be adopted in 2020.

Potential annual cost and funding sources: $25,000–$99,999/Grants from EPA, NOAA, GOMA.

Benefits: Baseline data on the presence and distribution of emerging pollutants.

5-year Performance measure: Establishment of sampling and analysis protocols; periodic water sampling using established sampling and analysis protocols at targeted locations.

2

Develop water quality standards, pollutant limits, and cleanup plans

OBJECTIVES:

Support development by FDEP of measurable and enforceable water quality criteria and targets, Total Maximum Daily Load (TMDL) pollutant limits, and Basin Management Action Plans (BMAPs) or Reasonable Assurance Plans (RAPs) to reduce pollutant loading in waterways.

BACKGROUND:

The CHNEP and its partners have a long-standing goal to establish and maintain water quality at a standard necessary to sustain natural communities and their designated human uses (CHNEP 2000, 2008, 2013). Multiple threats to water quality exist in the CHNEP area, including excess nutrients, harmful bacteria, eutrophication, metals, dissolved solids, pharmaceuticals, plastics, anthropogenic hydrologic alteration, and harmful algal blooms. To establish and maintain water quality necessary to sustain natural communities, the CHNEP and its water quality partners:

- Classify waters according to their intended designated human and aquatic life uses;
- Establish meaningful water quality standards and targets to protect intended uses;
- Identify impaired waterbodies not meeting those standards; and
- Develop and implement management plans and actions to correct impairments and adaptively manage them to achieve water quality standards.

◀ The Lake Hicpochee Shallow Hydrologic Enhancement Project is an example of a Total Maximum Daily Load activity in an adopted Basin Management Action Plan area. The project will benefit the Caloosahatchee River Estuary and Watershed by improving hydrology and water quality|*SFWMD.*

Designated Beneficial Uses and Water Quality Standards

The federal Clean Water Act (CWA) is the primary federal law governing water quality standards for surface waters of the United States and the impacts of pollution and pollutants discharges into them. Its main objective is to restore and maintain the chemical, physical, and biological integrity of the nation's waters. In Florida, the CWA is cooperatively administered by the U.S. EPA and FDEP.

Table 2. Florida water classifications for beneficial use. Florida's water quality standards are developed by the EPA in cooperation with FDEP.

CLASS	DESIGNATED USE
I	Potable (drinking) water supplies
II	Shellfish propagation or harvesting
III	Fish consumption; recreation, propagation, and maintenance of a healthy, well-balanced population of fish and wildlife
III-Limited	Fish consumption; recreation or limited recreation; and/or propagation and maintenance of a limited population of fish and wildlife
IV	Agriculture
V	Navigation, utility, and industry

The CWA requires that states classify surface waters according to their highest designated beneficial use — such as drinking water, recreation, aquatic life and fisheries, agriculture, or industry — and develop water quality standards to support each designated use (Table 2). Most surface waters in the CHNEP area are classified Class III waters, although many are classified as Class II and some even as Class I. Numerous waterbodies in the CHNEP area are also classified as

Outstanding Florida Waters (OFWs), designated as such with the intent to protect them from any water quality degradation.

In 2009, EPA determined that Florida's existing narrative water quality standards were insufficient to meet requirements of the CWA; instead, they required that water quality numeric nutrient criteria (NNC) be developed. In response, FDEP submitted and EPA approved NNC for springs, lakes, and flowing waters in Florida. In 2011, CHNEP partnered with Tampa Bay Estuary Program (TBEP) and Sarasota Bay Estuary Program (SBEP) to develop and recommend estuary-specific water quality NNC for chlorophyll a, nitrogen, and phosphorus based on seagrass light requirements and water clarity (Janicki 2011). These recommended NNC were adopted by FDEP in 2012, approved by the U.S. EPA, and became effective under Florida law in 2015 (Table 3).

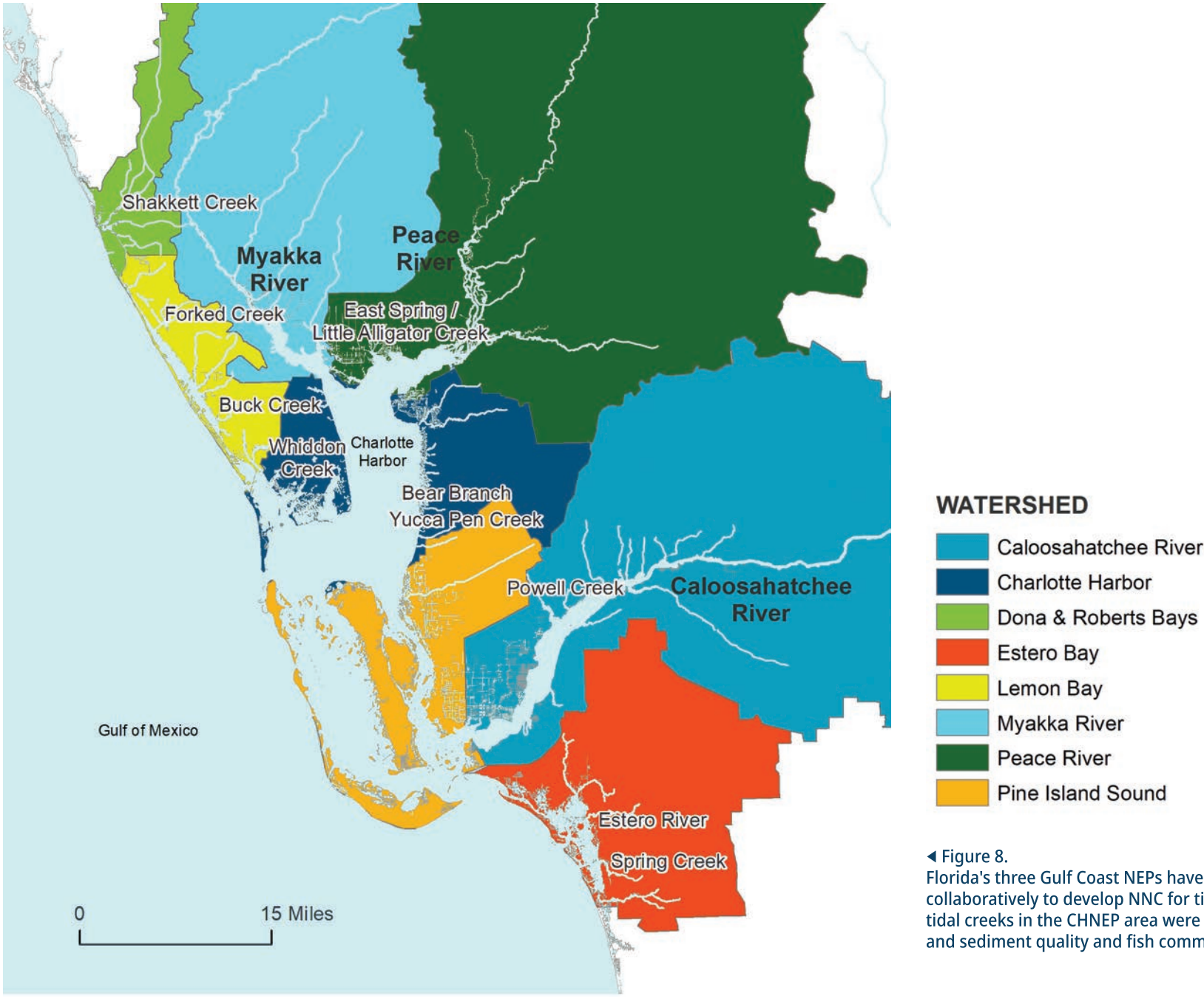
Table 3. Numeric nutrient criteria for Charlotte Harbor/Estero Bay estuary segments within the CHNEP area.

ESTUARY SEGMENT	TOTAL PHOSPHORUS	TOTAL NITROGEN	CHLOROPHYLL A
1. Dona and Roberts Bays[1]	0.18 mg/L	0.42 mg/L	4.9 µg/L
2. Upper Lemon Bay[1]	0.26 mg/L	0.56 mg/L	8.9 µg/L
3. Lower Lemon Bay[1]	0.17 mg/L	0.62 mg/L	6.1 µg/L
4. Charlotte Harbor Proper[1]	0.19 mg/L	0.67 mg/L	6.1 µg/L
5. Pine Island Sound[1]	0.06 mg/L	0.57 mg/L	6.5 µg/L
6. San Carlos Bay[2]	0.045 mg/L	0.44 mg/L	3.7 µg/L
7. Tidal Myakka River[1]	0.31 mg/L	1.02 mg/L	11.7 µg/L
8. Tidal Peace River[1]	0.50 mg/L	1.08 mg/L	12.6 ug/L
9. Matlacha Pass[1]	0.08 mg/L	0.58 mg/L	6.1 µg/L
10. Estero Bay[1]	0.07 mg/L	0.63 mg/L	5.9 µg/L
11. Upper Caloosahatchee River Estuary[2]	0.086 mg/L	See 62-304.800(2), F.A.C.	4.2 µg/L
12. Middle Caloosahatchee River Estuary[2]	0.055 mg/L	See 62-304.800(2), F.A.C.	6.5 µg/L
13. Lower Caloosahatchee River Estuary[2]	0.040 mg/L	See 62-304.800(2), F.A.C.	5.6 µg/L

[1] annual mean / [2] long-term average

Florida's three Gulf Coast NEPs have been working collaboratively to develop NNC for tidal creeks, as they are significant sources of freshwater to estuaries and provide critical nursery habitat for estuarine-dependent fish. Fundamental to this task is understanding creek biological integrity, or "the ability to support and maintain a balanced, integrated adaptive assemblage of organisms having species composition, diversity, and functional organization comparable to that of natural habitat of the region" (Karr et al. 1986). Currently, the only approved guidance for evaluating tidal creek biological integrity is narrative criteria based on State of Florida dissolved oxygen (DO) and chlorophyll-a threshold values alone.

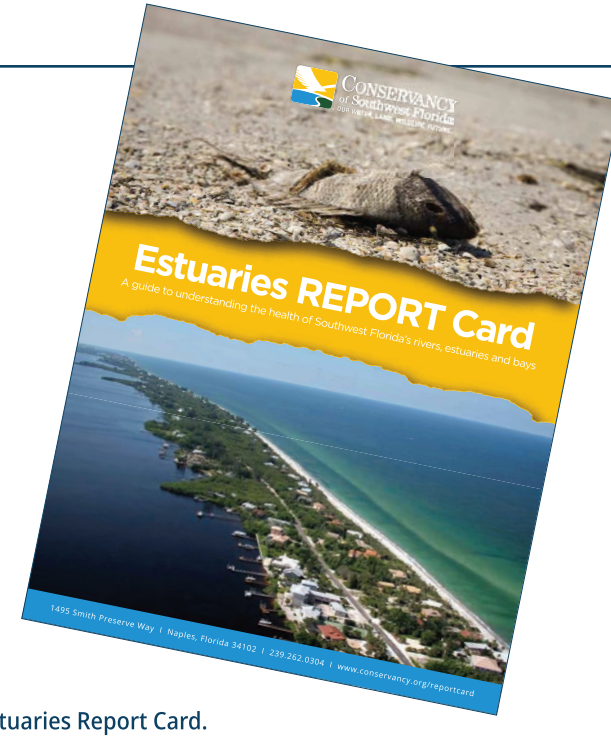
Partners for developing tidal creeks NNC for the region include CHNEP, SBEP, TBEP, Pinellas, Hillsborough, Manatee, Sarasota, Charlotte, and Lee County governments, Janicki Environmental, Inc., Mote Marine Laboratory, and Florida Fish and Wildlife Conservation Commission. To develop NNC, a study was conducted to evaluate the relationship between water column nutrient concentrations and dissolved oxygen, water column chlorophyll, sediment chlorophyll, and fish community structure. The project sampled tidal creeks from Tampa Bay to Charlotte Harbor (Eilers 2013, Eilers 2014, Janicki and Mote 2016), including Spring Creek, Estero River, Powell Creek, Yucca Pen Creek, Bear Branch, Little Alligator Creek/East Spring, Whidden Creek, Buck Creek, Forked Creek, and Shakett Creek in the CHNEP area (Figure 8).



◀ Figure 8.
Florida's three Gulf Coast NEPs have been working collaboratively to develop NNC for tidal creeks. Ten tidal creeks in the CHNEP area were sampled for water and sediment quality and fish community structure.

Estuaries Report Card

A guide to understanding the health of Southwest Florida's rivers, estuaries, and bays



The Conservancy of Southwest Florida produced an Estuaries Report Card in 2017 to summarize the health of 10 watersheds in Southwest Florida. The report is accompanied by an Action Plan that communities can follow to help improve water resources. Water quality assessments from FDEP, hydrologic information, impervious surface cover, and wetlands, mangroves, and conservation lands data from other agencies were used to grade each watershed on water quality and wildlife habitat quality.

Water Quality Grades were assessed in six categories:

- ***Pathogens*** (*e.g.*, bacteria)
- ***Nutrients*** (*e.g.*, nitrogen and phosphorus)
- ***Oxygen Depletion*** (biological oxygen demand and dissolved ***oxygen)***
- ***Metals*** (*e.g.*, copper, iron, lead, mercury)
- ***Physical Parameters*** (chloride, pH, turbidity, salinity)
- ***Biology*** (*e.g.*, stream condition index, lake vegetation index)

Wildlife Habitat Grades were assessed in three categories:

- ***Extent of Mangroves Remaining***
- ***Extent of Wetlands Remaining***
- ***Extent of Conservation Lands***

The full report, video segments, interactive maps, references, and additional information are on the the Conservancy's website www.conservancy.org/reportcard.

Table 4. Estuaries Report Card.

ESTUARY	WILDLIFE HABITAT	WATER QUALITY
Coastal Venice	C-	C-
Lemon Bay	B	D-
Greater Charlotte Harbor	B-	C+
Pine Island Sound	A+	D
Caloosahatchee	D-	D-
Estero Bay	B-	D
Wiggins Pass/Cocohatchee	B	D-
Naples Bay	D-	D-
Rookery Bay	B+	C
Ten Thousand Islands	A+	C+

Researchers observed no adverse effects in fish communities associated with low dissolved oxygen (DO) and elevated chlorophyll (Janicki and Mote 2016). This finding suggests that current narrative-based criteria for water quality in tidal creeks based on DO and chlorophyll may be ineffective and misleading as indicators of the biological integrity of tidal creeks.

Other notable findings included that water quality in tidal creeks is most characteristic of wetlands, and that nutrients can enter streams from both upstream and estuary sources. Work on establishing appropriate NNC for tidal creeks in the CHNEP area is ongoing.

Bioindicators

A variety of living resources can be used as bioindicators of water quality and provide insights into ecosystem health. For example, algal blooms can indicate excess nutrient supply (Lapointe 1985). Oysters can accumulate and concentrate pollutants, such as trace metals, over time. Because seagrasses require sunlight for photosynthesis, their presence or absence in a location can be used as an indicator of water clarity, which can be diminished by suspended sediments, particles, and nutrient-fueled algal blooms. The relationship between water clarity and seagrasses was used to develop a tool for the Charlotte Harbor area to assess whether water clarity conditions are supportive of seagrass protection and restoration targets (Dixon and Wessel 2014). Some estuary segments have demonstrated declining water clarity trends since 2013, matching poor water quality grades reported in the Conservancy of Southwest Florida's 2017 Estuaries Report Card (Table 4). Management targets for seagrass and other living resources are addressed in the Fish, Wildlife, and Habitat Protection Action Plan (see Fish, Wildlife, and Habitat Protection Action 1).

Pollutant Cleanup Plans

A waterbody that does not meet water quality standards is designated as impaired for the pollutant of concern. FDEP is periodically required to compile a list of impaired waters in Florida and report them to the EPA. A Total Maximum Daily Load (TMDL) is the amount of a given pollutant that an impaired waterbody can absorb and still meet water quality standards for its designated beneficial uses. Under the CWA and the Florida Watershed Restoration Act (FWRA), TMDLs must be developed for all verified impaired waters — unless it can be demonstrated that an existing management program is expected to correct the problem or if the impairment is due to a naturally occurring condition that cannot be corrected by a TMDL. Once a TMDL is developed, FDEP allocates "allowable" pollutant loads from the TMDL budget to sources of pollution discharging into the waterbody. Sources can be identifiable and discrete (point sources) or broad and not attributable to one source (nonpoint sources). Point source pollution permits, including those for stormwater discharge, are administered through the National Pollutant Discharge Elimination System.

Reasonable Assurance Plans (RAPs) and Basin Management Action Plans (BMAPs) are comprehensive pollutant cleanup plans that consolidate existing efforts and set a course for water quality restoration. They describe management strategies of existing water quality programs, timelines, tracking, and funding. BMAPS are measurable, enforceable plans that include all necessary stakeholders and are created by the FDEP to achieve water quality standards. RAPs are also enforceable plans, but they are created voluntarily by interested stakeholders to achieve water quality standards (*e.g.*, Shell, Prairie, and Joshua Creeks Watershed Management Plan Stakeholders Group 2004).

FDEP maintains an online interactive map of impaired waters, those with TMDLs, and those included in a BMAP. There are 21 TMDLs that are DEP-adopted and EPA-approved for impaired waterbodies in the CHNEP area (Figure 9 on page 50). There are 5 more that are FDEP-adopted, but not EPA-approved. There are 23 more that are on the planning list for 2022. Eight TMDL waterbodies are addressed under the Caloosahatchee Estuary Basin BMAP and two are addressed under the Everglades West Coast BMAP. The Sanibel Slough TMDL is addressed by the Sanibel Comprehensive Nutrient Management Plan. The CHNEP Management Conference aims to bring all impaired waterbodies in the CHNEP area under a TMDL and associated cleanup plan (BMAP or RAP), especially Outstanding Florida Waters.

In addition to TMDLs developed by FDEP, further TMDLs were developed for the CHNEP area by the EPA as a result of the 1998 Florida TMDL Consent Decree. These TMDL documents can be found on the EPA's ATTAINS website.

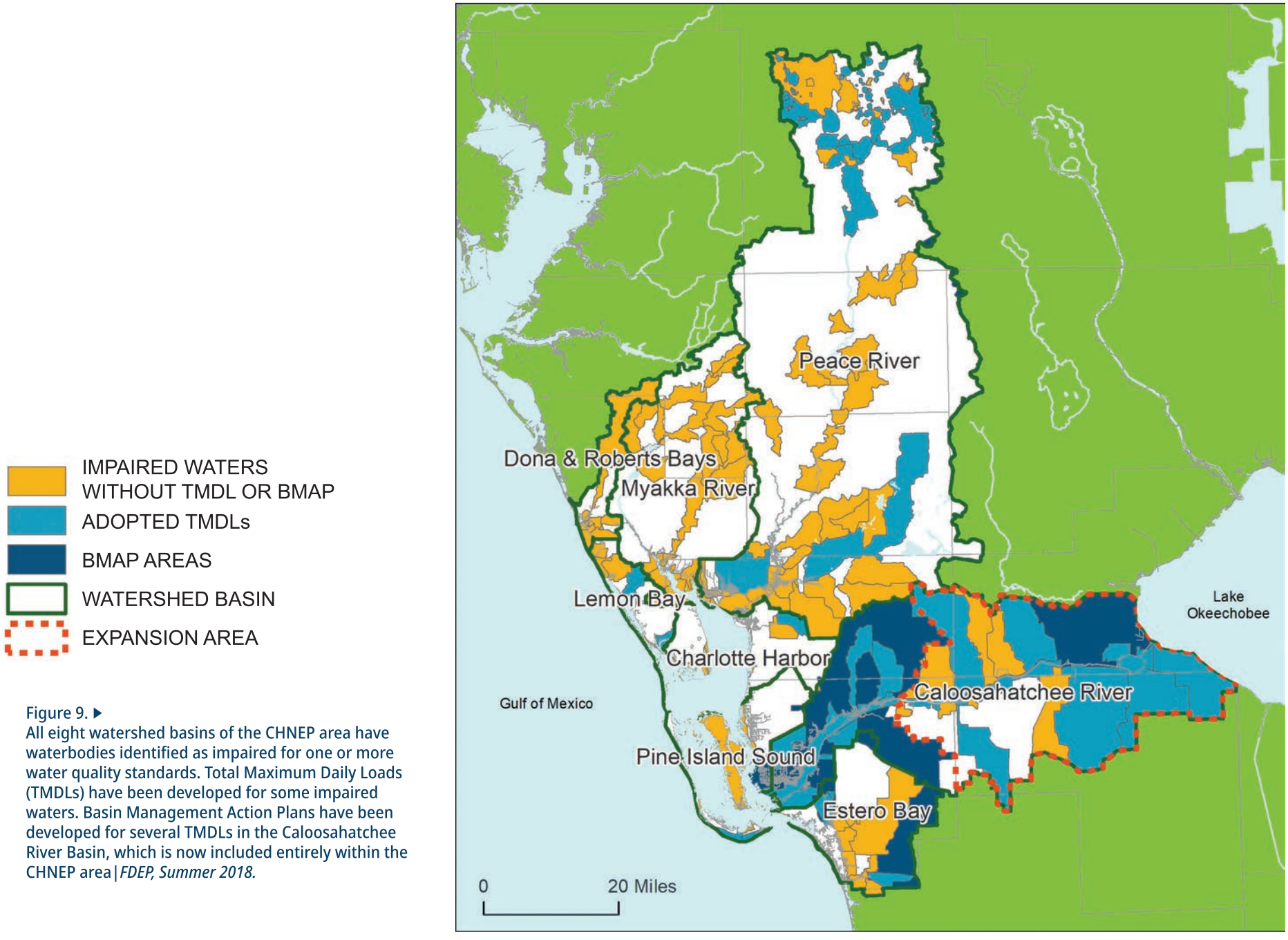


Figure 9. ▶
All eight watershed basins of the CHNEP area have waterbodies identified as impaired for one or more water quality standards. Total Maximum Daily Loads (TMDLs) have been developed for some impaired waters. Basin Management Action Plans have been developed for several TMDLs in the Caloosahatchee River Basin, which is now included entirely within the CHNEP area | *FDEP, Summer 2018.*

Other Water Quality Management Rules, Plans, and Tools

The Surface Water Improvement and Management (SWIM) Act was created in 1987 by the Florida Legislature to protect, restore, and maintain Florida's threatened water bodies. Under the Act, the Southwest Florida Water Management District (SWFWMD) identified Charlotte Harbor as a priority water body for protection and restoration and adopted the Charlotte Harbor SWIM Plan (SWFWMD 2000). SWFWMD works with CHNEP, FDEP, and local governments to implement projects from the 2000 SWIM Plan to reduce water pollution and improve habitat quality. Work on an update to the 2000 Charlotte Harbor SWIM Plan is underway.

The Southwest Florida Regional Planning Council (SWFRPC) is developing a functional assessment method to evaluate the water quality benefits of wetland restoration and designed freshwater ecosystems used for water quality treatment. The Water Quality Functional Assessment Method (WQFAM) is intended to be used to assess potential water quality improvement credits in BMAPS to address non-attainment of TMDLS.

STATUS:

Ongoing. Previous 2013–2018 CHNEP-CCMP Water Quality Actions WQ-A and WQ-G are combined here and updated to incorporate new information about water quality standards, pollutant limits, and cleanup plans. In particular, this Action details new work to establish water quality standards for tidal creeks. Quantifiable Objectives WQ-1 and WQ-2 from the 2013–2018 CHNEP-CCMP are carried forward and updated as Performance Measures.

RELATED ACTIONS:

Water Quality Improvement Action 1: Support a comprehensive and coordinated water quality monitoring and assessment strategy

ACTIVITY:

Encourage review, development, and implementation of additional water quality criteria and targets, pollutant limits, and cleanup plans that correct impairment, protect aquatic life, and prevent degradation of all surface waters, particularly Outstanding Florida Waters.

Location: All Class I, II, III, and III-L surface waters in the CHNEP area, particularly Outstanding Florida Waters.

Responsible parties: FDEP (State of Florida regulatory lead), EPA (federal regulatory lead), CHNEP (NNC development and implementation facilitator), County and Municipal governments, SWFWMD (funding and implementation), SFWMD.

Timeframe: Ongoing.

Potential annual cost and funding sources: Development of numeric water quality criteria for tidal creeks: $25,000–$499,999/Section 320 Funds; Development and implementation of TMDLs, BMAPs, RAs: $500,000–$999,999/FDEP, SWFWMD, SFWMD, County and Municipal governments.

Benefits: Improved water quality supportive of living resources; development of more accurate nutrient loading rates from various land uses; and identification of sources of bacteria, nutrients, and other indicators in water bodies.

5-year Performance measure: Restoration of water quality in at least five impaired waterbodies, demonstrated by water quality data indicating they are fully meeting the water quality standards for their designated beneficial use.

3 Reduce urban stormwater and agricultural runoff pollution

OBJECTIVES:

Support projects to increase retention of stormwater and reduce pollution loadings, including new and retrofit projects. Support green infrastructure techniques to offset manmade impacts and improve water quality and flows. Encourage implementation of FDACS Agricultural Best Management Practices (BMPs). Support regional cost-sharing programs and other incentives for implementing agricultural BMPs.

BACKGROUND:

Rainfall can percolate into the ground, accumulate onsite, or run off developed areas to become stormwater runoff. Historical stormwater management in Florida focused on rapidly moving rainwater away from development to reduce flooding. As it flows, stormwater can accumulate pollutants, including nutrients, bacteria, sediments, debris, metals, plastics, pesticides, and petroleum products. If untreated, pollutants can reach waterways and waterbodies, impacting fish, wildlife, and habitats — and damaging economic and recreational opportunities. Modern stormwater management considers rainwater to be an asset. Best management practices work to replicate the function of natural systems, allowing pollutants to be removed by soils and plants, and water to percolate into the ground to recharge aquifers.

Stormwater management will become more challenging with projected changes in rainfall patterns due to climate change. Generally, increased water vapor resulting from warming air and water temperatures is expected to increase frequency and intensity of precipitation extremes — so-called drier dries and wetter wets (Easterling 2017). The stormwater created by the first rain after prolonged dry periods will likely have higher concentration of nutrients and possibly bacteria, and increased storm intensity will increase erosion and sediment loading in stormwater. Larger freshwater pulses to the estuary could increase stratification in the water column and decrease dissolved oxygen at depth. Warmer, wetter conditions can facilitate the growth and persistence of bacteria and algae and can increase toxicity of stormwater pollutants (Lovett 2010). Impacts will be more severe in older coastal neighborhoods where little or no stormwater treatment infrastructure exists and where untreated stormwater flows directly into natural waterbodies.

Heavier rain events or longer droughts with warmer temperatures may affect the biological and mechanical functions of stormwater infrastructure, like vegetated swales and stormwater detention ponds, to filter sediment, toxins, trash, and nutrients from stormwater and to modulate the flow of freshwater to the estuary. Rising sea levels will interfere with the function of gravity-fed canal systems and coastal detention ponds, creating more nuisance flooding. The extent of critical coastal habitats such as mangroves and salt marsh and their effectiveness to naturally filter stormwater may also be impacted. For example, sea level rise can cause coastal squeeze, where saltwater wetland habitats erode or drown due to coastal structures blocking natural upland migration (Torio and Chmura 2013).

Urban Stormwater

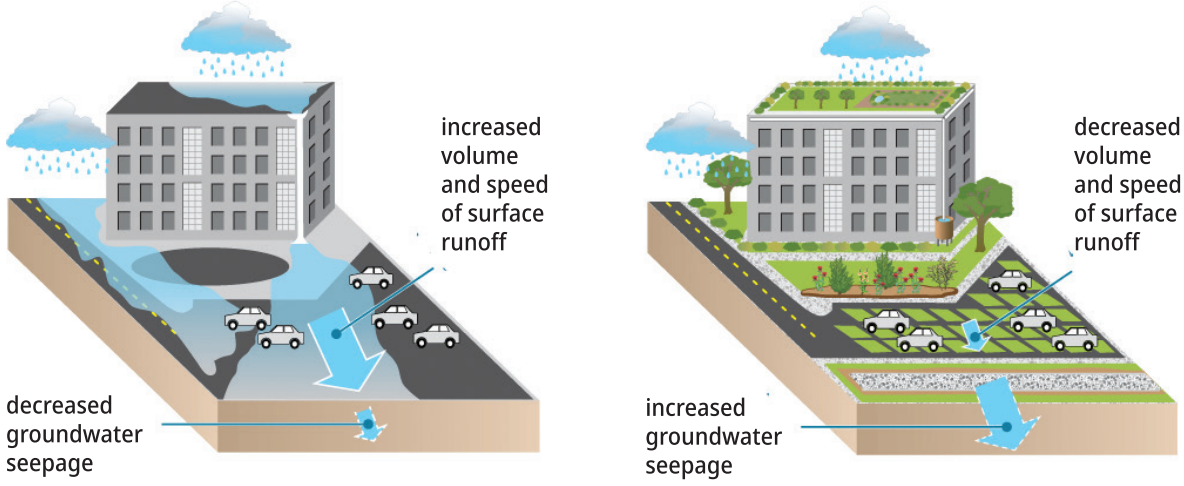
Southwest Florida is one of the fastest-growing areas in the country. Development to support the growing population commonly converts pervious surfaces to impervious ones, resulting in the creation of more stormwater. Stormwater is the largest contributor of pollutants to waterbodies in the CHNEP area (Janicki Environmental, Inc 2010). It is the largest source of total nitrogen (TN, 70 percent); total phosphorus (TP, 68 percent); total suspended solids (TSS, 95 percent); and biochemical oxygen demand (BOD, 90 percent) to area watersheds. Only about six percent of TN loading comes from atmospheric deposition. Industrial point sources account for 20 percent of TN, 28 percent of TP, three percent of TSS and seven percent of BOD. There is a need to update pollutant load estimates based on current land use maps.

Reducing stormwater runoff and pollution are important management activities in the CHNEP area. One way to reduce stormwater pollution is to reduce the availability of pollutants to stormwater. Residential fertilizer ordinances restricting the use of nitrogen fertilizer during the rainy season are adopted by all coastal cities and all counties in the CHNEP area. Education and outreach campaigns to reduce stormwater pollution include UF IFAS's Florida Friendly Landscaping™ program, Watershed Education Training Ponds Lakes and Neighborhoods

◀ Agricultural best management practices can help reduce negative impacts to soil and water resources while maintaining economically viable crop production levels | *April Sorrow.*

(WETPLAN), and pet waste education (see Public Engagement Action 1).

FDEP drafted a new Statewide Stormwater Treatment Rule in 2010. If adopted it would be the first update since the original 1982 rule. The draft rule proposes to increase the level of nutrient removal required from stormwater treatment systems serving new development, such that post-development nutrient loads do not exceed loads from comparable natural, undeveloped areas. The draft rule aims to create a unified statewide standard supporting the underlying objectives of low-impact development. As of 2019, the rule has not been adopted. Reevaluation of stormwater requirements should also consider additional retention and treatment capacity to accommodate projected climate change scenarios, such as rising seas.



▲ Figure 10.
Impervious 'hard' surfaces (roofs, roads, large areas of pavement, and asphalt parking lots) increase the volume and speed of stormwater runoff. This swift surge of water erodes streambeds, reduces groundwater infiltration, and delivers pollutants and sediment to downstream waters.

Pervious 'soft' surfaces (green roofs, rain gardens, grass paver parking lots, and infiltration trenches) decrease volume and speed of stormwater runoff. The slowed water seeps into the ground, recharges the water table, and filters out many pollutants and sediment before they arrive in downstream waters.

Chesapeake and Atlantic Coastal Bays Trust Fund, courtesy of Integration and Application Network (ian.umces.edu) University of Maryland Center for Environmental Science.

Large Capital Improvement Projects and Green Infrastructure

New and retrofit, and centralized and decentralized infrastructure improvement projects are being developed and implemented to better process stormwater in the CHNEP area. Large capital improvement projects typically require extensive planning and construction. Where large projects are impractical or too expensive, a series of smaller green infrastructure practices can be implemented. Green infrastructure practices, also known as Low Impact Development or Low Impact Design (LID), work with nature to reduce and treat stormwater at its source, minimizing the volume of water and pollution emanating from the constructed environment (Figure 10).

The best designed systems can simulate the pre-development hydrologic regime of an area. Green infrastructure can be a patchwork of natural areas that provides habitat, flood protection, cleaner air, and cleaner water. It is designed to mimic natural ecosystem services by capturing and storing water, filtering pollutants, and recharging underground aquifers. Retrofitting older developments using green infrastructure is particularly effective, and a series of different best management practices can be linked together to form an effective treatment train.

Barriers to implementing green infrastructure include limited education and training opportunities, Homeowner Association

rules and deed restrictions, and conflicting language in comprehensive plans and development codes.

In addition, data are needed on nutrient removal efficiencies of living shorelines, oyster reefs, seagrasses, and other BMPs for which data is lacking, so they can be assigned credits as BMPs.

Examples of green infrastructure practices include:

- ***Canopy trees and green roofs*** to intercept rainfall before it hits the ground;
- ***Rainwater harvesting systems***, such as rain barrels and cisterns, to capture rainfall and store it for later use;
- ***Vegetative buffers and littoral zones around shorelines, ponds, and waterways*** to filter pollutants and litter from runoff before it enters a waterbody;
- ***Pervious surfaces for parking areas, walkways, and drives — like pavers, bricks, or gravel***, to reduce runoff after light rainfalls, allowing gradual infiltration of rainfall into underlying soils;
- ***Rain gardens, vegetated swales, and recessed tree islands*** to capture runoff and allow it to evaporate, percolate into the ground, or be used by vegetation; and
- ***Stormwater parks*** to combine recreational opportunities, public amenities, wildlife habitat, flood protection, and stormwater storage and treatment into one area.

▲
Pervious surfaces are great alternatives to concrete in developed landscapes. They allow rain to percolate into the ground, reducing runoff into waterways and bays|*David Shafer.*

Dozens of stormwater reduction projects have been implemented in the CHNEP area since the 2013–2018 CHNEP-CCMP update.

Examples of Local projects include:

- City of Fort Myers is constructing small drainage improvement projects throughout the city to resolve localized flooding and water quality problems, including the Fort Myers Riverfront Downtown Detention Basin funded by FDEP;
- Town of Fort Myers Beach retrofit program is both improving existing and installing new stormwater infrastructure;
- City of Auburndale program is constructing stormwater BMPs in PK Avenue to improve water quality discharged to Lake Lena;
- City of Winter Haven is constructing small stormwater green infrastructure BMPs, such as rain gardens within the urban public right-of-way and park areas;
- Sarasota County is installing a vegetated floating island in Venice Gardens Lake to reduce polluted flow from Alligator Creek into Lemon Bay;
- City of North Port is installing small stormwater green infrastructure BMPs, such as pervious parking, bioswales, stormwater pond aerators, stormwater harvesting for irrigation, and is acquiring waterfront parcels for conservation as blueway buffers; and
- City of Cape Coral is upgrading catch basins and installing bioswales as part of a major utilities upgrade project in order to reduce stormwater pollutants in the City's Canal system, Matlacha Pass, and Charlotte Harbor Estuary.

Regional restoration and stormwater treatment projects:

- Sarasota County's Dona Bay Conveyance System is restoring approximately 363 acres of wetlands to improve water quality in Cow Pen Slough and Dona Bay;
- City of Bonita Springs is restoring Pine Lake Preserve and Kehl Canal to reduce nutrient loads to the Imperial River;
- Lehigh Acres' and SFWMD's Caloosahatchee Cross Link project is creating a stormwater system connection between the Section 10 mining pit and Greenbriar Swamp;
- Caloosahatchee Creeks Preserve restoration project is constructing flowways to rehydrate wetlands to improve pollutant removal;
- FDEP is treating water diverted from Powell Creek and Powell Creek Canal through a series of wetland areas over 18.8 acres, through its Powell Creek Filter Marsh project;
- SWFWMD is constructing a 1,000-acre wetland and pump station at the south shore of Lake Hancock. Wetland treatment is projected to reduce annual nitrogen load from the lake into the Peace River by 27 percent;
- SFWMD is constructing a facility for in-basin storage of stormwater runoff from the C-43 basin and Lake Okeechobee discharge;
- Polk County is restoring a 120-acre historical lakebed, in its Lake Gwyn wetland project, to receive and treat waters from the Wahneta Farms Canal before release into the Peace River; and
- Charlotte County is restoring Sunshine Lake and Sunrise Waterway by dredging the lake to remove accumulated algae biomass and sediment, installing circulation pumps and floating treatment wetlands, and constructing a weir and recharge wells to maintain water levels.

Stream and creek rehabilitation projects:

- Fitcher's Creek Restoration project is supporting the Caloosahatchee River Protection Plan and the Caloosahatchee Estuary BMAP;
- A project is restoring Hendry Creek West Branch in support of the Everglades West Coast BMAP; and
- City of Fort Myers is rehabilitating Billy's Creek by removing invasive exotic vegetation, urban trash and debris, and excess silt and sediment.

Agricultural Runoff

Runoff from agricultural land uses can carry excess nutrients from fertilizer and animal waste, bacteria from animal waste, and harmful chemicals from herbicides and pesticides to waterbodies. Agricultural best management practices (BMPs) can help reduce negative impacts to soil and water resources, while maintaining economically viable crop production levels. BMPs can include structural (*e.g.*, constructed swales or basins) and non-structural (*e.g.*, preservation or prevention) approaches to conserving water and reducing fertilizer and pesticide use.

The Florida Department of Agriculture and Consumer Services (FDACS) adopted BMPs that FDEP deemed effective at reducing pollutants for major agricultural commodities produced in the CHNEP area (Table 5). BMP manuals are reviewed at least every five years. FDACS also plans to develop a small farms manual that will incorporate practices for smaller farms and for livestock that are not yet included in an adopted manual.

Table 5. Adopted farm BMP manuals | *FDACS.*

COMMODITY	YEAR ADOPTED
Silviculture (Forestry)	2008
Sod	2008
Cow/Calf	2009
Specialty Fruit and Nut	2011
Equine	2012
Citrus	2013
Nursery	2014
Vegetable and Agronomic Crops	2015
Aquaculture	2015
Dairies	2016
Poultry	2016

Farms with large numbers of livestock in a confined area, known as animal feeding operations (AFOs), and concentrated animal feeding operations (CAFOs) are not regulated by FDACS. Instead, FDEP regulates AFOs under its industrial wastewater rules and CAFOs under its NPDES program. Hobby farmers are not currently enrolled in the FDACS BMP Program; however, FDACS plans to develop and adopt manuals for these operations.

Farmers who implement FDACS-adopted BMPs benefit from a presumption of compliance with state water quality standards for pollutants that the BMPs address. Farming operations in BMAP areas are required to implement FDACS-adopted BMPs; otherwise, they must conduct prescribed water quality monitoring that is approved by FDEP or a Water Management District to demonstrate compliance with water quality standards. In 2014, FDACS' Office of Agricultural Water Policy (OAWP) adopted a standardized statewide Implementation and Assurance Program consistent across all regions, commodities, and BMP manuals. In 2014, site visits to 267 operations in 42 Florida counties showed 55% needing improvement for one or more BMPs. In 2016, the OAWP revised the program per the new State Water Law.

There are more than one million acres of farms across the CHNEP area that have enrolled in FDACS' BMP program; almost half are cow/calf operations (Figure 11 on page 58). The top two commodities with BMP-enrolled operations are citrus and cow/calf (Table 6). DeSoto County leads in BMP-enrolled citrus farms, while Hardee County leads in BMP-enrolled cow-calf operations.

Table 6. Acres of farms enrolled in the FDACS BMP program by commodity | *FDACS.*

COMMODITY	ACRES ENROLLED
Cow/Calf	5525,417
Citrus	211,809
Conservation Rule/LOPP	124,578
Cow/Calf mixed with other	89,717
Row/Field Crops	87,620
Citrus mixed with other	59,335
Fruit-Nut	6,159
Nursery	3,164
Sod	2,809
Equine	431
Poultry	10
Total Enrolled	1,111,049

Cost-Sharing Incentives for Participation

FDACS and Water Management Districts incentivize adoption of BMPs through partnerships, such as SWFWMD's Facilitating Agricultural Resource Management Systems (FARMS) program, making it more feasible for farmers to implement new technologies. FARMS is a cost-share reimbursement program that incentivizes site-specific implementation of agricultural BMPS that focus on water quantity reductions through conservation and alternative water supply BMPs. South Florida Water Management District's Dispersed Water Management Program works cooperatively with public and private landowners through cost-share or cooperative agreements to keep excess stormwater on the landscape for cost-effective flood control and environmental benefits.

The mini-FARMS program is a partnership of FDACS and SWFWMD that provides reimbursement to farmers with less than 100 irrigated acres for 75% of the cost (up to $5,000) to implement water conserving BMP projects. Farmers must be enrolled in the FDACS BMP Program to be eligible for mini-FARMS grants. More than 600 acres of permanent "fertigation" (fertilizer and irrigation reduction) BMPs and 100 acres of water conservation BMPs have been implemented at more than a dozen citrus groves and row crop farms in the CHNEP area. The Florida Farm Bureau's County Alliance for Responsible Environmental Stewardship (CARES) program publicly recognizes farmers and ranchers that are enrolled with the FDACS BMP Program and remain in good standing with the FDACS Implementation Assurance Program. UF/IFAS Extension Agents provide outreach to both commercial and non-commercial operators to encourage BMP adoption.

STATUS:

Ongoing. Previous 2013 CHNEP-CCMP Water Quality Actions WQ-D, WQ-E, and HA-L are combined here and updated to incorporate new information about capital improvement projects and green infrastructure practices. This Action was expanded to address new agricultural best management practices to reduce polluted runoff and new incentives for farmers to adopt them.

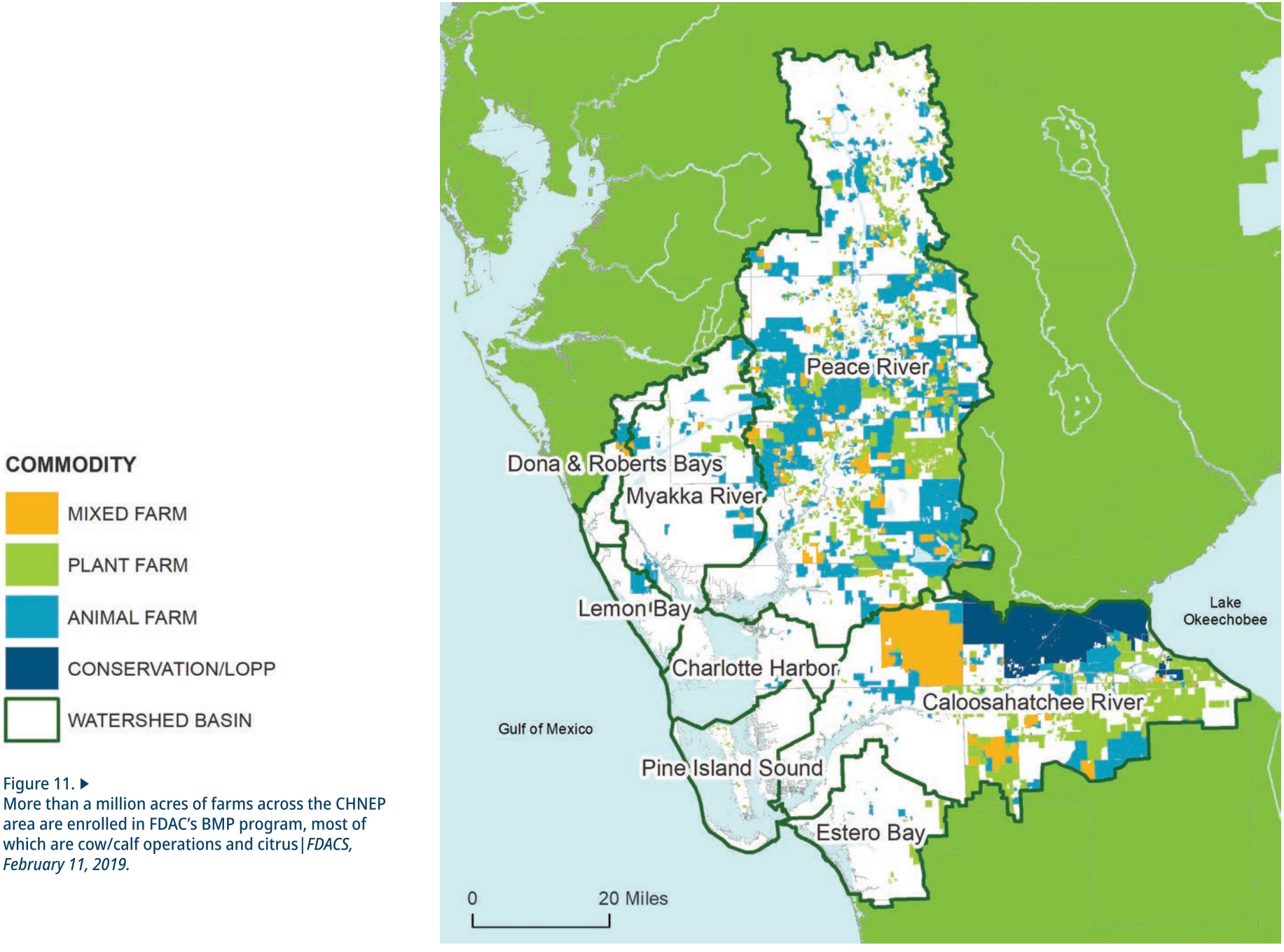


Figure 11. ▶
More than a million acres of farms across the CHNEP area are enrolled in FDAC's BMP program, most of which are cow/calf operations and citrus | *FDACS, February 11, 2019.*

RELATED ACTIONS:

- Water Quality Improvement Action 4: Reduce wastewater pollution
- Water Quality Improvement Action 5: Reduce harmful algal blooms
- Fish, Wildlife, and Habitat Protection Action 1: Protect, restore, and monitor estuarine habitats

ACTIVITIES:

Support urban BMPs that return freshwater inputs to receiving waters to a more natural pattern of quantity, timing, and distribution and that reduce pollutant loadings. Identify locations to install stormwater treatment areas and pursue installation in priority areas. Support new and retrofit projects to increase stormwater retention and reduce pollution loadings. Support development and implementation of green infrastructure practices, including reducing impervious surfaces.

Location: CHNEP area.

Responsible parties: FDEP (State of Florida regulatory lead), County and Municipal governments (capital improvement projects, adapting comprehensive plans and development codes to facilitate implementation of green infrastructure practices), SWFWMD, SFWMD, UF/IFAS Extension, CHNEP, private sector.

Timeframe: Ongoing.

Potential annual cost and funding sources: Capital improvement projects: $500,000–$999,999/County and Municipal governments, Section 319 Funds, SWFWMD, SFWMD; Green/LID infrastructure projects: $500,000–$999,999/County and Municipal governments, SFWMD; BMP research, development, and implementation: $25,000–$99,999/Grants, UF/IFAS Extension.

Benefits: Reduced pollutant loading and improved water quality necessary to support living things.

5-year Performance measure: Increased number of green infrastructure projects developed and implemented.

Support agricultural BMPs that return freshwater inputs to receiving waters to a more natural pattern of quantity, timing, and distribution and that reduce pollutant loadings. Support projects to increase retention of agricultural runoff and reduce pollutant loadings, including new and retrofit projects. Encourage implementation of FDACS Agricultural BMPs. Support regional cost-sharing programs and other incentives for implementing Agricultural BMPs.

Location: Watersheds in the CHNEP area, especially areas near impaired waters.

Responsible parties: FDEP (State of Florida regulatory lead), FDACS (Agricultural BMPs), SWFWMD-FARMS, SFWMD, UF/IFAS Extension, CHNEP.

Timeframe: Ongoing.

Potential annual cost and funding sources: Agricultural BMP implementation: $1M–10M/FDACS, SWFWMD-FARMS, SFWMD; BMP research and development: $500,000–$999,999/grants.

Benefits: Reduced pollutant loading and improved water quality necessary to support living things.

5-year Performance measure: Increased agricultural stakeholders enrolled in SWFWMD-FARMS, USDA NRCS, and FDACS BMP Programs.

4 Reduce wastewater pollution

OBJECTIVES:

Support wastewater conveyance and treatment improvements and conversion of septic systems to centralized sanitary sewer. Expand reuse water where appropriate, especially Advanced Wastewater Treatment (AWT) water. Assess impacts of septic systems, sewer overflows, and reuse water to water quality of surface water and groundwater, and recommend effective corrective action.

BACKGROUND:

Untreated or partially treated wastewater contains nutrients, bacteria, chemicals, and pharmaceuticals harmful to the environment and public health. Chronic and episodic high bacteria levels in waters are problematic for shellfish harvesting (see Fish, Wildlife, and Habitat Protection Action Plan) and other beneficial uses like swimming, fishing, and drinking. This Action describes challenges and improvements to wastewater collection and treatment, including central sanitary sewer systems and Onsite Sewage Treatment and Disposal Systems (OSTDS), like septic systems.

Wastewater produced in the CHNEP area is either treated in large, centralized Wastewater Treatment Plants (WWTPs) or small, private OSTDS. Depending on the county, either septic systems or centralized WWTPs are the dominant treatment pathway. In 2016, the Florida Department of Health (FDOH) completed a statewide inventory of OSTDS showing that they are more common in Polk, Hardee, and Desoto Counties; whereas central sewer systems are more common in Manatee, Sarasota, Charlotte, and Lee Counties (FDOH 2016). Although the accuracy of data is unverified and DeSoto County has a large data gap, general trends are likely correct (Table 7).

Table 7. Percentage of parcels using centralized sewer versus septic system for wastewater treatment in the historical CHNEP area | *FDOH 2016.*

COUNTY	SEWER	SEPTIC	UNKNOWN	NUMBER
Polk	34%	60%	6%	232,219
Hardee	35%	60%	5%	8,871
Desoto	4%	30%	66%	10,939
Manatee	56%	38%	6%	119,981
Sarasota	75%	18%	7%	217,107
Charlotte	52%	41%	7%	98,672
Lee	60%	36%	4%	271,176
Total Number	526,656	370,797	61,512	

Central Sanitary Sewer System

In central sewer systems, wastewater is collected at its source, conveyed to a WWTP, and treated. Treated wastewater can be discharged into surface waters, injected into underground wells and aquifers, released to infiltration basins and spray fields, or reused for beneficial uses, subject to water quality standards (Figure 12 on page 62). The solid waste byproduct remaining in the WWTP, called biosolids or sewage sludge, is commonly used as a fertilizer or soil amendment, subject to regulations established to protect public health and the environment (62-640 F.A.C.). Regulations include pollutant limits, requirements to destroy harmful microorganisms, and management practices for land application sites. Biosolids may be used on farms and ranches, forest lands, public parks, or in land reclamation projects and are a source of nutrients in CHNEP area watersheds (Figure 12 on page 62).

Nutrient concentrations vary in treated wastewater according to the level of treatment (Table 8 on page 63). Whereas Advanced Wastewater Treatment (AWT) reduces Total Nitrogen (TN) concentration to 3 mg/L, State requirements for Secondary Wastewater Treatment do not address TN. In fact, effluent from Secondary Treatment can have TN concentrations of 20 mg/L or higher. As a result, eliminating surface discharges of treated wastewater, especially wastewater only undergoing Secondary Treatment, is an important management strategy in Southwest Florida.

◀ Heavily urbanized coasts face a variety of water quality challenges, including wastewater pollution | *NASA.*

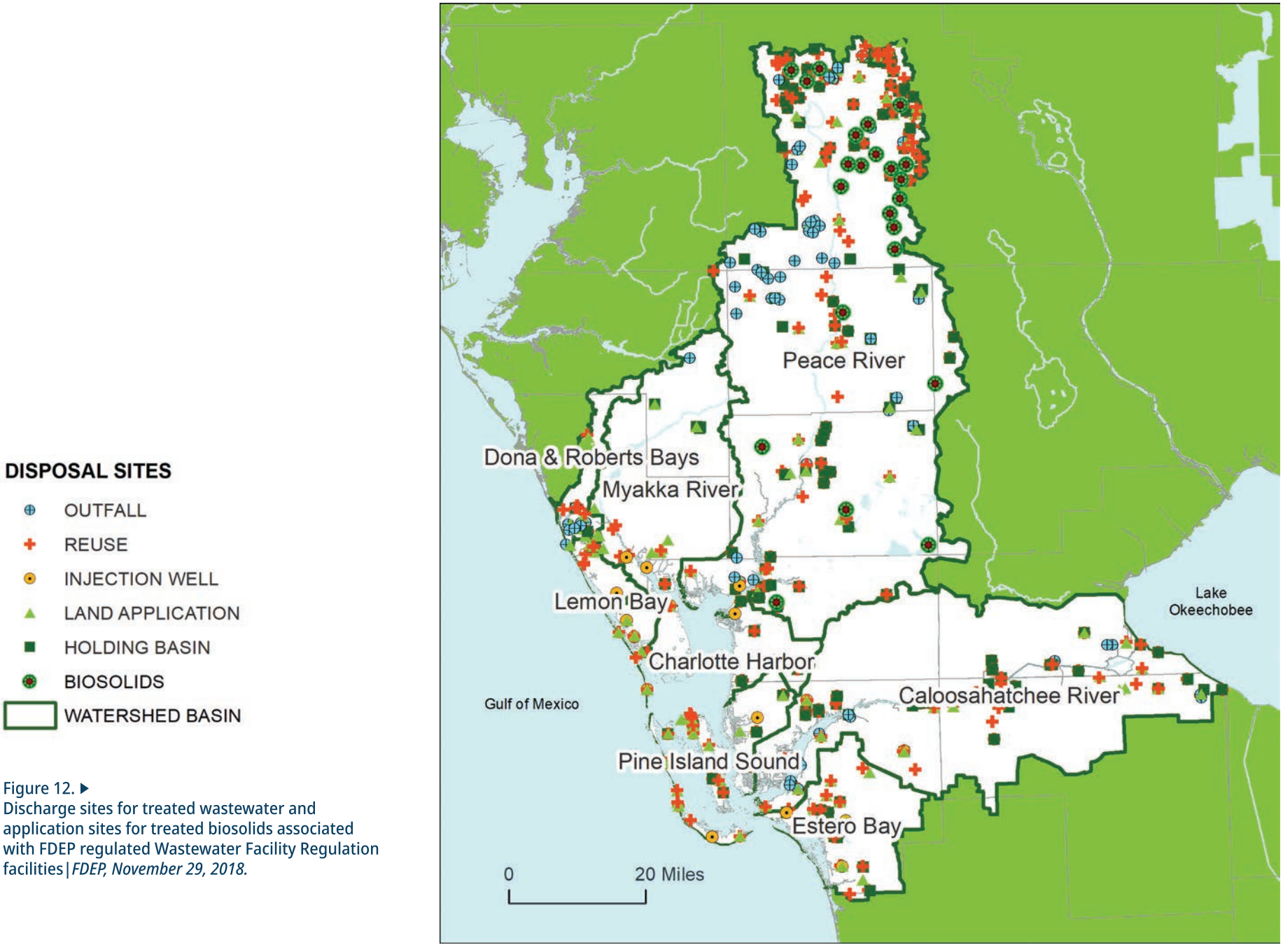


Figure 12. ▶
Discharge sites for treated wastewater and application sites for treated biosolids associated with FDEP regulated Wastewater Facility Regulation facilities | *FDEP, November 29, 2018.*

Table 8. State of Florida standards for Biological Oxygen Demand (BOD), Total Suspended Solids (TSS), Total Nitrogen (TN), and Total Phosphorus (TP) in treated wastewater effluent, according to treatment level.

CONTAMINANT	WASTEWATER TREATMENT LEVEL		
	Advanced	Advanced Secondary	Secondary
BOD	5 mg/L	10 mg/L	20 mg/L
TSS	5 mg/L	10 mg/L	20 mg/L
TN	3 mg/L	20 mg/L	N/A
TP	1 mg/L	10 mg/L	N/A

The Grizzle-Figg Act (1987: Florida Statute 403.086) requires wastewater to be treated to AWT standards before it can be discharged into Lemon Bay, Charlotte Harbor, and their direct tributaries. Furthermore, the Act stipulates that any discharge of AWT-water will not:

- By itself cause considerable impacts to an Outstanding Florida Water or to other waters;
- Substantially impact an approved shellfish harvesting area or water used as a domestic water supply; or
- Seriously alter the natural fresh-salt water balance of the receiving water after reasonable opportunity for mixing.

The Act provides exceptions for WWTPs permitted by February 1, 1987, and which discharge Secondary Treated effluent followed by water hyacinth treatment, to tributaries of tributaries of Lemon Bay and Charlotte Harbor Bay, and for WWTPs which are permitted to discharge into the non-tidally influenced portions of the Peace River.

WWTPs discharge more than 15 Million Gallons per Day (MGD) of treated wastewater into surface waters of the CHNEP area, including Fort Myers Central, Fort Myers South, and Fiesta Village, which discharge into the Caloosahatchee River Estuary (SFWMD 2017); and the City of Winter Haven WWTP #3, which discharges into the Peace Creek Canal, a tributary of the Peace River.

One alternative to releasing Secondary Treated wastewater to surface waters that are not specifically protected by the Grizzle-Figg Act is to reuse the water for beneficial uses. Currently, about 70 percent of treated wastewater from the seven-county area is reused. By 2035, reuse is projected to be 90 percent (Table 9 on page 64). Common uses include irrigation of residential and commercial landscapes, golf courses, and agricultural crops, groundwater recharge, industrial uses, and environmental enhancement.

Examples of reuse water projects in the CHNEP area include:

- City of Fort Myers project to expand production at the Fort Myers Central reuse water facility and convert the Fort Myers South facility to reuse water production to eliminate discharges into the Caloosahatchee River;
- City of Winter Haven project to construct reuse water rapid infiltration basins in order to recharge the aquifer, rather than discharge to the Peace Creek Canal;
- City of North Port project to expand its reuse water system to allow for reuse water conveyance to parks, commercial, and condominium properties for irrigation;
- Charlotte County project to expand supply of reuse water for commercial property and golf course irrigation;
- Sanibel Island Donax WWTP upgrade project to improve the quality of reuse water;
- Construction of a reuse water supply connection across the Caloosahatchee River linking City of Cape Coral with City of Fort Myers systems to create additional reuse capacity, instead of discharging into the Caloosahatchee; and
- Lee County project to construct a reuse aquifer storage and recovery well to store excess reuse water produced during the wet season when demand is low and recover it in dry season when irrigation demand is high.

Under the Grizzle-Figg Act, WWTPs that provide reuse water may also, pursuant to permit, be allowed to discharge Secondary Treated wastewater to surface waters during periods of reduced demand. These so called “backup discharges” may increase nutrient loading to surface waters if, for example, demand drops due to communities rejecting nutrient-rich reuse water. Potential changes in seasonal

Table 9. Projected changes in reuse water use in the historical CHNEP area (Million Gallons per Day, MGD), by county|*SWFWMD 2015, SFWMD 2017, and FDEP 2015.*

County	Actual 2015 (MGD)			Additional Capacity by 2020 (MGD)	Projected 2035 (MGD)*		
	WWTF Flow	Reuse Flow	% Reuse		WWTF Flow	Reuse Flow	% Reuse
Charlotte	11.9	5.45	46%	3.78	12.83	8.98	70%
DeSoto	1.57	0.71	45%	0	1.53	1.18	77%
Hardee	1.53	1.53	100%	0	1.14	1.05	92%
Lee	55.17	48.69	88%	36.4	87.68	83.69	95%
Manatee**	0	0	0%	0	0	0	0%
Polk	34.66	26.15	75%	11.9	47.8	43.14	90%
Sarasota	26.78	13.05	49%	1.96	16.49	12.64	77%
Total	131.61	95.58	73%	54.04	167.47	150.68	90%

*Projected 2040 for Lee County **There are no Manatee County WWTPs in the CHNEP area

rainfall patterns due to climate change may also alter demand for reuse water.

Because much of the reuse water in the CHNEP area only undergoes Secondary Treatment, there is a critical need to assess water quality impacts due to its reuse and to consider cost-benefits of upgrading plants to Advanced Wastewater Treatment.

Another critical need is to reduce the occurrence and severity of sanitary sewer overflows (SSOs). Frequent failures of sanitary sewer systems remain a challenge, resulting in releases of untreated sewage into the environment. Under Florida's Public Notice of Pollution Act effective July 1, 2017, all reportable pollution release events require public notice within 24-hours of the incident. In the first six months of reporting, 238 events were reported in seven counties of the CHNEP area (FDEP 2017). Based on a search of keywords used in the incident reports, at least 173 events involved release of sewage — on average one spill every day. Overflows were primarily caused or exacerbated by aging sewer infrastructure and storm related flooding, notably Hurricane Irma.

Sanitary sewer systems can fail for a variety of reasons, including design flaws and over-capacity, aging infrastructure, line blockages and breaks, stormwater infiltration and inflow, and equipment and power failures. Addressing these challenges through regular inspection and maintenance, capital improvement projects, education, and enforcement will help reduce the incidence of failures.

Rapid population growth can lead to waste volumes that exceed original system capacity. Solutions include retrofitting systems with larger pipes, bigger interceptors, greater storage, or WWTP treatment capacity.

Aging infrastructure can deteriorate and fail over time. Pumps, check valves, and other moveable parts can wear out leading to mechanical failure. Storms can cause electrical failures at lift stations, resulting

in overflows. Blockages can occur due to incursion of tree roots or improper disposal of items into sanitary drains, including fats, oils, grease, and sanitary products. Blockages can also produce a series of cascading failures due to added hydraulic stress. These failures can be reduced with proper routine maintenance, cleaning, rehabilitation, or replacement.

Sanitary sewers in Southwest Florida were not designed to transport groundwater and stormwater; when they do, they can backup, overflow, and cause emergency discharges at WWTPs. Infiltration occurs when groundwater enters sanitary sewer systems through defective, permeable, or broken pipes. Inflow occurs when stormwater enters the sanitary system through unauthorized connections (*e.g.*, yard and roof drains, and submersible pumps). Sanitary sewer overflows due to infiltration and inflow are most commonly associated with rainstorms. Infiltration and inflow can be reduced with regular inspection, rehabilitation, and maintenance of broken or failing infrastructure owned by utilities or private property owners. Construction inspections can assist in identifying and preventing illicit connections to sanitary sewer systems.

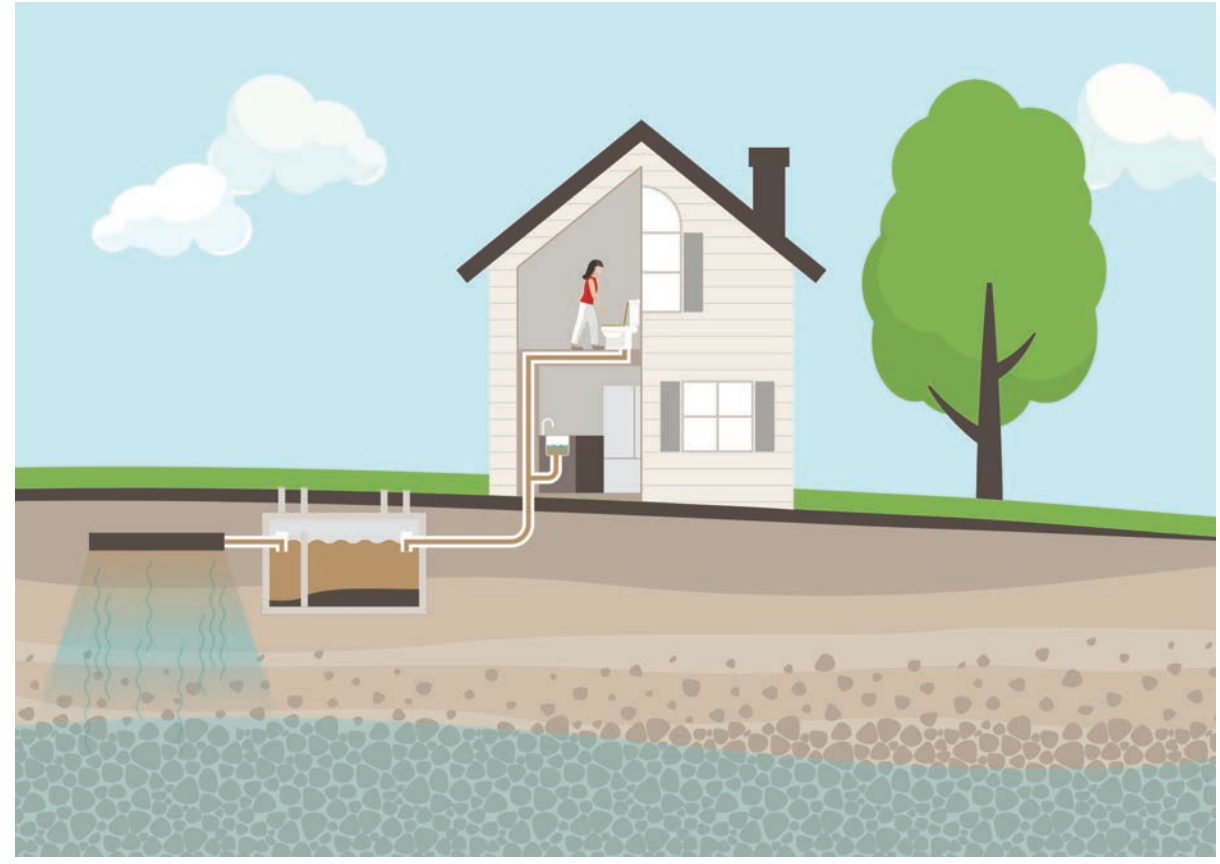
Climate stressors will further strain aging wastewater infrastructure. For example, anticipated increases in storm intensity may increase inflow and infiltration and overwhelm sewer system capacity. When rising groundwater or flooding stormwater enters the sanitary sewer system through leaky pipes, excess volume can lead to backups and accidental overflows of untreated wastewater at lift stations and sewer manholes, or emergency discharges at wastewater treatment plants. Once released, impacts from harmful nutrients, bacteria, and viruses can be magnified by warmer temperatures (Lovett 2010). Rising sea levels can also elevate groundwater and increase infiltration, corrode infrastructure, and alter the effectiveness of wastewater treatment. Increased intensities of precipitation and rising groundwater levels can saturate soils and reduce storage capacities of wet basins and spray fields to absorb reuse water. As a result of these stressors and others, climate vulnerabilities should be considered when planning new or retrofitting existing wastewater infrastructure. Under the lead of the Southwest Florida Regional Planning Council, innovative adaptation planning is underway in the CHNEP area (*e.g.*, Beever et al. 2009).

Aerial of the City of Cape Coral's Southwest Water Reclamation Facility where wastewater is treated and processed for reuse|*Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CHNES/Airbus DS, USDA, USGS, Aero GRID, IGN, and the GIS user Community.*

Septic Systems

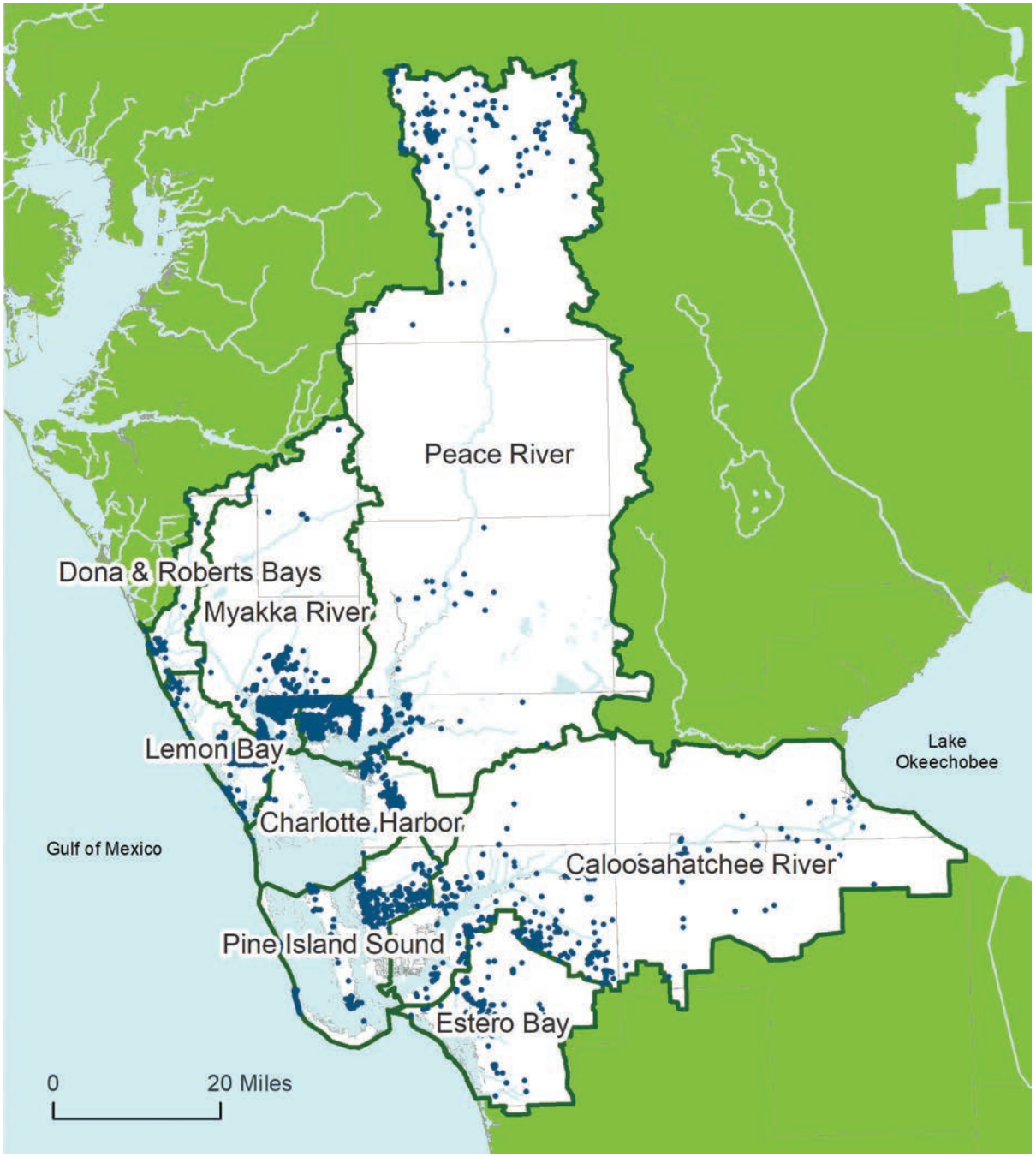
Conventional septic systems use a tank to trap solids, perforated pipes to remove water, and a drainfield to treat contaminants as water percolates through soil layers (Figure 13). Drainfield treatment effectiveness depends on having a sufficient volume of unsaturated soil for microbes to break down bacteria and nutrients before wastewater reaches groundwater. Relatively shallow water tables in Southwest Florida, combined with saturated soils during the wet season, can diminish septic system performance and result in the release of undertreated wastewater into the environment. Climate stressors such as rising sea levels, changes in precipitation patterns, and warmer temperatures may reduce the effectiveness of septic systems in preventing nutrient and bacterial pollutants from entering waterbodies (Cooper 2016). Flooding and soil saturation from rising seas and heavy rainfall can cause septic system failure when the water table rises and reduces the size of the drainfield treatment area. Even when operating properly, conventional septic systems only remove 30–40% of nitrogen, meaning 60–70% of nitrogen can reach groundwater (Toor et al. 2011).

Regular inspection, maintenance, and pumping of septic systems — especially those near to wells and surface waters — are important BMPs for septic systems. We do not know how many septic system owners do this. In 2010, the state legislature adopted a statewide septic evaluation program to require septic system maintenance, but this requirement was repealed in 2012. Destructive blue-green algal blooms and red tide blooms in 2018 have prompted legislators to reexamine the need for improved septic system maintenance and monitoring. A bill mandating regular septic system maintenance failed to pass during the 2019 Florida Legislative Session.



▲ Figure 13. Conventional residential septic systems are designed to treat bacteria. Because they only treat 30–40% of nitrogen input, they can be a source of nitrogen pollution in the watershed | *www.ourwatershed.ca.*

For these reasons and others, municipalities and counties throughout Southwest Florida have undertaken significant efforts to convert aging septic systems to central sewer, prioritizing areas near water bodies (Figure 14). Conversion from septic to sewer service has financial challenges, including relatively high costs for hookup fees, higher water bills due to inclusion of sewer fees, and additional costs to local governments for expanding WWTP operating capacity.



◂ Figure 14.
An inventory of known onsite sewage treatment disposal systems (OSTDS) in the CHNEP area reveals hotspots near Charlotte Harbor and the Lakes Region | *FDOH, March 23, 2018.*

Examples of projects to convert septic to sewer systems in the CHNEP area include:

- City of Cape Coral is providing municipal sewer service to 5,200 residential lots currently served by septic systems;
- City of Sanibel is expanding central sewer service to all remaining areas with septic systems;
- City of Fort Myers is installing central sanitary sewer to priority areas with high concentrations of septic tanks; and
- Charlotte County is constructing a vacuum sewage collection system and installing a reuse water main in the Spring Lake region.

There is a need to better understand nitrogen and bacteria loading from septic systems in the CHNEP area and to improve septic system performance. Florida Atlantic University's Harbor Branch Oceanographic Institute conducted a study in the Port Charlotte Area to better understand how septic systems contribute to nutrient and bacteria pollution in the Charlotte Harbor Estuary (Lapointe et al. 2016). Analysis of historic data and new sampling indicated that septic systems contributed significantly to nutrient and bacterial pollution of surface waters and groundwater. High concentrations of nitrogen and bacteria were consistently found down gradient from septic systems. Moreover, stable nitrogen isotope ratios in macroalgae, oysters, and hydroids indicated that wastewater, rather than fertilizer, was the dominant nitrogen source from the Port Charlotte Area into Charlotte Harbor. Presence of sucralose, something only humans consume, in surface waters and groundwater also confirmed contamination from septic systems.

STATUS:

Ongoing. Previous 2013–2018 CHNEP-CCMP Water Quality Actions WQ-H, WQ-J, and HA-O are combined here and updated to incorporate current information about improvements to wastewater treatment and the reduction of sewer inflow and infiltration.

RELATED ACTIONS:

- Water Quality Improvement Action 3: Reduce urban stormwater and agricultural runoff pollution
- Water Quality Improvement Action 5: Reduce harmful algal blooms
- Fish, Wildlife, and Habitat Protection Action 1: Protect, restore, and monitor estuarine habitats

ACTIVITIES:

Support wastewater treatment to AWT standards, encourage proactive inspection, maintenance, and replacement of failing or underperforming sanitary sewer infrastructure, including reduction of inflow and infiltration. Encourage, expand, and incentivize use of reuse water, especially AWT wastewater, which is protective of water quality and the natural hydrology in nearby waterways. Reduce discharges of treated wastewater to surface waters. Support additional wastewater treatment capacity to prevent overflows and other impacts to wastewater infrastructure and performance due to climate stressors.

Location: CHNEP area.

Responsible parties: County and Municipal Governments (Leads), FDEP, FDOH, SWFWMD, SFWMD, CHNEP.

Timeframe: Ongoing.

Potential annual cost and funding sources: Studies to understand pollutant loading from reuse water: up to $99,999/Section 320 Funds, grants; Improvements to sanitary sewer operation and maintenance: $1M–10M/ County and Municipal Governments, Section 319; Development of reuse water: $1M–10M/County and Municipal Governments, SWFWMD, SFWMD, FDEP.

Benefits: Reduction in nutrient and bacteria loading in CHNEP area waterbodies. Improved water quality to support natural communities.

5-year Performance measure: Reduced sanitary sewer system overflows and releases.

Continue to inventory and map septic systems in the CHNEP area. Support conversion of septic systems to centralized sanitary sewer systems. Support increased sanitary sewer capacity to handle new inflows from conversions. Encourage regular maintenance and inspection of septic systems. Support studies to better understand pollutant loading from septic systems. Encourage evaluation and adoption of new nitrogen-reducing septic system technology.

Location: CHNEP area, especially targeting areas designated as impaired for nutrients or bacterial contamination.

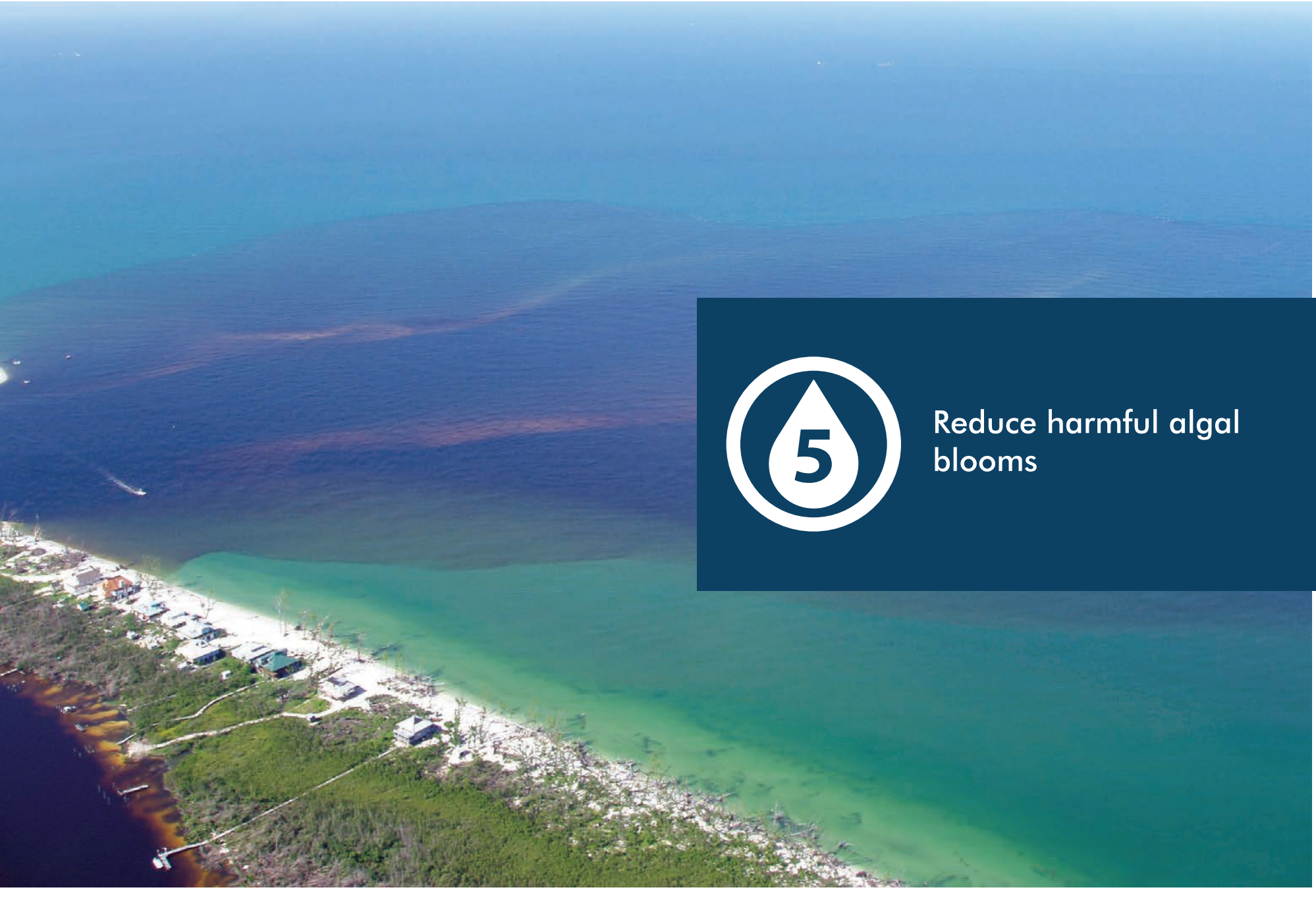
Responsible parties: County and Municipal Governments (Leads), FDEP, FDOH, CHNEP.

Timeframe: Ongoing.

Potential annual cost and funding sources: Inventory septic systems and track septic to sewer conversion: $100,000–$499,999/Section 319 Funds, County and Municipal Governments; Studies to understand pollutant loading from septic systems: $100,000–$999,999/Section 320 Funds, grants; Septic to sewer conversion: $1M–10M/ County and Municipal Governments, State of Florida; Improvements to septic system siting, design, and maintenance: $500,000–$999,999/grants.

Benefits: Reduction in nutrient and bacterial contamination in CHNEP area waterways. Improved water quality to support living resources.

5-year Performance measure: Reduced number of septic systems and small package plants threatening surface water and groundwater.



5 Reduce harmful algal blooms

OBJECTIVES:

Support measures to reduce harmful algal blooms, including studying natural phytoplankton composition and background levels, and relationships between phytoplankton and algal blooms and macro- and micronutrient limitation, physical conditions like circulation, rainfall, and freshwater pulses, and trophic dynamics with zooplankton and fish.

BACKGROUND:

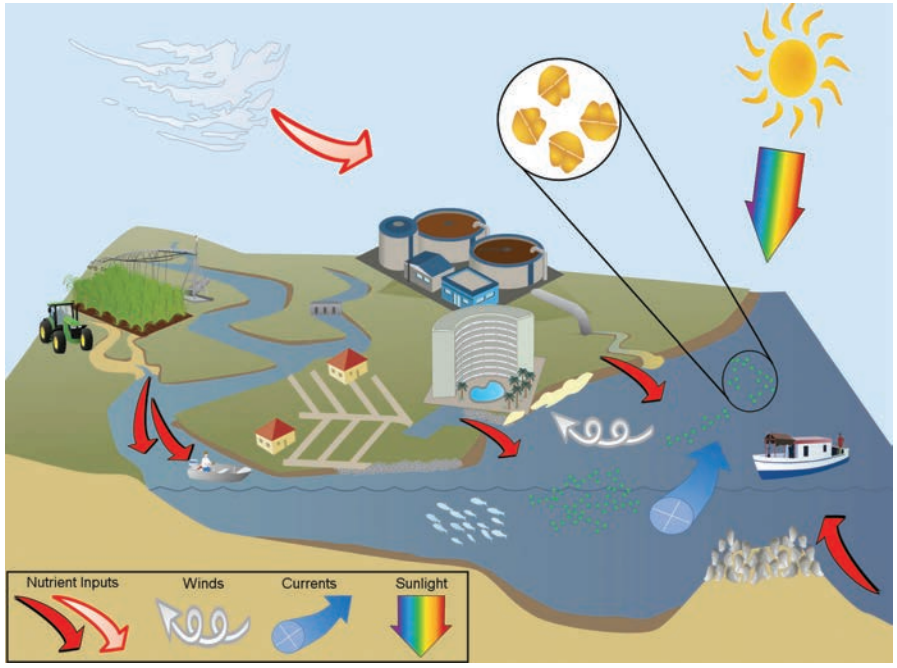
Harmful algal blooms (HABs) are the excess proliferation of harmful or nuisance algae. HABs can be generated by microscopic single-celled microalgae or larger multicellular macroalgae. HABs can reduce water quality, smother aquatic vegetation and hardbottom habitats, reduce sunlight availability for seagrasses, and kill aquatic invertebrates, fish, seabirds, turtles, and marine mammals. HABs can also impact public health via release of airborne toxins or bioaccumulation of toxins in edible seafood and can impact recreational and economic activities.

HABs have generally increased in frequency, extent, and duration throughout the world's waters (Anderson et al. 2002). In many cases, anthropogenic (human caused) nutrient pollution is a contributing factor. In addition to nutrient availability, HABs are influenced by water temperature, salinity, light availability, rainfall, and water circulation. They are also influenced by biotic interactions, such as competition with other algae, and grazing by zooplankton and shellfish (Smayda 2008). In addition to directly impacting ecosystems by blocking sunlight and releasing toxins, when algae die and decay — they deplete dissolved oxygen in the water — resulting in additional mortality of aquatic life. These cascading mortality events provide additional nutrition to sustain blooms (Figure 15).

HABs may also respond to climate-driven changes in water parameters, such as increasing temperature, lower solubility of oxygen, increased stratification in the water column, variable salinity, and increased acidity; which may alter nutrient cycling, primary productivity, competing algal communities, and cause cascading food chain effects (O'Brien et al. 2016). Harmful algae may have a competitive advantage over non-harmful species under conditions of warmer temperatures, higher nutrients, and ocean acidification (Paerl and Huisman 2008). Our limited understanding of the response of marine microalgae to physiochemical climate drivers — for example, whether their geographic range will expand or whether they will become increasingly toxic — requires more monitoring and study (Hallegraeff 2010).

The relationships between nutrient pollution and HABs are species-specific and can be complex (Anderson et al. 2002, Heil et al. 2014). This concept is illustrated in the cases of two of the most damaging phytoplankton HABs in southwest Florida: blue-green algal blooms and red tide.

Figure 15.
Formation of harmful algal blooms (HABs) is a complex interaction of physical, biological, and human factors that affect their timing and severity | *FWRI.*



◀ Red tide bloom outside Captiva Pass | *SFWMD.*

▲ Alligator swims through a mat of algae | *Betty Warner.*

Blue-Green Algal Blooms

A common freshwater HAB in the CHNEP area is produced by the toxin-producing, single-celled blue-green algae (cyanobacteria) *Microsystis*. The most common species is *Microsystis aeruginosa*, which has small gas spaces in its cell that causes it to float to the top of the water column. This ability allows it to block sunlight to other phytoplankton and monopolize nutrients. Its blooms are characterized by a thick, paint-like green slick, and can grow rapidly until they either run out of nutrients or encounter adverse environmental conditions like increasing salinity. Upon death, *Microcystis* releases toxins called microsystins, which can persist in the water for weeks to months. Microcystin can also bioaccumulate in aquatic animals and be transferred through the food web to higher trophic levels, including humans (*e.g.*, Smith and Haney 2006). In addition to their environmental impacts, microsystins can cause abdominal pain, headache, nausea, vomiting, liver and kidney damage, and potential tumor growth promotion in humans. Microsystins are listed on the EPA's third drinking water Candidate Contaminant list (EPA 2014), and the International Agency for Research and Cancer has classified Microcystin-LR as a possible human carcinogen. Pathways of human exposure include swallowing, skin contact, or inhalation of contaminated water. More research on the human health impacts of algal toxins is needed.

In the summer of 2018, a large *Microcystis* HAB formed in Lake Okeechobee. The bloom was fueled by sunlight, warm temperatures, and high levels of nitrogen and phosphorus from agricultural runoff. In anticipation of the summer hurricane season, the US Army Corps of Engineers released large quantities of polluted water and *Microcystis* from Lake Okeechobee downstream to the St. Lucie Estuary on the east coast and to Charlotte Harbor on the west coast. In the Caloosahatchee River, the bloom further benefited from Caloosahatchee watershed runoff — allowing the bloom to extend from the Lake along the entire length of the Caloosahatchee River into downtown Fort Myers. The toxic blue-green HAB caused significant environmental and economic damage on both coasts and prompted a state of emergency to be declared for seven Florida counties: Lee, Hendry, Glades, Martin, Okeechobee, St. Lucie, and Palm Beach.

Florida Red Tide

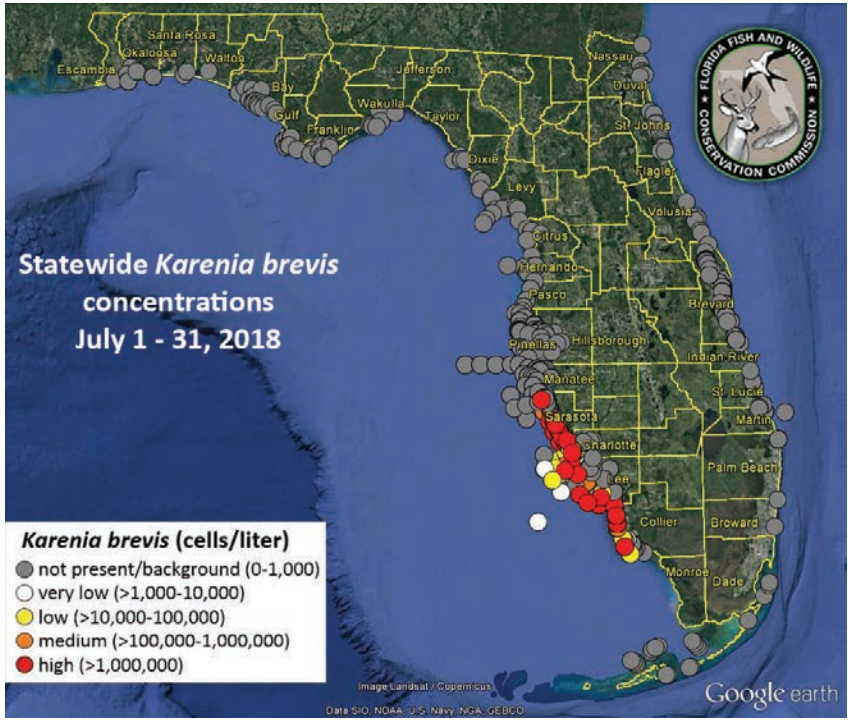
Florida red tide is a common saltwater HAB in the CHNEP area, formed by the toxic dinoflagellate *Karenia brevis*. This phytoplankton species produces brevetoxins,

neurotoxins that can bioaccumulate and kill fish, seabirds, turtles, and marine mammals. Aerosols of the toxin can also cause respiratory distress in humans, resulting in people avoiding bays and beaches.

Scientists characterize the life cycle of red tide blooms as having four stages: initiation, growth, maintenance, and termination (Steidinger 1975). *K. brevis* is commonly found in background concentrations throughout the Gulf of Mexico (Geesey and Tester 1991). Initiation typically occurs in deeper water 10–40 miles offshore. *K. brevis* grows slowly and can utilize low concentrations of a broad range of organic and inorganic nutrients. In these low-nutrient environments, cells can be supported by recycling or regenerating nutrients. Blooms can be transported inshore by currents and winds, where they can be maintained and intensified by land-based nutrients. Termination of a red tide bloom may result from a variety of stressors including changing nutrient ratios and nutrient limitation, dilution of water masses, or suboptimal temperatures or salinities. In the field, *K. brevis* can survive in water temperatures between 48–91 degrees F and is largely absent from brackish waters with salinities lower than 24 parts per thousand (PPT) of salt (Steidinger 2009).

The 2017–2019 red tide bloom outbreak in west Florida persisted for over 15 months and littered creeks, bays, and beaches with dead marine life. As of January 2019, Manatee County picked up 316 tons and Sarasota County picked up 255 tons of dead aquatic life. FWC attributed over 589 sea turtle and 213 manatee deaths to the bloom and NOAA attributed over 127 bottlenose dolphin deaths to it. Aerosolized brevetoxins can cause eye, nose, and throat irritation and more serious consequences for people with existing respiratory issues, like asthma (Kirkpatrick et al. 2004). Rotting aquatic life in the water and along the shoreline poses additional health threats. Impacts of the 2017–2019 Bloom to beach-goers, boaters, charters, and fishers were severe, resulting in significant impacts to local tourism. For example, Visit Sarasota County reported that hotel occupancy dropped by 11.3 percent in the County during the last three months of 2018, the steepest decline in that period since the September 11, 2001 terrorist attacks.

Red tide blooms have long impacted Florida's west coast, though some believe the problem is getting worse (Brand and Compton 2007). They concluded that *K. brevis* was 13–18 times more abundant in the 1994–2003 time period than it was in 1954–1963, and that it was approximately 20 times more abundant within 5 km of the shoreline than 20-30 km offshore. They hypothesized that greater nutrient availability in the ecosystem was the most likely cause for the increase and that human population growth and activity played a



◀ Screen capture of FWC's online red tide reporting service. High concentrations of *Karenia brevis* were common along Southwest Florida coasts in 2018. The bloom was responsible for the deaths of hundreds of sea turtles, manatees, dolphins, and tons of fish | *FWC.*

major role. Their analyses were based on a HAB monitoring database compiled and maintained by the Florida Fish and Wildlife Research Institute (FWRI) (Haverkamp et al. 2004). FWRI has cautioned that, due to a variety of limitations (reviewed in Alcock 2007), their database cannot be used to determine if red tides have increased in frequency or severity in the past 60 years. Other researchers (Heil et al. 2014) stress that complex bloom dynamics, multiple nutrient sources, and the importance of regenerated nitrogen in supporting blooms make singling out one unique cause for red tide blooms oversimplified.

More research and standardized monitoring are needed to better predict and track red tide blooms and to better understand the complex interaction between nutrients and bloom dynamics throughout the life cycle of a bloom. Our growing understanding of red tide blooms suggests that it may be difficult to altogether prevent the periodic recurrence of Florida red tides, though reducing anthropogenic nutrient sources with the aim to decrease the intensity and duration of blooms once they start is a rational strategy (Alcock 2007, Heil et al. 2014).

Macroalgal Blooms

Nuisance blooms of drifting and attached macroalgae can decrease light availability to seagrasses, resulting in lower seagrass productivity, habitat loss, low dissolved oxygen, and eventual die-offs of sensitive species. Large drifts of macroalgae can also wash onto beaches and decay, interfering with recreation and tourism.

Management Needs

We need to better understand and monitor taxonomic composition, severity (cell concentration), extent, and duration of blooms of *K. brevis*, blue-green algae, macroalgae, filamentous green algae, and other HABs of concern. For red tide, additional research and monitoring is necessary to better understand status and trends of blooms and the role various nutrient sources play in initiating, growing, maintaining, and terminating a bloom. We need to support measures to reduce the environmental, social, and economic impacts of HABs through the identification and reduction of anthropogenic influences, especially nutrient pollution. Documenting the environmental, social, and economic impacts of harmful algal blooms is an important management tool for decision-makers to assess cost-benefits of HAB management investments. Targeted communication of scientific results to the public will improve understanding of HABs and build support to reduce anthropogenic influences. Finally, we need to improve our capacity to prepare, respond, and recover from HABS, including reducing other anthropogenic stressors on and improving the resiliency of affected environments.

STATUS:

Ongoing. Previous 2013–2018 CHNEP-CCMP Water Quality Action WQ-I is updated to incorporate new information on the potential exacerbating effects of climate-driven changes in water chemistry on HAB occurrence and severity.

RELATED ACTIONS:

- Water Quality Improvement Action 3: Reduce urban stormwater and agricultural runoff pollution
- Water Quality Improvement Action 4: Reduce wastewater pollution
- Fish, Wildlife, and Habitat Protection Action: 1 Protect, restore, and monitor estuarine habitats

ACTIVITY:

Support Harmful Algal Bloom (HAB) research and monitoring and measures to reduce their environmental, social, and economic impacts through the identification and reduction of anthropogenic influences.

Location: CHNEP area.

Responsible parties: FWC (Lead), FDOH, FDEP, Florida Sea Grant, FGCU Marine Sciences, USF, and other academic institutions, Mote Marine Laboratory, CHNEP, SFWMD, Calusa Waterkeepers, and SWFWMD (potentially for water quality monitoring and source tracking studies).

Timeframe: Ongoing.

Potential annual cost and funding sources: $1M–10M/ grants, State of Florida.

Benefits: Improved knowledge of HABs and reduced severity, extent, duration and frequency of harmful effects, including macroalgae, phytoplankton, and periphyton, through the identification and reduction of anthropogenic influences.

5-year Performance measure: Tracking and dissemination of information about occurrences and reduction of harmful effects from algal blooms, including influencing factors and impacts of climate stressors on HABs.

HYDROLOGICAL RESTORATION ACTION PLAN

VISION: Appropriate freshwater flow across the landscape to sustain healthy wetlands, rivers, and estuaries.

GOAL: Enhanced and improved waterbodies with more natural hydrologic conditions.

OBJECTIVE: Adequate aquifer recharge and freshwater volume and timing of flow to support healthy natural systems, meet water quality criteria, and protect the designated use.

STRATEGY: Support data-driven watershed planning and hydrological restoration projects to protect and restore natural flow regimes and provide sufficient fresh surface water and groundwater to natural systems.

ACTION 1: Conduct data collection, modeling, and analyses to support hydrological restoration

ACTION 2: Increase fresh surface water and groundwater availability to support healthy ecosystems

ACTION 3: Protect and restore natural flow regimes

◀ Paddling on Curry Creek | *Sylvia Shirley, Kayaking Adventures.*

Hydrology is the science of the physical and chemical properties of surface and groundwater, the occurrence and movement of water, and its relationship with the living and non-living environment (Bales 2015). The CCMP Hydrological Restoration Action Plan addresses flows and levels of surface and groundwater in the CHNEP area. Aspects of water quality related to waters supporting aquatic life, while meeting their designated human uses for drinking, shellfish harvesting, or swimming and fishing, are addressed in the CCMP Water Quality Improvement Action Plan.

▲ The W.P. Franklin Lock and Dam on the Caloosahatchee River near Fort Myers was constructed to store water for irrigation and navigation. The dam starves the downstream Caloosahatchee Estuary of freshwater during dry periods and floods it with too much freshwater during the wet season | *USACE.*

In natural systems, a spectrum of salinity-based aquatic habitats exists from freshwater wetlands, lakes, and rivers — to brackish (mixed salinity) waters in estuaries and tidal rivers and creeks — to full strength seawater. Within ranges of tolerance, aquatic organisms are optimally adapted to particular salinity zones. For example, low-salinity habitats (0.5–5 parts per thousand (PPT) of salt), like upper tidal rivers and creeks, are important nursery areas for many fishes and invertebrates (Peebles 2005, Krebs et al. 2007). Moderate-salinity habitats (5–18 PPT) are important for oysters and a variety of fishes, including the endangered smalltooth sawfish (*Pristis pectinata*). Higher-salinity habitats (18–32 PPT), like those found in estuaries are important for juvenile fish, such as gag grouper (*Mycteroperca microlepis*). Many species, such as snook (*Centropomus undecimalis*), utilize different salinity waters during different life history stages. For these species, connectivity between freshwater and saltwater habitats is important.

Altered volume, velocity, timing, and location of freshwater flows

Variability in the timing, volume, velocity, and location of fresh surface water and groundwater flows can regulate the suitability of an area to sustain salinity-sensitive biological communities (Estevez et al. 1991, Morrison and Greening 2011). Rapid population growth in Southwest Florida and associated commercial and residential development, agriculture, and mining have profoundly, and in some places irreparably, altered the area's hydrology.

Alterations of Freshwater Flows in the CHNEP area include:

- Draining and filling wetlands;
- Damming, diking, straightening, widening, and deepening rivers and creeks;
- Diverting natural waterways into different watersheds and waterbodies;
- Hardening natural pervious areas;
- Withdrawals from surface water and groundwater systems for consumptive uses;
- Connecting isolated waterbodies with canals; and
- Dredging and filling estuaries.

These alterations have profoundly changed the dynamics of freshwater flows, which have impacted water quality, aquatic and riparian habitats, and the living things they support.

When streamflow volume is chronically reduced so that tidal saltwater replaces the historical freshwater regime, freshwater biological communities may be displaced. Similarly, if too much freshwater chronically floods a traditionally high-salinity habitat, biological communities requiring saline waters may be displaced. Some species can tolerate physiological stress related to suboptimum salinity regimes for limited durations; however, if the alteration becomes chronic or permanent — they too will be displaced.

For example, volumes of freshwater flow in the upper Myakka River and some of its tributaries have increased due to runoff from irrigated agricultural crops, negatively impacting Flatford Swamp and other riverine wetlands. In contrast, natural flows have been reduced in the lower Myakka River. Blackburn Canal and Cowpen Slough were modified to carry water away from the Myakka River towards Roberts and Dona Bays – reducing the historical flow of the Lower Myakka River by almost nine percent. Excess freshwater flows have occasionally caused these small bays to receive triple their historical water flows. Sarasota County and SWFWMD are working to restore more natural flow volume and timing to Dona Bay (see Hydrological Restoration Action 3) and SWFWMD is implementing a project at Flatford Swamp to utilize excess runoff to restore the Upper Floridan Aquifer through wells. Locations of other altered flows can be identified by comparing historical watershed boundaries with those of today and can assist in developing water budgets and restoration priorities (Figure 16 on page 80).

Straightening rivers and streams and connecting new areas through canals and pipes can increase the amount of freshwater flow to a river and estuary and change the timing and location of its effect. For example, the Caloosahatchee River was straightened, and its riverhead was connected to Lake Okeechobee. Water control structures, including dams and locks, were constructed along the Caloosahatchee River to store water for irrigation and navigation. These structures function to starve the Caloosahatchee Estuary of freshwater during dry periods and flood it with too much freshwater during the wet season. This alteration of flow has had catastrophic, cascading impacts on biological communities dependent on the Caloosahatchee Estuary. Various governmental entities are presently working to restore a more natural hydrology to the Caloosahatchee River and Estuary (see Hydrological Restoration Action 2).

Other examples of alterations to freshwater flows include decreased flow volumes due to the Sanibel Causeway in the Caloosahatchee Estuary Watershed, altered timing of flows resulting from drainage of Tatum Sawgrass, and altered location of flows due to the Clay Gully Cutoff and Vanderipe Slough Levee in the Myakka River Watershed.

Climate variability in Southwest Florida is expected to result in rising sea levels, warmer air and water temperatures, and alterations in precipitation patterns (CHNEP 2018a). Rainfall intensities are projected to increase during the wet season and more days without rain are expected during the dry season. Reduced rainfall during the dry season, combined with greater evaporation due to warmer air temperatures and increased water demand for agriculture and urban development, will compound existing problems where natural habitats are starved of water during the dry season. More intense rainfall events may also overwhelm existing stormwater infrastructure and cause large freshwater pulses to disrupt natural areas.

Figure 16. ▶
Historically, drainage projects to dry the land for agriculture and urban development rerouted surface water via canals to the closest water body, resulting in shifts to the historical boundaries of watersheds and their sub-basins | *CHNEP 2013.*

Surface Water and Groundwater Levels

Aquifers are bodies of permeable rock that can contain or transmit groundwater. In Southwest Florida, there are three main aquifers: the Surficial Aquifer System (SAS), Hawthorn (Intermediate) Aquifer System, and the Floridan Aquifer System. The Floridan Aquifer underlies all of Florida and areas of Alabama, Georgia, and South Carolina and is one of the main sources of withdrawals for consumptive use in the CHNEP area. Where waters in the Floridan Aquifer System are brackish, the Hawthorn Aquifer System is the main source of water supply for Sarasota, Charlotte, and Lee Counties.

When surface water levels are higher than surrounding groundwater, surface water can percolate into the ground and recharge the SAS aquifer. In areas where aquifer water levels are higher than surrounding surface waters, groundwater can discharge into surface water. As a result, groundwater levels in aquifers can affect the base flow of water in springs and streams, and water levels in lakes and wetlands. They can also maintain a positive head pressure to hold back saltwater intrusion into aquifers.

An aquifer becomes stressed if the amount of groundwater withdrawn for consumptive use exceeds the amount of recharge. Over-stressing can cause saltwater intrusion or groundwater levels to decline significantly — which can reduce discharges into surface waters. For example, groundwater pumping in the upper Peace River Watershed contributed to cessation of flow of Kissengen Springs and other minor springs into the Peace River (PBS&J 2007).

Lowered groundwater levels can result in decreased stream flows and lake levels and losses of plant and animal habitat. Reduced freshwater flows alter salinity gradients and make certain habitats no longer suitable for plants and animals. Reduced water levels in tidal creeks can also create barriers for mobile aquatic organisms and increase the predation efficiency on aquatic species by birds and other predators. Shallow water systems are susceptible to wider temperature variations, whereby warmer temperatures can stimulate algal blooms, reduce dissolved oxygen levels, and increase mortality of aquatic organisms. In addition, because coastal aquifers are commonly surrounded by saltwater, reduced aquifer water levels can cause saltwater to intrude into the aquifer. Saltwater intrusion has significant environmental repercussions for waterbodies that receive groundwater discharge and greatly increases the costs of treating water for consumptive uses. Rising sea levels increase saltwater intrusion into coastal aquifers, potentially impacting surface waters and groundwater supply for consumptive uses.

Hydrological Restoration Challenges and Management Actions

Restoring the natural hydrology of estuaries is critical to their protection and restoration. Significant challenges remain to reverse damage and balance limited water resources between people and natural ecosystems. Water resources do not usually follow jurisdictional lines of local, regional, and state governments, and the cumulative impact of many small land and water-related decisions may remain unnoticed until hydrologic alterations become significant. Furthermore, limited surface water and groundwater data exacerbate challenges for supporting restoration actions. Since resources are affected by management at all levels of government, cross-jurisdictional landscape-level data collection and watershed planning are important to the long- term health of the rivers, lakes, and aquifers feeding estuaries.

The CHNEP Management Conference has identified three major hydrological restoration actions to support the goal of enhanced and improved waterbodies with more natural hydrologic conditions: Action 1 calls for continued data collection, modeling, and analysis to support hydrological restoration; Action 2 aims to increase fresh surface water and groundwater availability to support healthy natural systems; and Action 3 seeks to preserve and restore natural flow regimes.

1 Conduct data collection, modeling, and analyses to support hydrological restoration

OBJECTIVES:

Conduct data collection, modeling, and analysis of historic, current, and projected hydrologic conditions to identify needs and guide hydrological restoration.

BACKGROUND:

Aquatic systems are complex. Effective hydrological restoration plans must integrate natural system preservation, water supply, water quality, and flood protection. Continuous scientific data collection of surface water and groundwater levels, flow rates, and surface water levels are crucial to understand spatial and temporal variations in hydrologic conditions and conduct effective science-based hydrological restoration planning. Continuous data collection is important for long-term local and regional hydrologic analyses. To document changes in surface water flows and patterns due to hydrologic alterations, we need to develop and maintain accurate, long-term databases for all watersheds within the CHNEP area.

Data Collection

The U.S. Geological Survey (USGS) currently operates hundreds of monitoring sites in Florida to collect information on surface water, groundwater, water quality, and precipitation. Many sites are equipped with satellite telemetry, which allow data to be posted online for public dissemination. Frequency of data collection ranges from 15 minutes to daily. For example, in the CHNEP area, collaboration between USGS and Lee County is yielding important data for hydrologic modeling and assessment of flood conditions in South Lee County flowways.

South Florida Water Management District (SFWMD) and Southwest Florida Water Management District (SWFWMD) also operate large monitoring networks to measure rainfall, stream flow, spring discharge, and surface water and groundwater levels. Frequency of data collection and reporting ranges from real-time to monthly. Data are collected, processed, analyzed, and uploaded to publicly accessible, searchable online databases (SWFWMD's Water Management Information System and SFWMD's DBHYDRO database).

While many areas within the CHNEP have extensive historical hydrologic records, other areas lack them. For these areas, we need to determine the minimum number and appropriate locations of gages to close these gaps. Improved monitoring of flow, salinity, and indicator species data will provide a stronger scientific basis to establish minimum flows and levels and assess future changes related to projected development and consumptive uses (see Hydrological Restoration Action 2).

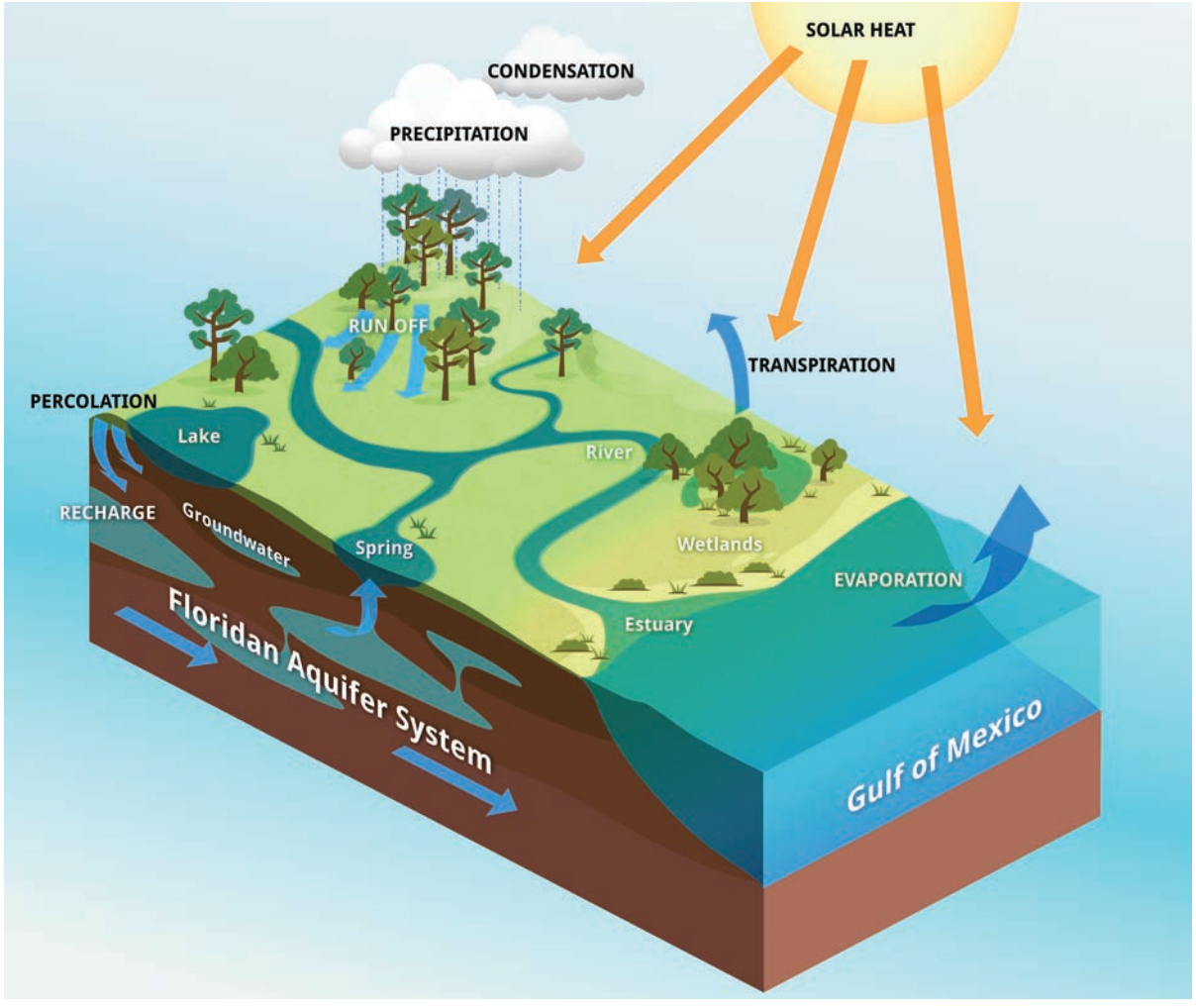
Modeling

Hydrologic data collection, analysis, and modeling are prerequisites for successful hydrological restoration.

Hydrologic models can simulate how much and where water can be stored and moved to in order to protect the environment. Such models can inform decision-making for evaluating and planning under different climatic and hydrologic conditions. Hydrologic models are most effectively used for restoration in conjunction with ecological and water quality models to determine how much water an ecosystem needs, where water is located, how it can be safely distributed to those areas of need, and how water quality can be protected and improved in the process.

Accurate data-driven water budget modeling is required to effectively manage and balance the water demands of people for drainage, drinking water, navigation, and recreation while preserving the ecological health of natural systems. It is especially important to develop water budgets that predict future water demands and supplies under climate change scenarios. Hydrologic interactions among factors such as evapotranspiration, precipitation, ground-water pumping, wastewater reuse, watershed connections, impermeable surfaces, constructed conveyances, barriers and reservoirs — in addition to future water demands due to population growth — also need to be modeled.

◀ Cypress and great white heron | *Linda Wroble.*



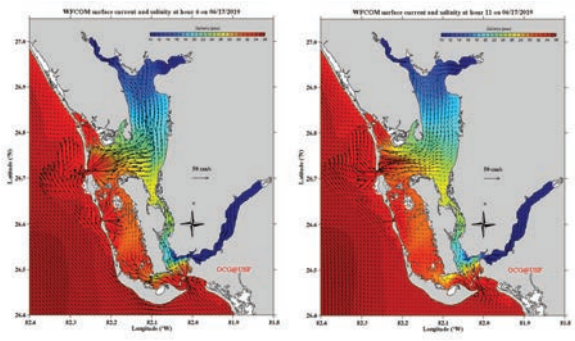
▲ Figure 17.
The hydrologic cycle | *James Seaman, courtesy of ClipPix ETC, Florida Center for Instructional Technology, USF.*

Groundwater models typically include basic components of the hydrologic cycle along with the physical properties of the aquifer and stresses to the system, such as pumping and saltwater intrusion (Figure 17). For example, SWFWMD developed a saltwater intrusion model for the Most Impacted Area of the Southern Water Use Caution Area (SWUCA) to support SWUCA Recovery (see Hydrological Restoration Action 2). The model represents and predicts changes to the saltwater-freshwater interface associated with the changes in climate, sea level, and groundwater levels.

Groundwater flow is influenced by surface waterbodies. Models have been developed to better understand how base flows, infiltration, and evaporation can affect surface water flows and levels during wet and dry periods. Sophisticated surface water and groundwater models have been developed to evaluate flood levels and the effects of flood protection management measures as they relate to base flows, water quality, water supply, and the health of ecosystems.

Improvements in computing power and modeling techniques have increased the accuracy of dynamic surface water models to evaluate the response of entire watersheds to changes made in surface water management (Figure 18). Hydrodynamic modeling of estuaries provides a basis for evaluating effects of freshwater inflow and physical alterations to flowways and waterbodies (*e.g.*, water control structures, causeways, and dredging or backfilling of channels) on ecological conditions and functions (*e.g.*, Zheng and Weisberg 2010).

This work aims to continually update, refine, and develop new models in order to better inform and guide hydrological restoration projects — especially under changing climatic conditions that could significantly impact freshwater flows, increase saltwater intrusion, and further alter drainage patterns and hydroperiods.



▲ Figure 18.
Screen capture of an online surface water model of the Charlotte Harbor area. Output shows hourly forecasts of surface currents and salinity for incoming and outgoing tides; generated from the West Florida Coastal Ocean Model | *http://ocgweb.marine.usf.edu/Models/WFCOM/wfcom_index.html.*

STATUS:

Ongoing. Previous 2013–2018 CHNEP-CCMP Hydrologic Alteration Actions HA-A (partially complete), HA-B, HA-H, HA-I, and HA-K are combined here.

RELATED ACTIONS:

- Hydrological Restoration Action 2: Increase fresh surface water and groundwater availability to support healthy natural systems
- Hydrological Restoration Action 3: Protect and restore natural flow regimes

ACTIVITY:

Review existing data collection and identify gaps. Conduct data collection, modeling, and analyses of historic, current, and projected hydrologic conditions to identify needs and guide hydrological restoration, including:

- water budget modeling including projected supply demands and natural system needs;
- estuary mixing models;
- impacts of manmade barriers to historical flows;
- relationship between reservoir and downstream resources; and
- integrated surface-groundwater models that consider climate change.

Location: CHNEP area.

Responsible parties: SWFWMD and SFWMD (Leads, except for examining impacts of manmade barriers to historical flows), CHNEP, County and Municipal Governments, FDEP, USGS, Research Institutions, Conservation NGOs.

Timeframe: Ongoing; Monitoring Strategy to be adopted in 2020.

Potential annual cost and funding sources: $1M–10M/ Section 320 Funds, Grants, SWFWMD, SFWMD.

Benefits: Increased knowledge of historic, current, and projected hydrologic conditions to better inform and guide hydrological restoration.

5-year Performance measures:

- Updated estuarine mixing, surface water, and groundwater models to support MFL development and recovery strategies and creation of regional watershed restoration plans, where needed.
- Increased number of surface water and groundwater level and flow gages in areas with limited data to monitor natural variations in flow and impacts of manmade barriers and alterations (including mining, ditching, channelizing, and damming).

2

Increase fresh surface water and groundwater availability to support healthy ecosystems

OBJECTIVES:

Develop, reevaluate, and implement scientifically-sound minimum flows and levels in surface water and groundwater, and implement recovery strategies to meet levels in order to prevent degradation of ecosystems, increase aquifer recharge, and encourage conservation, efficient water use, and use of alternative water supply sources, when and where appropriate.

BACKGROUND:

Timing, volume, and distribution of freshwater flows are critical ecological structuring elements for wetlands, lakes, rivers, and estuaries. Throughout the CHNEP area, water flows have been dramatically altered from their historical natural states — flooding some areas with too much water and starving others or alternately flooding and starving the same area — degrading waterbodies and their ability to sustain ecosystems. Similarly, surface water and groundwater levels have been lowered, impacting their functional capacity to support healthy natural systems. Climate stressors could further exacerbate shortages of fresh surface water and groundwater availability for healthy natural systems.

Water Management District Regulatory Mechanisms

Multiple stakeholders compete with the natural environment for use of fresh surface water and groundwater including agriculture, residential and commercial development, industry, and mining. Florida's Water Management Districts (Districts) are responsible for allocating freshwater to consumptive uses, water storage, and flood control — while protecting water quality, natural systems, recreational opportunities, navigation, and public health and safety. Allocation of freshwater to meet human and environmental needs is challenged by a rapidly growing population and complicated by temporal and spatial variability in rainfall across seasonal, inter-annual, decadal, multi-decadal, and longer climatic timescales (Misra et al. 2017). Regulatory requirements are enacted to protect water and ecosystems from potential harm caused by surface water and groundwater withdrawals through multiple regulatory mechanisms, including minimum flows and levels (MFLs), restricted allocation areas, and water reservations.

Minimum Flows and Levels (MFLs)

Florida law (Chapter 373.042, Florida Statutes) requires the state Water Management Districts or the Florida Department of Environmental Protection (FDEP) to establish minimum flows for rivers, streams, and estuaries and minimum water levels for lakes, wetlands, and aquifers. MFLs are used to plan for current and future water needs, which include the need to offset groundwater use through projects that encourage conservation and provide alternative water supplies. MFLs are also an important tool for District water use and environmental permitting programs to ensure that withdrawals do not exceed an established MFL and cause significant harm. MFLs provide regulation to protect springs, spring runs, rivers, lakes, wetlands, and aquifers from ground and surface water withdrawals that would cause "significant harm" to the water resources or ecology of the area. The term "significant harm" is not defined by statute; however, there are environmental values, such as fish and wildlife habitat and scenic attributes, as well as methods and criteria in rule that must be considered and used when establishing MFLs.

MFLs are determined by scientists who consider the ability of aquatic ecosystems and groundwater systems to adjust to changes in hydrologic conditions. For each MFL priority waterbody, Districts study and collect a large amount of information such as historical water levels and flow rates, soils and vegetation data, water quality data, wildlife variety and abundances, and other pertinent information. As each natural system is unique, District scientists and other experts in the field have developed a variety of methods for setting MFLs using the best available science and advanced computer models. An essential component of the MFL process includes the use of peer review, where a panel of independent scientists review and comment on proposed MFLs, including underlying data and methods used for their development. Other local, state, and federal agencies and the public have opportunities to review and comment as well. A public meeting is held to explain the proposed MFL and to record public comments. All comments are read and considered by staff before they make a recommendation to the District's Governing Board. Once MFLs are adopted by Governing Boards, they are implemented through District consumptive use permitting and water supply planning programs. If an MFL waterbody does not or is not expected to meet proposed MFL criteria during the planning horizon, Districts must also develop an appropriate recovery or prevention strategy.

◀ Babcock-Webb Wildlife Management Area | *Mike Kaplan.*

Water Reservations

A water reservation is a legal mechanism Districts can use to set aside water for maintaining the ecological health of a waterbody. Water reservations protect quantities and timing of water flows at specific locations. For example, SFWMD adopted a water reservation rule for the Caloosahatchee River West Basin Storage Reservoir (see Caloosahatchee Case Study on page 89).

Restricted Allocation in Water Use Caution Areas

In areas where water withdrawals are impacting or may impact water resources, natural resources, or the public interest, Districts may designate Water Use Caution Areas (WUCA). Management activities in WUCAs include funding projects, developing alternative water supplies, recovering resources, and implementing regulatory requirements and restrictions. For example, the Southern Water Use Caution Area (SWUCA) was designated in 1992 to address reduced flows in the upper Peace River, reduced lake levels in the Ridge Lakes area, and saltwater intrusion into the Upper Floridan aquifer. SWFWMD implements a cooperative funding program for local governments to fund alternative water supply conservation and restoration projects.

The first five-year assessment of the SWUCA strategy reported that SWFWMD and its partners met water supply needs, reduced groundwater withdrawal from the Upper Floridan aquifer by more than their targeted 50 MGD, and made progress toward achieving minimum flows set for the Upper Peace River. The Lake Hancock Lake Level Modification Project was designed to help achieve low minimum flows by replacing a water control structure to raise water levels by 1.3 feet — allowing more water to be stored in the lake during the wet season and released during the dry season (see Hydrological Restoration Action 3). There is more work to be done in the SWUCA. According to a recent 5-year SWUCA update, of the 41 MFLs adopted for priority waterbodies, 21 are met and 20 are not met; although flows and levels are trending upwards.

In Depth: MFL Criteria

Section 373.042, Florida Statutes (F.S.), provides that the minimum flow for a given watercourse is the limit at which further withdrawals would be significantly harmful to the water resources or ecology of the area. This section of the statutes also indicates that minimum flows (or minimum water levels) shall be calculated using the best information available, that the Governing Board shall consider and may provide for non-consumptive uses in the establishment of minimum flows, and when appropriate, minimum flows may be calculated to reflect seasonal variation. The statutes also require that when establishing minimum flows and levels, changes and structural alterations to watersheds, surface waters, and aquifers shall also be considered (Section 373.0421, F.S.).

The State Water Resource Implementation Rule (Chapter 62-40, Florida Administrative Code) includes additional guidance for establishing minimum flows and levels, providing that consideration shall be given to natural seasonal fluctuations in water flows or levels, nonconsumptive uses, and environmental values associated with coastal, estuarine, riverine, spring, aquatic, and wetlands ecology, including:

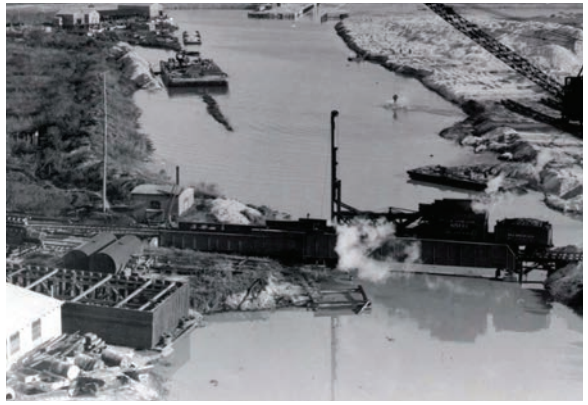
- Recreation, in and on the water;
- Fish and wildlife habitats and the passage of fish;
- Estuarine resources;
- Transfer of detrital material;
- Maintenance of freshwater storage and supply;
- Aesthetic and scenic attributes;
- Filtration and absorption of nutrients and other pollutants;
- Sediment loads;
- Water quality; and
- Navigation.

Guidance provided by this Rule should be considered when establishing MFLs.

Case Study: Caloosahatchee River and Estuary

Historically, the Caloosahatchee River was a shallow, meandering river starting at Lake Hicpochee and flowing to the Caloosahatchee Estuary. Beginning in the 1880s, the freshwater segment of the river was straightened, deepened, widened, and connected to Lake Okeechobee and the Kissimmee Chain of Lakes for water supply, flood control, and navigational purposes. These alterations significantly changed the timing, distribution, and amount of freshwater delivered to the estuary. For example, the Franklin Lock and Dam at the head of the Caloosahatchee River Estuary eliminated the historical estuarine gradient of salinity upstream of the dam during the dry season. Increased water withdrawals to meet agricultural and urban demand reduced dry season flow to the river and estuary downstream of the dam. During the wet season, water that once evaporated or percolated into wetland soils now runs into the estuary in higher quantities over shorter time periods — often carrying excessive nutrients from Lake Okeechobee and the river watershed.

To recover degraded habitats and displaced communities of salinity-sensitive organisms, SFWMD established a Caloosahatchee River MFL in 2001. MFL criteria were based on the distribution and density of tape grass, a salinity-sensitive keystone estuarine species. An independent scientific review of the original MFL concluded that significant science gaps prevented a thorough evaluation as to whether the MFL would prevent significant harm to the river and estuary (Edwards et al. 2000). A reevaluation of the MFL in 2003 indicated that the MFL criteria would likely be exceeded on a regular and continuing basis until new storage was developed to supply additional water needed during dry periods (SFWMD 2003). In the years since, tape grass populations in the estuary have suffered extensive losses. Presently, SFWMD is reevaluating the Caloosahatchee River MFL. The new MFL criteria will use additional science gathered in response to gaps identified in the 2000 independent scientific review (Edwards et al. 2000). The proposed MFL recovery strategy — the Caloosahatchee River West Basin Storage Reservoir — is anticipated to be completed in 2022. SFWMD adopted a water reservation rule in 2014 (effective in 2016) to reserve all water within and released from the reservoir for protection of natural resources.



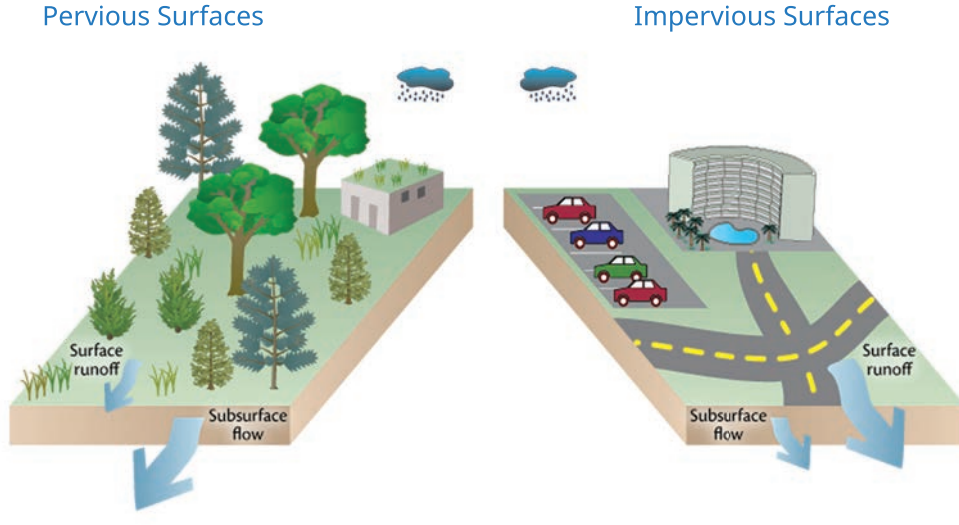
▲▲ Top to bottom.

Southwest gate at the Caloosahatchee River and Lake Okeechobee drainage areas, May 3, 1941 | *USACE.*

Caloosahatchee canal, January 23, 1936 | *USACE.*

Increase Groundwater Recharge

Groundwater and surface waters interact in important ways to maintain the ecological health of Florida's springs, lakes, rivers, wetlands, and estuaries. Aquifer levels can decline due to reduced rainfall associated with climate variability, overdraft for consumptive use, and loss of recharge areas. Reduced aquifer levels can negatively impact water flows in springs and streams, water levels in lakes and wetlands, and saltwater intrusion.



▲ Figure 19. Development converts pervious to impervious surfaces that impede percolation of rainwater into the ground | *Maryland Coastal Bays Program, courtesy of Integration and Application Network (ian.umces.edu) University of Maryland Center for Environmental Science.*

Development commonly converts pervious surfaces to impervious ones, reducing the surface area available to recharge aquifers (Figure 19). This unwelcome trend can be slowed down by decreasing impervious surface areas used in development.

Green infrastructure, also known as Low Impact Development or Low Impact Design (LID), can be used to mimic natural ecosystem services by capturing and storing water — reducing the impacts of high-volume runoff events and allowing water to percolate into the ground. Designing infrastructure that works with nature instead of against it is an effective and efficient strategy for improving hydrology (see Water Quality Improvement Action 3).

Examples of green infrastructure include:

- Canopy trees and green roofs that can intercept rainfall before it hits the ground;
- Rainwater harvesting systems like rain barrels and cisterns that can capture rainfall and store it for later use;
- Pervious pavers, bricks and gravel that can facilitate infiltration of rainfall into underlying soils; and
- Rain gardens and vegetated swales that can capture runoff and allow it to evaporate, be taken up by vegetation, or percolate into the ground.

The best designed green infrastructure systems can approximate the pre-development hydrologic regime of an area. Barriers to implementing green infrastructure include limited education and training opportunities, Home Owner Association rules and deed restrictions, access to the technology, and conflicting language in comprehensive plans and development codes.

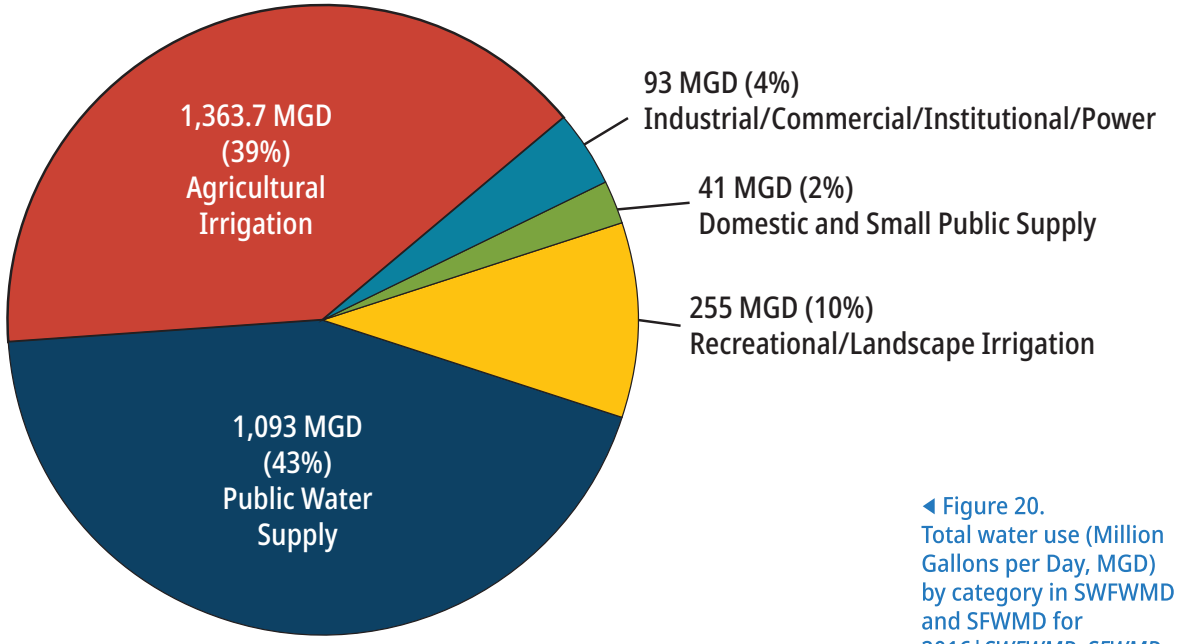
Acquisition of environmentally sensitive land and conservation easements on private lands are important tools for protecting water resources and facilitating recharge. For example, Lee County purchased Edison Farms, part of the 60,000+ acre Corkscrew Region Ecosystem Watershed, for $42.2 million in 2017 through its Conservation 20/20 Land Acquisition Program. The property

is located within a Density Reduction/ Groundwater Resource Area, designated to help store and protect critical water supplies for the region. Edison Farm's vast wetlands store and filter water, allowing it to percolate into soils and recharge aquifers. In addition, the property provides important flood protection for the City of Bonita Springs and Village of Estero, and hosts critical wildlife habitat, including designated primary habitat for Florida panthers and foraging habitat for imperiled wood storks.

Where artificially high flows exist, excess surface water can be used to recharge aquifers. The Saltwater Intrusion Minimum Aquifer Level (SWIMAL) recovery project at Flatford Swamp in Manatee County is examining the potential to use excess surface water inflow to the Swamp to recharge the Upper Floridan aquifer. If feasible, the fully operational project will help restore the natural hydrologic period and vegetation in the swamp while recovering groundwater levels and reducing the rate of saltwater intrusion in SWUCA's Most Impacted Area.

Reduce Future Demands on Surface Water and Groundwater Sources

Agricultural irrigation and public water supply are the two leading consumptive water uses in the CHNEP area (Figure 20). Demand for surface water and groundwater withdrawals can be reduced by conservation, more efficient use of water, and use of alternative water supply sources other than surface water and groundwater.



◀ Figure 20.
Total water use (Million Gallons per Day, MGD) by category in SWFWMD and SFWMD for 2016|*SWFWMD, SFWMD.*

Water Conservation

A variety of water conservation resources are available to homeowners and businesses detailing choices of appliances, plumbing fixtures, irrigation systems, and landscaping plants.

- **The Florida Water Star℠ Program** is a voluntary certification program for residential and commercial construction. The average Florida Water Star homeowner can expect to save up to 20 percent of water use annually.
- **The Water Conservation Hotel and Motel Program** (Water CHAMP℠) helps hotels and motels save water by encouraging guests to use towels and linens more than once during their stay.
- **SWFWMD** offers useful water savings tips to restaurants covering back of house, restrooms, building maintenance, and landscaping.

- **The University of Florida Institute of Food and Agricultural Sciences (UF/IFAS)** promotes water-saving Florida-Friendly Landscaping™ (FFL) for Florida homes and businesses. Florida-friendly plants require less fertilizer, pesticides, herbicides, and water than plants adapted to other climates. UF/IFAS offers free online resources detailing FFL principles and how to apply them to your own yard, including a list of plants adapted to the CHNEP area (Figure 21).

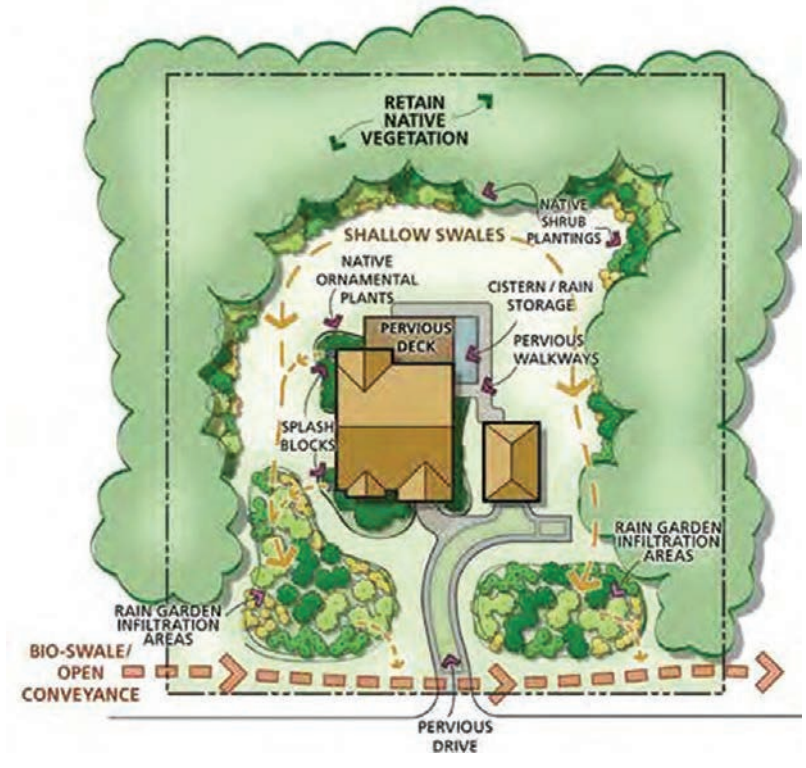


Figure 21. ▶ Green infrastructure techniques using Florida-Friendly Landscaping™ can capture and store water on residential lots | *Puget Sound Partnership and WSU Extension.*

EPA has developed Best Management Practices to help water utilities and governments to assess whether savings from future water conservation and more efficient water use can minimize the need to develop costly new water supplies (EPA 2016a). The tool focuses on six complementary practices including: 1) supply side and demand side accounting, 2) leak management, 3) metering, 4) conservation rate structure, 5) end use water conservation and efficiency analysis, and 6) water conservation and efficiency planning. Each practice includes descriptions with examples, metrics, benchmarks, deliverables, and resources for more information.

Advancements in agricultural BMPs are now available to improve watering efficiency and conservation on farms, including:

- Tailwater recovery or surface water irrigation pump stations;
- Conversion of existing irrigation systems to more efficient ones;
- Weather stations;
- Soil moisture sensors;
- Water-control structures;
- Reuse water connections;
- Automated pumps and valves; and
- Rainwater harvesting systems.

The Facilitating Agricultural Resource Management Systems (FARMS) Program is a public-private partnership developed by SWFWMD and the Florida Department of Agriculture and Consumer Services. FARMS is a cost-share reimbursement program designed to incentivize farmers to reduce groundwater withdrawals from the Upper Floridan aquifer system through BMPs addressing conservation and alternative water supplies. Over 130 FARMS Program projects are operational in the SWUCA, which collectively reduce groundwater withdrawals from the Upper Floridan aquifer system by 22 million gallons per day (MGD). The FARMS Program aims to reduce withdrawals by a total of 40 MGD by 2025. In the Upper Myakka River Watershed, eight projects conserve 3 MGD through reuse of tailwater recovery and other conservation measures. FARMS Program BMPs also yield improvements to

water quality and natural systems (see Water Quality Improvement Action 3).

Alternative Water Supplies

The Peace River Regional Water Supply Authority, created in 1982, provides wholesale drinking water to the City of North Port plus all of DeSoto, Manatee, and Sarasota Counties and parts of Charlotte County under the jurisdiction of SWFWMD (Peace River Manasota Regional Water Supply Authority 2017). The Authority is an independent special district pursuant to Florida Statutes and established by interlocal agreement among its member Counties. The Authority works to maximize the development of water resources while reducing adverse environmental effects. Among its many collaborative and coordinating roles, the Authority aims to diversify the region's water supplies, increase water conservation and wastewater beneficial reuse, and support protection and enhancement of water-dependent natural resources.

Decreased withdrawals from surface water and groundwater sources can be achieved through developing and promoting alternative supply sources, including captured stormwater, potable water aquifer storage and recovery, seawater desalination, farm tailwater recovery, and beneficial reuse of appropriately treated wastewater. Today, approximately 70 percent of treated wastewater is reused in CHNEP's historical seven-county area; by 2035 approximately 90 percent is projected to be reused (see Water Quality Improvement Action 4). For example, the City of Cape Coral has reduced irrigation-related demands on the Mid Hawthorne

▲ The Mobile Irrigation Lab Program, implemented by SWFWMD and the USDA, began in 1987 to assist area growers with water conservation. Growers can invite a Program technician to evaluate their irrigation system. The technician will evaluate system performance and provide a detailed report with recommendations for system improvements and irrigation schedules | *Casey Cumley, SWFWMD.*

◀ By using tensiometers to measure soil dryness, growers can know better when to irrigate | *Casey Cumley, SWFWMD.*

Aquifer by using reclaimed water from the City's two wastewater facilities, supplemented with freshwater pumped from a 300-mile canal system.

Climate Change

Stresses on ecosystems due to increased demands for consumptive water use and altered hydrology are expected to be exacerbated by climate change. Rising sea levels will alter the timing, depth, and duration of saltwater inundation and salinity gradients. Maintaining locations of isohaline zones in rivers and creeks may require additional volumes of freshwater to be reserved for natural systems. Rising sea levels will also increase saltwater intrusion into coastal aquifers, potentially impacting surface waters where they interact with groundwater and water supply for consumptive uses.

Climate change is expected to alter precipitation patterns in Southwest Florida (Easterling 2017). Reduced rainfall during the dry season, combined with greater evaporation due to warmer air temperatures and increased water demand for agriculture and urban development, will compound existing problems. Increased flooding during more intense rainfall events may flood natural areas and overwhelm infrastructure designed to manage stormwater. Changes of freshwater input into creeks and bays will alter their chemical, physical, and ecological characteristics — further disrupting salinity zonation important as nursery and forage areas for fish and invertebrates. Overall, climate stressors will likely make increasing fresh surface water and groundwater availability more challenging.

STATUS:

Ongoing. Previous 2013–2018 CHNEP-CCMP Water Quality Actions WQ-F and WQ-K and Hydrologic Alteration Actions HA-D, HA-E, HA-L, and HA-O are combined here and updated to incorporate new information on CHNEP activities, projects, and climate variability. Quantifiable Objectives HA-1 and HA-2 from the 2013–2018 CHNEP-CCMP are carried forward and updated as Performance Measures.

RELATED ACTIONS:

- Hydrological Restoration Action 1: Conduct data collection, modeling, and analyses to support hydrological restoration
- Hydrological Restoration Action 3: Protect and restore natural flow regimes
- Water Quality improvement Action 3: Reduce urban stormwater and agricultural runoff pollution
- Water Quality improvement Action 4: Reduce wastewater pollution

ACTIVITIES:

Participate in development, reevaluation, and implementation of scientifically sound freshwater Minimum Flows and Levels (MFLs) for surface water and groundwater resources that consider climate stressors, and recovery strategies to meet MFLs in order to prevent degradation of natural systems.

Location: CHNEP area, focusing on minimum aquifer levels for the Floridan aquifer system and minimum flows for waterways, as needed.

Responsible parties: SWFWMD and SFWMD (leads), FDEP (regulatory lead), USACE, County and Municipal Governments, Water Utilities, CHNEP.

Timeframe: MFL development, reevaluation, and implementation are ongoing. Adoption of the Caloosahatchee River MFL is expected in 2019; recovery is expected to follow completion of the Caloosahatchee River West Basin Storage Reservoir (anticipated in 2022); Climate Vulnerability Analysis adopted in 2018; Habitat Restoration Needs Plan adopted in 2019.

Potential annual cost and funding sources: Reevaluation $1M–10M; Implementation >$10M/SWFWMD, SFWMD, USACE, County and Municipal Governments.

Benefits: Increased availability of fresh surface water and groundwater to support natural systems.

5-year Performance measure: Increased number of recovery strategies and projects to reduce or eliminate MFL exceedances.

Increase aquifer recharge by supporting local plans and codes that decrease impervious surfaces; incorporate green infrastructure practices; protect recharge and wellfield areas; and protect and restore wetlands.

Location: CHNEP area.

Responsible parties: County and Municipal Governments, SWFWMD, SFWMD, UF/IFAS Extension, CHNEP, FDEP, USACE, private sector.

Timeframe: Ongoing; Communication and Outreach Strategy to be adopted in 2020.

Potential annual cost and funding sources: $25,000–$99,999/County and Municipal Governments.

Benefits: Increased freshwater availability to support natural systems, restored hydrology, and improved water quality.

5-year Performance measure: Increase in long-term average annual levels in aquifers.

Encourage conservation and efficient water use and promote aquifer recharge through construction of green infrastructure projects where appropriate, adoption of agricultural irrigation BMPs, and promotion of alternative water supply sources, including increased appropriate reuse of treated wastewater.

Location: CHNEP area.

Responsible parties: County and Municipal Governments, SWFWMD, SFWMD, FDACS, UF/IFAS Extension, Water Utilities, FDEP, CHNEP, USDA, private sector.

Timeframe: Ongoing; Communication and Outreach Strategy to be adopted in 2020.

Potential annual cost and funding sources: $500,000–$999,999/County and Municipal Governments, SWFWMD, SFWMD, FDEP, USDA, FDACS.

Benefits: Increased freshwater availability to support natural systems and conserve water supply sources.

5-year Performance measure: Increased water conservation.

3 Protect and restore natural flow regimes

OBJECTIVES:

Support integrated and coordinated watershed management planning and project implementation that protects headwaters, restores flow courses and floodplains, and reestablishes flow volume and timing to historical receiving waters, where possible. Accommodate and mitigate impacts on flow regime anticipated from climate change.

BACKGROUND:

Development in Central and Southwest Florida has altered historical natural watershed flow regimes. Natural watershed flows, volumes, and timing have been redirected, impeded, or accelerated by efforts to quickly drain water off the landscape to protect development from flooding. Natural streams were channelized straighter and deeper, wetlands were ditched, and cross-basin channels were dug, resulting in a loss of natural water recharge and water quality treatment functions, as well as bird, fish, and other wildlife habitat. This engineered inter-basin water transfer has resulted in some areas where surface flows no longer contribute to their historical watersheds and other areas where flows contribute too much. In some areas, hydrologic alterations have caused significant changes in both the amount and seasonal characteristics of flows of major rivers and creeks, leading to increased and excessive wet season discharges to the coastal environment. These excessive discharges often contain higher pollutant loads and create high volume freshwater pulses that alter and impact estuarine and marine habitats — a problematic condition known as flashiness.

Watershed Management Planning

Comprehensive watershed management plans identify human and ecological water requirements for major watersheds and establish goals and objectives to meet those needs. By focusing attention and resources on an overall watershed strategy, restoration projects can yield greater cost-benefits. Watershed initiatives are a way to build partnerships, leverage funding, and address complex problems. Initiatives in the CHNEP area include the Upper Peace Initiative (SWFWMD), the Myakka River Initiative (SWFWMD), the Charlotte Harbor Flatwoods Initiative (SFWMD), the LeHigh Headwaters Initiative (SFWMD), and the South Lee County Watershed Initiative (SFWMD).

Additionally, the Comprehensive Everglades Restoration Plan (CERP) provides a framework and guide to protect and restore the water resources of central and southern Florida, including the Everglades.

FDEP Basin Management Action Plans (BMAPs) consolidate and coordinate water pollution reduction across jurisdictions (see Water Quality Improvement Action 2), which in some cases can have watershed restoration components to store and treat more stormwater. There are many opportunities for hydrologic improvements to watersheds that provide multiple benefits of flood protection in conjunction with wetland restoration, increased recreational opportunities, improved water quality (see Water Quality Improvement Action 3), and water supply enhancement (see Hydrological Restoration Action 2).

Hydrological Restoration

Protecting and restoring headwater tributaries and reestablishing flows to their historical receiving waterbodies are restoration priorities that can benefit the entire watershed. Sometimes, it is not feasible to return altered waterways to their original natural state. In those cases, water conveyances, barriers, and reservoirs can be built or restored to mimic natural function; for example, canals can incorporate shallow, broad, vegetated, and serpentine stream-like components. Estuarine and freshwater wetland areas can be restored by backfilling ditches, removing spoil piles, and eliminating exotic vegetation.

Poorly constructed stream crossings can be a significant barrier to natural flow and aquatic life passage. They have been found to be a significant contributor to increased flooding and damage during extreme weather events and hurricanes. CHNEP encourages inclusion of adequate stream crossing in all new construction to facilitate natural flow and aquatic life passage. Problems with existing culverts should also be addressed.

Dams that no longer serve a functional purpose should be evaluated for removal. By removing obsolete dams, communities can make significant gains in water quality, ecological restoration, economic development, flood control, recreational opportunities, restoration of fish spawning and migration, and public safety (EPA 2016b).

◀ J.N. "Ding" Darling National Wildlife Refuge, Sanibel, Florida | *Miguel Hnatow.*

Retrofitting and restoring important ecosystem services lost due to historical development activities can be costly. It is more desirable and cost-effective to protect natural flowways and waterbodies during development planning than to try to restore them post-impact. Remaining natural flowways require attention in order to remain unaltered by future development projects.

Many coordinated and strategic multi-benefit hydrological restoration projects have been completed or are underway across the CHNEP area.

- **Caloosahatchee River West Basin Storage Reservoir Project (C-43 Reservoir)** is designed to store water during wet periods and later release it to the Caloosahatchee River Estuary during dry periods to improve salinity balance, flow, and storage capacity (USACE & SFWMD 2010, SFWMD 2017b) (see Hydrological Restoration Action 2).
- **Ten Mile Canal** is a SFWMD flood protection, recharge, and water quality project featuring the creation of a 6,000-foot long filter marsh adjacent to the Ten Mile Canal in Fort Myers (Lee County Division of Natural Resources 2007). The project consists of four different cells of varying depths connected through a piping system that allows for regulated water flow in and out of the marsh and back into Ten Mile Canal.
- **Dona Bay** is a SWFWMD and Sarasota County project to improve water quality and limit large pulses of freshwater flow from Cow Pen Slough into Dona Bay (Sarasota County 2016). The project features a conveyance system to divert flow into approximately 363 acres of restored wetlands and newly created wet detention areas. It also includes a new 380-acre surface water storage and treatment facility connected to the wetland by a 1.5-mile pipeline to control freshwater flow and nutrient pollution and provide up to 15 MGD of water for public use.
- **Charlotte Harbor Flatwoods Initiative** is a regional multi-partner effort lead by SFWMD and FWC to restore historical sheet flow from the Babcock-Webb Wildlife Management Area across the Yucca Pens area. The project will increase groundwater recharge and water retention, reduce pollution, and restore more natural flow volume from the Gator Slough Canal to Matlacha Pass in the Charlotte Harbor Aquatic Preserve.
- **Lehigh Acres Headwaters Initiative** is a project managed by Lee County's East County Water Control District to restore wetlands and construct weirs to attenuate, store, and treat surface water flows. The project will reduce flooding in Lehigh Acres and restore the headwaters of Orange River, Hickey Creek, and Bedman Creek.

▲ Coral Creek site before SWFWMD restoration, June 28, 2017 | *SWFWMD.*

- **Pine Lake Preserve/Kehl Canal** is a hydrological restoration project by the City of Bonita Springs that reduces sheet flow, enhances the wetland hydroperiod, creates littoral zones within existing borrow pit lakes, reduces stormwater flow within roadside ditches, reduces nutrient loads from stormwater discharges into the Imperial River, and enhances the water flow within historical reaches of the Imperial River and feeder creeks.
- **Alligator Creek and Coral Creek** are two SWFWMD habitat restoration projects located on the east and west walls of Charlotte Harbor, respectively. The projects block mosquito control ditches, restore and enhance natural and manmade creek channels, create filter marshes, and remove invasive exotic vegetation to restore natural hydrology and habitat mosaics and functions.

▲
Coral Creek site after SWFWMD restoration, April 3, 2019|*SWFWMD.*

- **Southern Corkscrew Regional Ecosystem Watershed (CREW)/ Imperial River Flowway** is a SFWMD project to degrade road berms, remove spoil piles, and plug or fill ditches and agricultural drainage canals. The project restores wetlands and the historical sheet flow, thereby reducing excessive freshwater discharges to Estero Bay during the rainy season, reducing nutrient loads and pollutants to the Imperial River and Estero Bay, and mitigating flooding of private property.
- **South Lee County Watershed Initiative** is a regional multi-partner effort to restore flowways and tidal creeks that flow through the Lee County and City of Bonita Spring's Density Reduction Groundwater Recharge areas into Estero Bay in southern Lee County.
- **Lake Hancock Lake Level Modification Project** is a SWFWMD project to restore lake levels in Lake Hancock, a 4,500-acre lake in the headwaters of the Peace River (Figure 22 on page 100; SWFWMD 2010). The Lake Level Modification Project includes the replacement of the control structure on Lake Hancock to increase storage in the lake. This is accomplished by raising the control elevation of the existing outflow structure on Lake Hancock and slowly releasing water during the dry season to help meet the minimum flow requirements in the upper Peace River between Bartow and Zolfo Springs (see Hydrological Restoration Action 2).

Due to the large scale, complexity, and cost of these projects, most are multi-partner, multi-phase, and multi-year and will be ongoing for years. The CHNEP Management Conference supports continued effective coordination between Water Management Districts and local, state, and federal government permitting and capital programs affecting hydrologic flow, water storage, flood control, and water quality.

▲ Figure 22. SWFWMD completed replacement of Structure P-11 at the outfall from Lake Hancock in 2013. The new structure increases storage in the lake to provide increased flow downstream to the Peace River in the dry season | *SWFWMD.*

Ongoing and future comprehensive watershed management planning and project design must consider projected climate change impacts on water availability and flow regimes. For example, hydrologic models will need to simulate alternate future climate change scenarios (see Hydrological Restoration Action 1).

Impacts to natural hydrology from rising seas, increasing air and water temperatures, and changing precipitation and storm patterns will reduce capacity for natural systems to uptake excess nutrients, regulate water flows, and support native vegetation, birds, fish, and other wildlife (Beever et al. 2009). These impacts will be compounded by continued development pressure. Wetland locations, quality, and types may be affected by changes in precipitation patterns and water availability as a result of increased evapotranspiration and increased water demand with higher temperatures (FWC 2016). Changes to wetlands will in turn affect freshwater flows and watershed boundaries. Potential effects of climate change on hydrology, like seasonal shifts in flow, flashiness from increased storm intensity, saltwater intrusion, and shifting isohaline zones may make restoration of historical flowways and watershed boundaries difficult, and in some areas unattainable (Twilley 2001). Nevertheless, reestablishing landscape scale flowways and protecting tidal tributary isohaline zones should remain a management priority to support critical habitat migration and improve resilience of natural systems with changing climate conditions.

Climate stressors could create more frequent flooding and increased demand for further alteration and drainage, making restoring natural hydrologic conditions more challenging. The community's priority response to these changes may be to build more protective structures and barriers to prevent flooding and water intrusion into built environments, while abandoning infrastructure that becomes obsolete. Priority should be given to implementing hydrologic protection and restoration, especially for Outstanding Florida Waters.

STATUS:

Ongoing. Previous 2013–2018 CHNEP-CCMP Water Quality Action WQ-A, Hydrologic Alteration Actions HA-C, HA-F, HA-G, HA-I, HA-J, HA-K, HA-M, HA-N, and Fish & Wildlife Habitat Loss Action FW-C are combined here. Quantifiable Objectives HA-1, HA-2, and HA-3 from the 2013–2018 CCMP are carried forward and updated as Performance Measures.

RELATED ACTIONS:

- Hydrological Restoration Action 1: Conduct data collection, modeling, and analyses to support hydrological restoration
- Hydrological Restoration Action 2: Increase fresh surface water and groundwater availability to support healthy natural systems
- Water Quality Improvement Action 3: Reduce urban stormwater and agricultural runoff pollution

ACTIVITIES:

Support integrated and coordinated watershed management planning to protect headwaters, restore flowways and floodplains, and reestablish historical flow direction, volume, and timing to receiving waters. Incorporate anticipated future climate stressors into flow regime restoration.

Location: CHNEP area.

Responsible parties: FDEP (State of Florida regulatory lead), EPA (federal regulatory lead), SWFWMD and SFWMD (implementation facilitators), USACE, County and Municipal Governments, FDACS, CHNEP, private sector.

Timeframe: Ongoing; Climate Change Vulnerability Analysis adopted in 2018.

Potential annual cost and funding sources: $1M–10M/ FDEP, SWFWMD, SFWMD, USACE, USDI, USDA, Section 320 Funds, County and Municipal Governments.

Benefits: Integrated watershed management plan components that are coordinated across agency, local government, and private sector activities and lead to more comprehensive hydrologic watershed protection and restoration in support of natural systems.

5-year Performance measure: Increased number of completed plans with hydrological restoration projects that are ready for implementation.

Support implementation of projects to reestablish and protect wetlands and hydrologic watersheds, including Everglades restoration, Lake Hancock shoreline restoration, and other projects to build or remediate flowways, barriers, and water storage that mimic and restore natural flow conditions necessary to support healthy ecosystem function and account for anticipated climate change stressors.

Location: CHNEP area.

Responsible parties: CHNEP (implementation facilitator), FDEP, County and Municipal Governments, SWFWMD, SFWMD, USACE, FWC, USFWS, USDI (NPS and other USDI), USDA, FDOT, NGOs, FDACS, Private sector.

Timeframe: Ongoing; Climate Change Vulnerability Analysis adopted in 2018; Habitat Restoration Needs Plan adopted in 2019.

Potential annual cost and funding sources: $500,000–10M/Section 319 Funds, USACE, FWC, USFWS, USDI (NPS and other USDI), USDA, FDOT, NGOs, County and Municipal Governments, SWFWMD, SFWMD, RESTORE Act, FDACS, Grants.

Benefits: Improved natural hydrologic flow and watershed boundaries for surface waterbodies, especially Outstanding Florida Waters.

5-year Performance measure: Increased acres or linear miles of hydrologically restored or reconnected habitat that maintain or improve water quality and flood protection.

FISH, WILDLIFE, & HABITAT PROTECTION ACTION PLAN

VISION: A diverse environment of interconnected, healthy habitats that support natural processes and viable, resilient native plant and animal communities.

GOAL: Natural habitat protection and restoration.

OBJECTIVE: Permanently acquire, connect, protect, restore, and manage natural terrestrial and aquatic habitats.

STRATEGY: Promote and facilitate permanent acquisition and effective protection and management of critical natural habitats including wildlife dispersal areas, movement and habitat migration corridors, wetlands, flowways, and environmentally sensitive lands and estuarine habitats.

ACTION 1: Protect, restore, and monitor estuarine habitats

ACTION 2: Protect, restore, and monitor environmentally sensitive lands and waterways including critical habitat areas

ACTION 3: Assess and promote the benefits of land, waterway, and estuary protection and restoration

◀ Ospreys at meal time | *Steven Richardson.*

The CHNEP area is renowned for its spectacular birds, fish, and other wildlife. The rich diversity and abundance of these species requires a diverse environment of interconnected habitats that support natural processes and viable, resilient native plant and animal communities — including lakes, creeks, rivers, swamps, marshes, bays, and uplands. Since the 1950s, many of these habitats have become fragmented, degraded, or lost due to human activities related to urban development, agriculture, transportation, and mining. These anthropogenic (manmade) impacts are further exacerbated by climate stressors. In recent decades, more upland forest habitat and salt marsh have been lost (Table 10).

Table 10. Habitat losses and gains within the CHNEP area | *CHNEP 2019.*

Habitat	1995 Total Acreage	2009/2011 Total Acreage	Acreage Loss/ Gain	% Change
Upland Coniferous Forest	267,232	198,335	-68,897	-26%
Upland Hardwood Forest	84,915	69,816	-15,099	-18%
Wetland Hardwood Forest	164,424	178,819	14,395	9%
Mangrove	60,990	61,894	904	1%
Wetland Coniferous Forest	53,401	60,673	7,272	14%
Wetland Forested Mixed	15,923	12,815	-3,108	-20%
Vegetated Non-Forested Wetlands	196,930	242,525	45,595	23%
Saltwater Marsh	12,436	12,206	-230	-2%
Salt Flats	4	563	559	*

*Differences in mapping methodologies between periods may account for some anomalies in these data.

Preserving the diversity of birds, fish, and other wildlife requires protection and restoration of priority habitats and natural corridors that connect them. This is especially true for managing threatened and endangered species. Adaptive management must consider how habitats may change in the future in order to meet both current and future needs. CHNEP's Habitat Restoration Needs Plan (HRNP) is informed by the Habitat Resiliency to Climate Change Project (HRCC), which uses in-depth spatial analysis to examine the projected effects of sea level rise on future habitat conditions. The HRCC Project aims to understand existing and future habitat connectivity in order to provide informed resiliency solutions, such as migration corridors.

Priority habitats in the CHNEP area include:

- Seagrass meadows and other submerged aquatic vegetation;
- Submerged and intertidal non-vegetated bottom;
- Emergent tidal wetlands including mangrove forests and salt marshes;
- Oyster reefs;
- Tidal tributaries and rivers;
- Freshwater wetlands; and
- Native uplands.

Seagrass Meadows and Other Submerged Aquatic Vegetation

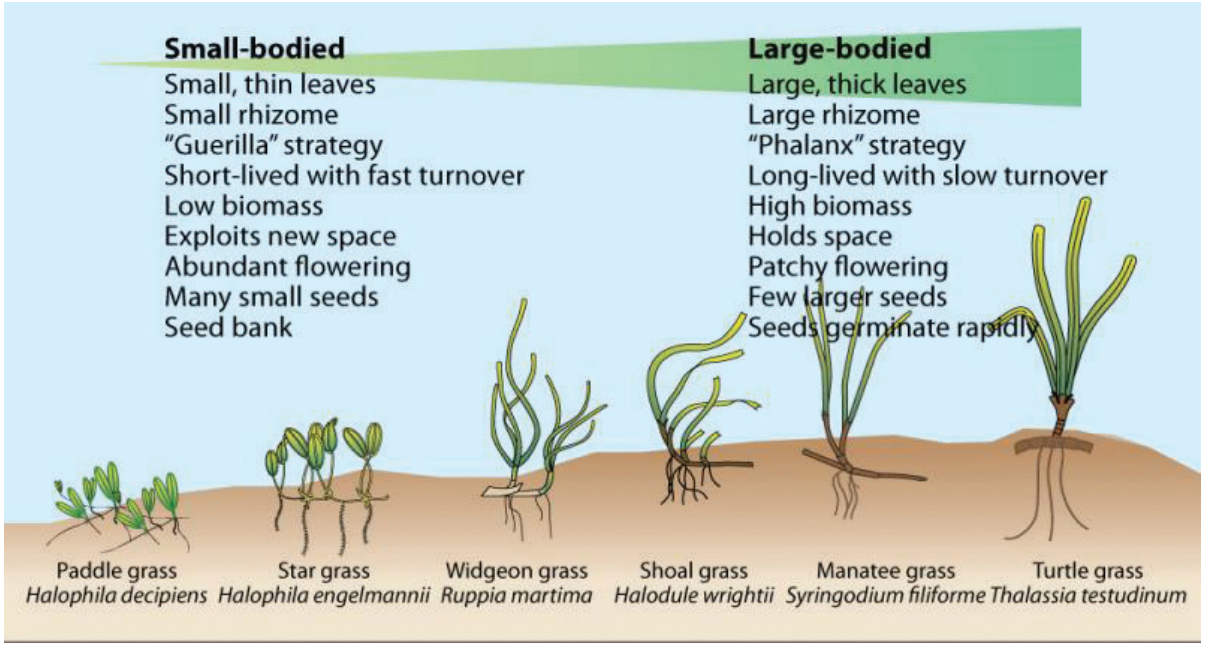
Submerged aquatic vegetation includes marine and estuarine vascular plants, like seagrasses and macroalgae, as well as freshwater vascular plants. Seagrasses are underwater flowering plants that live in shallow marine and estuarine environments. Six species of seagrass are found in the CHNEP area; each has different ecological attributes and requirements (Figure 23). Turtle grass (*Thalassia testudinum*), shoal grass (*Halodule wrightii*), manatee grass (*Syringodium filiforme*), and tape grass or eel grass (*Vallisneria americana*) are the most common, while widgeon grass (*Ruppia maritima*), paddle grass (*Halophila decipiens*), and star grass (*Halophila engelmannii*) are ephemeral. Some types of macroalgae, such as *Caulaerpa spp*. and *Sargassum*, can provide many benefits to the estuary, such as providing oxygen, food, and shelter for marine animals.

Shoal grass is a narrow-bladed seagrass found in dynamic areas like river mouths, where salinity and light fluctuate, in shallow waters

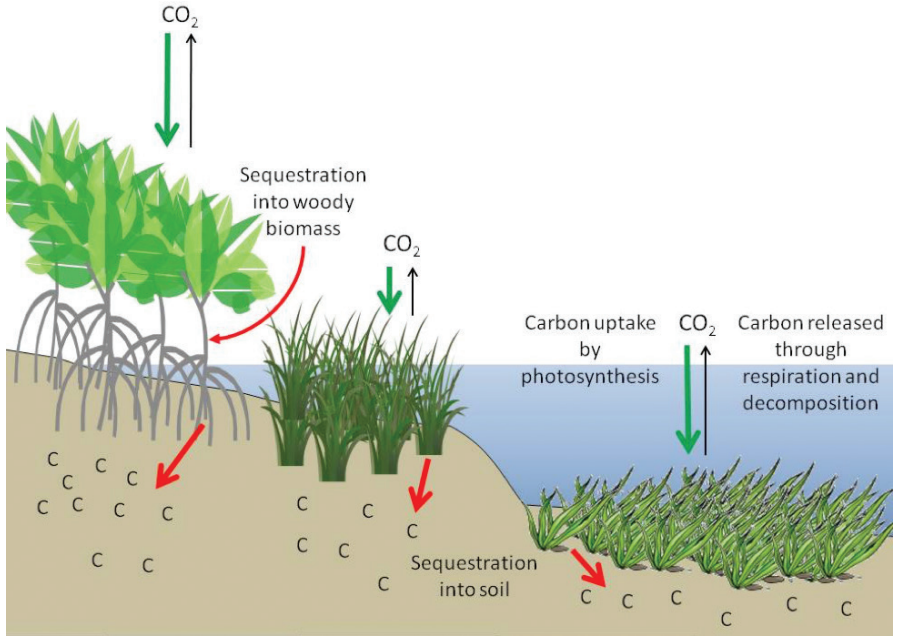
exposed during extreme low tides, and in deep light-limited waters. It has a relatively rapid growth rate, is usually first to colonize disturbed areas, and tends to hold most of its biomass in its leaves. Turtle grass is a wide-bladed species found in estuarine areas where salinity and light are more stable. Manatee grass is commonly found in areas with higher salinity and can tolerate relatively low levels of light. Both turtle grass and manatee grass tend to grow more slowly than shoal grass and hold most of their biomass in their roots. Tape grass (or eel grass) is a freshwater species that can tolerate salt. Tape grass leaves can be an inch wide and several feet long.

Seagrasses are considered "keystone" species because of the important habitat-creating role they play in the estuary (Dawes et al. 2004). Seagrasses stabilize sediments, filter nutrient pollution, reduce wave action and coastal erosion, and serve as an important food source for many aquatic organisms. They also store carbon, and in some areas, may buffer waters from ocean acidification (Figure 24). About 80 percent of commercially and recreationally important fish and shellfish utilize seagrass habitat during their life cycle. Some fish, like spotted seatrout (*Cynoscion nebulosus*), spend their entire life in seagrass meadows.

Seagrass distribution and abundance varies by season and by year, but is generally dependent on water clarity, salinity, temperature, and rainfall. Seagrasses generally grow in waters less than six feet deep, but in the clear waters around Boca Grande Pass they can be found in waters 8–10 feet deep.



▲ Figure 23. Morphology of seagrasses of Southwest Florida | *Integration and Application Network (ian.umces.edu) University of Maryland Center for Environmental Science.*



◀ Figure 24. Mangroves, marshes, and seagrasses take up carbon dioxide from the air and water through photosynthesis and store it as "blue carbon" in plant biomass and wet soils | *Howard et al. 2017.*

Reduced water clarity from sedimentation, nutrient pollution, color changes, and excessive algal growth threatens seagrass. Algal growth is related to nitrogen concentrations, making it a nutrient of primary concern for seagrass management (see Water Quality Improvement Action Plan). Seagrasses require adequate water clarity, because they require sunlight for photosynthesis. As a result, they can serve as an important biological indicator of water quality and bay health.

Table 11. Seagrass coverage by sampling area in the Charlotte Harbor region in 2008 and 2014/2016 compared to management targets | *SWFWMD (2008, 2016) and SFWMD (2008, 2014).*

LOCATION	2008 (acres)	2014*/2016 Cover (acres)	Target (acres)	% Target achieved	Target Goal	
					Protect	Restore
Dona and Roberts Bays	187	198	112	176%	x	x
Upper Lemon Bay	1,148	1,343	1,009	133	x	
Lower Lemon Bay	2,607	2,830	2,882	98%	x	x
Tidal Myakka River	311	452	456	99%	x	
Tidal Peace River	247	701	975	72%	x	x
Charlotte Harbor West Wall	2,049	2,158	2,106	102%	x	x
Charlotte Harbor East Wall	2,691	3,704	3,898	95%	x	x
Charlotte Harbor Lower	3,689	4,169	3,342	125%	x	
Cape Haze	6,672	7,188	6,998	103%	x	
Pine Island Sound	27,084	29,114*	26,837	108%	x	
Matlacha Pass	7,704	8,272*	9,315	89%	x	x
San Carlos Bay	6,482	7,167*	4,372	164%	x	
Tidal Caloosahatchee River	293	411*	93	442%	x	x
Estero Bay	3,590	3,683*	3,662	101%	x	
TOTAL	**64,754**	**71,389**	**66,057**			

Seagrass-based water quality targets were developed throughout the Charlotte Harbor region based on seagrass light requirements, water depth at the deep edge of seagrass beds, and the historical acreage of seagrass (see Water Quality Improvement Action 2).

Storms can increase suspended sediments and sedimentation, decrease salinity favorable for seagrass, or uproot grasses. Seagrass in San Carlos Bay is stressed by large freshwater flows stemming from the Caloosahatchee River (Orlando et al. 2013). In the CHNEP area, climate change is expected to intensify storms during the summer and prolong periods of drought in the winter (Beever et al. 2009), potentially changing salinity regimes favorable for seagrass growth. Furthermore, rising sea levels may increase bottom depths beyond which adequate sunlight can reach existing seagrass meadows. Similarly, dredging can bury seagrasses, block sunlight with suspended sediments, and increase bottom depths beyond the reach of adequate sunlight to support seagrasses.

Loss of seagrass by boat propeller scarring is a significant issue. Seagrass beds in Pine Island Sound and Matlacha Pass in Lee County have experienced the most damage (Madley et al. 2004). Docks and boats can shade seagrass, reducing or eliminating sunlight. Increased boating activity due to growing population numbers and tourism continues to be a challenge.

After major seagrass losses in the late-20th century due to development, dredging, and water pollution — seagrass coverage throughout the CHNEP area has improved over the last decade. Its recovery has been

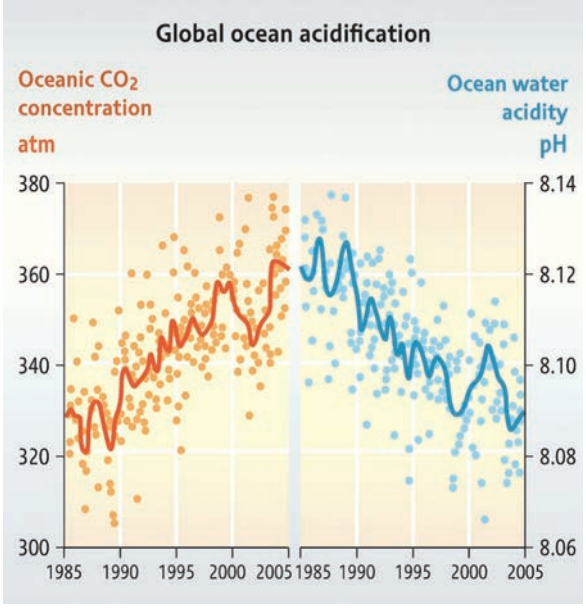
largely attributed to improvements in water quality and reduced dredging (see Water Quality Improvement Action Plan). In 2008, seagrass acreage in the Greater Charlotte Harbor area was about 65,000 acres, and by 2016, there were about 71,000 acres (Table 11). Seagrass coverage in the greater Charlotte Harbor area now exceeds historical estimates of seagrass from the 1950s (68,000 acres), and nine of fourteen areas have seagrass coverage exceeding their management targets. While overall seagrass coverage in the estuary has improved, acreage of the freshwater tape grass (*Vallisneria americana*) in the Caloosahatchee River has declined. Over two thousand acres of the freshwater tape grass in the upper Caloosahatchee Estuary have been lost since 2001. In response to this, CHNEP and its partners are engaging in seagrass restoration efforts on multiple levels. Management activities to maintain and enhance seagrass coverage in the CHNEP area are detailed in Fish, Wildlife, and Habitat Restoration Action 1.

Oysters Reefs and Other Shellfish

Oysters (*Crassostrea virginica*) provide many valuable economic and ecosystem services. Oyster reefs stabilize and protect shorelines and reduce erosion. As filter feeders, they process large quantities of water — an adult oyster can filter up to 50 gallons of water per day — reducing turbidity and excess waterborne nutrients. Oyster reefs also provide food and complex structural habitat to a diverse assemblage of marine invertebrates and fish, including recreationally important species like red drum (*Sciaenops ocellatus*), sea trout (*Cynoscion spp.*), and flounder (*Paralichthys spp.*). As a result, oyster reefs are designated Essential Fish Habitat and are protected under state and federal regulations, including the Magnuson-Stevens Fishery Conservation and Management Act.

Oyster reefs form by the cumulative buildup of successive generations of oyster shells, predominately in shallow estuarine areas near creek and river mouths. They also grow readily on mangroves, seawalls, and other natural and artificial hard structures.

Optimal hydrologic conditions are important for sustainable oyster populations. For example, oysters require sufficient water flow to bring oxygen and food and carry away wastes, but too much flow can flush larvae away from suitable settlement habitat. In Southwest Florida, the optimal salinity range for oysters is 14–28 practical salinity units (PSU), though they can live in salinities ranging from 5–40 PSU (GSMFC 2012). Adult oysters can survive in low salinity waters (*e.g.*, 2 PSU) only up to a month. In addition to suboptimal freshwater flow, threats to oyster reefs include altered shorelines and development, poor water quality, sedimentation, disease, dredging, and overfishing. Changes in climate stressors are expected to exacerbate the effects of other ongoing stressors. For example, increasing ocean acidification resulting from rising atmospheric carbon dioxide concentrations may negatively affect formation of oyster shells (Figure 25). Sea level rise, more intense rainfall events, prolonged droughts, and altered flowways arising from coastal morphology changes will affect salinity levels and impact growth and survival of oysters (Tolley et al. 2010).



◀ Figure 25. Ocean carbon versus ocean pH. Ocean acidification interferes with calcium carbonate shell formation in shellfish| *Intergovernmental Panel on Climate Change.*

Oyster reefs have been a dominant feature in the Charlotte Harbor area for at least the past 470 years (Savarese et al. 2004). Prior to European colonization of Southwest Florida, Native Americans utilized oysters as a food source and large mounds of discarded oyster shells remain today throughout the area. Reports from the late 1800s indicate oyster reefs were extensive, but already degraded.

▲ Little blue heron hunts among red mangrove prop roots and oysters | *J.P Launay.*

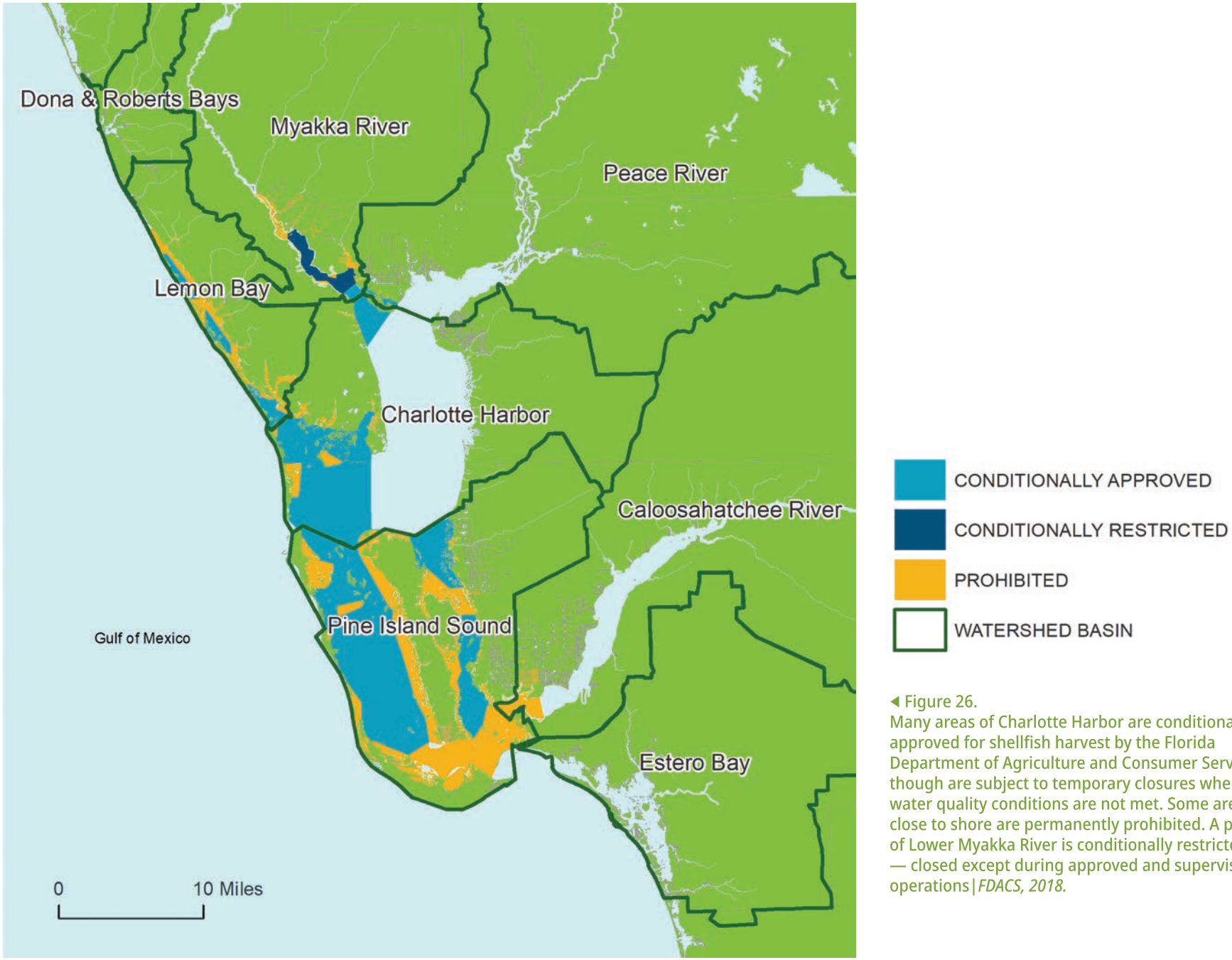
By the early 1970s, over 11,000 acres of oysters were impacted by development of Port Charlotte, Punta Gorda, Cape Coral, Fort Myers, and Sanibel and large areas were closed to harvest due to pollution (Taylor 1974).

The earliest quantitative estimate of historical oyster habitat comes from 1950s aerial photographs. Interpretation of these early surveys is limited due to lack of ground-truthing, low-resolution imagery, uncertainty of the depth to which oysters were detected, and the inability to estimate abundance of oysters associated with mangroves or small reefs (Boswell et al. 2012). With these caveats in mind, a comparison of oyster acreage from the 1950s to 1999 shows a 2,450 acre — or 90% loss in the greater Charlotte Harbor watershed (Avineon 2004). These limited studies, together with anecdotal information, suggest that thousands of acres of oysters have been lost in the CHNEP area (Boswell et al. 2012).

More than 275 species of shellfish, including oysters, are found throughout Southwest Florida estuaries. In the ancient past, the Calusa Indians of Southwest Florida gathered large amounts of shellfish and constructed immense mounds from the discarded shell. These shell mounds still dot the coastal landscape and some are protected as state archaeological sites.

In the more recent past, oysters, hardshell clams (*Mercenaria campechiensis*), and bay scallops (*Argopecten irradians*) were harvested commercially and recreationally throughout Lemon Bay, Gasparilla Sound, Charlotte Harbor, and Pine Island Sound. The heyday of the shellfish industry in the Charlotte Harbor area occurred during the 1940s. Since then, commercial harvest of shellfish has been declining with the disappearance of the scallop fishery in Pine Island Sound by the early 1960s. Marine shellfish aquaculture in Charlotte Harbor is based primarily on hardshell clams.

Shellfish are a reliable measure of the environmental health of an estuary. For example, clams require proper salinity, oxygen, and nutrients to grow, as well as good water quality to be safe to eat. Because shellfish feed by filtering estuary water, they assimilate and concentrate materials carried in the water. In water free from bacteria, red tide, and other pollutants, shellfish can generally be safely eaten throughout the year (Figure 26). In areas affected seasonally by red tide or nearby urban areas, shellfish may not be safe to eat (see Water Quality Improvement Action *5*). Management activities to maintain and enhance oyster reefs in the CHNEP area are detailed in Fish, Wildlife, and Habitat Protection Action 1.



◀ Figure 26.
Many areas of Charlotte Harbor are conditionally approved for shellfish harvest by the Florida Department of Agriculture and Consumer Services, though are subject to temporary closures when water quality conditions are not met. Some areas close to shore are permanently prohibited. A portion of Lower Myakka River is conditionally restricted — closed except during approved and supervised operations|*FDACS, 2018.*

Mangrove Forests and Salt Marshes

Coastal wetlands are extremely productive ecosystems made up of mangrove forests and salt marshes. They provide essential habitats for various species of fish, crustaceans, and coastal birds, stabilize shorelines, and filter pollutants from runoff. Salt marshes occur in low-energy intertidal zones and are dominated by specially-adapted salt-tolerant plants, such as black needle rush (*Juncus roemerianus*) and cord grasses (*Spartina spp.*). Although almost 74% of remaining salt marsh habitat is protected in the CHNEP area, it remains threatened by impacts from development including altered hydrology, pollution, and by sea level rise where upland habitat migration is blocked (Beever et al. 2012).

Mangrove forests are common in Southwest Florida and form a broad margin around its estuaries (Beever et al. 2016). They cover more than 60,000 acres in the CHNEP area and can extend inland several miles from open water. Mangrove forests are characterized by six geomorphic types, including overwash island, fringe, riverine, basin, hammock, and scrub. Southwest Florida mangrove species include red (*Rhizophora mangle*), black (*Avicennia germinans*), and white (*Laguncularia racemosa*) mangroves and the mangrove-like buttonwood (*Conocarpus erectus*). Mangroves perform vital, irreplaceable roles in providing food for species such as striped mullet (*Mugil cephalus*) and pink shrimp (*Farfantepenaeus duorarum*), habitat for birds and wildlife, and buffer inland areas from storm surges. Mangrove systems have the highest annual productivity of any system measured in the world and are critical to the world's carbon balance because they can store large amounts of carbon in the living and decomposing litter and soils that accumulate around their roots.

Natural threats to mangroves include high winds from tropical storms, lightning strikes, wave erosion, freezing, root and leaf predation, guano burial, and sea level rise. Human-related threats include coastal hardening, insufficient culverting and elimination of tidal creek circulation, development and road construction, direct fill with spoil or channelization for mosquito-control ditches, dredging, pollution, and excessive trimming (Beever et al. 2016). The high cost of these impacts to mangrove habitat is ultimately paid by taxpayers in terms of flood damage, shoreline erosion, water quality corrections, and other lost ecosystem services.

Sea level rise further stresses coastal wetlands like mangrove forests and salt marsh. Coastal wetlands are vulnerable to erosion, inundation, and drowning if the rate of natural soil accumulation cannot keep pace with sea level rise. Artificial structures such as roads, sea walls, and other flood protection structures can impede natural upland migration of coastal wetlands and result in habitat loss as sea level rises (Twilley 2007).

Management activities to maintain and enhance mangroves and other saltwater wetland habitats in the CHNEP area are detailed in Fish, Wildlife, and Habitat Protection Action 1.

Tidal Creeks

Tidal Creeks are "manmade or natural water conveyance channels with fluctuations in salinity caused by exchange of fresh and estuarine waters" (Janicki and Mote 2016). They support fisheries production, nutrient cycling, wading bird foraging, water retention, and flood prevention. A collaborative study of all three Florida Gulf Coast National Estuary Programs, led by Sarasota Bay Estuary Program, identified a total of 306 creeks in Lee, Charlotte, Sarasota, Manatee, Hillsborough, and Pinellas counties (Figure 27 on page 112). In a representative subset of these creeks, researchers found that creek

segments with low dissolved oxygen and high chlorophyll levels can still support high densities of juvenile fishes and baitfish (Janicki and Mote 2016). Large differences among creeks suggested that no single optimum water quality criterion may be appropriate for setting nutrient targets and thresholds to maintain ecological health for all creeks (see Water Quality Improvement Action 2). Instead, the study suggested that ecological health may be more reliably indicated by the status of juvenile fishes utilizing the creeks.

Threats to tidal creeks include dredging and draining, shoreline hardening for development, road construction, channelization for flood control, manmade barriers to prevent salinity intrusion upstream, nutrient pollution, bacterial pollution, and sedimentation. Climate change stressors including warming air and water temperatures, increased intensities of rainfall and storms, prolonged winter droughts, and rising sea levels will further magnify stresses to these systems. For example, rising sea levels or reduced flow due to extended drought will shift tidally influenced portions of creeks and rivers upstream — lengthening the upstream reach of stratified estuarine conditions and compressing the upper isohaline zones. Isohaline zones create important refuge habitat for plankton, macroinvertebrates, and fishes (Jassby et al. 1995). Management activities to maintain and enhance tidal creeks and associated habitats and fisheries in the CHNEP area are detailed in Fish, Wildlife, and Habitat Protection Action 1.

Freshwater Wetlands

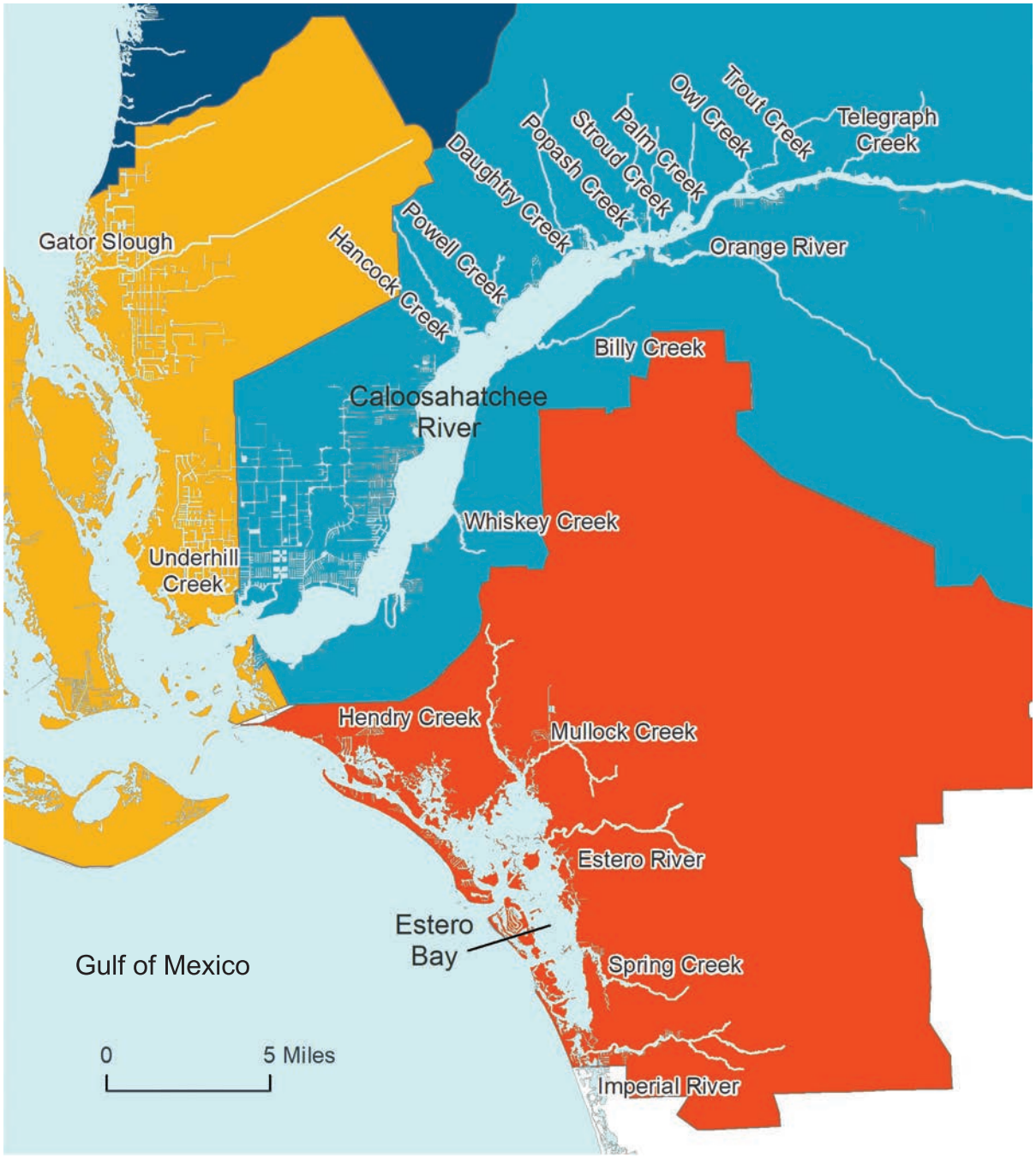
Freshwater wetlands are highly productive ecosystems that are either permanently or seasonally inundated with water. They include ponds, sloughs, swamps, and marshes. They naturally occur where the water table is at or near the land surface, resulting in soils that are either permanently or seasonally saturated by water, with low or no oxygen. Wetland habitats provide important ecosystem services including water purification and nutrient cycling, water storage and flood control, groundwater recharge, shoreline stability, and carbon sequestration. They support a wide range of plant and animal life and are integral to naturally functioning ecosystems in Southwest Florida.

The CHNEP area has lost more than 43 percent of its original wetland habitat — mostly to agricultural drainage, mining, and urban development (CHNEP 2013). Land drained by connector ditches for farming accounts for the largest loss of freshwater wetlands. Prior to 1975, phosphate companies strip-mined land without always restoring wetlands, especially along tributaries of the Peace River in Polk County when mining was a leading economic force. Today, regulations require the phosphate industry to reconstruct and replace every acre of wetlands it destroys. Urban and rural development also damages and destroys wetlands. All impacts to or loss of wetlands for urban and rural development go through a permitting process requiring mitigation; however, some wetland losses still occur where mitigation measures are unsuccessful (Beever et al. 2011). Climate stressors also threaten wetlands, including reduced rainfall during extended droughts and greater evaporation due to higher temperatures.

▲ Cypress swamp at Babcock Ranch | *Ruth Spies.*

◀ Mangroves at the mouth of Yucca Pen Creek. Tidal creeks are an important source of freshwater to estuaries and provide critical connections between freshwater and estuarine systems | *Douglas Shaw.*


Cow Pen Slough
Myakka River
Fox Creek
Salt Creek
Shakkett Creek
Curry Creek
Hatchett Creek
Dona & Roberts Bays
Deer Prairie Creek
Alligator Creek
Myakahatchee Creek
Sam Knight Creek
Deep Creek
Thornton Branch
Lee Branch
Hunter Creek
Shell Creek
Forked Creek
Gottfried Creek
Rock Creek
Lemon Bay
Peace River
North Fork Alligator Creek
Trout Creek
Oyster Creek
Buck Creek
Big Muddy Creek
Alligator Creek
Lemon Creek
Gulf of Mexico
Coral Creek
Sister Pond Creek
Whiddon Branch
South Silcox Creek
Big Mound Creek
Winegourd Creek
Whiddon Creek
Charlotte Harbor
Bear Branch
Pig Branch
Yucca Pen Creek
Durden Creek
0
5 Miles



◂◂ Figure 27 (left and right).
More than 55 tidal creeks drain into the coastal bays and estuaries of the CHNEP area from Venice to Bonita Springs. Tidal creeks support fisheries production, nutrient cycling, wading bird foraging, water retention, and flood prevention.

Coastal Strand

In Southwest Florida, little of the original coastal strand ecosystem remains. While residential and urban development converted most of the original coastal strand community, sections remain in the undeveloped barrier islands in Lee County, particularly Cayo Costa and the Stump Pass area of Charlotte County. This plant community consists of long, narrow bands of well-drained sandy soils affected by salt spray along Gulf and estuarine waters. Vegetation includes low-growing grasses, sea grape (*Coccoloba uvifera*), prickly pear cactus (*Opuntia humilis*), cabbage palm (*Sabal palmetto*) and live oak (*Quercus virginiana*). Coastal strands provide invaluable habitat to sea turtles, shorebirds, and amphibians.

Pine Flatwoods

Until the 1920s, the CHNEP area hosted large areas of pine flatwoods. One or more pine species grow on these nearly level lands, accompanied by understory wax myrtle (*Myrica cerifera*) and saw palmetto (*Serenoa repens*). Pines were intensively logged for a period extending through World War II until they were commercially exhausted. By 1987, pine flatwoods had been reduced significantly, with area coverage less than grasslands, cypress swamp, dry prairies, freshwater marsh, and urban areas. Throughout the CHNEP area, improved pasture, citrus, vegetable farms, and urban development have commonly replaced pine flatwoods. Displaced animal inhabitants include the pileated woodpecker (*Dryocopus pileatus*), American kestrel (*Falco sparverius*), sandhill crane (*Grus canadensis*), black bear (*Ursus americanus*), Florida panther (*Puma concolor coryi*), Eastern indigo snake (*Drymarchon corais couperi*), and gopher tortoise (*Gopherus polyphemus*).

Oak Scrub and Scrubby Flatwoods

Within the CHNEP area, both oak scrub and scrubby flatwood ecosystems provide animal habitat similar to pine flatwoods. Various species of oak, as well as saw palmetto (*Serenoa repens*), Florida rosemary (*Ceratiola ericoides*), and fetterbush (*Lyonia lucida*) dominate oak scrub habitat. Groundcover is generally sparse and is dominated by grasses, herbs, and ground lichens. Occurring along coastal shorelines, ridges, tributaries, and rivers, it has been vulnerable to urban development.

The CHNEP area also includes scrubby flatwoods. Similar to sand pine scrub, the South Florida slash pine (*Pinus elliottii densa*) generally dominates this community. Typical understory consists of wiregrass (*Aristida stricta*) and herbs. Remaining stands of scrubby flatwood have been severely depleted by selective- or clear-cutting pines. Due to the flatwood's rapidly percolating soils and high elevations, citrus groves and residential development commonly displace this habitat. Scrubby flatwoods are the preferred habitat for the endemic Florida scrub jay (*Aphelocoma coerulescens*) — the only bird in Florida that occurs nowhere else in the world.

Species of Special Management Concern

Preserving the rich diversity of birds, fish, and other wildlife in the CHNEP area requires protection and restoration of priority habitats and natural corridors that connect them. Species of special management concern include invasive species, threatened or endangered species, and species of commercial and recreational value.

Invasive species

Invasive species can outcompete and displace native plants and animals and damage native habitats. Our vision for the CHNEP area is to stop new infestations and reduce current infestations to manageable levels, especially on publicly owned lands. A total of 67 exotic pest plant species have been identified in the CHNEP area. The Florida Exotic Pest Plant Council maintains a database of sightings and locations. Climate induced changes in physical habitat characteristics due to changes in temperature, pH, sea level, and precipitation may expand the range of invasive species and reorganize community interactions — shifting dominance of some species and causing local extinction of others.

◀◀◀ Left to right.

Doe Branch Prairie in Hardee County | *John Kiefer*.

Pine flatwoods at Coral Creek Peninsula | *Lee Amos.*

Scrubby flatwoods are a critical habitat for the iconic Florida scrub jay | *Tony Clements.*

A partial list of invasive plants and animals includes:

Australian pine (*Casuarina equisetifolia*) is a pine-like tree introduced a century ago for windbreaks and erosion-control along coastlines. It is toppled by strong winds, displaces coastal vegetation and associated native wildlife, and spreads easily.

Brazilian pepper (*Schinus terebinthifolius*) is a holly look-alike tree introduced to Manatee and Charlotte counties in the 1920s. It forms dense stands, displaces native plants and associated native wildlife, encroaches into wetlands, and is easily spread by wildlife.

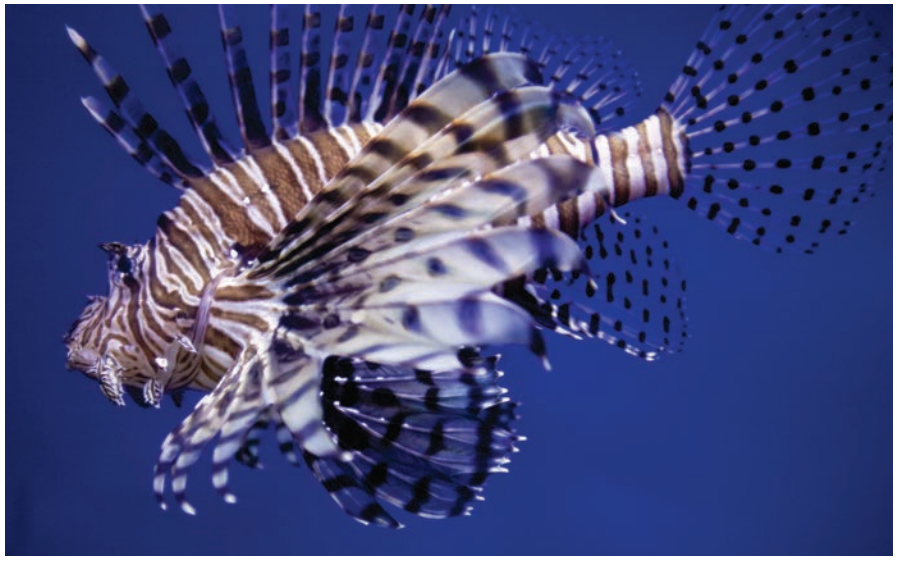
Eradication of Brazillian pepper on Sanibel Island | *SWFWMD.*

Melaleuca (*Melaleuca quinquenervia*) is a fast-growing, white-barked tree introduced to Florida in 1906 for windbreaks and to drain wetlands. It forms dense thickets, displaces native plants and wildlife, and is progressively spreading northward.

Hydrilla (*Hydrilla verticillata*) is an aquatic plant that entered Tampa through the aquarium trade in the 1950s. It grows dense strands of whorled leaves that chokes water bodies, depletes oxygen, and displaces native plants and fish. Control efforts are making steady progress against this threat.

Water hyacinth (*Eichhornia crassipes*) is a large floating plant with dark green leaves and lavender flowers. It was introduced in the 1800s, slows water flow and boats, and depletes oxygen. Efforts are increasing to control it.

Cogon grass (*Imperata cylindrica*) is a grass introduced in 1911 for cattle forage and soil stabilization, though it was later found to be not good forage for cattle. In contrast, it has been very good at invading native habitats, agricultural forests, roadsides, altered phosphate mining lands, and pinelands — displacing entire communities of native species.



Invasive animal species are also present in the CHNEP area, including:

Cane toad (*Rhinella marinus*) is a large omnivorous toad that eats insects, vegetation, small birds, other toads or frogs, lizards, small mammals, and snakes. Their skin-gland secretions are highly toxic and can sicken or even kill animals that bite or feed on them. It was first introduced to Florida in the 1930s to control agricultural pests.

Cuban tree frog (*Osteopilus septentrionalis*) is widespread in wooded, wetland, and suburban habitats in southern Florida. It preys upon smaller native tree frogs and their noxious skin secretions make it unpalatable to many predaceous birds and snakes. They were accidentally introduced to Florida in the 1920s through shipping and packing materials.

Nile monitor lizard (*Varanus niloticus*) was first identified in Cape Coral and preys on native animals and small pets. Growing up to two meters in length, it was first introduced to Florida as an escaped or released pet.

Lionfishes (*Pterois volitans* and *Pterois miles*) are popular ornamental aquarium fishes that were probably released or discarded by hobbyists. They were first reported off Florida's Atlantic Coast in 2002; by 2009 they had invaded the Gulf of Mexico. They are predatory reef fishes that compete with native fishes like grouper and snapper, and impact other native species that serve important ecological roles like keeping algae in check.

Feral hog (*Sus scrofa*) eats a variety of native plants and animals and causes significant environmental damage by "rooting" up soil and groundcover searching for food. It was likely introduced to Florida by Spanish slaver and conquistador Hernando DeSoto as early as 1539.

◀◀◀ Left to right.

Water hyacinth | *Chris Evans, University of Illinois, courtesy of Bugwood.org.*

Cane toad | *USGS, courtesy of Bugwood.org.*

Lionfish | *Rebekah D. Wallace, University of Georgia, courtesy of Bugwood.org.*

Threatened and endangered species

The CHNEP area supports more than 40 species listed as Threatened or Endangered by the United States Fish and Wildlife Service (USFWS) or listed as Threatened or Species of Special Concern by FWC (Table 12). In addition to habitat protection and restoration, management of these species requires assessment and monitoring, law enforcement, and education. Protecting and restoring priority habitats, including nesting and nursery areas, seasonal refuges, and critical corridors among habitats, is foundational to protecting threatened and endangered species (CHNEP 2019).

In 2016, FWC adopted a new comprehensive Imperiled Species Management Plan (ISMP) which became effective January 2017. The ISMP features species-specific Action Plans with targeted conservation goals, objectives, and actions. In addition, the ISMP describes integrated conservation strategies to benefit multiple species and their shared habitats. It lists 133 imperiled species in Florida, and more than half the listed reptiles and birds are found in the CHNEP area.

Burrowing owl|*Steven Russell*

Table 12. Partial listing of Endangered, Threatened, and Species of Special Concern occurring in the CHNEP area. On this page and opposite|*FWC.*

	COMMON NAME	SCIENTIFIC NAME	STATUS
MAMMALS	Big Cypress fox squirrel	*Sciurus niger avicennia*	ST
	Florida bonneted bat	*Eumops floridanus*	FE
	Florida panther	*Puma (=Felis) concolor coryi*	FE
	Homosassa shrew	*Sorex longirostris eionis*	SSC
	West Indian manatee	*Trichechus manatus*	FT
	Sanibel [Island] rice rat	*Oryzomys palustris sanibeli*	ST
REPTILES	American crocodile	*Crocodylus acutus*	FT
	bluetail mole skink	*Eumeces egregius lividus*	FT
	Eastern indigo snake	*Drymarchon corais couperi*	FT
	Florida pine snake	*Pituophis melanoleucus mugitus*	ST
	gopher tortoise	*Gopherus polyphemus*	ST
	green sea turtle	*Chelonia mydas*	FE
	hawksbill sea turtle	*Eretmochelys imbricata*	FE
	Kemp's ridley sea turtle	*Lepidochelys kempii*	FE
	leatherback sea turtle	*Dermochelys coriacea*	FE
	loggerhead sea turtle	*Caretta caretta*	FT
	sand skink	*Neoseps reynoldsi*	FT
	short-tailed snake	*Lampropeltis extenuata*	ST

FT = Federally Listed Threatened
FE = Federally Listed Endangered
T = State Listed Threatened
SSC = State Listed Species of Special Concern

	COMMON NAME	SCIENTIFIC NAME	STATUS
BIRDS	American oystercatcher	*Haematopus palliatus*	ST
	Audubon's crested caracara	*Polyborus plancus audubonii*	FT
	black skimmer	*Rynchops niger*	ST
	Everglade snail kite	*Rostrhamus sociabilis plumbeus*	FE
	Florida burrowing owl	*Athene cunicularia floridana*	ST
	Florida grasshopper sparrow	*Ammodramus savannarum floridanus*	FE
	Florida sandhill crane	*Grus canadensis pratensis*	ST
	Florida scrub-jay	*Aphelocoma coerulescens*	FT
	least tern	*Sternula antillarum*	ST
	little blue heron	*Egretta caerulea*	ST
	piping plover	*Charadrius melodus*	FT
	red knot	*Calidris canutus rufa*	FT
	red-cockaded woodpecker	*Picoides borealis*	FE
	reddish egret	*Egretta rufescens*	ST
	roseate spoonbill	*Platalea ajaja*	ST
	snowy plover	*Charadrius nivosus*	ST
	Southeastern American kestrel	*Falco sparverius paulus*	ST
	tricolored heron	*Egretta tricolor*	ST
	wood stork	*Mycteria americana*	FT
FISH	Atlantic sturgeon (Gulf subspecies)	*Acipenser oxyrinchus (=oxyrhynchus) desotoi*	FT
	smalltooth sawfish	*Pristis pectinata*	FE

Commercial and recreational fisheries

Charlotte Harbor is a nursery ground for important commercial and recreational marine and estuarine species. Up to 90 percent of commercial and 70 percent of recreational species caught in Florida spend all or part of their lives in estuaries.

The bountiful waters of the greater Charlotte Harbor watershed provide some of the best saltwater sportfishing in the world, including snook, tarpon, redfish, and spotted seatrout. Charlotte Harbor and surrounding areas derive substantial economic benefits from the maintenance of healthy fisheries. For example, in the four coastal counties surrounding the Greater Charlotte Harbor Area, active locally-licensed saltwater anglers numbered 67,936 in 2009–2010. Tarpon anglers alone spent $63 million in direct expenditures in 2010 with a total economic impact of $108 million (Fedler 2011). Recreational fishing in freshwater creeks, rivers, and lakes is a popular pastime in inland areas. Snook are caught as far upstream as Fort Meade. Freshwater fish such as largemouth bass (*Micropterus salmoides*), black crappie (*Pomoxis nigromaculatus*), and Florida gar (*Lepisosteus platyrhincus*) are also highly prized game fish throughout the CHNEP area.

Florida Fish and Wildlife Research Institute's Fisheries-Independent Monitoring (FWRI-FIM) Program regularly samples fish throughout coastal waters of the Greater Charlotte Harbor area and in estuaries around the State (Figure 28 on page 120). The goal of the FWRI-FIM program (initiated in Charlotte Harbor in 1989) is to provide high quality fisheries data to managers regarding fish abundance and population trends. A variety of techniques and sampling gears (*e.g.*, seine nets and otter trawls) are used by the FWRI-FIM program to ensure that the wide range of species, sizes, and ages necessary for stock management are sampled during each monthly survey. Analyses of FWRI-FIM program data are used by resource

A SRS began in Apr. 1989; purse seine used 1998-2004

B SRS began in Apr. 1989; purse seine used 1998-2004

C SRS began in Apr. 1989; purse seine used 1998-2004

D SRS began in Mar. 1994; 21.3-m seine dropped Jan. 1998-Nov.2003; purse seine used 1998-2003

K River zone added for Age 1 Snook Study; July 2014 to present

M SRS began in Apr. 1989

P SRS began in Apr. 1989; Grids 189 - 190 & 195 - 197 dropped in Jan. 1998

Dropped

1 Peace River Oligohaline Study from Jul 2007 - Apr 2010
2 Myakka River Study from May 2003 - Jan 2004
3 Lemon Bay Study from Jun 2009 - Apr 2010 (bimonthly SRS)
4 Coral Creek Study from July 2014 - June 2015
5 Peace River Study from 1997-1999 (study included parts of Peace River and "Zone S" for Shell Creek)
6 Charlotte Harbor Southern Expansion Study (Zones E, G & H) from Nov 2003 - Dec 2007. Haul seines only in Zones E & G from Jan 2008 - Jun 2008. Complete SRS again Jul 2008 - Jun 2009 Haul seines in lower H as part of Sawfish Study from Nov 2004 - Dec 2009
7 Blind Pass Study from May 2010 - Apr 2011
8 Estero Bay Study from Jan 2005 - Dec 2007
9 Zones A,B & C tidal creeks Study of Age 1 Snook from July 2014 - ongoing

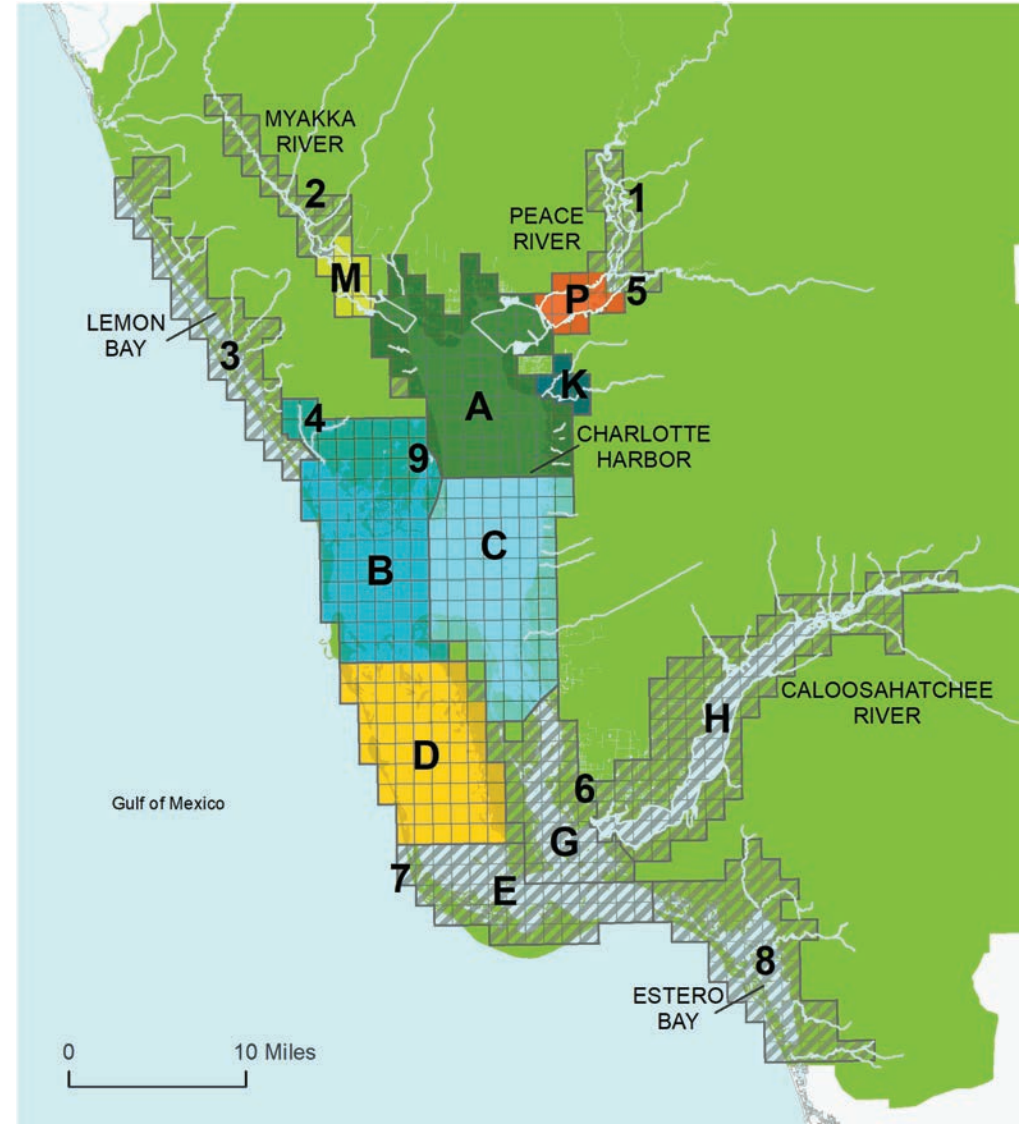


Figure 28. ▶
Map of the sampling universe and efforts for Florida Fish and Wildlife Conservation Commission's Fisheries-Independent Monitoring (FIM) program in the CHNEP area. Monthly stratified-random sampling (SRS) is occurring in Zones A–D. SRS in the Caloosahatchee River estuary (Zones G, E, and H) occurred during 2004-2007, in Estero Bay 2005–2007, and for one year in Lemon Bay during 2009–2010. A one-year sampling study was also conducted in Dona and Roberts Bays | *FWRI-FIM.*

managers to assess abundance trends for resource species, define essential fish habitat, and describe life-history parameters such as age, growth, and age at maturity. It is important to support continued or expanded monitoring in CHNEP estuaries, as fish abundance and diversity are indicators of the health of water bodies, and robust data sets are needed to establish trends. FWRI-FIM program data is also frequently used to assess the impact of environmental perturbations such as red tides, extreme cold events, and oil spills.

Fish, Wildlife, and Habitat Protection Challenges and Management Actions

Protecting and restoring bird, fish, and other wildlife habitat, particularly critical areas and corridors, is essential to sustaining viable communities of plants and animals. Many estuarine waters in the CHNEP area are designated aquatic preserves and are considered public property to be managed for the public. While significant tracts of land within the CHNEP area are publicly owned, most terrestrial habitats exist on private property. Progress has been made in acquiring and protecting conservation lands, but challenges from development pressure and climate stressors remain. Cooperation among agencies at all levels of government, private land trusts, and landowners is essential. The best habitat management incorporates effective management of large contiguous public lands along with cooperative management on private lands.

The CHNEP Management Conference has identified three major Actions for Fish, Wildlife, and Habitat Protection: Action 1 calls for protecting and restoring estuarine habitats, including seagrasses and submerged aquatic vegetation, oysters, tidal creeks, and coastal wetlands; Action 2 aims to protect and restore environmentally sensitive lands and waterways, including critical upland and freshwater wetland habitat areas; and Action 3 focuses on promoting the benefits of land, waterway, and estuary protection and restoration.

Commercially and Recreationally Important fishery species in the CHNEP Area include:

- striped mullet (*Mugil cephalus*);
- spotted seatrout (*Cynoscion nebulosus*);
- redfish (*Sciaenops ocellatus*);
- black drum (*Pogonias cromis*);
- kingfish (*Menticirrhus spp*);
- Gulf flounder (*Paralichthys albigutta*);
- blue crab (*Callinectes sapidus*);
- pink shrimp (*Farfantepenaeus duorarum*);
- stone crab (*Menippe mercenaria*);
- Southern hardshell clam (*Mercenaria campechiensis*);
- snook (*Centropomus undecimalis*);
- tarpon (*Megalops atlanticus*);
- groupers (*Epinephelus spp* and *Mycteroperca spp*);
- black sea bass (*Centropristis striata*);
- snappers (*Lutjanus spp*);
- Florida pompano (*Trachinotus carolinus*);
- bluefish (*Pomatomus saltatrix*);
- sand seatrout (*Cynoscion arenarius*);
- Spanish and king mackerel (*Scomberomorus maculatus* and *S. cavalla*);
- sheepshead (*Archosargus probatocephalus*); and
- several species of sharks.

1 Protect, restore, and monitor estuarine habitats

OBJECTIVES:

Protect, restore, and monitor seagrasses, oyster reefs, and coastal wetlands; and research and promote best management practices for canals, tidal creeks, rivers, and dredged channels that support habitats and native aquatic life, including installation of living shorelines.

BACKGROUND:

Since the Greater Charlotte Harbor area was designated as an *Estuary of National Significance* in 1995, CHNEP and its partners have made significant progress in protecting and restoring estuarine habitats. Maintaining these gains in the face of population growth, dramatic land-use changes, and climate change will be an ongoing challenge for generations to come.

Many estuarine waters in the CHNEP area are designated aquatic preserves, including Gasparilla-Charlotte Harbor, Cape Haze, Matlacha Pass, Pine Island Sound, Lemon Bay and Estero Bay. The Florida Coastal Office of FDEP maintains management responsibility for these preserves.

Seagrasses and other Submerged Aquatic Vegetation

Seagrass Restoration Targets

Seagrass protection and restoration targets have been developed for 14 designated seagrass management segments in the CHNEP area (Table 11 on page 106). Because seagrass requires adequate water clarity, water clarity targets were developed to achieve segment-specific seagrass targets. Measuring light directly to determine water clarity in shallow estuarine waters is complex and error-prone; instead, the major contributors to water clarity (water color, chlorophyll, and turbidity) are more reliably, precisely, and accurately measured. CHNEP funded research to develop an optical model to utilize these variables to quantify water clarity (Dixon and Wessel 2014), allowing CHNEP and its partners to better understand and manage water quality variables to attain desired water clarity, and by extension — desired seagrass targets in each management segment. See Water Quality Improvement Action 2.

Seagrass Monitoring

Southwest Florida Water Management District (SWFWMD) and South Florida Water Management District (SFWMD) conduct regular aerial mapping of seagrass meadow locations and acreage throughout the CHNEP area. SWFWMD maps seagrass every two years in five waterbodies, including Lemon Bay, Cape Haze/Gasparilla Sound, Charlotte Harbor, and the Tidal Myakka and Peace Rivers. SFWMD maps seagrass every five years in six waterbodies, including Charlotte Harbor, Pine Island Sound, Matlacha Pass, San Carlos Bay, Estero Bay and the Tidal Caloosahatchee River. Researchers identify and map continuous seagrass, patchy seagrass, unvegetated tidal flats, and oyster reefs using ground-truthing and photo-interpretation of aerial images. In the most recent surveys (2014/2016), seagrass coverage in the Greater Charlotte Harbor Area was about 71,000 acres, exceeding historical estimates of seagrass from the 1950s (68,000 acres), and nine of fourteen waterbodies have seagrass coverage exceeding their management targets (Table 11 on page 106). Improved coordination of the mapping schedules of SWFWMD and SFWMD could allow for full coverage of CHNEP estuaries more often.

FDEP, Charlotte Harbor Aquatic Preserves (CHAP), and Estero Bay Aquatic Preserve (EBAP) conduct annual in-water seagrass monitoring along permanent transects extending from shore to the deepest edge of seagrass meadows. Aquatic Preserves staff and volunteers monitor ten waterbodies, including Lemon Bay, Cape Haze/Gasparilla Sound, Charlotte Harbor, Pine Island Sound, Matlacha Pass, San Carlos Bay, Estero Bay, and the Tidal Myakka, Peace and Caloosahatchee Rivers. Species presence, abundance, blade length, shoot counts, epiphyte abundance, sediment type, and water depth are monitored. CHNEP provides public access to these data through the CHNEP Water Atlas, participates in annual Quality Assurance training sessions, and assists with monitoring.

◀ Redfish catch and release | *www.waterlifemagazine.com.*

Seagrass Restoration

Projects to restore seagrass focus on improving water quality (see Water Quality Improvement Action Plan), stabilizing sediments, promoting natural recruitment, and directly planting seagrass. For example, the Caloosahatchee Citizen Seagrass Gardening Project, funded by a grant from NOAA and FDEP, aims to restore populations of tape grass (*Vallisneria americana*) and widgeon grass (*Ruppia maritima*) in the tidal Caloosahatchee by establishing seed-source colonies protected from herbivores.

▲ Citizen scientists participate in "seagrass gardening" by replanting tape grass and widgeon grass in the Caloosahatchee River.

The project uses volunteers to monitor seagrass percent cover, density, and reproduction as well as water clarity, salinity, and temperature. Successful restoration protocols are being documented for use in other areas. CHNEP also created a volunteer manual of standard operating procedures to assist in training citizens participating in the Seagrass Gardening Project (CHNEP 2018b).

Other Management Activities

CHNEP convened the Caloosahatchee River SAV Targets Working Group in 2013 to develop sound submerged aquatic vegetation (SAV) targets for tidal and some oligohaline reaches of the Caloosahatchee River. CHNEP also participates in the Southwest Florida Seagrass Working Group and FWC Seagrass Integrated Monitoring and Mapping technical team. In addition, Charlotte Harbor and Estero Bay Aquatic Preserve staff have been documenting macroalgae since 1999 during annual fixed seagrass transect monitoring.

Oysters

CHNEP's management goal for oysters is to enhance and restore self-sustaining oyster habitat and related ecosystem services throughout the estuaries and tidal rivers and creeks in the CHNEP area.

In 2012, the CHNEP Management Conference approved the Charlotte Harbor Oyster Habitat Restoration Plan, created by CHNEP, The Nature Conservancy (TNC), and the Southwest Florida Oyster Working Group, a diverse group of representatives from state and federal agencies, municipalities, non-profits, academia, and civic organizations. The Plan identifies oyster habitat restoration goals, methods, and partnerships using a technically-sound, consensus-based approach (Boswell et al. 2012). The Plan features a Restoration Suitability Model to map locations of suitable restoration areas based on five criteria: bathymetry, tidal river salinity isohalines, seagrass persistence, proximity to boat channels, and presence of aquaculture lease areas. The model identified over 40,000

acres of highly suitable areas for oyster restoration within the CHNEP area. The Plan set an oyster restoration target of 1,000–6,000 acres of oyster habitat based on the proportional extent of oyster coverage in suitable habitat areas of natural reference sites and the amount of suitable habitat areas in the CHNEP area.

To accomplish this target, the CHNEP Management Conference and its partners support the Oyster Habitat Restoration Plan's recommended actions to:

- Map oyster habitats by type within the CHNEP;
- Design, implement, and monitor the success of pilot oyster restoration projects in a variety of habitats in 50% of CHNEP estuary segments;
- Increase public awareness of the ecosystem value of native oyster habitats by including community stewardship components in each oyster restoration project; and
- Assist partners in seeking state, federal, and organizational funding opportunities to support oyster habitat restoration projects.

The plan also provides guidance on permitting, success criteria, monitoring, funding opportunities, and incorporating community stewardship opportunities into restoration projects.

Oyster Monitoring and Mapping

Examples of oyster mapping and monitoring in the CHNEP area include:

- Florida Gulf Coast University's Oyster Monitoring Network for the Caloosahatchee Estuary, funded by SFWMD, conducts oyster monitoring in the Caloosahatchee Estuary and Estero Bay (1999-present) in support of the Comprehensive Everglades Restoration Plan.
- Sarasota County has an oyster mapping program and has monitored oysters in Dona and Roberts Bays since 2003.
- Oyster reefs were monitored in the Pine Island Sound area in 2010–2011 as part of a broader study to determine possible effects from the Deepwater Horizon spill. Even though oil never reached the Pine Island Sound, the study provided important baseline information on oyster densities, growth rates, and genetic connectivity among sites in Florida (Proffitt et al. 2013).

Oyster Restoration

To date, oyster restoration projects in the CHNEP area have focused on shallow and intertidal waters of less than four feet. The Oyster Habitat Restoration Plan identified a need to study project successes at different depths to better guide future restoration efforts. In 2016, TNC, CHNEP, and FDEP-CHAP completed the Trabue Harborwalk Oyster Habitat Restoration Project, which featured nine oyster habitat restoration sites located along tidal portions of the Peace River in the City of Punta Gorda.

Volunteers monitor oyster growth on constructed oyster reefs. ▼

The project, funded by Mosaic and private donors, was designed to test three restoration methods: loose fossil shell, bags of loose fossil shell, and oyster mats using recycled shell.

To monitor progress, CHNEP created the Volunteer Oyster Habitat Monitoring Program (VOHMP), which trains participants in water quality monitoring, oyster counting and measuring, water bird surveys, and data entry. As of 2018, VOHMP volunteers and over 1,300 community volunteers have contributed almost 3,000 hours to construct and monitor reefs. The project demonstrated that bagged shell reefs resulted in the highest production of new oysters as well as the greatest positive change in reef height. In 2017, the Trabue Harborwalk Oyster Habitat Restoration Project was augmented with a fourth experimental design that eliminates the use of plastic. This new design, called Biodegradable EcoSystem Engineering Elements, or BESE-elements, uses a three-dimensional grid made from potato starch, a byproduct in potato chip manufacturing.

Volunteers carry trays of oysters out to construct a new oyster reef. ▼

Other examples of oyster restoration in the CHNEP area include:

- The Coastal Watershed Institute at FGCU and their partners conduct community-based restorations of oyster reefs, including reefs in the Caloosahatchee River/lower San Carlos Bay, Estero Bay, and Henderson Creek (in Collier County). More than 600 volunteers have donated over 4,300 hours of time to reestablish 23 oyster reefs.
- Sanibel Captiva Conservation Foundation began a research-based oyster restoration project in 2010 to build oyster reefs in Clam Bayou on Sanibel Island. The collaborative efforts continued with volunteer-assisted oyster restorations at City of Sanibel Boat Ramp, and locations around the Causeway Islands and Tarpon Bay using discarded oyster shell collected from local restaurants. Seven complete oyster reefs totaling approximately four acres have been created in the Caloosahatchee Estuary as of 2018.

Mangroves

Mangrove research and improved management capacity

To better understand saltwater wetland loss, CHNEP conducted research to define the distribution, abundance, and composition of saltwater wetlands, with a focus on mangrove ecosystems throughout the CHNEP area (Beever et al. 2016). CHNEP staff mapped mangroves by location and species

for Charlotte Harbor proper (including the tidal Peace and Myakka Rivers). Mapped information and site data were used in combination with satellite imagery to develop mangrove community and species interpretations for the entire CHNEP area. The results offered a sensitive and detailed accounting of mangrove distribution, giving clues to underlying hydrology difficult to map from aerial photography and LiDAR digital elevation models alone.

The study overturned the classic paradigm of mangrove ecology that held that mangrove communities were organized according to a landward zonation pattern of red mangroves, black mangroves, white mangroves and buttonwood. Instead, mixes of mangrove species were far more common than classic mangrove zonation would suggest. The highlight of the project was the use of the Green Normalized Difference Vegetation Index (Pastor-Guzman et al. 2015) to identify areas of poor mangrove condition and excellent mangrove condition using Landsat satellite spectral imagery data. The 2015 index was coupled with 1985 Landsat data to develop mangrove condition trend maps, which were used to identify 90 potential restoration opportunities throughout the CHNEP area. The study also identified sites with poor or declining condition due to natural causes, where there was no remedy or where restoration was already in progress.

The Mangrove Condition and Change Tool brings new management capacity to the CHNEP area, as the technique requires no pre-restoration monitoring because of the ongoing collection and archiving of Landsat data by the Unites States Geological Survey (USGS). The tool can also be used to assess the fate of mangrove systems as they respond to human-caused hydrologic and climate change stressors, identify mangrove forest die-offs and locations of potential future loss, document changes in the position, composition, and health of the landward and waterward edges of fringing mangrove ecosystems, and document changes in the relative proportions of mangrove ecosystem types in Southwest Florida.

▲ Volunteers monitoring mangroves as part of Clam Bayou Restoration | *SCCF.*

Mangrove restoration

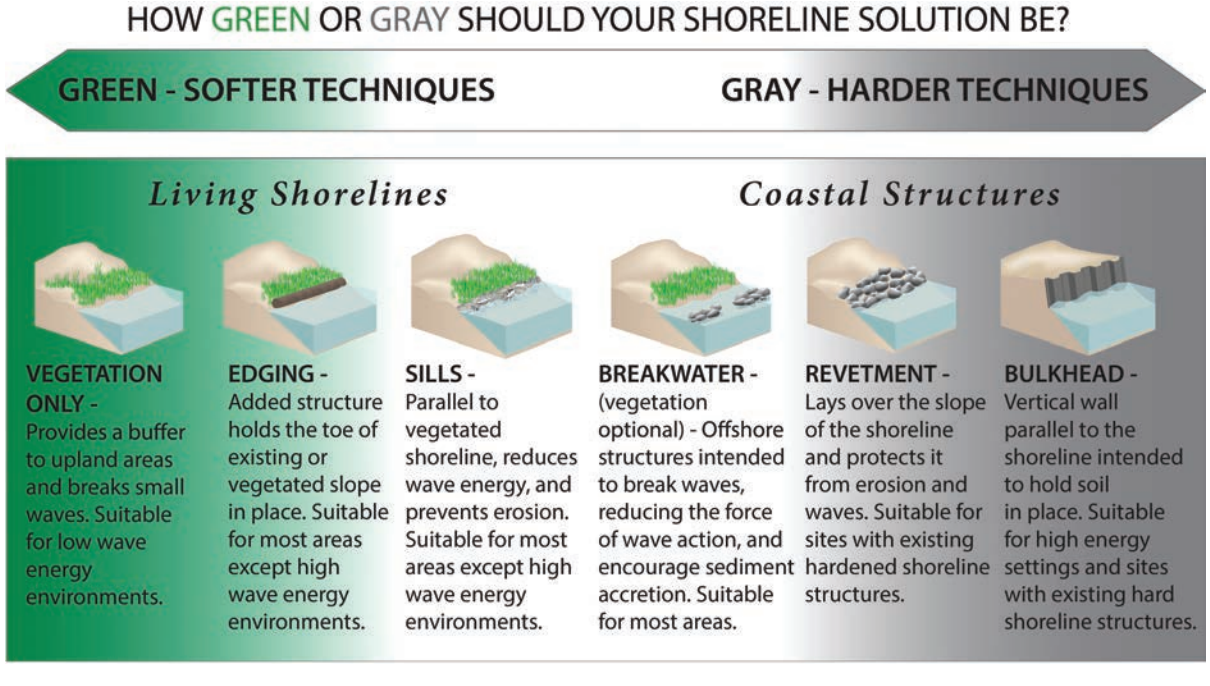
Efforts to restore estuarine shorelines are ongoing in the CHNEP area. For example, in 2011–2012, Lee County 4-H Trailblazers teamed

with local agencies to plant Red Mangrove propagules on Lee County Conservation 20/20 property at Smokehouse Bay on Pine Island to help restore mangrove fringe along the estuarine shoreline. Smokehouse Bay, on the north end of Pine Island, is part of the Conservation 20/20 program, which purchased parcels of land in 1999 and 2007. The 268 acres were dramatically altered five decades ago when cleared for a mosquito ditch, intended to drain standing water.

Living Shorelines

While much of the estuarine shoreline in the CHNEP area remains natural, the rivers, creeks, and canals along urbanized waterfronts are largely hardened (Figure 29). These artificial shorelines increase erosion, harm water quality, magnify storm damage and flooding, provide poor habitat for birds, fish, and other wildlife, and may cause coastal squeeze of habitats subject to sea level rise (Figure 30; RAE 2015).

Figure 29. A continuum of shoreline types from natural to hardened | *NOAA Office of Habitat Conservation.*



In contrast, living shorelines utilize "softer," sloped, more natural materials that buffer wave action, absorb storm impacts, filter pollutants, and provide food and shelter for fish, shellfish, and wading birds. Living shorelines may also help increase resiliency to impacts associated with climate change and sea level rise by buffering the effects of increased storm and floods. They protect dunes, mangrove forests, and other coastal habitats that in-turn shield manmade infrastructure, support wildlife, and add aesthetic value.

The Nature Conservancy is spearheading a living shoreline project on the Peace River along the seawall area of the Four Points Sheraton Hotel in Punta Gorda. The Tiki Point at Harborwalk Living Shoreline Project will be the City's first living shoreline project and will be a model for future living shorelines within the CHNEP area. The City of Punta Gorda, FDEP-CHAP, Sheraton Hotel, CHNEP, and Jacobs Engineering are working together to successfully implement this project. CHNEP and its partners will continue to support research and restoration projects to improve habitat capacity and resiliency to preserve and enhance native populations of birds, fish, and other wildlife.

Tidal Creeks and Fisheries

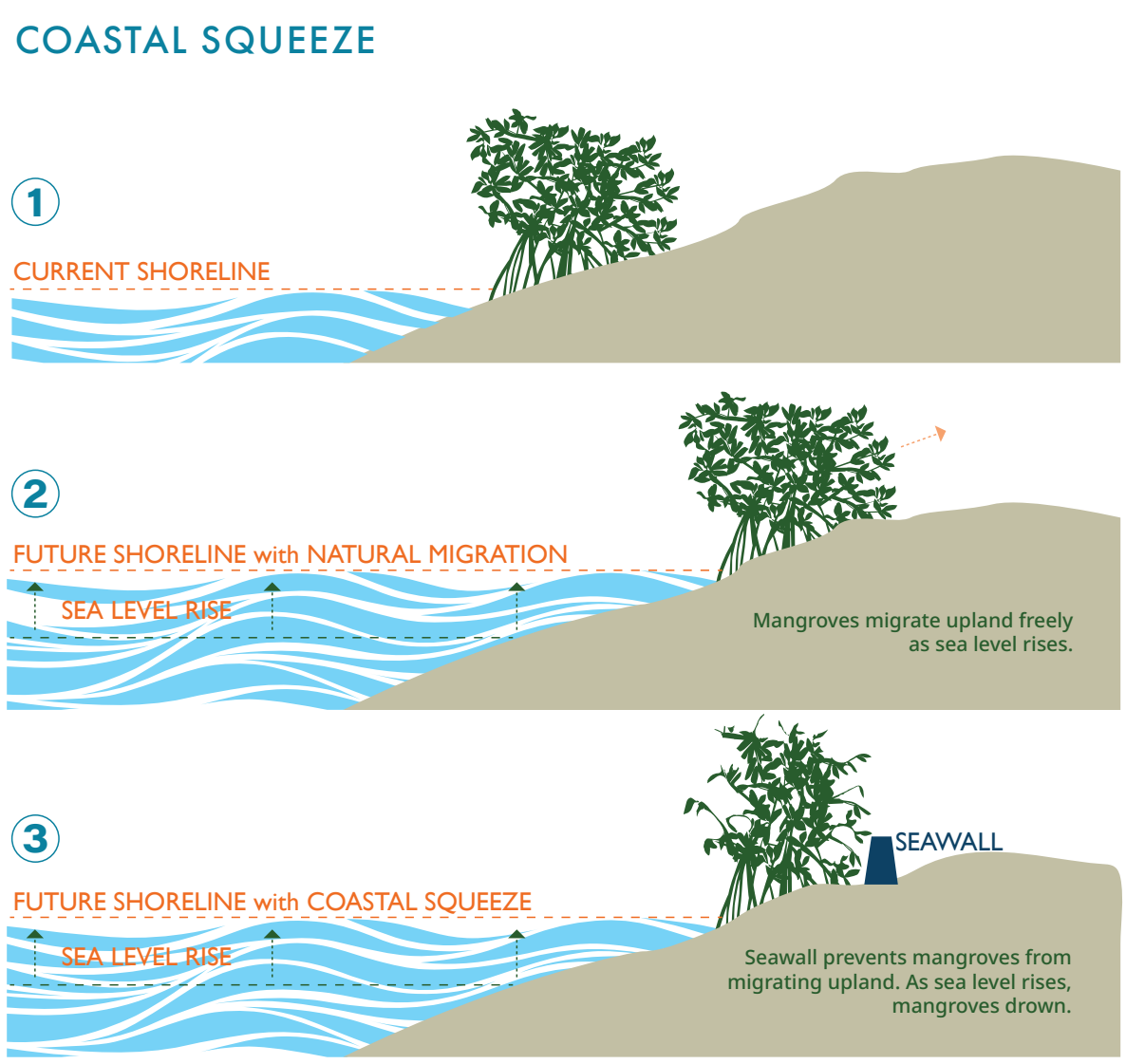
Coastal wetlands and associated tidal creeks rank among the most productive estuarine habitats and serve as essential juvenile fish nursery areas. CHNEP supports tidal creek research and restoration across the region to advance understandings of how fish use these areas and how best to restore hardened

and degraded shorelines for maximum productivity.

An example of this work is ongoing at Coral Creek, the largest creek on Cape Haze. Located across from a major pass, it serves as important juvenile habitat to offshore spawning species in the Gulf of Mexico. However, Coral Creek has undergone considerable hydrologic disturbance as a result of upstream coastal development, degradation of wetlands, and channelization.

The Coral Creek Ecosystem Restoration project targets the tidal creek with its riparian shoreline and mangrove fringe plus about 2,600 acres of upland and wetland habitats. This work aims to restore historic hydrology, improve water quality, enhance shallow water habitat for the endangered wood stork, provide improvement to essential fish habitat, and enhance recreational/educational opportunities.

To assist SWFWMD, FDEP, and other partners with assessing the functional effects of hydrologic and habitat restoration activities at Coral Creek, CHNEP contracted with FWC's Fisheries Independent Monitoring program to conduct fish monitoring in Coral Creek and two adjacent reference creeks on the Cape Haze peninsula prior to initiation of restoration activities in 2014. In 2016, CHNEP contracted additional fish monitoring through the Bonefish and Tarpon Trust to compare fishery response to different hydrological restoration designs in six finger canals along Coral Creek. Researchers found that the seagrass-dominated tidal creeks on the Cape Haze Peninsula support greater numbers of fish and potential prey for juvenile sport fish than unvegetated creeks of upper Charlotte



▲ Figure 30.
Coastal squeeze occurs when upslope migration of habitat is impeded by development.

Harbor (Blewett et al. 2017a). These results will guide future restoration efforts in tidal creeks.

New research on habitat-use patterns of the endangered smalltooth sawfish (*Pristis pectinata*) has provided valuable information for their management. Sawfish are known to use multiple Southwest Florida estuaries as juveniles. Researchers found they have affinities for brackish waters less than a meter deep, warmer than 24 degrees C, and with dissolved oxygen levels greater than 4 mg/L (Huston et al. 2017).

Fishery scientists from the Bonefish and Tarpon Trust, FWC, and Mote Marine Laboratory are studying how water and habitat quality affect snook ecology | *FWRI-FIM.*

Differences in distribution and abundance of common snook, Florida gar, and largemouth bass in the Peace and Myakka Rivers appear to be related to habitat differences in dissolved oxygen (Blewett et al. 2017b). Lower dissolved oxygen (less than 3 mg/L) was suggested to be a contributing factor to lower bass abundance in the Myakka; whereas the abundance of snook and Florida gar in the Myakka was comparable to the Peace River. Low DO in the Myakka was found to occur downstream of a large marsh, prone to large mortality events. Improved understandings of the ways natural habitats can affect water quality can better improve management expectations.

New research into the ecological requirements for snook and tarpon nursery habitats holds promise for better understanding how these fishes are impacted by habitat quality. Scientists from the Bonefish and Tarpon Trust and FWC have analyzed statewide maps of juvenile snook and tarpon locations and assembled a list of habitat characteristics common to successful nursery habitats (Wilson 2017). Mote Marine Laboratory conducted a study in Sarasota County to determine shoreline habitat preference of snook in tidal creeks. They found that areas with curved channels, wetland plants, or slower moving waters, tend to have more fish, as these sections better resemble natural creeks. They also found more fish associated with natural vegetated shorelines than hardened ones. Stormwater conveyances can be designed or retrofitted with weirs and fish ladders to encourage fish passage and migration (see Hydrological Restoration Action 3).

STATUS:

Ongoing. Previous 2013–2018 CHNEP-CCMP Fish and Wildlife Habitat Actions FW-A, FW-B, FW-C, FW-D, FW-E, and FW-F are combined here and updated to incorporate new information on management activities, projects, and climate variability. Previous Actions FW-O and FW-P related to environmental education are addressed in the new Public Engagement Action Plan. Previous Action FW-G related to environmental compliance and enforcement has been retired as it is solely within partners' responsibilities and beyond the scope of the Partnership, while education on compliance issues is integrated throughout the Public Engagement Action Plan. Quantifiable Objective FW-1 from the 2013–2018 CCMP is carried forward and updated as a Performance Measure.

RELATED ACTIONS:

- Water Quality Improvement Action 1: Support a comprehensive and coordinated water quality monitoring and assessment strategy
- Water Quality Improvement Action 2: Develop water quality standards, pollutant limits, and cleanup plans
- Water Quality Improvement Action 3: Reduce urban stormwater and agricultural runoff pollution
- Water Quality Improvement Action 5: Reduce harmful algal blooms
- Hydrological Restoration Action 2: Increase fresh surface water and groundwater availability to support healthy natural systems
- Hydrological Restoration Action 3: Protect and restore natural flow regimes

ACTIVITIES:

Protect and restore beneficial submerged aquatic vegetation, including seagrasses, oysters, and coastal wetlands, to manage and enhance ecosystem services.

Location: CHNEP area.

Responsible parties: CHNEP, County and Municipal Governments, FDEP, SWFWMD, SFWMD, FWC, USFWS, NOAA, USACE, J.N. "Ding" Darling NWR Complex, Land Conservation NGOs.

Timeframe: Ongoing; Climate Change Vulnerability Analysis adopted in 2018; Habitat Restoration Needs Plan adopted in 2019; Monitoring Strategy to be adopted in 2020.

Potential annual cost and funding sources: $1M–10M/ SWFWMD, SFWMD, County and Municipal Governments, NOAA, FDEP, FWC, 320 Funds.

Benefits: Improved habitat capacity and resiliency to support sustainable native populations of birds, fish, and other wildlife.

5-year Performance measure: Increased created and restored oyster reefs, living shorelines, and seagrass meadows.

Research and promote best management practices for tidal creeks, rivers, canals, dredged channels, and stormwater conveyances that support habitats and native aquatic life.

Location: CHNEP area.

Responsible parties: County and Municipal Governments, SWFWMD, SFWMD, FDEP, FDACS, FWC, WCIND, USACE, USFWS, NOAA, UF/IFAS, Research Institutions, NGO Neighborhood Groups.

Timeframe: Ongoing; Monitoring Strategy to be adopted in 2020.

Potential annual cost and funding sources: $500,000–$999,999/CHNEP, County and Municipal Governments, FDACS, FDEP, SWFWMD, SFWMD, Florida Sea Grant.

Benefits: Improved BMPs resulting in improved resource protection.

5-year Performance measure: Improved understanding and additional data on habitat condition and function for supporting native aquatic life.

2

Protect, restore, and monitor environmentally sensitive lands and waterways including critical habitat areas

OBJECTIVES:

Continue to encourage and support the permanent conservation of environmentally sensitive lands and critical habitat areas through land acquisition and conservation easements, and encourage management activities to protect, restore, and create thriving native plant and animal communities.

BACKGROUND:

CHNEP's vision for land conservation is to protect and restore flowways and corridors that allow movement of birds, fish, wildlife, and water, and to protect uplands adjacent to coastal and riparian habitats that allow habitat migration due to sea level rise. Many of these wetland and upland habitats are fragmented, degraded, or locally lost due to activities related to urban development, agriculture, transportation, and mining (see Hydrological Restoration Action 3).

For habitats that remain, many areas have been extensively impacted and altered by invasive exotic vegetation such as cogongrass, Old World climbing fern, and Brazilian pepper; and exotic nuisance animals such as feral hogs, apple snails, Cuban tree frogs, and monitor lizards. Spread of invasive species and pathogens, both native and non-native, is increasing with increasing temperatures, fewer extreme cold events, and habitat shifts resulting from climate change. More catastrophic events, such as droughts, floods, and intense storms, could create opportunities for colonization by more exotics. Biodiversity could change as flora and fauna geographical ranges change, shifting dominance of some species and causing local extinctions of others.

Fire is a natural and necessary feature of many upland habitats. Climate change may result in more frequent or intense droughts, causing temporal and spatial characteristics of natural fire regimes to shift and increasing the possibility of more intense and long-burning wildfires. There may be increased burn risk for desiccated wet mesic or hydric habitats that are not well-adapted to frequent wildfire. As a result, use of prescribed fire as a landscape management tool to maintain habitat conditions for plants and animals may become more difficult and riskier in some locations (Scott 2008).

◀ Renewal after a fire in the Charlotte Harbor Preserve State Park in Cape Coral | *Gail Stenger.*

Land Acquisition

Land acquisition to protect wildlife habitat, water flows, and water quality has been a major objective of CHNEP and its partners. Together, we have made significant progress in protecting and restoring priority habitats. Since CHNEP's inception in 1994, the acreage of conservation land in the CHNEP area has tripled. In 1994, CHNEP's area included 187,000 acres of managed conservation lands. The 2013–2018 CCMP set targets to conserve 25% more acreage than the 1998 baseline by 2018 and 100% more by 2025. In 2018, over 565,000 acres within the CHNEP area are under conservation, exceeding the target set for 2025 (Figure 31 on page 134; FNAI 2019). Between 2013 and 2018, more than 46,000 areas have been conserved (FNAI 2013, 2019). These protected lands support threatened and endangered species, including 300,000 acres of Panther Focus Area, 37,000 acres of Florida scrub Jay habitat, 11 woodstork nesting locations, nine gopher tortoise recipient sites, and 372 red-cockaded woodpecker observation sites (CHNEP 2019). Over time, sea level rise will force some conservation lands to transition to submerged or intertidal habitats, resulting in a net loss of conservation land and less land available for strategic acquisition to connect existing conservation lands through habitat corridors.

Land conservation is a significant and essential undertaking in Southwest Florida. Steady gains have been achieved by the sustained efforts of municipal, county, state, and federal governments, water management districts, and a variety of non-governmental entities over decades (Table 13 on page 135). These entities own and manage, often jointly, the mosaic of conservation lands in the CHNEP area, including parks, preserves, reserves, refuges, forests, and private lands.

State Parks like the 42,500-acre Charlotte Harbor Preserve State Park that serves as a coastal buffer to much of Charlotte Harbor are managed by FDEP. The Florida Forest Service of the Department of Agriculture and Consumer Services manages primary state forests in the Charlotte Harbor area, including the Myakka State Forest and the Peace River State Forest.

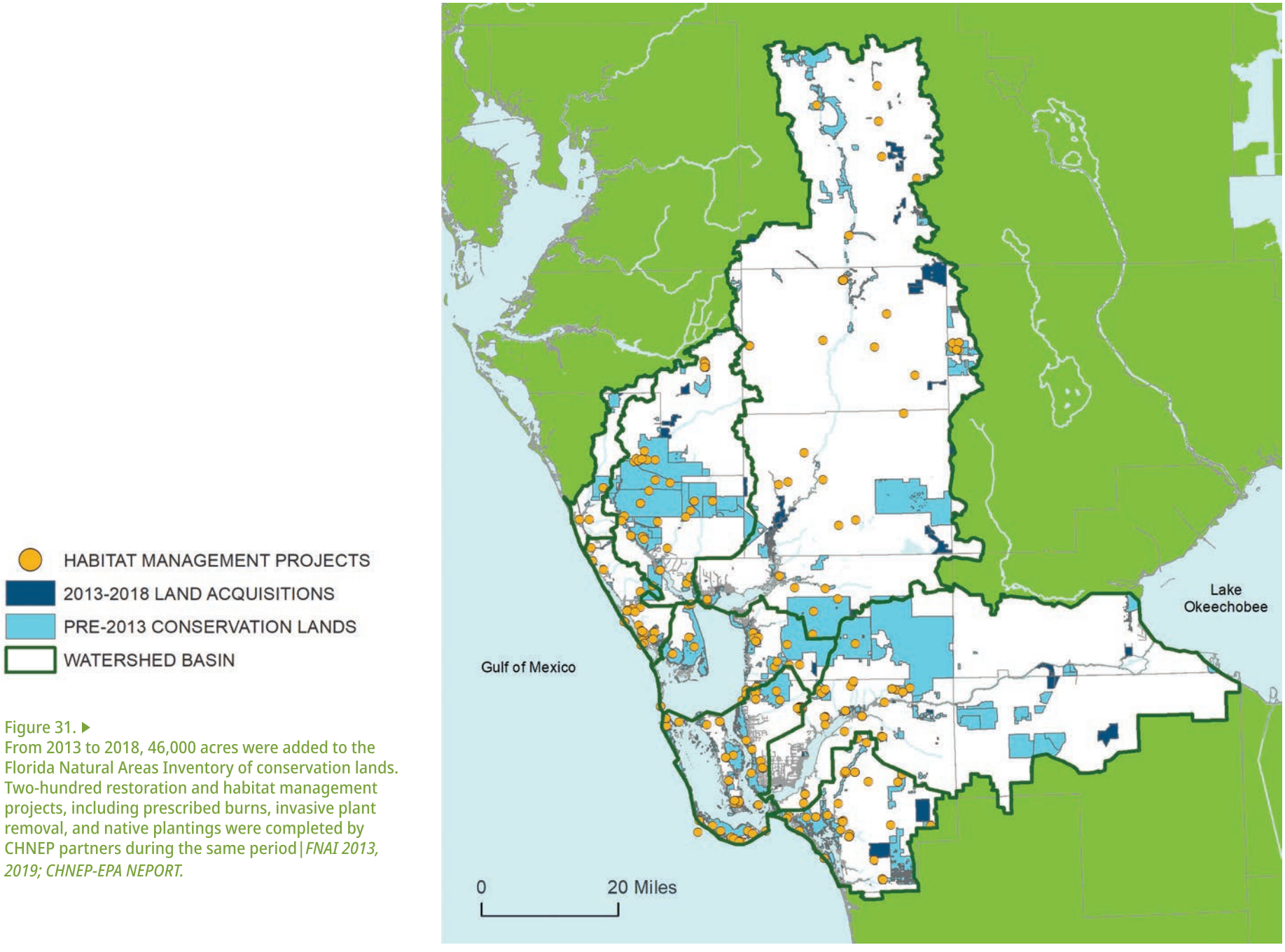


Figure 31. ▶
From 2013 to 2018, 46,000 acres were added to the Florida Natural Areas Inventory of conservation lands. Two-hundred restoration and habitat management projects, including prescribed burns, invasive plant removal, and native plantings were completed by CHNEP partners during the same period | *FNAI 2013, 2019; CHNEP-EPA NEPORT.*

Wildlife Management Areas, such as the 80,000-acre Fred C. Babcock/Cecil M. Webb Wildlife Management Area, are managed by Florida Fish and Wildlife Conservation Commission (FWC). FWC also manages Critical Wildlife Areas (CWA), like Little Estero Island and a small island in the Myakka River critical to wood stork breeding, for the protection of endangered species. In 2016, six CWAs critical to threatened colonial nesting birds were added in the CHNEP area, including three in Pine Island Sound (Broken Islands, Useppa Oyster Bar, and Hemp Key) and three in Estero Bay (Matanzas Pass Island, Big Carlos Pass, and Coconut Point East).

The South and Southwest Florida Water Management Districts own and jointly manage numerous preserves throughout the area, such as the Circle B Bar Reserve with Polk County and Six Mile Cypress Slough Preserve with Lee County. The U.S. Department of the Interior (USDI) through the National Wildlife Refuge System also has holdings in Southwest Florida, including the J. N. "Ding" Darling National Wildlife Refuge Complex.

Counties in the CHNEP area also purchase and manage conservation lands (Table 13). Lee, Charlotte, Sarasota, and Polk Counties all have conservation land acquisition programs approved by voter referendum and financed through dedicated *ad valorem* property tax revenue and other sources. Cities also support local recreational, ecological, conservation, and environmental parks — many located along the waterfront.

In addition to public initiatives, private groups provide leadership and initiate conservation land acquisitions. The Calusa Land Trust and Nature Preserve of Pine Island, Inc., the Sanibel-Captiva Conservation Foundation (SCCF), the Lemon Bay Conservancy, the CREW Land and Water Trust, Conservation Foundation of the Gulf Coast, and others all help to acquire, manage, and preserve in perpetuity environmentally sensitive or historically important land.

In many cases, private lands are protected through purchase of conservation easements, rather than outright fee-simple purchase. A conservation easement is a legal agreement between a property owner and a qualified conservation organization, such as a land trust or government agency.

The easement usually contains permanent restrictions on the use or development of land in order to protect its conservation values. These easement restrictions vary greatly for each agency or organization, as do landowner motivations to offer conservation easements. There are many advantages to conservation easements: property remains in private ownership and contributes to the tax base, flexibility, permanency, property tax reductions, charitable tax deductions, and estate tax reductions (Beever and Walker 2015).

Table 13. Managed conservation lands (acres) in seven counties of the historical CHNEP area include public and some privately-owned lands | *Florida Natural Areas Inventory. Florida Conservation Lands, updated 5-10-2018.*

County	Local	State	Federal	Private	Total	County Area	% Conserved
Charlotte	4,550	172,280	620	110	177,560	444,160	40%
DeSoto	220	46,030	3,050	400	49,700	407,680	12%
Hardee	0	5,360	820	480	6,660	407,680	2%
Lee	41,166	52,940	5,440	3,850	102,396	514,560	20%
Manatee	26,040	30,840	1,090	1,660	59,630	474,240	13%
Polk	17,510	195,440	58,820	19,620	291,390	1,200,000	24%
Sarasota	47,580	60,590	10	880	109,060	366,080	30%
TOTAL	137,066	563,480	69,850	27,000	796,396	3,814,400	21%

▲
Triangle Ranch is a spectacular new addition to protected lands in the CHNEP area. The land is adjacent to Myakka River State Park and hosts three miles of Myakka River shoreline | *Glenn Gardner.*

Acquisitions of conservation lands (2015–2018) include:

- **Blackbeard's Ranch** is a 4,468-acre working ranch located north of Myakka River State Park in Manatee County. The property contains a variety of native habitats and wetland systems, including the headwaters of Deer Prairie Slough that feeds the Myakka River. Three conservation easements covering 85% of the ranch are planned; the first "wetland reserve easement" covering the 1,414-acre Deer Prairie Slough wetland area was purchased for $4 M in 2018 by the National Resources Conservation Service with support from the National Fish and Wildlife Foundation.
- **Edison Farms** is a 3,996-acre property acquired for $42.4 M in 2017 through the Lee County 20/20 land acquisition program. This ecologically important land is located at the confluence of the Estero River, Halfway Creek, and Imperial River and lies within the 60,000+ acre Corkscrew Regional Ecosystem Watershed. The property includes over 3,500 acres of high-quality wetlands, 425 acres of undisturbed native uplands, and habitat for Florida panther and endangered woodstorks. In addition to wildlife and habitat benefits, Edison Farms area also provides significant flood protection, water quality improvement, and aquifer recharge.
- **Triangle Ranch** is a 1,088-acre ranch in Manatee County acquired through a three-way $5.5 M transaction in 2016. The Conservation Foundation of the Gulf Coast established a permanent conservation easement on the property, which was purchased by SWFWMD with Florida Forever funds, coupled with the simultaneous sale of the land to a philanthropic landowner. Triangle Ranch is adjacent to Myakka River State Park and features three miles of Myakka River shoreline and a mosaic of native wetland forests, marshes, and prairie — which support hundreds of species including gopher tortoise, swallow-tailed kite, crested caracara, sandhill crane and Florida panther.

- **Bond Ranch** is a 669-acre property within the Charlotte Harbor Flatwoods Initiative Florida Forever project located northwest of Fort Myers. It was acquired in 2015 for $4 M through the Florida Forever Program. Bond Ranch protects the largest and highest-quality slash-pine flatwoods in Southwest Florida and connects Charlotte Harbor Preserve State Park to the Babcock-Webb Wildlife Management Area. When fully implemented, the project will restore natural sheet flow to Yucca Pens, Prairie Pines Preserve, Gator Slough, and Charlotte Harbor and enhance protection and restoration of native habitats within and adjacent to the parcel.
- **The Corkscrew Regional Ecosystem Watershed** (CREW) Florida Forever project acquired 620 acres in 2015 for $9.8 M, adding to the CREW Wildlife Environmental Area and providing connectivity between three conservation areas. The SFWMD property offers critical protection for wildlife such as the Florida panther and Florida black bear, supports at least two species of rare and endangered orchids and an unusual strain of dwarf bald cypress, and protects wetlands and water flow.

Additional conservation easements acquired include: Lake Pembroke Grassland Reserve Program Conservation Easements (725 acres); Long Island Marsh Wetland Reserve Program Conservation Easements (3,045 acres); Mule Island Wetland Reserve Program Conservation Easements (2,455 acres); Myakka Prairie Conservation Easements (2,259 acres); Candy Bar Ranch Perpetual Conservation Easement (834 acres); and Fussell Farms Perpetual Conservation Easement (384 acres).

CHNEP continues to assist in these efforts by providing letters and comments at public meetings, supporting private land trust projects, and promoting existing federal, state, water management district, and local conservation land acquisition programs, such as:

- Florida Forever;
- Florida Communities Trust;
- Florida Rural and Family Land Protection Program;
- U.S. Fish and Wildlife Service Land and Water Conservation Fund;
- U.S. Department of Agriculture National Resources Conservation Service; and
- Save our Rivers.

Boardwalk at Corkscrew Swamp Sanctuary | *Roy Winkelman, courtesy of ClipPix ETC, Florida Center for Instructional Technology, USF.*

In addition, CHNEP provides funding support for local conservation efforts, assists with the formation and maintenance of local land trusts, provides information and education on behalf of local conservation efforts, and facilitates strategic regional planning for land acquisition targets, including hosting a master restoration database and map files.

▲ Prescribed burn at Charlotte Harbor Buffer Preserve | *Lee County Conservation 20/20.*

Land Management

Once acquired for protection, conservation sites often require restoration. For example, the Wildflower Preserve on Lemon Bay was acquired by Lemon Bay Conservancy in 2010 as an 80-acre abandoned golf course, overgrown with exotic vegetation and cut by a series of culverts and manmade ponds.

FWC identified the golf course waterways to be one of the most productive juvenile tarpon spawning areas in the region, as well as supporting bobcats, otters, and many species of birds. With funds from SWFWMD and NOAA, the site was restored to enhance existing freshwater and estuarine wetlands, added nine acres of estuarine wetlands and five acres of freshwater wetlands, removed exotic vegetation, reestablished tidal connectivity, provided habitat for juvenile tarpon, snook and other species, improved overall ecosystem function, and enhanced recreational opportunities.

Some habitats are not self-sustaining in the absence of natural fire and must be cleared or burned to reestablish stable and functional communities of native plants and animals. For example, a Myakka River State Park Prairie Restoration included 2,278 acres of roller chopping to reduce saw palmetto density and shrub height and increase density of herbaceous vegetation. At Highlands Hammock State Park, a Scrubby Flatwoods Restoration included removing 10,277 sand pines across 1,063 acres to reduce fuel load and increase optimum habitat for threatened Florida scrub jays.

Fire management occurs regularly across CHNEP area watersheds, with partners cooperating to carry out prescribed burns to reduce fuel load and restore species diversity. Between 2015 and 2017, more than thirty prescribed burn projects were carried out on more than 67,000 acres of conservation lands in the CHNEP area, including major annual

Table 14. Habitat restoration opportunities and targets for the CHNEP area by major habitat type | *CHNEP 2019.*

MAJOR HABITAT TYPES	OPPORTUNITIES		TARGETS	
	Preservation / Reservation	Reservation	Management/ Enhancement	Restoration
Uplands	151,080	N/A	207,767	56,092
Freshwater Wetlands	148,781	N/A	181,214	31,952
Tidal Wetlands	9,134	N/A	58,702	86
Non-Native	208,781	1,590	N/A	N/A
TOTAL	517,776	1,590	447,683	88,130

burns at Myakka River State Park and Charlotte Harbor Preserve State Park.

Invasive exotic species removal is an ongoing management activity on conservation lands. Hundreds of feral hogs are removed regularly from State Parks and Preserves to reduce impacts of rooting, including disruptions to water flow and damage to native vegetation that makes areas more susceptible to rapid recolonization by exotic vegetation. Thousands of acres of conservation lands across the CHNEP area are treated each year for invasive vegetation like cogongrass and Brazilian pepper trees.

Restoration Planning

CHNEP's Habitat Restoration Needs Plan (CHNEP 2019) guides habitat preservation/conservation, connectivity, management, restoration, sustainability, and resiliency throughout the CHNEP area.

The Plan identifies preservation/conservation and reservation opportunities, as well as management/enhancement and restoration targets, in each area (Table 14). Full implementation of the Plan will have substantial positive impacts on the long-term sustainability of water quantity, water quantity, natural systems, and species populations. The Plan articulates CHNEP's habitat restoration vision for the next 50 years of "A diverse environment of interconnected, healthy habitats that support natural processes and viable and resilient native plant and animal communities."

The overarching goal of the Plan is to increase the acreages of native habitats in the CHNEP area, both strategically and opportunistically. In support of this goal, several alternative approaches to developing quantitative habitat targets were assessed and evaluated. Several types of information were considered including habitat status and trends analysis; existing preservation and conservation lands; proposed land acquisition priorities; listed species critical habitats and migratory corridors; river floodplain functions; long-term trends in freshwater flows; historical soils distributions; projected sea level rise; and modeled coastal habitat migration in response to sea level rise.

Feral hogs are ▶ an important land management concern in the CHNEP area. Wallowing, rooting, and predatory behaviors knock down and trample native vegetation, cause erosion, degrade water quality, and impact ground-nesting wildlife | *Pedro Mendes.*

Major recommendations include:

- Increase existing acreage of preservation and conservation areas to 17 percent of the watershed, or 521,148 acres;
- Reserve less than one percent of the watershed, or 1,590 acres, to accommodate future coastal habitat migration due to sea level rise; and
- Increase restored areas by 88,130 acres and increase managed or enhanced areas to 447,683 acres in order to offset projected habitat losses due to development, climate change and sea level rise, and other stressors.

The HRNP will coordinate with FWC's Critical Habitat Conservation Plan to identify multi-partner opportunities and priorities and it will assist local, regional, state and federal agencies, and organizations to identify, plan, and implement habitat restoration and land acquisition projects needed to achieve CHNEP habitat restoration goals and vision.

STATUS:

Ongoing. Previous 2013–2018 CHNEP-CCMP Fish and Wildlife Actions FW-C, FW-F, FW-H, FW-I, FW-L, and FW-M and Stewardship Gaps Action SG-N are combined here and updated to incorporate new information on land acquisitions, management activities, restoration projects, and planning. Previous Actions FW-N and FW-P are addressed in the new Public Engagement Action Plan. Previous Action FW-K related to acquisition of Babcock Ranch was completed and retired. The 2013–2018 CCMP Quantifiable Objective FW-2 (an interim 5-year goal) was met with 565,000 acres of environmentally sensitive lands conserved across the CHNEP area. Quantifiable Objectives FW-1 and FW-3 from the 2013–2018 CCMP are carried forward and updated as Performance Measures.

RELATED ACTIONS:

- Hydrological Restoration Action 2: Increase fresh surface water and groundwater availability to support healthy natural systems
- Hydrological Restoration Action 3: Protect and restore natural flow regimes

ACTIVITIES:

Encourage and support the permanent conservation of environmentally sensitive lands and critical habitat areas through land acquisition and conservation easements held in perpetuity, including freshwater wetlands, flowways, corridors, and uplands adjacent to coastal habitats necessary for habitat resilience and migration.

Location: CHNEP area with a focus on protecting habitats and migration corridors as recommended by HRNP.

Responsible parties: County and Municipal Governments, Florida Forever, SWFWMD, SFWMD, Land Conservation NGOs, FWC, USFWS, NOAA, FDACS, FDEP, USDA-NRCS.

Timeframe: Ongoing; Habitat Restoration Needs Plan adopted in 2019; Monitoring Strategy to be adopted in 2020.

Potential annual cost and funding sources: >$10M/State of Florida: Florida Forever and other programs, County and Municipal Governments, Land Conservation NGOs, Landowners, SWFWMD, SFWMD, USFWS, FWC, NOAA, FDACS, FDEP, USDA-NRCS.

Benefits: A diverse environment of interconnected, healthy habitats that support natural processes and viable and resilient native plant and animal communities.

5-year Performance measures:

- Updated and adopted Habitat Restoration Needs Plan that includes priority projects.
- Increased acreage of conserved land.

Encourage management of public lands and private lands with public conservation easements to protect, restore, and create native plant and animal communities, including eradication of invasive exotic species, prescribed fire, and other appropriate management activities.

Location: CHNEP area with a focus on protecting habitats and migration corridors as recommended by HRNP.

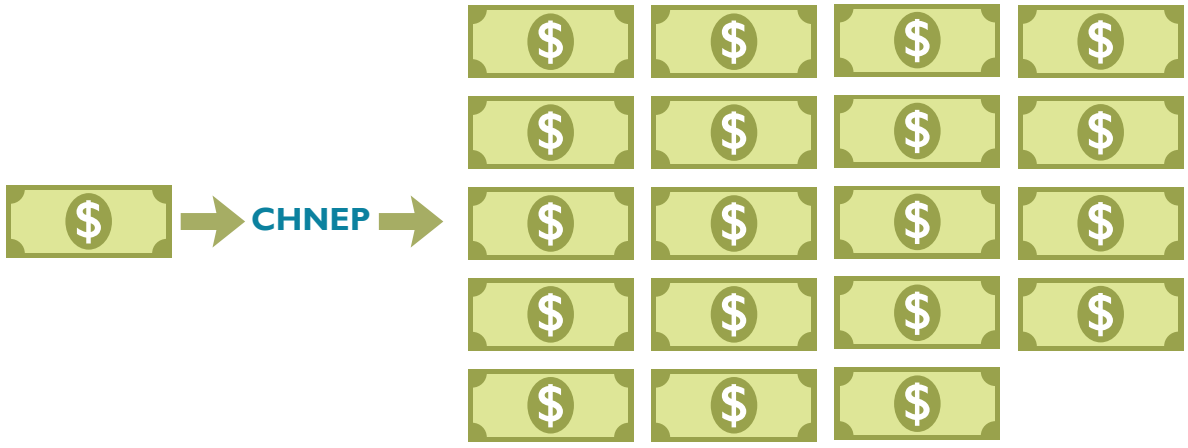
Responsible parties: County and Municipal Governments, FDEP, Land Conservation NGOs, Landowners, FWC, USFWS, SWFWMD, SFWMD, FDACS, FDEP, USDA-NRCS.

Timeframe: Ongoing; Habitat Restoration Needs Plan adopted in 2019; Monitoring Strategy to be adopted in 2020.

Potential annual cost and funding sources: $1M–10M/ County and Municipal Governments, FDEP, FWC, USFWS, SWFWMD, SFWMD, FDACS, FDEP, USDA-NRCS.

Benefits: Effective management practices resulting in improved resource protection.

5-year Performance measure: Increased acres of restored aquatic, wetland, and upland habitat and habitat under maintenance phase management.



For every $1 of federal funding received by CHNEP, $19 of restoration is achieved, thanks to public-private partnerships with private individuals and organizations who donate time, money, and materials.

3

Assess and promote the benefits of land, waterway, and estuary protection and restoration

OBJECTIVES:

Assist in assessing and promoting the economic, social, and environmental benefits of land protection and habitat restoration.

BACKGROUND:

Conservation, preservation, and stewardship of environmentally sensitive lands provides significant economic, social, and environmental benefits to local and regional areas in the form of ecosystem services (Beever and Walker 2014). Florida communities with the most expansive areas of conservation lands tend to enjoy both an increased quality of life and an enhanced tax base from adjacent private lands. The presence of conservation lands can reduce infrastructure needs, including transportation, health care, public safety, and utility services — saving local governments and taxpayers millions of dollars in capital improvements and operating costs. Conservation and agricultural lands generate net positive revenue through associated taxes, fees, and tourism support. For example, the one-time purchase price of conservation lands in the Estero Bay Basin is equivalent to one-third of tourist spending related to those lands in a single year (Beever 2013). Hunting, fishing, and non-consumptive outdoor recreational activities are a major contributor to Coastal and Heartland Southwest Florida tourist industries. The economic, social, and environmental benefits of land conservation and habitat restoration should continue to be assessed and promoted (see Public Engagement Action Plan).

STATUS:

Ongoing. Previous 2013–2018 CHNEP-CCMP Fish and Wildlife Action FW-J is updated to incorporate new information on cost-benefit and ecosystem services of land conservation.

◀ Florida Fish and Wildlife Conservation Commission and Big Cypress National Preserve annually capture panthers to assess their health and fit them with radio collars | *Ralph Arwood.*

RELATED ACTIONS:

- Fish, Wildlife, and Habitat Protection Action 1: Protect, restore, and monitor estuarine habitats
- Fish, Wildlife, and Habitat Protection Action 2: Protect, restore, and monitor environmentally sensitive lands and waterways including critical habitat areas
- Public Engagement Action 1: Promote environmental literacy, awareness, and stewardship through expanded education and engagement opportunities for the general public
- Public Engagement Action 4: Increase outreach to policymakers to enhance understanding and support for CCMP implementation

ACTIVITY:

Assist in assessing and promoting the economic, social, and environmental benefits of land protection and habitat restoration, including as a response to climate stressors.

Location: CHNEP area.

Responsible parties: CHNEP, Land Conservation NGOs, NOAA, Colleges and Universities, SWFRPC, FDEO, County Visitors Bureaus, County Land Conservation Programs.

Timeframe: Ongoing; Climate Change Vulnerability Analysis adopted in 2018; Communication and Outreach Strategy to be adopted in 2020.

Potential annual cost and funding sources: $100,000–$499,999/CHNEP, Land Conservation NGOs, Visit Florida, SWFRPC, FDEO, County Visitors Bureaus, County Land Conservation Programs.

Benefits: Increased public support for land protection and habitat restoration. Recognition of the social and economic benefits of nature-based tourism and recreation.

5-year Performance measure: Updated cost-benefit and/or ecosystem services analyses of ecosystem protection and restoration.

PUBLIC ENGAGEMENT ACTION PLAN

VISION: An informed, engaged public making choices and taking actions that increase protection and restoration of estuaries and watersheds.

GOAL: Public education and engagement.

OBJECTIVE: Increase the proportion of the population that supports and participates in actions to protect and restore estuaries and watersheds.

STRATEGY: Promote environmental awareness, understanding, and stewardship to the general public, new target audiences, and policymakers; and strengthen non-profit partner collaboration in education and engagement programs.

ACTION 1: Promote environmental literacy, awareness, and stewardship through expanded education and engagement opportunities for the general public

ACTION 2: Engage underrepresented and underserved communities, businesses, and other priority stakeholders in estuary and watershed protection activities and educational programs

ACTION 3: Strengthen non-profit partner collaboration in education and engagement programs

ACTION 4: Increase outreach to policymakers to enhance understanding and support for CCMP implementation

◀ Volunteer shows off her collection during an Alligator Creek cleanup, one of CHNEP's monthly volunteer events.

The Goals and Objectives of the CCMP are rooted in sound science and measured results; but for the general public, scientific information is often difficult to access and understand. CHNEP and its partners work to present science-based initiatives and progress toward accomplishing CCMP Goals and Objectives in ways that are meaningful and easy to understand by all stakeholders, including policymakers. Implementation of the CCMP is only successful if initiatives and results are understood, valued, and used by public officials, educators, and private citizens. Sharing effective public outreach methods increases environmental knowledge and awareness exponentially across partner networks.

Table 15. Population growth and projections for the seven counties in the historical CHNEP area | *U.S. Census Bureau data provided by the Florida Office of Economic and Demographic Research.*

COUNTY	1977	1987	1997	2007	2017	2027
Charlotte	44,313	88,230	131,307	164,584	172,720	192,705
DeSoto	17,973	22,890	27,224	33,983	35,621	37,097
Hardee	17,407	22,095	22,447	27,520	27,426	27,914
Lee	172,330	293,713	394,244	615,741	698,468	853,851
Manatee	129,313	181,684	241,422	315,890	368,782	449,461
Polk	279,574	389,056	459,010	581,058	661,645	790,999
Sarasota	170,621	251,253	311,043	387,461	407,260	463,610
TOTAL	831,531	1,248,921	1,586,697	2,126,237	2,371,922	2,815,637

Many issues addressed in the this CCMP's Action Plans for Water Quality Improvement, Hydrological Restoration, and Fish, Wildlife, and Habitat Protection require effective public communication and engagement. Increased public understanding of these issues, together with opportunities for public participation in their solutions, can lead to better individual choices and actions that increase protection and restoration of estuaries and watersheds.

Southwest Florida is one of the fastest growing regions in one of the fastest growing states in the nation. Over the last forty years, the population of the seven-counties in the historical CHNEP area has almost tripled, with the greatest growth occurring in the coastal counties of Charlotte and Lee (Table 15). Rapid growth and development in the area are expected to continue, with the total population of the historical CHNEP seven-county area projected to grow by 18.7% in the next decade.

Visitors further add to the total population and its impact on natural ecosystems, especially in the coastal counties. For example, in 2017 Lee County received 4.8 million visitors, seven times the number of permanent residents, or about 443 thousand visitors per month during the peak Spring season. In 2017, total visitor expenditures in Lee County exceeded $3 billion and total revenue to local government was almost $180 million. These striking statistics point to both the impacts and opportunities for public engagement on environmental issues.

Many tourists and seasonal residents return to Central and Southwest Florida over many years, and some decide to move here permanently. Surveys indicate that beaches remain the top attraction for both domestic and international visitors. Other popular natural attractions include touring regional botanical gardens, canoeing and freshwater fishing at Winter Haven Chain of Lakes and the Peace and Myakka Rivers, camping in the area's numerous State Parks and private campgrounds, boating and fishing around Charlotte Harbor and Estero Bay, and shelling and bird watching.

◀ Holiday weekend on Dog Island in Gasparilla Sound. Boating is a popular recreational activity throughout the CHNEP area. Growing population size and tourism present challenges for waterfront recreation areas|*Neil Heisner.*

In 2017, there were over 145,000 registered boats in the seven-county historical CHNEP area (Table 16). The attraction to the outstanding natural environment of the area creates a tremendous outreach opportunity.

Many new and seasonal residents may be familiar with common environmental issues and problems, but often can lack specific understanding of Florida's ecology and management requirements. Many residents do not see their personal connection to impacts or solutions. Understandably, it is difficult to envision the cumulative impacts of what seem to be isolated, individual actions.

Public exposure to environmental issues occurs most commonly through the media, such as when Red Tide washes tons of dead fish onto beaches, rivers are choked with neon-green algal blooms, beaches are closed with health warnings, or shellfish are contaminated and inedible. It is important to deepen and broaden public awareness and knowledge of these issues, as well as to promote how individual actions can improve or degrade the natural environment. Public education through outreach and volunteer engagement is an ongoing necessity as a steady stream of new residents continue to make Central and Southwest Florida their home every year.

Public education and volunteer engagement efforts typically target the general public. To address specific problems, information must be tailored to specific audiences associated with the solutions, for example specific industries, boaters, or fishers. Some important target audiences are difficult to reach. These underrepresented and underserved audiences can be engaged through more targeted outreach that meets them where they are and addresses their interests and values in easily understandable language.

Table 16. Number of registered boats by county in the historical CHNEP area in 2017|*Florida Department of Highway Safety and Motor Vehicles.*

	BOAT TYPE			
COUNTY	Pleasure	Commercial	Dealer	Total
Charlotte	22,153	575	94	22,822
De Soto	2,211	84	3	2,298
Hardee	1,646	21	3	1,670
Lee	46,354	1,153	269	47,776
Manatee	18,757	714	133	19,604
Polk	28,321	457	47	28,825
Sarasota	22,138	396	217	22,751
Total	141,580	3,400	766	145,746

◀ CHNEP staff attend outreach events throughout the CHNEP area to share information and volunteer opportunities with the public.

Reaching different stakeholder groups requires the use of a variety of media and outreach methods.

- Websites and magazines can have a wide reach and can effectively explore foundational concepts about watersheds and estuaries and how human activities play a role in their health.
- Social media offers useful ways to convey smaller amounts of information quickly and remind people about upcoming events, best practices, and CHNEP successes.
- Events offer person-to-person learning opportunities and community access to multiple organizations at the same time. They leverage and highlight partnerships, showcasing collaborative efforts and partner programs. They also allow for audience feedback through surveys and interviews.
- Outdoor volunteer activities offer hands-on exposure to the natural world, providing immersive educational opportunities for participants to see first-hand how they are connected to their watershed.
- Workshops and conferences bring experts, stakeholders, and interested citizens together to learn about and discuss relevant issues and innovations. They often spark new ideas, partnerships, and action towards projects and solutions.

CHNEP hosts ▶ conferences like the Watershed Summit to discuss priority issues and share the latest science with partners and the public.

As digital technology and norms about how people receive and share information continue to change, it will be essential to routinely assess the best communication channels.

Often, gaps in stewardship are correlated with gaps in actionable information. Scientists need long-term monitoring and data management strategies in order to analyze changes to the environment. Resource managers need analysis of the best available data to create sound management plans. Government leaders need trusted advisors and solid management plans to help them make effective policy decisions in a policy framework of competing community priorities. Residents need information that is compelling and useful to help make better choices that may be personally more expensive or less convenient. Effective stewardship requires more than just access to information — it requires translation and transfer of that information in ways that resonate with the community's identity, values, and sense of responsibility and pride.

Public Engagement Challenges and Management Actions

Encouraging individual behaviors that reduce cumulative impacts is one of the most valuable ways to protect and restore estuaries and their watersheds. CHNEP plays an important role in promoting education and engagement opportunities across the entire community both directly and by building the capacity of local non-profit and community organizations to deliver collaborative programs in environmental education and citizen science.

This Public Engagement Action Plan focuses on the public education and outreach capabilities of CHNEP staff to implement four public engagement actions: Action 1 calls for promoting environmental literacy, awareness, and stewardship through expanded education and engagement opportunities for the general public. Action 2 aims to expand the reach of education and engagement opportunities to new target audiences. Action 3 works toward strengthening non-profit partner collaboration in education and engagement programs. Action 4 seeks to increase outreach to policymakers to enhance understanding and support for CCMP implementation.

Promote environmental literacy, awareness, and stewardship through expanded education and engagement opportunities for the general public

OBJECTIVES:

Continue to support educational activities that focus on key messages communicated in readily understandable language related to priority issues, including water quality, hydrology, habitat, and wildlife. Provide CHNEP volunteers with activities to participate in research, monitoring, restoration, and public outreach.

BACKGROUND:

Watershed-scale educational outreach is important for the CHNEP. The CHNEP area is vast and includes residents who may not implicitly realize their connection or impact to downstream waterways, habitats, and wildlife. Educating the general public about estuary and watershed issues through a mosaic of tools and distribution channels will expand awareness, create a sense of place, encourage stewardship, and empower communities to take positive environmental actions. CHNEP has a relatively small staff that must cover a large area. Supplementing staff initiatives with organized community-driven support and coordinating with the outreach programs of agencies, counties, and municipalities is vital for educational initiatives to promote healthy, well-functioning ecosystems.

Because population growth in Central and Southwest Florida increases the burden on local resources, reaching new residents in growing communities is a growing public engagement priority. To address this issue, CHNEP participated in developing new resident packages and a guide to summarize information on CHNEP area ecosystems and their stewardship. This information should be updated and redistributed by utilities, libraries, parks, Chambers of Commerce, county extension offices, government administrative offices, car and boat registration departments, and local civic and business organizations.

There is an ongoing need to provide educational outreach to students, as many of them will play a key role in the future management and protection of Central and Southwest Florida ecosystems. There are over 300,000 K–12 students enrolled in public schools throughout seven school districts in the historical CHNEP area, and there are six public colleges and universities and many private ones as well. Non-profit and citizen organizations and government agencies also provide informal educational programming.

◀ CHNEP volunteers receive training on water quality testing | *Gary Brownell*.

Events and Educational Content

CHNEP has offered many programs and opportunities to increase environmental literacy among diverse stakeholder groups, including the following examples of communication tools and partnerships that leverage resources to increase overall reach.

Nature Festival

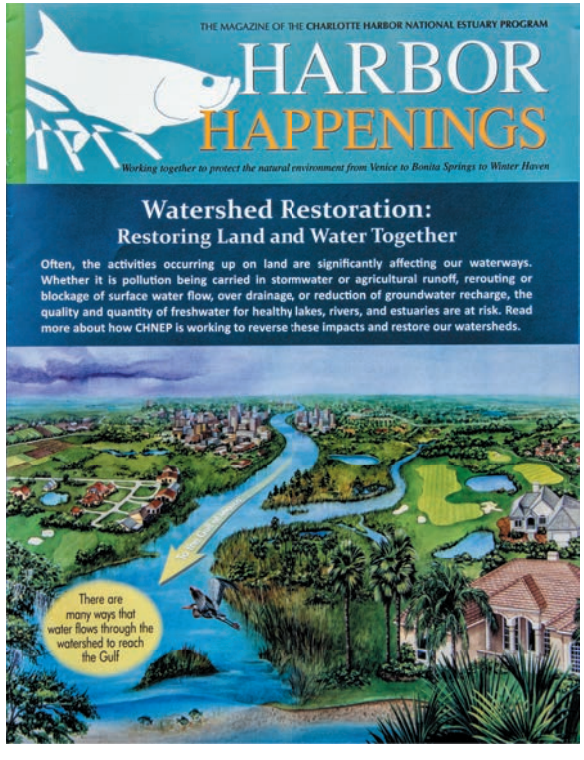
CHNEP hosted an outdoor educational festival for many years. The popular free event enabled residents and visitors to visit educational booths, go on guided nature hikes, experience hands-on-learning activities, and create nature-inspired arts and crafts, while enjoying live music in a family-friendly setting. The 2017 Festival showcased over 40 environmental non-profits, government agencies, and businesses that shared their expertise and enthusiasm with more than 1,500 attendees. From 2013–2018, the Festival engaged approximately 6,000 people, ranging from the general public to environmental professionals and policymakers.

Children's Book

In 2008, CHNEP published *Adventures in the Charlotte Harbor Watershed: A Story of Four Animals and Their Neighborhoods*, a 64-page book that explores different Southwest Florida environments. Written by Carol Mahler and illustrated by Rachel Renne, the story follows a yellow-crowned night-heron on the Caloosahatchee River, an alligator on the Peace River, an otter on the Myakka River, and a mullet in the estuaries. Public-school students throughout the CHNEP area received copies of the book. It has also been given to private schools, home school associations, and summer camps. Now in its ninth edition, the book has been adapted into a series of YouTube read-along videos and will be developed into online e-learning modules with correlations to Florida educational standards for 3rd grade STEM so that chapters can be incorporated into educator lesson plans. In 2016, CHNEP was recognized as the Conservation Organization of the Year by the Florida Wildlife Federation for its outreach and education to students as a result of the book.

Citizens Academy

In 2015, CHNEP and WGCU Public Media collaborated on a YouTube video series to provide information about environmental topics in Southwest Florida. The six-video series covers general information about the natural environment, weather, water habitats, stewardship, and ways to contribute to protecting and restoring the environment. The videos feature experts from various environmental fields and focus on specific audiences using targeted messaging.



▲
171,000 copies of *Harbor Happenings* educational magazines were distributed between 2013 and 2018.

Publications

- CHNEP creates and distributes large format illustrated posters to help explain topics like estuaries, shellfish, water flow, and watersheds.
- CHNEP produces and distributes 35,000 educational calendars each year featuring donated photographs that highlight the beauty and natural wonder of local watersheds. The popular calendar provides environmental education and encourages people to become more engaged with their local environment and CHNEP.
- CHNEP publishes a quarterly magazine, *Harbor Happenings*, that highlights news, programs, and events happening at the CHNEP as well as environmental topics related to CCMP implementation. Between 2013 and 2018, 171,000 copies were distributed to the public.

Website and Social Media

CHNEP curates its website to provide information about educational resources, current projects, meetings, grants, volunteer opportunities and other ways to get involved in restoration and protection activities.

Educational information is also distributed on various social media channels including:

- Over 400 videos and presentations on YouTube;
- Events on Eventbrite;
- Weekly Facebook updates about projects and other related topics. Beginning in 2016, CHNEP's Facebook Page has grown to 1,005 followers in 2018; and

THE CHNEP WATER ATLAS

chnep.wateratlas.usf.edu

CHNEP contracts with the University of South Florida (USF) to maintain and update the CHNEP Water Atlas, an online tool and database that hosts current and historical technical information, data, maps, photos, resource management reports, news, and volunteer opportunities related to watersheds in the CHNEP area.

The CHNEP Water Atlas is designed and maintained for scientists, resource managers, policymakers, and the public. The user-friendly site offers access to a clearinghouse of primary data that address water quality, hydrology, habitat, and public engagement initiatives.

From 2012–2018, the CHNEP Water Atlas recorded 240,270-page visits and 70,842 unique site visits, tripling the number of previous users.

- An active Constant Contact email list that has grown by 3,245 subscribers between 2013 and 2018. Subscribers are notified about Management Conference meetings, events, and public-comment and draft report review requests.

Special Places Map

Hosted online by Lee County, CHNEP provides an interactive, online map tool that identifies available amenities like boat ramps, hiking trails, birding, pet friendly activities, and camp sites. Users can search by location to see what amenities are available, or by desired activities.

Partner Educational Resources

CHNEP promotes its partners' programs that inform the public about priority issues, like fertilizer, pet waste pollution, Florida-friendly yards, and invasive species. There is an ongoing need to reinforce these issues and provide readily understandable content that informs people about the topic and offers solutions and resources to encourage behavior change.

The Florida Yards and Neighborhoods Program, developed by the University of Florida Institute of Food and Agricultural Sciences (UF/IFAS), encourages homes and businesses to reduce their water and chemical fertilizer needs by employing nine Florida-Friendly Landscaping™ principles. The program highlights the use of Florida native and Florida-friendly plants that are adapted to local climate and soil conditions. They provide online resources and a list of plants suitable for the CHNEP area. Every year since 2005, CHNEP has coordinated a conservation landscaping workshop for residents in Hardee, DeSoto, and Highlands counties. This fills an important gap, as these areas do not have UF/IFAS staff capacity to inform the public about Florida-Friendly Landscaping™, nor do they have an active chapter of the Florida Native Plant Society.

There is also a need to update resources addressing exotic and invasive plants and animals that target both managers and the public, as well as a need for collaborative efforts focused on early detection, consistent messaging, and holistic, adaptive management strategies. Regional Cooperative Invasive Species Management Areas (CISMA) provide education, outreach, and leveraged resources to help minimize and eliminate impacts of invasive, non-native species on public and private lands. CISMA is a coalition of local, state, and federal agencies, local land conservancies, local chapters of the Audubon Society, U.S. Fish and Wildlife Service, Florida State Park Service, FDEP, SWFWMD and SFWMD, and the Florida Department of Agriculture.

To date, CISMA outreach strategies have included an Exotic Pet Amnesty Day, workdays at parks and preserves in multiple counties, public workshops on invasive

CHNEP staff utilize outreach materials produced in-house and by partners to inform the public about priority issues and volunteer opportunities. ▼

species, continuing education and training for field staff, and development of a clearinghouse for members' educational resources. Additional support for this volunteer-based coalition could help expand the group's capacity and contribute to consistent educational messaging to residents, especially those new to Florida, about problems associated with invasive species.

Citizen Science, Stewardship Training, and Volunteer Engagement

Hands-on environmental stewardship enhances understanding of human-nature connections through experiential learning and motivates individuals to be more environmentally mindful in their everyday lives. CHNEP aims to increase public understanding and responsibility for Central and Southwest Florida's environment by offering more opportunities, including citizen science activities, community cleanups, and workdays. Integrating stewardship into a weekend outing or a regular activity can strengthen the public's association between everyday behaviors — and their impacts on nature.

Two programs developed by UF/IFAS Extension offer stewardship training opportunities in the CHNEP area:

- **Florida Master Naturalist Program** educates adults on environmental topics like coastal, freshwater, and upland systems, conservation science, environmental interpretation,

habitat evaluation, and wildlife monitoring. This training combines classroom modules with field exercises to build foundational environmental knowledge and understanding, especially for those who serve as informal educators, tour guides, and natural resource managers.

- **Florida Waters Stewardship Program** explores local water-related topics and strives to increase understanding about how communities are connected to their waterways. Participants learn from water resource experts and work together on a stewardship project during the course.

CHNEP hosts monthly volunteer events to engage citizens in stewardship activities and CHNEP projects. Examples include paddle cleanups, horseshoe crab monitoring, bird surveys, invasive exotic plant removals, marsh plantings, seagrass gardening, marine debris surveys, and water quality sampling training where participants take home field kits to test and report about waterways in their neighborhoods. As of 2018, CHNEP's volunteer corps includes 490 enthusiastic citizen scientists.

Ongoing citizen science programs in the CHNEP area include:

Marine Debris Monitoring – Microplastics

CHNEP offers citizen science opportunities to survey microplastics on beaches and in waterways as part of a collaborative regional monitoring initiative with Florida Sea Grant and NOAA. During coastal cleanup events, volunteers collect sediment and water samples for lab analysis. Microplastics are sorted by type and size, and data are shared with resource managers and scientists. Sampling in the CHNEP area in 2017 found microplastics in 86% of the samples collected. Microfiber from synthetic clothing was the most common type of microplastic found.

Seagrass Gardening

CHNEP, with support from FDEP, engages citizen science volunteers from CHNEP and Calusa Waterkeeper, and Environmental Studies students from Florida Gulf Coast University in monitoring and growing seagrass in the Caloosahatchee River. Volunteers raise tape grass and widgeon grass shoots inside mesh cages to establish seed-source colonies at five locations on the north and south sides of the tidal portion of the Caloosahatchee River. Seeds are then used to help restore seagrasses downstream along a 13-mile stretch between downtown Fort Myers and the Franklin Lock. Public outreach focuses on engaging citizens in restoration efforts and building an understanding of the value of seagrass habitats and the threats they face.

◀◀◀ Left to right.

Citizen scientists count microplastic particles from a sand sample collected at the beach.

Citizen scientist collects a sand sample at the beach.

Volunteers meet to learn standard procedures for collecting water samples for water quality analysis.

Oyster Reef Building and Monitoring

In 2012, CHNEP identified a need in their Oyster Habitat Restoration Plan (see Fish, Wildlife, and Habitat Protection Action 1) to conduct long-term restoration monitoring. In partnership with The Nature Conservancy and Charlotte Harbor Aquatic Preserves, CHNEP created the Volunteer Oyster Habitat Monitoring Program (VOHMP) to monitor the Trabue Harborwalk oyster restoration site in Punta Gorda on the Peace River and to assess other existing restoration sites within the CHNEP area. As of 2018, 42 volunteers, contributing 778 hours, have been trained in water quality monitoring, oyster counting and measuring, bird surveys, and data entry. In November of 2017, the group hosted its second restoration monitoring event for the oyster reefs at Trabue Harborwalk. Citizen science efforts have expanded to include weekly salinity measurements and support from Peace River Audubon Society members in monitoring bird usage of the area.

▲
CHNEP volunteer monitors oysters from the Trabue Harborwalk oyster restoration.

1,776
Volunteer hours donated since 2017

Watershed Education Training - Ponds, Lakes, And Neighborhoods (WETPLAN)

In 2012, CHNEP and partners developed the WETPLAN program to help homeowners enhance the health and quality of nearby stormwater ponds and lakes. Free workshops, tools, and resources are used to inform residents about their waterways. During a 3-hour workshop and group discussion, participants learn how to maintain appropriate plants or trees along their ponds, restore shorelines to reduce erosion, manage weeds, and foster increased water quality and habitat features to support local birds, fish, and other wildlife. From 2013–2017, CHNEP hosted 20 workshops with over 550 participants, including 2 neighborhood specific workshops. The program continues to expand with plans to include more modules and adaptations for other counties.

Charlotte Harbor Estuaries Volunteer Water Quality Monitoring Network (CHEVWQMN)

The CHEVWQMN is a monthly citizen science opportunity to monitor water quality and other field conditions for 50 sites in Lemon Bay, Cape Haze/Gasparilla Sound, Charlotte Harbor, Pine Island Sound, Matlacha Pass, San Carlos Bay, Estero Bay, and the Tidal Myakka and Myakka Rivers. Coordinated by FDEP-CHAP and Estero Bay Aquatic Preserve (EBAP), volunteers go out within an hour of sunrise to collect data on 13 water quality parameters. CHNEP supports this effort through volunteer recruitment and training, sample transport, data access through the CHNEP Water Atlas, and participation in biannual Quality Assurance training sessions. In addition, CHNEP supports volunteer water quality monitoring in neighborhood stormwater ponds and canals through the Lee County Hyacinth Control District's Pond Watch and Cape Coral's Canal Watch.

Tidal Shoreline Survey

In support of CCMP objectives to protect and restore mangroves, CHNEP conducted volunteer shoreline surveys (in conjunction with aerial photography) in 2007, 2010, and 2013. Surveys identified coastline conditions from Venice to Estero Bay, including the tidal Peace, Myakka, and Caloosahatchee Rivers with respect to the status and extent of mangroves, hardened infrastructure, and exotic and invasive species. This baseline information will be used to help identify development impacts, areas suitable for protection and restoration, and needs for long-term planning.

These citizen science opportunities fill an important gap in capacity for research, monitoring, communication, and restoration and highlight management efforts by CHNEP and its partners. In a media landscape crowded with competing problem-based messages, stewardship activities bring participants into a solution space, which can spark innovation, a sense of ownership and commitment, and ultimately motivate environmentally beneficial behaviors.

STATUS:

Ongoing. Previous 2013–2018 CCMP Stewardship Gaps Actions SG-B, SG-D, SG-F, SG-H, SG-I, and SG-J; previous Fish and Wildlife Habitat Actions FW-N and FW-P; Hydrologic Alteration Action HA-P; and Water Quality Actions WQ-K, WQ-L, and WQ-M are combined here and updated to incorporate CHNEP activities and accomplishments. Quantifiable Objective SG-4 from the 2013–2018 CCMP is carried forward and updated as a Performance Measure.

RELATED ACTIONS:

- Public Engagement Action 2: Expand reach of education and engagement opportunities to new target audiences
- Public Engagement Action 3: Strengthen non-profit partner collaboration in education and engagement programs
- Public Engagement Action 4: Increase outreach to policymakers to enhance understanding and support for CCMP implementation

ACTIVITIES:

Support programs, events, presentations, and educational content that focus on key messages communicated in readily understandable language related to protection and restoration of estuaries and watersheds, including water quality, hydrology, habitat, and wildlife issues.

Location: CHNEP area.

Responsible parties: CHNEP.

Timeframe: Ongoing; Finance Strategy to be adopted in 2020; Communication and Outreach Strategy to be adopted in 2020.

Potential annual cost and funding sources: $25,000–$99,999/CHNEP, 320 Funds, Grants.

Benefits: Increased public environmental awareness, understanding, and stewardship; increased support for management activities.

5-year Performance measure: 10 research, restoration, or outreach initiatives showcased in educational materials, presentations, or at public events annually.

Provide CHNEP volunteers with activities to participate in research, monitoring, and restoration.

Location: CHNEP area.

Responsible parties: CHNEP.

Timeframe: Ongoing; Finance Strategy to be adopted in 2020; Communication and Outreach Strategy to be adopted in 2020.

Potential annual cost and funding sources: < $25,000/CHNEP, 320 Funds.

Benefits: Increased public environmental awareness, understanding, and stewardship; increased support for management activities; increased scientifically-sound monitoring data; improved water and habitat quality.

5-year Performance measure: At least 10 CHNEP volunteer activities hosted annually.

Expand reach of education and engagement opportunities to new target audiences

OBJECTIVES:

Engage underrepresented and underserved communities, businesses, and other priority stakeholders in estuary and watershed protection activities and educational programs.

BACKGROUND:

Active retirees make up a high percentage of participants who attend CHNEP events and volunteer activities. Families are another significant source of volunteers, along with students fulfilling community service requirements. We need to expand educational outreach to new audiences on a broad array of watershed issues and increase hands-on training and participation in stewardship activities.

Underrepresented and underserved segments of the population can be difficult to reach by traditional methods. Some are constrained by low income, language barriers, and cultural differences. Strategies for increasing educational outreach and engagement among these groups focus on connecting with them where they work and play and using readily understandable language. Multilingual materials and programs can help cross language barriers, and framing issues in terms of their values can help make messaging more relevant. Self-organized groups within minority communities — such as faith groups, community and youth centers, and large employers — can be engaged with specific events. Personal connections, especially with community leaders, are critical for establishing trust, maintaining outreach connections, and building CHNEP ambassadors.

CHNEP's outreach to underserved communities occurs primarily through support of community groups through grants programs (see Public Engagement Action 3). CHNEP has supported youth experiences, such as Big Brothers Big Sisters of the Sun Coast's Cedar Point wading trip, Englewood Sailing Club's youth sailing camps, the "Real in the Fun" Kids' Pier Fishing Tournament, and the Happe Teen River Lab and Eco Camp that hosted students from farm worker families. CHNEP has also helped fund larger projects serving minority communities, such as the Harlem Heights Elementary School Outdoor Classroom, which provides hands-on learning to 1,100 children by creating an outdoor learning environment in a mangrove forest. Since 2000, CHNEP has encouraged student participation in regional science fairs throughout the area through recognition and cash prizes for outstanding projects that address estuary and watershed science.

Other priority target audiences include the business sector, farmers, fishers, boaters, environmental consultants, miners, farmers, developers, real estate agents, and hospitality workers. Some of these audiences may be difficult to reach because they have other priorities or interests and may not have strong connections with existing environmental messaging, spokespeople, or events. Like underserved communities, these diverse stakeholders can be engaged where they work and play and with targeted messaging delivered by trusted sources that speak to their interests and values.

Hotels and Marinas

A variety of targeted programs and educational resources are already available detailing environmentally friendly best management practices (BMPs) for hotels and marinas.

▲ CHNEP funded the Happehatchee Eco Camp, which provides environmental education to young people.

◀ Fishing in Charlotte Harbor | *Jennifer Huber.*

CLEAN MARINA

CLEAN MARINAS

WATERSHED BASIN

Figure 32. ▶
Locations of Clean Marinas certified by the Florida Department of Environmental Protection through the Clean Boating Partnership | *FDEP.*

Table 17. Boat registrations by size and county in the historical CHNEP area in 2017 | *Florida Department of Highway Safety and Motor Vehicles.*

County	Boat Size Class						canoes	TOTAL
	< 12 ft	12-16 ft	16 - 26 ft	26-40 ft	40-65 ft	65+ ft		
CHARLOTTE	3,059	2,698	13,776	2,528	419	6	242	22,728
DESOTO	276	702	1,143	117	18	0	39	2,295
HARDEE	182	568	853	25	2	0	37	1,667
LEE	6,502	5,344	27,814	6,322	909	56	560	47,507
MANATEE	3,097	3,142	10,398	2,111	435	38	250	19,471
POLK	4,011	7,428	16,107	747	165	9	311	28,778
SARASOTA	3,094	3,333	12,394	2,882	503	35	293	22,534
TOTAL	20,221	23,215	82,485	14,732	2,451	144	1,732	144,980

Water conservation and pollution-reduction education programs focus on choices of appliances, plumbing fixtures, irrigation systems, landscaping plants, and waste disposal, including:

- The Water Conservation Hotel and Motel Program (Water CHAMP^{SM}) (SWFWMD) helps hotels and motels save water by encouraging guests to use towels and linens more than once during their stay.
- The Florida Green Lodging Program (FDEP) is a voluntary certification program offering hotels resources such as a BMP guide and green meeting guide to help conserve and protect natural Southwest Florida's environment.
- The Clean Marina Program (FDEP) is a voluntary certification program for marinas, featuring educational outreach, workshops, technical assistance, environmental compliance assistance, evaluation, and mentoring provided by the Clean Boating Partnership (Figure 32). The Partnership is a unique public-private partnership consisting of marina and boatyard operators, representatives from the Marine Industries Association of Florida and its local chapters, Florida Sea Grant Program, U.S. Coast Guard (USCG), USCG Auxiliary, USCG Sea Partners Program, Florida Fish and Wildlife Conservation Commission (FWC), and FDEP.

Boaters

Boating can frequently have unintended and unnecessary negative consequences on the environment. Prop scar severity and extent, water quality degradation, and marine mammal injuries all increase with increasing boater activity. Between 2013 and 2017, 10,000 more boats were registered in the seven-county historical CHNEP area, an increase of over 10% in Charlotte and Manatee Counties. The vast majority are small fishing and pleasure craft (Table 17).

Many organizations help educate boaters including FWC, Sea Grant, West Coast Inland Navigational District (WCIND), USCG, and boating clubs. The Florida Boaters Guide, produced by FWC, includes information on invasive aquatic plants, discharge of pollutants like oil, trash, sewage and waste, regulatory speed zones, and seagrass protection. It is published as a free e-book and is available in print for

▲
CHNEP partners target fishers with information about about safe and ethical angling, including outreach on monofilament line and bird entaglements | *Marianne Wroble.*

bulk purchase. Multiple agencies cooperate in producing Boating and Angling Guides for local waters of Sarasota County, Charlotte Harbor, and Lee County, which provide safe boating, ethical angling, marine resource protection guidance, and detailed navigation information.

Possible means of reaching watercraft users with this information include Coast Guard auxiliaries, marine dealers, watercraft rental businesses, marinas, tackle shops, sporting goods stores, civic and business groups, schools, boating and fishing associations, and boat registration packages.

Fishers

Commercial and recreational fishers can be readily targeted through industry publications, fishing supply stores, fishing groups, marinas, boat ramps, and fishing piers.

Fishing Lines magazine was developed by FWC's Division of Marine Fisheries Management Outreach and Education Program as an educational resource on Florida's marine resources. The publication provides ethical and sustainable fishing guidance to fishers through engaging articles about marine angling, saltwater fishes and their habitats, and state efforts to enhance marine resources. Information is also included about fisheries management in Florida, the importance of catch and release, plus a field guide to help anglers and the public identify 145 of Florida's fishes. FWC also offers one-day saltwater fishing clinics for kids and adults that introduce fishing and responsible marine resource stewardship.

Florida Sea Grant Agents target fishers with educational outreach about monofilament line and derelict fishing gear recovery, boating and waterways management, and marine habitat and species restoration. Lee County and Sarasota County also provide sustainable fisheries education targeted to underserved communities.

Farmers

Florida Department of Agriculture and Consumer Services and Water Management Districts provide outreach to farmers and incentivize adoption of BMPs through partnerships, such as SWFWMD's Facilitating Agricultural Resource Management Systems (FARMS) program, that make it more feasible for farmers to implement new technologies (see Water Quality Improvement Action 3).

CHNEP supports outreach events like the Sustainable Fishing Clinic, where participants from Heartland communities learn about the importance of habitat and best fishing practices.
▼

UF/IFAS Extension Agents working throughout the CHNEP area provide outreach to both commercial and non-commercial farm operators to encourage BMP adoption. Outreach to rural hobby operators (*e.g.*, horse boarding facilities, alpaca ranches, rabbit breeding operations) and urban farmers (*e.g.*, community gardens, backyard gardens, and chicken coops), especially those with property adjacent to waterways, should be a focus for education.

STATUS:

Ongoing. Previous 2013–2018 CCMP Stewardship Gaps Actions SG-C and SG-G, and previous Fish and Wildlife Habitat Action FW-O are combined here and updated to incorporate CHNEP activities and accomplishments.

RELATED ACTIONS:

Public Engagement Action 1: Promote environmental literacy, awareness, and stewardship through expanded education and engagement opportunities for the general public

ACTIVITIES:

Engage businesses and other priority stakeholders in estuary and watershed protection activities and educational programs.

Location: CHNEP area.

Responsible parties: CHNEP.

Timeframe: Ongoing; Finance Strategy to be adopted in 2020; Communication and Outreach Strategy to be adopted in 2020.

Potential annual cost and funding sources: < $25,000/ CHNEP, 320 Funds.

Benefits: Increased public environmental awareness, understanding, and stewardship; increased support for management activities.

5-year Performance measure: An annual event or activity that focuses on business and/or other priority stakeholders.

Engage underrepresented and underserved communities in estuary and watershed protection activities and educational programs.

Location: Underrepresented and underserved communities in the CHNEP area.

Responsible parties: CHNEP.

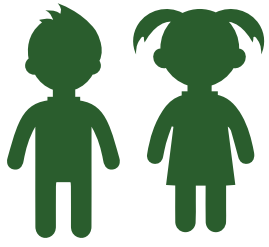
Timeframe: Ongoing; Finance Strategy to be adopted in 2020; Communication and Outreach Strategy to be adopted in 2020.

Potential annual cost and funding sources: < $25,000/ CHNEP, 320 Funds.

Benefits: Increased public environmental awareness, understanding, and stewardship; increased support for management activities.

5-year Performance measures:

- An annual event or activity that focuses on underserved communities.
- Translation of educational materials into multiple languages or formats.



558

Kids funded by CHNEP to go to Environmental Camp or on wading trips in 2018

3

Strengthen non-profit partner collaboration in education and engagement programs

OBJECTIVES:

Build and support capacity of non-profit and community partners to educate and engage volunteers in outreach and activities that further CCMP implementation.

BACKGROUND:

As convener and facilitator of many partners on a variety of issues, CHNEP plays a role in helping develop pilot or foundational programs that can be adopted and adapted by partners. By seeking out and collaborating with partners who are aligned on key education initiatives, CHNEP can help build their capacity to train and engage their volunteers in outreach and activities that further CCMP implementation.

Facilitating Development and Implementation of New Programs

CHNEP helps partners obtain training, funding, equipment, and other tools to do the research, restoration, and educational work needed to protect our waters. These partnerships amplify and expand the reach and effectiveness of CHNEP public education and engagement, while ensuring a strong scientific foundation.

For example, CHNEP works with The Nature Conservancy and Charlotte Harbor Aquatic Preserves to build and monitor oyster habitat restoration sites in the Peace River (see Public Engagement Action 1). In 2017, CHNEP developed and implemented the Volunteer Oyster Habitat Monitoring Program (VOHMP) to measure the progress of these sites. The VOHMP Volunteer Manual details protocols, equipment, and supplies needed to train and engage volunteers of local nonprofit partners in oyster reef monitoring.

In 2018, CHNEP, Florida Sea Grant, and other partners launched a citizen science microplastics research project to gather information about its presence in Southwest Florida (see Public Engagement Action 1). In addition to training CHNEP volunteers, CHNEP expanded the capacity of two local organizations to contribute to microplastics sampling and analysis. CHNEP and Hardee County school district staff facilitated a microplastic sampling project to conduct water and sediment sampling at Cayo Costa State Park with students from the Hardee County Outdoor Classroom summer program. In addition, CHNEP helped establish microplastic sampling capacity for students and citizen scientists at Florida Gulf Coast University's Vester Field Station in Bonita Springs, now the southernmost microplastic sampling station in the CHNEP area.

The Watershed Education Training - Ponds, Lakes And Neighborhoods (WETPLAN) program is a collaborative program created by CHNEP and its partners to assist homeowners in improving the condition of the waters they live near (see Public Engagement Action 1).

The Charlotte Harbor Estuaries Volunteer Water Quality Monitoring Network (CHEVWQMN) is a monthly citizen science opportunity coordinated by Florida Department of Environmental Protection, Charlotte Harbor Aquatic Preserve (CHAP), and Estero Bay Aquatic Preserve (EBAP), that engages citizen scientists in water quality monitoring across 50 sites in the CHNEP area (see Public Engagement Action 1).

Facilitating Networking and Professional Development

CHNEP plays a central role as convener and facilitator for learning, information sharing, and problem solving for watershed and estuary issues in the CHNEP area. CHNEP organizes conferences to help communities organize and build capacity to solve local problems, while giving scientists a public venue to communicate recent findings. Professional development workshops sponsored by CHNEP help partners to protect the natural environment and further the goals of the CCMP.

Since 2012, CHNEP has organized and hosted an annual Conservation Lands Workshop featuring presentations from government, environmental non-profits, and private landowners. Speakers and panelists share strategies, priorities, and accomplishments in land protection and management. In 2018, over 80 participants from Southwest Florida attended. CHNEP also hosts regular Environmental Education Workshops for the environmental community of practice

◀ The Nature Conservancy and CHNEP joint oyster restoration project work.

to network and learn more about solutions to issues facing Southwest Florida's natural environment.

A Watershed Summit is organized by CHNEP every three years (most recently in 2017) to exchange technical information on research, restoration, and management efforts throughout the CHNEP area. Topics include a wide range of scientific disciplines, geographical locations, and critical environmental issues. Watershed Summit Proceedings are typically published as a special issue of a scientific, peer-reviewed journal. Presentations from CHNEP-hosted workshops and conferences are typically archived on the web in PDF or video formats. The Watershed Summit is sponsored by CHNEP partners.

CHNEP also offers professional development workshops, typically in cooperation with the NOAA Office for Coastal Management and a local partner that sponsors the venue. Examples include:

- Introduction to Coastal GIS (2012);
- Public Issues and Conflict Management (2013);
- Project Design and Evaluation (2013);
- Managing Visitor Use in Coastal and Marine Conservation Areas (2014); and
- Climate Adaptation for Coastal Communities (2016).

In 2016, a National Association of Interpretation certified interpretive guide training was offered in collaboration with staff from the Florida Aquarium. Typically, professional development workshops feature local experts from partner organizations who donate their time to share their knowledge and experience.

Organizing and hosting events that promote partner networking and professional development continues to be a priority. Effectiveness of events should continue to be evaluated using tools such as pre- and post-surveys, exit interviews, and overall attendance.

Grant and Sponsorship Support

CHNEP awards grants to community groups to help build their capacity for environmental education and stewardship. Awarding grants to community groups also helps increase community understanding and their support of CCMP goals.

As of 2018, CHNEP has awarded over 850 grants to help implement a variety of projects and programs. These awards are typically highly

CHNEP hosts and supports events that promote networking and professional development for partner organizations. ▼

leveraged with project funding from other sources (*e.g.*, in 2016 by more than 5:1), extending both the capacity of partners to complete projects and the reach of CHNEP's assistance.

In fiscal year 2018, CHNEP began offering sponsorships of $100–$1,000 to partners to support partner events, workshops, conferences, festivals, and projects that implement the CCMP. In addition, CHNEP provides assistance to partners requesting letters of support.

STATUS:

Ongoing. Previous 2013–2018 CCMP Stewardship Gaps Actions SG-B and SG-E and previous Fish and Wildlife Habitat Action FW-P are combined here and incorporate new CHNEP activities and accomplishments.

RELATED ACTIONS:

Public Engagement Action 1: Promote environmental literacy, awareness, and stewardship through expanded education and engagement opportunities for the general public

ACTIVITY:

Build and support capacity of non-profit and community partners to educate and engage volunteers in outreach and activities that further CCMP implementation.

Location: CHNEP area.

Responsible parties: CHNEP, TNC, local land trusts, Sanibel Sea School, National Audubon, Audubon of Florida, Charlotte Harbor Environmental Center, SCCF, Calusa Waterkeeper, Colleges and Universities.

Timeframe: Ongoing; Finance Strategy to be adopted in 2020; Communication and Outreach Strategy to be adopted in 2020.

Potential annual cost and funding sources: $100,000–$499,999/CHNEP, 320 Funds, Grants.

Benefits: Improved access to and use of best available science and best management practices to promote protection and restoration of estuaries and watersheds.

5-year Performance measure: 5 new non-profit collaborative projects over 5 years.

931

Environmental professionals received science-based training since 2017

Increase outreach to policymakers to enhance understanding and support for CCMP implementation

OBJECTIVES:

Provide regular updates to policymakers showcasing use of best available science and examples of success to reinforce the relationship between land use, water resource management decisions, environment, economy, and community.

BACKGROUND:

Communicating the science-based strategies and data-driven recommendations of the CCMP to public officials is essential for encouraging adoption and implementation of effective environmental policy and sound decision-making in support of the CCMP. Showcasing CHNEP project results, especially the National Estuary Program (NEP) approach to leveraging federal dollars with other sources to have a more significant impact, is essential for continued legislative and public support of the CHNEP.

CHNEP staff travel to Tallahassee and to Washington DC at least once a year to meet with state and federal agency and elected leaders and to inform them about science and consensus-based solutions for improving water resources. Providing examples of successful projects and what new projects are needed is important to maintaining strong state and federal funding support for water resource restoration in our region. A recent success in communicating and securing a funding priority was a $3.6 M state budget allocation to the Florida Department of Environmental Protection (FDEP) for coastal resiliency projects. As a result, CHNEP will be applying for funding to assist our communities with adaptation planning, as well as working with FDEP to host resiliency workshops to support communities in our region.

CHNEP has a vital role to play in building community resiliency by bringing federal, state, and local governments together to share knowledge and technologies, request additional funding, and implement watershed restoration across jurisdictional boundaries. CHNEP organized and hosted a task force from Collier County where CHNEP, The Nature Conservancy, and speakers from the cities of Punta Gorda and Sarasota shared adaptation and resiliency approaches with City of Naples community leaders. The CHNEP also helped the City of Punta Gorda develop their own custom Climate Adaptation Plan, which was adopted in 2009. CHNEP is now assisting implementation of that Plan with initiatives such as created oyster reef and living shoreline projects to provide protective buffers and more robust aquatic habitat (see Fish, Wildlife, and Habitat Protection Action 1). CHNEP facilitates collaboration and information sharing that leverages resources and supports expanded resiliency in our region.

CHNEP provides science-based review on important environmental issues, consistent with CHNEP Policy Review Procedures updated in 2018 by the Policy Committee. This capacity enables the CHNEP Management Conference to be used as a resource by local and federal policymakers and their staffs. For example, at the local level, CHNEP staff was asked to provide comments to the Charlotte County Board of County Commissioners and the Punta Gorda City Council regarding improvements to their Urban Fertilizer Ordinances.

At the state level, staff has supported the continued ability of local governments to adopt Urban Fertilizer Ordinances tailored to their soils and climate. Charlotte County staff asked CHNEP to present water quality information to help inform decisions regarding expansion of their central sewer system. At the federal level, the three Southwest Florida NEPs (Tampa Bay Estuary Program, Sarasota Bay Estuary Program and CHNEP) used a science-based, consensus-driven approach to recommend estuarine Numeric Nutrient Standards to FDEP and the EPA. The approach was accepted by FDEP and EPA, and the state adopted the recommendations verbatim in Chapter 62-302, with an effective date of Dec. 20, 2012.

Engaging with the network of other National Estuary Programs and partners can be an effective way to amplify program accomplishments and support. For example, CHNEP recently coauthored an article with staff from other NEPs around the Gulf of Mexico highlighting how the National Estuary Program played an important role in emergency response efforts and outreach initiatives related to the Deepwater Horizon oil spill in the communities they serve (Greening et al. 2018).

During and following the environmental catastrophe, Gulf NEPs used their science-based cooperative partnerships to support recovery efforts, their monitoring networks to provide environmental data on conditions prior to and after the spill, and the NEP's collaborative process to build consensus on how recovery funds for the region will be utilized. Bringing influential stakeholders in the Central and Southwest Florida region together to work collaboratively and speak

◀ Cormorants call a meeting in Pine Island Sound | *Lynn Berreitter.*

with one voice increases opportunities for additional financial and policy support to solve complex, large-scale environmental challenges in our watersheds.

STATUS:

Ongoing. Previous 2013–2018 CCMP Stewardship Gaps Actions SG-J and SG-L are updated to incorporate CHNEP activities, accomplishments, and revised procedures for the Management Conference to conduct policy review and policymaker education. Quantifiable Objective SG-2 from the 2013–2018 CCMP is carried forward and updated as a Performance Measure.

RELATED ACTIONS:

- Fish, Wildlife, and Habitat Protection Action 1: Protect and restore estuarine habitats
- Public Engagement Action 2: Expand reach of education and engagement opportunities to new target audiences

ACTIVITY:

Provide regular updates to policymakers showcasing use of best available science and examples of success to reinforce the relationship between land use, water resource management decisions, environment, economy, and community.

Location: CHNEP area.

Responsible parties: CHNEP.

Timeframe: Ongoing; Finance Strategy to be adopted in 2020; Communication and Outreach Strategy to be adopted in 2020.

Potential annual cost and funding sources: $25,000–$99,999/CHNEP, 320 Funds.

Benefits: Increased environmental awareness, understanding, and leadership from policymakers; increased policy and policymaker support for CCMP goals and objectives.

5-year Performance measure: 10 meetings with elected or appointed officials or governmental entities annually.

▲
CHNEP staff meet with legislators in Tallahassee to discuss priority water issues and solutions in CHNEP area watersheds.

REFERENCES

Alcock, F. 2007. *An Assessment of Red Tide: Causes, Consequences, and Management Strategies*. Mote Marine Laboratory Technical Report #1190. 46 pp.

Anderson, D.M., P.M. Glibert, and J.M. Burkholder. 2002. Harmful algal blooms and eutrophication: nutrient sources, composition and consequences. *Estuaries* 25(4b):704-726.

Avineon, 2004. *Analysis of submerged aquatic vegetation, inter-tidal unvegetated, saltwater marsh, mangrove, oyster, freshwater wetland and native upland habitats within the greater Charlotte Harbor Watershed*. CHNEP FY03 Technical Project final map and data base.

Bales, R.C. 2015. Hydrology, floods and droughts. Pp 180-184 in: *Encyclopedia of Atmospheric Sciences*, 2nd Ed.

Beever III, J. and T. Walker. 2015. *A unified conservation easement mapping and database for the State of Florida*. 70 pp.

Beever III, J. and T. Walker. 2014. Measuring and Forecasting Total Ecosystem Services Values (TEV) from *Habitat Condition Analyses of Habitats in Southwest Florida: The ECOSERVE METHOD*.

Beever III, J., W. Gray, L. Beever, D. Cobb and T. Walker. 2012. *Climate Change Vulnerability Assessment and Adaption Opportunities for Salt Marsh Types in Southwest Florida*. Southwest Florida Regional Planning Council and Charlotte Harbor National Estuary Program. 379 pp.

Beever III, J. 2013. *Estimate of the Ecosystem Services of Existing Conservation 20/20 Lands in Lee County Florida*. 18 pp.

Beever III, J., W. Gray, L. Beever, and D. Cobb 2011. *A Watershed Analysis of Permitted Coastal Wetland Impacts and Mitigation Methods within the Charlotte Harbor National Estuary Program area*. Southwest Florida Regional Planning Council and Charlotte Harbor National Estuary Program. 391 pp.

Beever, III, J., W. Gray, D. Trescott, D. Cobb, J. Utley, and L. Beever. 2009. *Comprehensive Southwest Florida/Charlotte Harbor Climate Change Vulnerability Assessment.* Southwest Florida Regional Planning Council and Charlotte Harbor National Estuary Program, Technical Report 09-3. 298 pp.

Beever, L., J. Beever, III, R. Lewis, L. Flynn, T. Tattar, E. Donley, E. Neafsey. 2016. *Identifying and Diagnosing Locations of Ongoing and Future Saltwater Wetland Loss: Mangrove Heart Attack*. Charlotte Harbor National Estuary Program. Punta Gorda, Florida. 224 pp.

Blewett, D., G. Huston, P. Stevens, and D. Mertzlufft. 2017a. *Fish communities and diet of a juvenile sportfish in the seagrass associated tidal creeks of Charlotte Harbor's Cape Haze peninsula: A Pre-Restoration Fish Community Assessment*. 2017 Charlotte Harbor Watershed Summit, Punta Gorda, Florida, March 30, 2017.

Blewett, D., P. Stevens, E. Johnson, and C. Oliver. 2017b. *Environmental drivers affecting river use by large predatory fishes in Southwest Florida*. 2017 Charlotte Harbor Watershed Summit, Punta Gorda, Florida, March 30, 2017.

Boswell, J., J. Ott, A. Birch, D. Cobb. 2012. *Charlotte Harbor National Estuary Program Oyster Habitat Restoration Plan*. 84 pp. + appendices.

Brand, L.E. and A. Compton. 2007. Long term increase in *Karenia brevis* abundance along the Southwest Florida coast. *Harmful Algae* 6:232-252.

Bridger, K. 2010. *Final TMDL Report Dissolved Oxygen TMDL for Coral Creek-East Branch (WBID 2078B)*. 33 pp.

Buskey, E.J., J. Pinckney, J.B. Pollack, W. Lung, and J. Shen. 2017. *Minimum Flow Criteria for the Caloosahatchee River Estuary.* Final Peer Review Report submitted to the South Florida Water Management District, West Palm Beach, FL. 15 pp.

Charlotte Harbor National Estuary Program (CHNEP). 2005. *Environmental Indicators for the Charlotte Harbor National Estuary Program*. Charlotte Harbor National Estuary Program Technical Report Technical Report 05-1. 69 pp.

Charlotte Harbor National Estuary Program (CHNEP). 2011. Healthy Rivers, Healthy Bays, Healthy Communities: The Charlotte Harbor Seven-County Watershed Report. *Harbor Happenings*. Volume 15, Issue 1. 28 pp.

Charlotte Harbor National Estuary Program (CHNEP). 2013. *Committing to Our Future: A Comprehensive Conservation and Management Plan for the Greater Charlotte Harbor Watershed from Venice to Bonita Springs to Winter Haven*. Update 2013. 156 pp.

Charlotte Harbor National Estuary Program (CHNEP). 2015. *Coastal Charlotte Harbor Monitoring Network Standard Operating Procedures 2015 Updates*. Charlotte Harbor National Estuary Program Technical Report 15-4. 33 pp.

Charlotte Harbor National Estuary Program (CHNEP). 2016. *Coastal Charlotte Harbor Monitoring Network Lower Charlotte Harbor Field Sampling Quality Assurance Project Plan*. Charlotte Harbor National Estuary Program. 73 pp.

Charlotte Harbor National Estuary Program (CHNEP). 2018a. *Climate Change Vulnerability Assessment of the Charlotte Harbor National Estuary Program's 2013 Comprehensive Conservation & Management Plan*. 45 pp.

Charlotte Harbor National Estuary Program (CHNEP). 2018b. *Caloosahatchee Citizen Seagrass Gardening Project: Volunteer Manual Standard Operating Procedures*. 53 pp.

Charlotte Harbor National Estuary Program (CHNEP). 2019. *Habitat Restoration Needs Plan*. 118 pp.

Cook, M.M. 2015. Endocrine-Disrupting Compounds: Measurement in Tampa Bay, Removal from Sewage and Development of an Estrogen Receptor Model. *Graduate Theses and Dissertations*. University of South Florida. 155 pp.

Cooper J.A., G.W. Loomis, and J.A. Amador. 2016. Hell and high water: Diminished septic system performance in coastal regions due to climate change. *PLoS ONE* 11(9):e0162104.

Conservancy of Southwest Florida (CSWF). 2005. *Estuaries Report Card for Southwest Florida*. Prepared by the Conservancy of Southwest Florida. 199 pp.

Conservancy of Southwest Florida (CSWF). 2011. *Estuaries Report Card*. Prepared by the Conservancy of Southwest Florida. 251 pp.

Conservancy of Southwest Florida (CSWF). 2017. *Estuaries Report Card: A guide to understanding the health of Southwest Florida's rivers, estuaries and bays*. Prepared by the Conservancy of Southwest Florida. 302 pp.

Dawes, C.J., R.C. Phillips, and G. Morrison. *2004. Seagrass communities of the Gulf coast of Florida: Status and ecology*. Florida Fish and Wildlife Conservation Commission Fish and Wildlife Research Institute and the Tampa Bay Estuary Program. St. Petersburg, FL. 74 pp.

Dixon, K. and M. Wessel. 2014. *The Optical Model Spectral Validation and Water Clarity Reporting Tool Refinement: Draft Final Report*. Mote Marine Laboratory Technical Report No. 1748. 47 pp.

Easterling, D.R., K.E. Kunkel, J.R. Arnold, T. Knutson, A.N. LeGrande, L.R. Leung, R.S. Vose, D.E. Waliser, and M.F. Wehner. 2017. Precipitation change in the United States. Pp 201-230 in: D.J. Wuebbles, D.W. Fahey, K.A. Hibbard, D.J. Dokken, B.C. Stewart, and T.K. Maycock (eds) *Climate Science Special Report: Fourth National Climate Assessment, Volume I*. U.S. Global Change Research Program, Washington, DC, USA.

Edwards, R.E., W. Lung, P.A. Montagna and H. L. Windom. 2000. *Final Review Report, Caloosahatchee Minimum Flow Peer Review Panel, September 27–29, 2000*. Report to the South Florida Water Management District, West Palm Beach, FL. 32 pp.

Environmental Protection Agency, U.S. (EPA). 2014. *Cyanobacteria and Cyanotoxins: Information for Drinking Water Systems*. EPA-810F11001. 11 pp.

Environmental Protection Agency, U.S. (EPA). 2016a. *Best Practices to Consider when Evaluating Water Conservation and Efficiency as an Alternative for Water Supply Expansion*. U.S. Environmental Protection Agency, Office of Water, EPA-810-B-16-005. 63 pp.

Environmental Protection Agency, U.S. (EPA). 2016b. *Frequently Asked Questions on Removal of Obsolete Dams*. U.S. Environmental Protection Agency, Office of Water, EPA-840-F-16-001. 15 pp.

Eilers, D.T. 2013. *West-Central Florida Tidal Stream Assessment Summary*. Final Report to the Sarasota Bay Estuary Program, December 2013. 152 pp.

Eilers, D.T. 2014. *Sarasota Bay Tidal Stream Assessment Summary*. Final Report to the Sarasota Bay Estuary Program, December 2014. 70 pp.

Estevez, E., R.E. Edwards, and D.M. Hayward. 1991. An ecological overview of Tampa Bay's tidal rivers. Pp 263–275 in: S.F. Treat and P.A. Clark (eds) *Proceedings, Tampa Bay Area Scientific Information Symposium 2*. Tampa, Florida.

Florida Department of Environmental Protection (FDEP). 2015. *Report on Expansion of Beneficial Use of Reclaimed Water, Stormwater and Excess Surface Water (Senate Bill 536).* Office of Water Policy, Florida Department of Environmental Protection. 230 pp.

Florida Department of Environmental Protection (FDEP). 2017. *Public Notice of Pollution*. https://floridadep.gov/pollutionnotice. Accessed December 21, 2017.

Florida Department of Health (FDOH). 2016. *Florida Onsite Sewage Treatment and Disposal Systems Inventory*. Florida Department of Health Final Project Report. DEP Contract No. G0431. 162 pp.

Florida Natural Areas Inventory (FNAI). 2013. Florida Conservation Lands, 2013.

Florida Natural Areas Inventory (FNAI). 2019. Florida Conservation Lands, Updated January 2019.

Fedler, T. 2011. *The Economic Impact of Recreational Tarpon Fishing in the Caloosahatchee River and Charlotte Harbor Region of Florida*. Prepared for The Everglades Foundation. 20 pp.

Ferguson, J.F. 2017. *Southwest Florida Water Management District, 2016 Estimated Water Use Report*. Southwest Florida Water Management District, 232 pp.

Florida Fish and Wildlife Conservation Commission (FWC). 2016. *A Guide to Climate Change Adaptation for Conservation- Version 1*. Florida Fish and Wildlife Conservation Commission. 295 pp.

Gelsleichter, J. 2008. *Identities and ecological effects of ecoestrogens present in the tidal Caloosahatchee River*. Final Report Prepared by Mote Marine Laboratory submitted to Charlotte Harbor National Estuary Program. 50 pp.

Greening, H., R. Swann, K. St. Pé, S.Testroet-Bergeron, R. Allen, M. Alderson, J. Hecker, and S. Bernhardt. 2018. Local implementation of a national program: The National Estuary Program response following the Deepwater Horizon oil spill in the Gulf of Mexico. *Marine Policy* 87:60-64.

Gulf States Marine Fisheries Commission (GSMFC). 2012. *The oyster fishery of the Gulf of Mexico, United States: a regional management plan*. Gulf States Marine Fisheries Commission. March 2012, no. 202. 376 pp.

Harper, H.H. 1999. Pollutant removal efficiencies for typical stormwater management systems in Florida. *Florida Water Resources Journal* September 1999:22-26.

Haverkamp, D., K.A. Steidinger and C.A. Heil. 2004. HAB Monitoring and Databases: The *Karenia brevis* example. In S. Hall, S. Etheridge, D. Anderson, J. Kleindinst, M. Zhu, and Y. Zou. (eds.), *Harmful Algae Management and Mitigation*, Asia-Pacific Economic Cooperation (Singapore): APEC Publication#204-MR-04.2.

Heil, C.A., K. Dixon, E. Hall et al. 2014. Blooms of *Karenia brevis* (Davis) G. Hansen & Ø. Moestrup on the West Florida Shelf: Nutrient sources and potential management strategies based on a multi-year regional study. *Harmful Algae* 38:127–140.

Heisler, J., P.M. Glibert, J.M. Burkholder, D.M. Anderson, et al. 2008. Eutrophication and harmful algal blooms: A scientific consensus. *Harmful Algae* 8:3-13.

Howard, J., A. Sutton-Grier, D. Herr, J. Kleypas, E. Landis, E. Mcleod, E. Pidgeon, and S. Simpson. 2017. Clarifying the role of coastal and marine systems in climate mitigation. *Frontiers in Ecology and the Environment* 15(1):42-50.

Huston, C., P. Stevens, R. Blaxton, R. Scharer, S. Tolley, and G. Poulakis. 2017. *Diel Movements and Habitat Use of the Smalltooth Sawfish in the Peace River: Implications for Defining the Size of a Nursery Hotspot*. 2017 Charlotte Harbor Watershed Summit, Punta Gorda, Florida, March 30, 2017.

Janicki Environmental, Inc. 2010. *Empirical Approaches to Establishing Numeric Nutrient Criteria for Southwest Florida Estuaries*. Prepared for Tampa Bay Estuary Program, Sarasota Bay Estuary Program and Charlotte Harbor National Estuary Program. 56 pp.

Janicki Environmental, Inc. 2010. *Final Water Quality Target Refinement Project*. Task 4: Pollutant Loading Estimates Development. Prepared for CHNEP. 257 pp.

Janicki Environmental, Inc. 2011. *Proposed Numeric Nutrient Criteria for the Charlotte Harbor National Estuary Program Estuarine System*. Prepared for CHNEP. 110 pp.

Janicki Environmental, Inc and Mote Marine Laboratory. 2016. *Southwest Florida Tidal Creeks Nutrient Study*. Final Report to the Sarasota Bay Estuary Program, January 2016. 100 pp.

Jassby, A.D., W.J. Kimmerer, S.G. Monismith, C. Armor, J.E. Cloern, T.M. Powell, J.R. Schubel, and T.J. Vendlinski. 1995. Isohaline position as a habitat indicator for estuarine populations. *Ecological Applications* 5:272–289.

Karr, J.R., K.D. Fausch, P.L. Angermeier, P.R. Yant, and I.J. Schlosser. 1986. *Assessing biological integrity in running waters, a method and its rational*. Illinois Natural History Survey, Special Publication 5. 31 pp.

Kirkpatrick, B., L.E. Fleming, D. Squicciarini, et al. 2004. Literature review of Florida red tide: implications for human health effects. *Harmful Algae* 3:99-115.

Krebs, J.M., A.B. Brame, and C.C. McIvor. 2007. Altered mangrove wetlands as habitat for estuarine nekton — Are dredged channels and tidal creeks equivalent? *Bulletin of Marine Science* 80:839–861.

Lane, H., J.L. Woerner, W.C. Dennison, C. Neill, C. Wilson, M. Elliott, M. Shively, J. Graine, and R. Jeavons. 2007. *Defending our national treasure*. Department of Defense Chesapeake Bay Restoration Partnership 1198-2004. Integration and Application Network (ian.umces.edu) University of Maryland Center for Environmental Science, Cambridge Maryland.

Lapointe, B.E. 1985. Strategies for pulsed nutrient supply to *Gracilaria* cultures in the Florida Keys: interactions between concentration and frequency of nutrient pulses. *Journal of Experimental Marine Biology and Ecology* 93:211–222.

Lapointe, B.E., L. Herren, A. Paule, A. Sleeman, and R. Brewton. 2016. *Charlotte County Water Quality Assessment. Phase I: Data Analysis and Recommendations for Long-Term Monitoring*. Prepared for Charlotte County Utilities Department, Port Charlotte FL. 59 pp.

Lee County Division of Natural Resources. 2007. *Ten Mile Filter Marsh Final Report*. Lee County Division of Natural Resources. 40 pp.

Lovett, R.A. 2010. A warming Earth can mean stronger toxins. *Nature News*: 09 November 2010.

Madley, K.A., J. Krolick, and B. Sargent. 2004. *Assessment of boat propeller scar damage within the greater Charlotte Harbor region*. Prepared for the Charlotte Harbor National Estuary Program by the Florida Fish and Wildlife Conservation Commission Fish and Wildlife Research Institute, St. Petersburg, Florida. 27 pp.

Misra, V., C. Selman, A.J. White, S. Bastola, and A. Mishra. 2017. Terrestrial and ocean climate of the 20th century. Pp 485–509 in: E.P. Chassignet, JW. Jones, V. Misra, and J. Obeysekera (eds) *Florida's Climate: Changes, Variations, & Impacts. Florida Climate Institute*. 632 pp.

Morrison, G. and H. Greening. 2011. Freshwater Inflows. In: K.K. Yates, H. Greening and G. Morrison (eds) *Integrating Science and Resource Management in Tampa Bay, Florida*. US Geological Survey Circular 1348. US Government Printing Office, Washington, DC., pp. 157–202.

Novak, R., J.G. Kennen, R.W.Abele, et al. 2016. *Final EPA-USGS Technical Report: Protecting Aquatic Life from Effects of Hydrologic Alteration: U.S. Geological Survey Scientific Investigations*. Report 2016–5164, U.S. Environmental Protection Agency EPA Report 822-R-156-007, 156 pp.

O'Brien, P.A., K.M. Morrow, B.L. Willis, and D.G. Bourne. 2016. Implications of ocean acidification for marine microorganisms from the free-living to the host-associated. *Frontiers in Marine Science* 3(47):1–14.

Orlando, B.A., P.H. Doerin, R.H. Chamberlain. 2013. Seagrass in the Caloosahatchee River estuary: the effect of annual rainfall patterns. *Florida Scientist* 76:107–120.

Paerl, H.W., and J. Huisman. 2008. Blooms like it hot. *Science* 320:57–58.

Pastor-Guzman, J., P. Atkinson, J. Dash, and R. Rioja-Nieto. 2015. Spatiotemporal Variation in Mangrove Chlorophyll Concentration Using Landsat 8. *Remote Sens*. 2015(7):14530-14558.

Peace River Manasota Regional Water Supply Authority. 2017. *Peace River Manasota Regional Water Supply Authority Strategic Plan, Board Approved 2017*. 15 pp.

Peebles, E.B. 2005. *An Analysis of Freshwater Inflow Effects on the Early Stages of Fish and Their Invertebrate Prey in the Alafia River Estuary*. Prepared for Southwest Florida Water Management District. 147 pp.

Post, Buckley, Schuh & Jernigan (PBS&J). 2007. *Peace River Cumulative Impact Study*. Prepared for Florida Department of Environmental Protection and the Southwest Florida Water Management District, Tampa, Florida.

Proffitt, C.E., L. Coen, S. Geiger, D. Kimbro, H. Nance, and J. Weinstein. 2013. *The Deepwater Horizon oil spill: Assessing impacts on a critical habitat, oyster reefs and associated species in Florida Gulf estuaries*. GoMRI Block Grants Final Technical Report submitted to FIO, 28pp

Restore America's Estuaries (RAE). 2015. *Living Shorelines: From Barriers to Opportunities*.

Sarasota County. 2016. *Dona Bay Conveyance Improvements*. CIP# 75501. Sarasota County Public Works Capital Projects. 1 p.

Savarese, M., A.N. Loh, and J.H. Trefrey. 2004. *Environmental and hydrologic history of Estero Bay: implications for watershed management and restoration*. Final Report for SFWMD Contract #C-15871. 131 pp.

Scott, J. 2008. Florida's wildlife: *On the Front Line of Climate Change*. Climate Change Summit Report. Florida Fish and Wildlife Conservation Commission. 40 pp.

Shell, Prairie, and Joshua Creeks Watershed Management Plan Stakeholders Group. 2004. *Shell Creek and Prairie Creek Watersheds Management Plan*. Reasonable Assurance Documentation. 108 pp.

Smayda, T. 2008. Complexity in the eutrophication-harmful algal bloom relationship, with comment on the importance of grazing. *Harmful Algae* 8:140-151.

Smith, J.L. and J.F. Haney. 2006. Foodweb transfer, accumulation, and depuration of microcystins, a cyanobacterial toxin, in pumpkinseed sunfish (*Lepomis gibbosus*). *Toxicon* 48:580–589.

South Florida Water Management District (SFWMD). 2017. *Lower West Coast Water Supply Plan Update Appendices*. South Florida Water Management District. 204 pp.

South Florida Water Management District (SFWMD). 2017a. *South Florida Water Management District 2016 Estimated Water Use Report*. Water Supply Bureau of the South Florida Water Management District; J Harmon, N. Kennedy and N. Kraft (staff contributors). 42 pp.

South Florida Water Management District (SFWMD). 2017b. *Caloosahatchee River (C-43) West Basin Storage Reservoir*. South Florida Water Management District. 2 pp.

South Florida Water Management District (SFWMD). 2018. *Technical Document to Support Reevaluation of the Minimum Flow Criteria for the Caloosahatchee River Estuary*. South Florida Water Management District. 520 pp.

Southwest Florida Water Management District (SWFWMD). 2000. *Charlotte Harbor Surface Water Improvement and Management (SWIM) Plan*. SWIM Section, Southwest Florida Water Management District, Tampa, Florida. 94 pp.

Southwest Florida Water Management District (SWFWMD). *2012. Lake Hancock Land Use and Management Plan*. Southwest Florida Water Management District. 87 pp.

Southwest Florida Water Management District (SWFWMD). 2015. *Regional Water Supply Plan Appendix 4-1*. Southwest Florida Water Management District.

Southwest Florida Water Management District (SWFWMD). 2017. *Southwest Florida Water Management District 2016 Estimated Water Use Report*. Water Supply Section of the Southwest Florida Water Management District; J. F. Ferguson. 232 pp.

Steidinger, K.A. 1975. Basic factors influencing red tides. In: LoCicero, V.R. (ed.) *Proceedings of the 1st International Conference on Toxic Dinoflagellate Blooms*. Massachusetts Science and Technology Foundation, Boston, pp. 153–162.

Steidinger, K.A. 2009. Historical perspective on Karenia brevis red tide research in the Gulf of Mexico. *Harmful Algae* 8:549-561.

Stralberg D., D. Jongsomjit, C.A. Howell, M.A. Snyder, J.D. Alexander J.A. Wiens, and T.L. Root. 2009. Re-shuffling of species with climate disruption: A no-analog future for California birds? *Plos ONE* 4(9):e6825.

Taylor, J.L. 1974. The Charlotte Harbor Estuarine System. *Florida Scientist* 37(4):205-216.

Tolley, S., D. Fugate, M. L. Parsons, S. E. Burghart, and E. B. Peebles. 2010. *The Responses to Turbidity, CDOM, Benthic Microalgae, Phytoplankton and Zooplankton to Variation in Seasonal Freshwater Inflow to the Caloosahatchee Estuary*. Final Project Report to South Florida Water Management District, West Palm Beach, Florida.

Toor, G.S., M. Lusk, and T. Obreza. 2011. *Onsite Sewage Treatment and Disposal Systems: Nitrogen*. Department of Soil and Water Sciences, UF/IFAS Extension document SL348. 6 pp.

Torio, D.D. and G.L. Chmura. 2013. Assessing coastal squeeze of tidal wetlands. *Journal of Coastal Research* 29(5):1049–1061.

Twilley, R.R. 2007. *Coastal Wetlands & Global Climate Change: Gulf Coast Wetland Sustainability in a Changing Climate*. Pew Center on Global Climate, Arlington, VA.

Twilley, R.R., E.J. Barron, H.L. Gholz, M.A. Harwell, R.L. Miller, D.J. Reed, J.B. Rose, E.H. Siemann, R.G. Wetzel, and R.J. Zimmerman. 2001. *Confronting Climate Change in the Gulf Coast Region: Prospects for Sustaining Our Ecological Heritage*. Union of Concerned Scientists and Ecological Society of America. 84 pp.

Twining, B.S. and S.B. Baines. 2013. The Trace metal composition of marine phytoplankton. *Annual Review of Marine Science* 5:191-215.

United States Army Corps of Engineers (USACE) and South Florida Water Management District (SFWMD). 2010. *Central and Southern Florida Project Caloosahatchee River (C-43) West Basin Storage Reservoir Project: Final Integrated Project Implementation Report and Final Environmental Impact Statement*. United States Army Corps of Engineers and South Florida Water Management District. 482 pp.

United States Geological Survey (USGS). 2017. *USGS Data Management*. https://www2.usgs.gov/datamanagement/qaqc.php. Accessed January 7, 2017.

Walther, G.R., A. Roques, P.E. Hulme, M.T. Sykes, P. Pysek, I. Kuhn, and M. Zobel. 2009. Alien species in a warmer world: risks and opportunities. *Trends in Ecology and Evolution* 24(12):686–693.

Wilson, J. 2017. *Impacts of coastal development and altered watersheds on juvenile fish nursery habitat*. 2017 Charlotte Harbor Watershed Summit, Punta Gorda, Florida, March 30, 2017.

Yarbro, L. and P. Carlson, Jr. 2016. *Summary Report for the Charlotte Harbor Region. Seagrass Integrated Mapping and Monitoring Program*. Mapping and Monitoring Report Version 2.0. FWRI Technical Report TR-17.

Zheng, L. and R. Weisberg. 2010. Rookery Bay and Naples Bay circulation simulations: Applications to tides and freshwater inflow regulation. *Ecological Modeling* 221:986-996.

ACRONYMS

AFO	Animal Feeding Operation
BMAP	Basin Management Action Plan
BMP	Best Management Practice
BOD	Biochemical Oxygen Demand
BPA	Bisphenol A
BSCD	Bonita Springs Community Development
CAC	Citizens Advisory Committee
CAFO	Concentrated Animal Feeding Operation
CARES	County Alliance for Responsible Environmental Stewardship
CCVA	Climate Change Vulnerability Analysis
CCHMN	Coastal Charlotte Harbor Monitoring Network
CCMP	Comprehensive Conservation and Management Plan
CERP	Comprehensive Everglades Restoration Plan
CFRPC	Central Florida Regional Planning Council
CHAMP	Conservation Hotel and Motel Program
CHAP	Charlotte Harbor Aquatic Preserve
CHEVWQMN	Charlotte Harbor Estuaries Volunteer Water Quality Monitoring Network
CHNEP	Charlotte Harbor National Estuary Program (1995–2019) or Coastal and Heartland National Estuary Partnership (2019–future)
CISMA	Cooperative Invasive Species Management Area
CREW	Corkscrew Regional Ecosystem Watershed
CSWCD	Charlotte Soil and Water Conservation District
CWA	Clean Water Act
CWA	Critical Wildlife Area
DDT	Dichlorodiphenyltrichloroethane
DO	Dissolved oxygen
EBAP	Estero Bay Aquatic Preserve
EE2	Ethinyl estradiol
EPA	United States Environmental Protection Agency
FARMS	Facilitating Agricultural Resource Management System
FDACS	Florida Department of Agriculture and Consumer Services
FDEO	Florida Department of Economic Opportunity
FDEP	Florida Department of Environmental Protection
FDOH	Florida Department of Health
FDOT	Florida Department of Transportation
FFL	Florida Friendly Landscaping
FGCU	Florida Gulf Coast University
FW	CCMP Fish, Wildlife, and Habitat Protection Action Plan
FWC	Florida Fish and Wildlife Conservation Commission
FWRA	Florida Watershed Restoration Act
FWRI-FIM	Fish and Wildlife Research Institute Fisheries Independent Monitoring Program
GICIA	Gasparilla Island Conservation and Improvement Association
GIS	Geographic Information System
GOMA	Gulf of Mexico Alliance
HAB	Harmful Algal Bloom
HOA	Home Owner Association
HR	CCMP Hydrological Restoration Action Plan
HRNP	Habitat Restoration Needs Plan
ISMP	Imperiled Species Management Plan
LID	Low Impact Development or Low Impact Design
MFL	Minimum Flows and Levels
MGD	Million Gallons per Day
MPO	Metropolitan Planning Organization
NEP	National Estuary Program
NGO	Non-governmental organization
NNC	Numeric Nutrient Criteria
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
OAWP	Office of Agricultural Water Policy
OFW	Outstanding Florida Waters
OSTDS	Onsite Sewage Treatment and Disposal Systems
PBDE	Polybrominated diphenyl ethers
PCB	Polychlorinated biphenols
PE	CCMP Public Engagement Action Plan
PPT	Parts Per Thousand

PRMSWSA	Peace River Manasota Regional Water Supply Authority
QA/QC	Quality Assurance/Quality Control
RAP	Reasonable Assurance Plan
SAS	Surficial Aquifer System
SBEP	Sarasota Bay Estuary Program
SCCF	Sanibel Captiva Conservation Foundation
SSO	Sanitary Sewer Overflow
SFWMD	South Florida Water Management District
STORET	Storage and Retrieval (now called Watershed Information Network, WIN)
SWFRAMP	Southwest Florida Regional Ambient Monitoring Program
SWFRPC	Southwest Florida Regional Planning Council
SWFWMD	Southwest Florida Water Management District
SWIM	Surface Water Improvement and Management Plan
SWIMAL	Saltwater Intrusion Minimum Aquifer Level
SWUCA	Southern Water Use Cation Area
TAC	Technical Advisory Committee
TBEP	Tampa Bay Estuary Program
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorus
TSS	Total Suspended Solids
UF/IFAS	University of Florida Institute of Food and Agricultural Sciences
USACE	U.S. Army Corps of Engineers
USDA	Unites States Department of Agriculture
USCG	United States Coast Guard
USF	University of South Florida
USDI	United States Department of the Interior
USFWS	United States Fish and Wildlife Service
USGS	United States Geologic Survey
VOHMP	Volunteer Oyster Habitat Monitoring Program
WCIND	West Coast Inland Navigation District
WETPLAN	Watershed Education Training Ponds Lakes and Neighborhoods
WIN	Watershed Information Network
WMA	Wildlife Management Area
WQ	CCMP Water Quality Improvement Action Plan
WGFAM	Water Quality Functional Assessment Method
WUCA	Water Use Caution Areas
WWTP	Wastewater Treatment Plant

APPENDIX: Crosswalk of 2013 to 2019 CCMP Actions

2013 Actions	2013 Action Summary	Status	2019 Actions
WQ-A	Participate in the development and implementation of coordinated watershed management programs...	Ongoing & updated	WQ-2, HR-3
WQ-B	Continue collecting water quality data...to assess impairments, determine limits, and develop management plans	Ongoing & updated	WQ-1
WQ-C	Use tools...to identify water quality problems and select less polluting alternatives	Ongoing & updated	WQ-1
WQ-D	Reduce nonpoint-source pollutants associated with stormwater runoff...	Ongoing & updated	WQ-3
WQ-E	Implement projects to improve or protect water quality to offset anthropogenic impacts	Ongoing & updated	WQ-3
WQ-F	Promote water conservation, stormwater treatment and intergovernmental coordination within local plans and codes...	Ongoing & updated	HR-2
WQ-G	Develop and implement water quality criteria that are protective of living resources...	Ongoing & updated	WQ-2
WQ-H	Assess the bacteria, nutrient load and base flow impacts of septic systems, wastewater treatment plants and reuse water	Ongoing & updated	WQ-4
WQ-I	Determine the relationship between macro- and micronutrients and phytoplankton/algal blooms. Support measures to reduce blooms	Ongoing & updated	WQ-5
WQ-J	Provide central sanitary sewers to developed areas within 900 feet of waters...	Ongoing & updated	WQ-4
WQ-K	Implement conservation landscaping plant programs...	Ongoing & updated	HR-2, PE-1
WQ-L	Increase the use of personal and home best management practices by residents and visitors...to reduce nonpoint-source pollution	Ongoing & updated	PE-1
WQ-M	Support public involvement programs addressing water quality issues	Ongoing & updated	PE-1
HA-A	Utilize historic, current and future scenario estuarine mixing models...for better evaluation of proposed capital and operations projects	Ongoing & updated	HR-1
HA-B	Utilize integrated ground and surface water models to improve decision making...in the context of water demands	Ongoing & updated	HR-1
HA-C	Protect headwater tributaries from elimination and restore these tributary courses and their floodplains...	Ongoing & updated	HR-3

2013 Actions	2013 Action Summary	Status	2019 Actions
HA-D	Set and achieve minimum aquifer levels. Reduce the rate of saltwater intrusion in the Floridan aquifer	Ongoing & updated	HR-2
HA-E	Meet established minimum flows and levels (MFLs)	Ongoing & updated	HR-2
HA-F	Participate in Everglades restoration and related planning and restoration efforts	Ongoing & updated	HR-3
HA-G	Reestablish hydrologic watersheds to contribute flows to their historic receiving water bodies	Ongoing & updated	HR-3
HA-H	Identify natural, existing and target water budgets for each watershed	Ongoing & updated	HR-1
HA-I	Evaluate the impacts of man-made barriers to historic flows and modify them to establish more natural hydrologic conditions	Ongoing & updated	HR-1, HR-3
HA-J	Build and restore water conveyances to have shallow, broad, vegetated and serpentine components that also restore floodplains	Ongoing & updated	HR-3
HA-K	Identify the hydrologic and environmental interactions on surface water reservoirs on estuaries... to mimic natural systems	Ongoing & updated	HR-1, HR-3
HA-L	Encourage the use of low-impact development (LID) and green infrastructure techniques...	Ongoing & updated	WQ-3, HR-2
HA-M	Limit big-pulsed release events	Ongoing & updated	HR-3
HA-N	Implement watershed projects to address hydrologic alterations, loss of water storage and changed hydroperiod, and improve water quality	Ongoing & updated	HR-3
HA-O	Encourage, expand and develop incentives for the reuse of waters...	Ongoing & updated	WQ-4, HR-2
HA-P	Support public involvement programs addressing ... hydrology, water resources, water conservation and water use	Ongoing & updated	PE-1
FW-A	Restore submerged and intertidal habitats (seagrass, oyster and unvegetated bottoms)...	Ongoing & updated	FW-1
FW-B	Ensure navigation programs protect CHNEP study area habitat resources	Ongoing & updated	FW-1
FW-C	Restore freshwater and estuarine wetland areas, especially those adversely impacted by ditching...	Ongoing & updated	HR-3, FW-1, FW-2
FW-D	Enhance fish and wildlife habitat along shorelines...	Ongoing & updated	FW-1
FW-E	Improve canal, pond, lake and river management activities to benefit fish and wildlife	Ongoing & updated	FW-1
FW-F	Restore and protect a balance of native plant and animal communities	Ongoing & updated	FW-1, FW-2

2013 Actions	2013 Action Summary	Status	2019 Actions
FW-G	Provide additional support for environmental compliance and enforcement on land and water	Retired	Beyond scope & resources
FW-H	Bring environmentally sensitive land under protection through ownership and/or management...	Ongoing & updated	FW-2
FW-I	Advocate land acquisition and conservation easement programs	Ongoing & updated	FW-2
FW-J	Provide information on the economic, social and environmental benefits of protected land and environmental restoration...	Ongoing & updated	FW-3
FW-K	Acquire as much of Babcock Ranch as possible for public stewardship and promote conservation management of the entire ranch	Completed	
FW-L	Where practical, identify and remove areas of heavy invasive exotic vegetation and exotic nuisance animals	Ongoing & updated	FW-2
FW-M	Promote local programs to research and eliminate nuisance exotic animal species	Ongoing & updated	FW-2
FW-N	Provide education programs on the impacts of invasive exotic plants and exotic nuisance animals	Ongoing & updated	PE-1
FW-O	Provide multifaceted environmentally responsible boater education programs	Ongoing & updated	PE-2
FW-P	Support public involvement programs in habitat and wildlife issues	Ongoing & updated	PE-1, PE-3
SG-A	Gauge public involvement	Retired	Beyond scope & resources
SG-B	Provide people with opportunities to be involved in research, monitoring and restoration activities	Ongoing & updated	PE-1, PE-3
SG-C	Identify underrepresented populations and develop methods to include them in estuary and watershed protection	Ongoing & updated	PE-2
SG-D	Produce watershed and estuary communication tools	Ongoing & updated	PE-1
SG-E	Offer grants to broaden participation of individuals and groups in implementing the CCMP	Ongoing & updated	PE-3
SG-F	Provide events that involve people in the stewardship of their local natural resources...	Ongoing & updated	PE-1
SG-G	Implement target audience programs	Ongoing & updated	PE-2
SG-H	Incorporate estuary and watershed protection in educational curricula	Ongoing & updated	PE-1
SG-I	Conduct new resident programs to inform and encourage environmental stewardship	Ongoing & updated	PE-1

2013 Actions	2013 Action Summary	Status	2019 Actions
SG-J	Identify and showcase accomplishments and excellent examples of research findings, restoration, legislative, and outreach successes...	Ongoing & updated	PE-1, PE-4
SG-K	Present scientific information in a form readily understood by the majority of people	Ongoing & updated	Integrated throughout
SG-L	Implement the Advocacy and Review Procedures.	Ongoing & updated	PE-4
SG-M	Vigorously pursue the Long-Range Funding Strategy and funding mechanisms to implement watershed and estuary protection	Ongoing & updated	Merged with Financing Strategy
SG-N	Update comprehensive inventories of research, restoration, legislative and outreach needs	Ongoing & updated	FW-2 and merged with Research and Monitoring Strategy
SG-O	Create incentives to protect desired ecosystem resources	Retired	Beyond scope & resources
SG-P	Incorporate into federal, state and local permits, and public works improved standard practices that better protect estuaries...	Ongoing & updated	Integrated throughout
SG-Q	Build capacity for communities and their local leadership to mitigate and adapt to the effects of climate change...	Ongoing & updated	Integrated throughout
SG-R	Track and present monitoring data according to CHNEP-adopted environmental indicator targets	Ongoing & updated	Merged with Research and Monitoring Strategy
SG-S	Post raw data, geographic information system (GIS) and technical analysis on the Internet under the data management strategy	Ongoing & updated	WQ-1 and merged with Research and Monitoring Strategy

Key to Action Codes

2013 CCMP		*2019 CCMP*	
WQ	Water Quality Degradation	WQ	Water Quality Improvement
HA	Hydrologic Alterations	HR	Hydrological Restoration
FW	Fish and Wildlife Habitat Loss	FW	Fish, Wildlife, and Habitat Protection
SG	Stewardship Gaps	PE	Public Engagement

ACKNOWLEDGEMENTS

CHNEP thanks our dedicated Management Conference members who contributed to the 2019 CCMP revision during 2017–2019.

POLICY COMMITTEE MEMBERS 2017–2019

Patricia Steed – Central Florida Regional Planning Council
Bill Truex – Charlotte County
Robert Heine Jr. – City Of Arcadia
S. Delshay Turner – City Of Arcadia
Billy Simpson – City Of Bartow
Fred Forbes – City Of Bonita Springs
Jessica Cosden – City Of Cape Coral
Fred Burson – City Of Fort Myers
Debbie McDowell – City Of North Port
Gary Wein – City of Punta Gorda
Mick Denham – City Of Sanibel
Fred Fraize – City Of Venice
Mitzie Fiedler – City Of Venice
M.J. Carnevale – City Of Winter Haven
James Selph – Desoto County
Judy Schaefer – Desoto County
Jon Iglehart – Florida Department of Environmental Protection
Courtney Saari – Florida Fish and Wildlife Conservation Commission
Phil Stevens – Florida Fish and Wildlife Conservation Commission
Tom Graef – Florida Fish and Wildlife Conservation Commission
Colon Lambert – Hardee County
Frank Mann – Lee County
Misty Servia – Manatee County
Stephan Jonsson – Manatee County
Gaye Sharpe – Polk County
Jeff Spence – Polk County
Mike Moran – Sarasota County
Nancy Detert – Sarasota County
Chauncey Goss – South Florida Water Management District
Phil Flood – South Florida Water Management District
Rick Barber – South Florida Water Management District
Don McCormick – Southwest Florida Regional Planning Council
John Henslick – Southwest Florida Water Management District
Joanne Shamp – Town Of Fort Myers Beach
Becky Allenbach – U.S. Environmental Protection Agency Region 4
Brian Smith – U.S. Environmental Protection Agency Region 4
Doug Mundrick – U.S. Environmental Protection Agency Region 4
Katy Errington – Village Of Estero

MANAGEMENT COMMITTEE MEMBERS 2017–2019

Chad Allison – Central Florida Regional Planning Council
Jamie Scudera – Charlotte County
Wendy Lang – Charlotte County Soil and Water Conservation District
Laura Gibson – City of Bonita Springs
Connie Jarvis – City of Cape Coral
Maya Robert – City of Cape Coral
James Ink – City of Fort Myers
Elizabeth Wong – City of North Port
James Evans – City of Sanibel
Gillian Carney – City of Venice
M.J. Carnevale – City of Winter Haven
Tara Poulton – DeSoto County
Tricia Hobson – Florida Department of Agriculture
Heather Stafford – Florida Department of Environmental Protection, Coastal Office
Jennifer Carpenter – Florida Department of Environmental Protection, South District
Corey Anderson – Florida Fish and Wildlife Conservation Commission
Courtney Saari – Florida Fish and Wildlife Conservation Commission
Betty Staugler – Florida Sea Grant
Misty Nichols – Gasparilla Island Conservation and Improvement Association
West Palmer – Hardee County
Ed Hanlon – Institute of Food and Agricultural Services
Roland Ottolini – Lee County
Lisa Drieger – Lee County
Charlie Hunsicker – Manatee County
David Dale – National Oceanic and Atmospheric Administration
Mike Coates – Peace River Manasota Regional Water Supply Authority

MANAGEMENT COMMITTEE MEMBERS 2017–2019 continued

Hans Zarbock – Polk County
John Ryan – Sarasota County
David Hutchinson – Sarasota-Manatee Metropolitan Planning Organization
Linda Lindstrom – South Florida Water Management District
Samantha Lynch – South Florida Water Management District
Jim Beever – Southwest Florida Regional Planning Council
Jennette Seachrist – Southwest Florida Water Management District
Randy Smith – Southwest Florida Water Management District
Will Van Gelder – Southwest Florida Water Management District
Rae Burns – Town of Fort Myers Beach
Tiana Blount – U.S. Environmental Protection Agency Region 4
Paul Tritaik – U.S. Fish and Wildlife Service Ding Darling National Wildlife Refuge
Eduardo Patino – U.S. Geological Survey
Aubree Hershorin – United States Army Corps of Engineers
Muriel Blaisdell – United States Army Corps of Engineers
Justin McBride – West Coast Inland Navigation District

TECHNICAL ADVISORY COMMITTEE MEMBERS 2017–2019

Amanda Booth – U.S. Geological Survey
Steve Adams – City of Punta Gorda
Mike Gurr – Central Florida Regional Planning Council
Bill Byle – Charlotte County
Bobbi Rodgers – Charlotte Harbor Environmental Center
Kraig Hankins – City of Cape Coral
David Jayroe – City of North Port
Teresa Payne – City of North Port
James Evans – City of Sanibel
Holly Milbrandt – City of Sanibel
M.J. Carnevale – City of Winter Haven
Devon Moore – City of Winter Haven
Dianne Rosensweig – ESA Scheda
Yesenia Escribano – Florida Department of Agriculture & Consumer Services
Tricia Hobson – Florida Department of Agriculture & Consumer Services
Melynda Brown – Florida Department of Environmental Protection
Dave Blewett – Florida Fish and Wildlife Conservation Commission
Don Duke – Florida Gulf Coast University
Betty Staugler – Florida Sea Grant
David Ceilley – Johnson Engineering
Rick Armstrong – Lee County
Keith Kibbey – Lee County
Ernesto Lasso de la Vega – Lee County Mosquito/Hyacinth Control District
Greg Blanchard – Manatee County
Shelley Thornton – Mosaic
Jim Culter – Mote Marine Laboratory
Mark Sramek – National Oceanic and Atmospheric Administration
David Nellis – Nellis Enterprises
Sam Stone – Peace River Manasota Regional Water Supply Authority
LeAnna Himrod – Peace River Valley Citrus Growers Association
Art Wade – Polk County
Hans Zarbock – Polk County
Steve Suau – Progressive Water Resources
Rick Bartleson – Sanibel-Captiva Conservation Foundation
Justin Saarinen – Sarasota County
Cassondra Armstrong – South Florida Water Management District
Jim Beever – Southwest Florida Regional Planning Council
Lizanne Garcia – Southwest Florida Water Management District
Rae Burns – Town of Fort Myers Beach
Cynthia Ovdenk – U.S. Army Corps of Engineers
Angela Ryan – U.S. Army Corps of Engineers
Kevin Kalasz – U.S. Fish and Wildlife Service
Patty Metz – U.S. Geological Survey
Dan Schabilion – USDA Natural Resources Conservation Service
Jeff Devine – West Coast Inland Navigation District
Dave Sumpter – Wildlands Conservation

CITIZENS ADVISORY COMMITTEE MEMBERS 2017–2019

Jeff Anlauf
Robert Ballard
Gary Brownell
Bob Clark
James Cooper
Roger DeBruler Jr.
Edie Driest
Bill Goetz
Allain Hale
Mollie Holland
Wilma Katz
Bill Kimber
Jim Knoy
Lou Kovach
Ernesto Lasso de la Vega
Kaley Miller
David Moe
Jackson Mosley
Bill Muir
Heather Nedley
Kayton Nedza
Ann O'Leary
Debi Osborne
Harry Phillips
Pete Quasius
Frances Reimondo
Chuck Richardson
Maya Robert
Bobbi Rodgers
George Ruby
Sheila Scolaro
Scott Wilkinson
Robert Winter
Rob Wright
Alfred Yeno

WATER QUALITY IMPROVEMENT ACTION PLAN - part 1: At a Glance

Action	Activities	Location	Responsible Parties
1 Support a comprehensive and coordinated water quality monitoring and assessment strategy	1.1 Assist with the consistent and efficient collection of technically-sound long-term water quality data throughout the study area, including supporting key programs like the Coastal Charlotte Harbor Water Quality Monitoring Network, partners' long-term fixed stations, and volunteer monitoring programs like the Charlotte Harbor Estuaries Volunteer Monitoring Network, Lee County Pond Watch, and the Cape Coral Canal Watch programs. Work with partners to obtain additional resources, increase efficiencies, and identify and fill sampling gaps.	CHNEP area sampling stations from Lemon Bay to Estero Bay.	CHNEP (Lead), SWFWMD, SFWMD, FDEP (Lead for data sufficiency and QA/QC), FDACS, FWC, CHAP, EBAP, SCCF, Calusa Waterkeeper, FGCU, County and Municipal governments.
	1.2 Support uploading and archiving of data in standard, common public databases, including FDEP's database and the CHNEP Water Atlas.	CHNEP area	CHNEP (Lead for data input to Water Atlas), Water Atlas, SWFWMD, SFWMD, FDEP, FWC, CHAP, EBAP, SCCF, Calusa Waterkeeper, County and Municipal governments.
	1.3 Assess and report water quality status and trends to identify water quality.	CHNEP area	CHNEP (Lead for Water Atlas), FDEP (Lead for TMDL/BMAP), FWC, SWFWMD, SFWMD, County and Municipal governments.
	1.4 Identify, study, and monitor new emerging pollutants of concern and their potential sources.	Targeted areas in the CHNEP area.	CHNEP, Florida Sea Grant UF/IFAS Extension, NOAA, FDEP, FGCU, County and Municipal governments.
2 Develop water quality standards, pollutant limits, and cleanup plans	2.1 Encourage review, development, and implementation of additional water quality criteria and targets, pollutant limits, and cleanup plans that correct impairment, protect aquatic life, and prevent degradation of all surface waters, particularly Outstanding Florida Waters.	All Class I, II, III, and III-L surface waters in the CHNEP area, particularly Outstanding Florida Waters.	FDEP (State of Florida regulatory lead), EPA (federal regulatory lead), CHNEP (NNC development and implementation facilitator), County and Municipal governments, SWFWMD (funding and implementation), SFWMD.

Timeframe	Annual Costs & Sources*	Benefits	5-Year Performance Measures
Ongoing; Monitoring Strategy and Communication and Outreach Strategy to be adopted in 2020.	$$$$$/Section 320 Funds, additional CCHMN funding from SWFWMD, in-kind support from SFWMD, FDEP, FWC, CHAP, EBAP, SCCF, Calusa Waterkeeper, County and Municipal governments.	Sufficient long-term technically--sound data to support identification of waterbody improvements or impairments, pollutant limits, and corrective management actions to improve water quality.	Maintenance or increase of the current spatial and temporal extent of ambient water quality monitoring data collection with appropriate QA/QC.
Ongoing; Monitoring Strategy to be adopted in 2020.	$$$ / Section 320 Funds, in-kind support from SWFWMD, SFWMD, FDEP, FWC, CHAP, EPAP, SCCF, Calusa Waterkeeper, County and Municipal governments.	Publicly accessible comprehensive database of water quality in waterbodies throughout the CHNEP area.	Updates of water quality data to the Water Atlas at least twice per year, and continuous public online access to water quality data via the Water Atlas.
Ongoing; Monitoring Strategy and Communication and Outreach Strategy to be adopted in 2020.	$$$/Section 320 Funds.	Readily accessible and reliable index of water quality status and trends.	Creation and dissemination of water quality status summaries for all basins in the CHNEP area at least once per year.
Ongoing; Monitoring Strategy to be adopted in 2020.	$$/Grants from EPA, NOAA, GOMA.	Baseline data on the presence and distribution of emerging pollutants.	Establishment of sampling and analysis protocols; periodic water sampling using established sampling and analysis protocols at targeted locations.
Ongoing	Development of numeric water quality criteria for tidal creeks: $$–$$$/Section 320 Funds; Development and implementation of TMDLs, BMAPs, RAs: $$$$/FDEP, SWFWMD, SFWMD, County and Municipal governments.	Improved water quality supportive of living resources; development of more accurate nutrient loading rates from various land uses; and identification of sources of bacteria, nutrients, and other indicators in water bodies.	Restoration of water quality in at least five impaired waterbodies, demonstrated by water quality data indicating they are fully meeting the water quality standards for their designated beneficial use.

*Key to Potential Costs: $ (<25,000) $$ (25,000–99,999) $$$ (100,000–499,999) $$$$ (500,000–999,999) $$$$$ (1M–10M) $$$$$$ (>10M)

WATER QUALITY IMPROVEMENT ACTION PLAN - part 2: At a Glance

Action	Activities	Location	Responsible Parties
3 Reduce urban stormwater and agricultural runoff pollution	3.1 Support urban BMPs that return freshwater inputs to receiving waters to a more natural pattern of quantity, timing, and distribution that reduce pollutant loadings. Identify locations to install stormwater treatment areas and pursue installation in priority areas. Support new and retrofit projects to increase stormwater retention and reduce pollution loadings. Support development and implementation of green infrastructure practices, including reducing impervious surfaces.	CHNEP area	FDEP (State of Florida regulatory lead), County and Municipal governments (capital improvement projects, adapting comprehensive plans and development codes to facilitate implementation of green infrastructure practices), SWFWMD, SFWMD, UF/IFAS Extension, CHNEP, private sector.
	3.2 Support agricultural BMPs that return freshwater inputs to receiving waters to a more natural pattern of quantity, timing and distribution that reduce pollutant loadings. Support projects to increase retention of agricultural runoff and reduce pollutant loadings, including new and retrofit projects. Encourage implementation of FDACS Agricultural BMPs. Support regional cost-sharing programs and other incentives for implementing Agricultural BMPs.	Watersheds in the CHNEP area, especially areas near impaired waters.	FDEP (State of Florida regulatory lead), FDACS (Agricultural BMPs), SWFWMD-FARMS, SFWMD, UF/IFAS Extension, CHNEP.
4 Reduce wastewater pollution	4.1 Support wastewater treatment to AWT standards, encourage proactive inspection, maintenance, and replacement of failing or underperforming sanitary sewer infrastructure, including reduction of inflow and infiltration. Encourage, expand, and incentivize reuse water, especially AWT wastewater, which is protective of water quality and the natural hydrology in nearby waterways. Reduce discharges of treated wastewater to surface water. Support additional wastewater treatment capacity to prevent overflows and other impacts to wastewater infrastructure and performance due to climate stressors.	CHNEP area	County and Municipal governments (Leads), FDEP, FDOH, SWFWMD, SFWMD, CHNEP.
	4.2 Continue to inventory and map septic systems in the CHNEP area. Support conversion of septic systems to centralized sanitary sewer systems. Support increased sanitary sewer capacity to handle new inflows from conversions. Encourage regular maintenance and inspection of septic systems. Support studies to better understand pollutant loading from septic systems. Encourage evaluation and adoption of new nitrogen-reducing septic system technology.	CHNEP area, especially targeting areas designated as impaired for nutrients or bacterial contamination.	County and Municipal governments (Leads), FDEP, FDOH, CHNEP.
5 Reduce harmful algal blooms	5.1 Support Harmful Algal Bloom (HAB) research and monitoring and measures to reduce their environmental, social, and economic impacts through the identification and reduction of anthropogenic influences.	CHNEP area	FWC (Lead), FDOH, FDEP, Florida Sea Grant, FGCU Marine Sciences, USF, and other academic institutions, Mote Marine Laboratory, CHNEP, SFWMD, Calusa Waterkeepers, and SWFWMD (to potentially monitor water quality and implement source tracking studies).

Timeframe	Annual Costs & Sources*	Benefits	5-Year Performance Measures
Ongoing	Capital improvement projects: $$$$/County and Municipal governments, Section 319 Funds, SWFWMD, SFWMD; Green/LID infrastructure projects: $$$$/County and Municipal governments, SFWMD; BMP research, development, and implementation: $$/Grants, UF/IFAS Extension.	Reduced pollutant loading and improved water quality necessary to support living things.	Increased number of green infrastructure projects developed and implemented.
Ongoing	Agricultural BMP implementation: $$$$$/FDACS, SWFWMD-FARMS, SFWMD; BMP research and development: $$$$/grants.	Reduced pollutant loading and improved water quality necessary to support living resources.	Increased agricultural stakeholders enrolled in SWFWMD-FARMS, USDA NRCS, and FDACS BMP Programs.
Ongoing	Studies to understand pollutant loading from reuse water: $-$$/Section 320 Funds, grants; Improvements to sanitary sewer operation and maintenance: $$$$$/County and Municipal governments, Section 319; Development of reuse water: $$$$$/County and Municipal governments, SWFWMD, SFWMD, FDEP.	Reduction in nutrient and bacteria loading in CHNEP area waterbodies. Improved water quality to support natural communities.	Reduced sanitary sewer system overflows and releases.
Ongoing	Inventory septic systems and track septic to sewer conversion: $$$/Section 319 Funds, County and Municipal governments; Studies to understand pollutant loading from septic systems: $$$-$$$$/Section 320 Funds, grants; Septic to sewer conversion: $$$$$/County and Municipal governments, State of Florida; Improvements to septic system siting, design, and maintenance: $$$$/grants.	Reduction in nutrient and bacterial contamination in CHNEP area waterways. Improved water quality to support living things.	Reduced number of septic systems and small package plants threatening surface water and groundwater.
Ongoing	$$$$/grants, State of Florida.	Improved knowledge of HABs and reduced severity, extent, duration and frequency of harmful effects, including macroalgae, phytoplankton, and periphyton, through the identification and reduction of anthropogenic influences.	Tracking and dissemination of information about occurrences and reduction of harmful effects from algal blooms, including influencing factors and impacts of climate stressors on HABs.

*Key to Potential Costs: $ (<25,000) $$ (25,000–99,999) $$$ (100,000–499,999) $$$$ (500,000–999,999) $$$$$ (1M–10M) $$$$$$ (>10M)

HYDROLOGICAL RESTORATION ACTION PLAN: At a Glance

Action	Activities	Location	Responsible Parties
1 Conduct data collection, modeling, and analyses to support hydrological restoration	1.1 Review existing data collection and identify gaps. Conduct data collection, modeling, and analyses of historical, current, and projected hydrologic conditions to identify needs and guide hydrological restoration, including: • water budget modeling including projected supply demands and natural system needs; • estuary mixing models; • impacts of manmade barriers to historic flows; • relationship between reservoir and downstream resources; and • integrated surface-groundwater models that consider climate change.	CHNEP area	SWFWMD and SFWMD (Leads, except for examining impacts of manmade barriers to historical flows), CHNEP, County and Municipal Governments, FDEP, USGS, Research Institutions, Conservation NGOs.
2 Increase fresh surface water and groundwater availability to support healthy ecosystems	2.1 Participate in development, reevaluation, and implementation of scientifically sound freshwater Minimum Flows and Levels (MFLs) for surface water and groundwater resources that consider climate stressors and recovery strategies to meet MFLs in order to prevent degradation of natural systems.	CHNEP area, focusing on minimum aquifer levels for the Floridan Aquifer System and minimum flows for waterways, as needed.	SWFWMD and SFWMD (leads), FDEP (regulatory lead), USACE, County and Municipal Governments, Water Utilities, CHNEP.
	2.2 Increase aquifer recharge by supporting local plans and codes that decrease impervious surfaces; incorporate green infrastructure practices; protect recharge and wellfield areas; and protect and restore wetlands.	CHNEP area	County and Municipal Governments, SWFWMD, SFWMD, UF/IFAS Extension, CHNEP, FDEP, USACE, private sector.
	2.3 Encourage conservation and efficient water use and promote aquifer recharge through construction of green infrastructure projects where appropriate, adoption of agricultural irrigation BMPs, and promotion of alternative water supply sources including increased appropriate reuse of treated wastewater.	CHNEP area	County and Municipal Governments, SWFWMD, SFWMD, FDACS, UF/IFAS Extension, Water Utilities, FDEP, CHNEP, USDA, private sector.
3 Protect and restore natural flow regimes	3.1 Support integrated and coordinated watershed management planning to protect headwaters, restore flowways and floodplains, and reestablish historical flow direction, volume, and timing to receiving waters. Incorporate anticipated future climate stressors into flow regime restoration.	CHNEP area	FDEP (State of Florida regulatory lead), EPA (federal regulatory lead), SWFWMD and SFWMD (implementation facilitators), USACE, County and Municipal Governments, FDACS, CHNEP, private sector.
	3.2 Support implementation of projects to reestablish and protect wetlands and hydrologic watersheds, including Everglades restoration, Lake Hancock shoreline restoration, and other projects to build or remediate flowways, barriers, and water storage that mimic and restore natural flow conditions necessary to support healthy ecosystem function and account for anticipated climate change stressors.	CHNEP area	CHNEP (implementation facilitator), FDEP, County and Municipal Governments, SWFWMD, SFWMD, USACE, FWC, USFWS, USDI (NPS, other USDI), USDA, FDOT, NGOs, FDACS, Private sector.

Timeframe	Annual Costs & Sources*	Benefits	5-Year Performance Measures
Ongoing; Monitoring Strategy to be adopted in 2020.	$$$$$/Section 320 Funds, Grants, SWFWMD, SFWMD.	Increased knowledge of historical, current, and projected hydrologic conditions to better inform and guide hydrological restoration.	• Updated estuarine mixing, surface water, and groundwater models to support MFL development and recovery strategies and creation of regional watershed restoration plans, where needed. • Increased number of surface water and groundwater level and flow gauges in areas with limited data to monitor natural variations in flow and impacts of man-made barriers and alterations (including mining, ditching, channelizing, and damming).
MFL development, reevaluation, and implementation are ongoing. Adoption of the Caloosahatchee River MFL is expected in 2019; recovery is expected to follow completion of the Caloosahatchee River West Basin Storage Reservoir (anticipated in 2022); CVA adopted in 2018; HRNP adopted 2019.	Reevaluation $$$$$; Implementation $$$$$$/ SWFWMD, SFWMD, USACE, County and Municipal Governments.	Increased availability of fresh surface water and groundwater to support natural systems.	Increased number of recovery strategies and projects to reduce or eliminate MFL exceedances.
Ongoing; Communication and Outreach Strategy to be adopted in 2020.	$$/County and Municipal Governments.	Increased freshwater availability to support natural systems, restored hydrology, and improved water quality.	Increase in long-term average annual levels in aquifers.
Ongoing; Communication and Outreach Strategy to be adopted in 2020.	$$$$/County and Municipal Governments, SWFWMD, SFWMD, FDEP, USDA, FDACS.	Increase freshwater availability to support natural systems and conserve water supply sources.	Increased water conservation.
Ongoing; Climate Change Vulnerability Analysis adopted in 2018.	$$$$$/FDEP, SWFWMD, SFWMD, USACE, USDI, USDA, Section 320 Funds, County and Municipal Governments.	Integrated watershed management plan components that are coordinated across agency, local government and private sector activities and lead to more comprehensive hydrologic watershed protection and restoration in support of natural systems.	Increased number of completed plans with hydrological restoration projects that are ready for implementation.
Ongoing. Climate Change Vulnerability Analysis adopted in 2018; Habitat Restoration Needs Plan adopted in 2019.	$$$$-$$$$$/Section 319 Funds, USACE, FWC, USFWS, USDI (NPS and other USDI), USDA, FDOT, NGOs, County and Municipal governments, SWFWMD, SFWMD, RESTORE Act, FDACS, Grants.	Improved natural hydrological flow and watershed boundaries for surface waterbodies, especially Outstanding Florida Waters.	Increased acres or linear miles of hydrologically restored or reconnected habitat, while maintaining or improving water quality and flood protection.

*Key to Potential Costs: $ (<25,000) $$ (25,000–99,999) $$$ (100,000–499,999) $$$$ (500,000–999,999) $$$$$ (1M–10M) $$$$$$ (>10M)

FISH, WILDLIFE, & HABITAT RESTORATION PLAN: At a Glance

Action	Activities	Location	Responsible Parties
1 Protect, restore, and monitor estuarine habitats	1.1 Protect and restore beneficial submerged aquatic vegetation, including seagrasses, oysters, and coastal wetlands, to manage and enhance ecosystem services.	CHNEP area	CHNEP, County and Municipal Governments, FDEP, SWFWMD, SFWMD, FWC, USFWS, NOAA, USACE, J.N. "Ding" Darling NWR Complex, Land Conservation NGOs.
	1.2 Research and promote best management practices for tidal creeks, rivers, canals, dredged channels, and stormwater conveyances that support habitats and native aquatic life.	CHNEP area	County and Municipal Governments, SWFWMD, SFWMD, FDEP, FDACS, FWC, WCIND, USACE, USFWS, NOAA, UF/IFAS, Reseach Institutions, NGO neighborhood groups.
2 Protect, restore, and monitor environmentally sensitive lands and waterways including critical habitat areas	2.1 Encourage and support the permanent conservation of environmentally sensitive lands and critical habitat areas through land acquisition and conservation easements held in perpetuity, including freshwater wetlands, flowways, corridors, and uplands adjacent to coastal habitats necessary for habitat resilience and migration.	CHNEP area with a focus on protecting habitats and migration corridors as recommended by HRNP.	County and Municipal Governments, Florida Forever, SWFWMD, SFWMD, Land Conservation NGOs, FWC, USFWS, NOAA, FDACS, FDEP, USDA-NRCS.
	2.2 Encourage management of public lands and private lands with public conservation easements to protect, restore, and create native plant and animal communities, including eradication of invasive exotic species, prescribed fire, and other appropriate management activities.	CHNEP area with a focus on protecting habitats and migration corridors as recommended by HRNP.	County and Municipal Governments, FDEP, Land Conservation NGOs, Land owners, FWC, USFWS, SWFWMD, SFWMD, FDACS, FDEP, USDA-NRCS.
3 Assess and promote the benefits of land, waterway, and estuary protection and habitat restoration	3.1 Assist in assessing and promoting the economic, social, and environmental benefits of land protection and habitat restoration, including as a response to climate stressors.	CHNEP area	CHNEP, Land Conservation NGOs, NOAA, Colleges and Universities, SFWRPC, FDEO, County Visitors Bureaus, County Land Conservation Programs.

Timeframe	Annual Costs & Sources*	Benefits	5-Year Performance Measures
Ongoing; Climate Change Vulnerability Analysis adopted in 2018; Habitat Restoration Needs Plan to be adopted in 2019; Monitoring Strategy to be adopted in 2020.	$$$$$/SWFWMD, SFWMD, County and Municipal Governments, NOAA, FDEP, FWC, 320 Funds.	Improved habitat capacity and resiliency to support sustainable native populations of birds, fish, and other wildlife.	Increased created and restored oyster reefs, living shorelines, and seagrass meadows.
Ongoing; Monitoring Strategy to be adopted in 2020.	$$$$/CHNEP, County and Municipal Governments, FDACS, FDEP, SWFWMD, SFWMD, Florida Sea Grant.	Improved BMPs resulting in improved resource protection.	Improved understanding and additional data on habitat condition and function for supporting native aquatic life.
Ongoing; Habitat Restoration Needs Plan adopted in 2019; Monitoring Strategy to be adopted in 2020.	$$$$$$/State of Florida: Florida Forever and other programs, County and Municipal Governments, Land Conservation NGOs, Land owners, SWFWMD, SFWMD, USFWS, FWC, NOAA, FDACS, FDEP, USDA-NRCS.	A diverse environment of interconnected, healthy habitats that support natural processes and viable and resilient native plant and animal communities.	• Updated and adopted Habitat Restoration Needs Plan that includes priority projects. • Increased acreage of conserved land.
Ongoing; Habitat Restoration Needs Plan adopted in 2019; Monitoring Strategy to be adopted in 2020.	$$$$$/County and Municipal Governments, FDEP, FWC, USFWS, SWFWMD, SFWMD, FDACS, USDA-NRCS.	Effective management practices resulting in improved resource protection.	Increased acres of restored aquatic, wetland, and upland habitat and habitat under maintenance phase management.
Ongoing; Climate Change Vulnerability Analysis adopted in 2018; Communication and Outreach Strategy to be adopted in 2020.	$$$/CHNEP, Land Conservation NGOs, Visit Florida, SWFRPC, FDEO, County Visitors Bureaus, County Land Conservation Programs.	Increased public support for land protection and habitat restoration. Recognition of the economic impact of nature-based tourism and recreation.	Updated cost-benefit and/or ecosystem services analyses of ecosystem conservation and restoration.

*Key to Potential Costs: $ (<25,000) $$ (25,000–99,999) $$$ (100,000–499,999) $$$$ (500,000–999,999) $$$$$ (1M–10M) $$$$$$ (>10M)

PUBLIC ENGAGEMENT ACTION PLAN: At a Glance

Action	Activities	Location	Responsible Parties
1 Promote environmental literacy, awareness, and stewardship through expanded education and engagement opportunities for the general public	1.1 Support programs, events, presentations, and educational content that focus on key messages communicated in readily understandable language related to protection and restoration of estuaries and watersheds, including water quality, hydrology, habitat, and wildlife issues.	CHNEP area	CHNEP
	1.2 Provide CHNEP volunteers with activities to participate in research, monitoring, and restoration.	CHNEP area	CHNEP
2 Expand reach of education and engagement opportunities to new target audiences	2.1 Engage businesses and other priority stakeholders in estuary and watershed protection activities and educational programs.	CHNEP area	CHNEP
	2.2 Engage underrepresented and underserved communities in estuary and watershed protection activities and educational programs.	Underrepresented and underserved communities in the CHNEP area.	CHNEP
3 Strengthen non-profit partner collaboration in education and engagement programs	3.1 Build and support capacity of non-profit and community partners to educate and engage volunteers in outreach and activities that further CCMP implementation.	CHNEP area	CHNEP, TNC, local land trusts, Sanibel Sea School, National Audubon, Audubon of Florida, Charlotte Harbor Environmental Center, SCCF, Calusa Waterkeeper, Colleges and Universities.
4 Increase outreach to policymakers to enhance understanding and support for CCMP implementation	4.1 Provide regular updates to policymakers showcasing use of best available science and examples of success to reinforce the relationship between land use, water resource management decisions, environment, economy, and community.	CHNEP area	CHNEP

Timeframe	Annual Costs & Sources*	Benefits	5-Year Performance Measures
Ongoing; Finance Strategy to be adopted in 2020; Communication and Outreach Strategy to be adopted in 2020.	$$/ CHNEP, 320 Funds, Grants.	Increased public environmental awareness, understanding, and stewardship; increased support for management activities.	At least 10 research, restoration, or outreach initiatives showcased in educational materials, presentations, or at public events annually.
Ongoing; Finance Strategy to be adopted in 2020; Communication and Outreach Strategy to be adopted in 2020.	$/CHNEP, 320 Funds.	Increased public environmental awareness, understanding, and stewardship; increased support for management activities; increased scientifically-sound monitoring data; improved water and habitat quality.	At least 10 CHNEP volunteer activities hosted annaully.
Ongoing; Finance Strategy to be adopted in 2020; Communication and Outreach Strategy to be adopted in 2020.	$/ CHNEP, 320 Funds.	Increased public environmental awareness, understanding, and stewardship; increased support for management activities.	An annual event or activity that focuses on business and/or other priority stakeholders.
Ongoing; Finance Strategy to be adopted in 2020; Communication and Outreach Strategy to be adopted in 2020.	$/CHNEP, 320 Funds.	Increased public environmental awareness, understanding, and stewardship; increased support for management activities.	• An annual event or activity that focuses on underserved communities. • Translation of educational materials to multiple languages or formats.
Ongoing; Finance Strategy to be adopted in 2020; Communication and Outreach Strategy to be adopted in 2020.	$$$/CHNEP, 320 Funds, Grants.	Improved access to and use of best available science and best management practices to promote protection and restoration of estuaries and watersheds.	At least 5 new non-profit collaborative projects over 5 years.
Ongoing; Finance Strategy to be adopted in 2020; Communication and Outreach Strategy to be adopted in 2020.	$$/CHNEP, 320 Funds.	Increased environmental awareness, understanding, and leadership from policy-makers; increased policy and policy-maker support for CCMP goals and objectives.	10 meetings with elected or appointed officials or governmental entities annually.

*Key to Potential Costs: $ (<25,000) $$ (25,000–99,999) $$$ (100,000–499,999) $$$$ (500,000–999,999) $$$$$ (1M–10M) $$$$$$ (>10M)

“

Never doubt that a small group of thoughtful, committed citizens can change the world; indeed, it's the only thing that ever has.

Margaret Mead

326 West Marion Avenue
Punta Gorda, FL 33950-4417
941.575.5090 | 866.835.5785
www.CHNEP.org